Assistive Technology Assessment Handbook
SECOND EDITION

edited by
Stefano Federici • Marcia J. Scherer
REHABILITATION SCIENCE IN PRACTICE SERIES

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At its most general, the challenge of assistive technology (AT) assessment is to balance the technological–engineering conception of the user–AT interface with the modern biopsychosocial understanding of functioning and disability, in order to account for the user experience, without neglecting the ergonomic features of the AT. The *Assistive Technology Assessment Handbook* elegantly achieves this balance through the integration of the Matching Person & Technology model developed by Marcia Scherer and the theoretical insights and practical applications of the “psychotechnology” of Stefano Federici. This much-expanded second edition is therefore highly welcome.

The *Handbook* has tracked the salient developments in disability conceptualization, measurement, and policy development at the World Health Organization (WHO), beginning in 2001 with the endorsement of the *International Classification of Functioning Disability and Health* (ICF). The ICF provided both the impetus and the theoretical and technical foundations for the WHO's *World Report on Disability* in 2011, the *Disability Action Plan, 2014–2020* (in which access to high-quality AT is a major action objective), the launch of the *Global Cooperation on Assistive Technology* (GATE) initiative and the release of the *World Report on Ageing and Health* in 2016, and, most recently, the WHO's *Rehabilitation Call for Action 2030*.

Not only does the crucial importance of affordable, available, appropriate, and accessibility AT figure prominently in all of these WHO documents, but also the key components of the The Assistive Technology Assessment Model developed in the *Handbook* are also the building blocks of the WHO programmatic approach. These are, namely, the ICF foundations, the Person-Environment Matching model, the need for multidisciplinary assessment, the key role of rehabilitation, the user-driven approach (with its full-bodied acknowledgment of the emotional, psychological, and social dimensions of the user), and the lifespan perspective.

The recent initiatives at the WHO have led to a more coherent and theoretically sound approach to thinking about disability, rehabilitation, and AT that directly impacts how we understand AT, its place within rehabilitation services, and the assessment process. Three developments can be highlighted in this context.

First, after decades of silence, the WHO has now brought rehabilitation to the forefront. Demographic aging and the rapidly increasing prevalence of chronic noncommunicable diseases means that people are living longer but with more disability. The overall objective of rehabilitation as a health strategy is to optimize a person's intrinsic health capacity and to enhance the person's facilitating environment by the provision of AT so that the interaction results in optimal health and well-being, manifested by participation in all domains of life. Owing to this objective, the WHO argues, rehabilitation will become the prominent health strategy of the twenty-first century. The *Handbook* reflects this new role for rehabilitation.

Second, as the GATE initiative emphasizes, traditional service delivery models are responsible for the fact only 1 out of 10 individuals who could profit from an assistive devices has access to one. These models are notable for financing and procurement mechanisms and restrictive regulatory that serve primarily to limit access to AT. Viewing AT as “special equipment” is a barrier to access when it sends the message that these products require high levels of regulatory scrutiny. One of the many strengths of this *Handbook* is that it not only recognizes this issue—and the role it plays in adverse phenomena such
as abandonment—but also offers thoughtful discussions about how to overcome these socially created obstacles.

Finally, the WHO has, at least since the development of the ICF in the late 1990s, been skeptical of the view that “disability” is a particular social marker of a minority of individuals, the so-called “people with disabilities.” Inherent in the ICF model of functioning and disability, and the Handbook as well, is the proposition that both health determinants—the impairments associated with health conditions such as diseases, injuries, and aging—and environmental determinants—including AT—create the experience of disability. Since functioning in a domain is assessed on a continuum, problems in functioning—certainly when viewed across the life span—are an absolutely universal human phenomenon. Everyone has, or will have, some degree of limitation in functioning—some degree of disability—in one or more domains. Disability is not a matter of “yes or no” but “more or less.”

Consequently, as the authors in this Handbook are fully aware, AT is not some special product or technology designed and provided to a designated minority of people called “disabled”—it is an environmental facilitator that can compensate, relieve, modify, moderate, neutralize, prevent, or merely monitor some limitation in participation in domains the individual views as important that has resulted either from an environmental restriction on performance or a health limitation on capacity.

In this second edition of the Assistive Technology Assessment Handbook, the same robust theoretical foundations from the first edition are supplemented with high-quality chapters setting out the Assistive Technology Assessment Model and related tools for assessment within centers for AT evaluation and provision. The Handbook’s chapters explain the competencies of the diverse assessment professionals who comprise the multidisciplinary assessment team. Finally, other chapters explain the role of user experience evaluation in AT assessment and introduce the reader to cutting-edge technological advances to address diverse needs in all facets of people’s lives. In this last section, recognizing the impossibility of keeping abreast with technological developments, the editors wisely choose to focus on “new landscapes” in AT development—technology that tracks bodily gestures, brain–computer interfaces, graphic-user interfaces, and robotic exoskeleton assistance for mobility.

Reading through this third section, with all of its wonders of innovation, one might do well to focus on another balance, one as challenging as that which the editors have already achieved between the user–experience and technological–ergonomic realities: Exciting new technological developments that enhance participation and well-being are of little social importance if their availability is limited to a small group of people who can afford them. Breaking through the limits of our technological boundaries is challenging and exciting, but equally important is finding the social mechanisms of distribution that ensure that as many of those who could profit from a technological marvel have access to it.

Jerome Bickenbach

Swiss Paraplegic Research, Nottwil, Switzerland

and

Department of Health Sciences and Health Policy
University of Lucerne
Preface to First Edition

This book is the result of scientific collaboration and sincere friendship that was initiated in 2001 and has gradually strengthened over time. The collaboration begins with the creation, at the Faculty of Psychology, University “La Sapienza” of Rome, of the first course of psychotechnology that was held in Italy. This course aimed to combine multiple topics, bringing together on the one hand, technological and ergonomic arguments and issues concerning the psychology of rehabilitation in order to train competent psychologists within assistive technology provision.

The course, designed by Stefano Federici, addressed hundreds of Italian students who have enrolled for eight years at the University of Rome. The term “psychotechnology,” with the meaning adopted and introduced in the psychology of rehabilitation by Federici, initially sounded like a neologism. In fact, the objective of the course was to integrate technology and ergonomic aspects with those more specific to cognitive ergonomics, read under the lens of the biopsychosocial model of disability, in order to train psychologists with both psychological and technological expertise and who were able to lead a user to meet their needs. Only in this way would it have been possible for the user to search and find a technological product that not only was satisfactory to his or her own person, but was also able to support him or her in the integration process within the relevant milieu, by preventing, compensating, monitoring, relieving, or neutralizing disability and social barriers. The psychotechnologist, therefore, should possess those skills useful in centers for technical aid which, at the end of the last millennium, have begun to be characterized as autonomous centers of technology device assessment and assignment for an individual’s disability and independent living.

The main theoretical difficulty in designing the psychotechnologies course was to integrate technological-engineering models—not dissimilar in some ways to certain models of cognitive functioning that tend to generalize and idealize the individual—with the biopsychosocial model of disability. The ergonomic approach to technology, both of cognitive and engineering types, indeed, often tends to neglect the emotional, motivational, and social user experience, so that it does not take into account those factors which very often are affecting it with a higher rate of incidence in the successful outcome in device use.

The discovery, by Federici, of the Matching Person and Technology model by Marcia Scherer was like the key to closing the circle. It is a model that has combined people with disabilities’ needs with assistive technologies in a user-centered context, without neglecting the functional and ergonomic features of the device. It was found to be the answer to that fateful question that the psychotechnologist usually turned to him- or herself, “What is the most effective integration of what I know about this unique person?” As Federici was used to repeating in the Psychotechnology course at the University of Rome: “this course could also be called Matching Person and Technology from the psychologist’s standpoint.” The collaboration between the University “La Sapienza” of Rome and the Institute for Matching Person and Technology has produced dozens of theses and several doctoral dissertations concerning the adaptation and validation of the Matching Person and Technology model and tools related to the professional profile and role of the psychologist in the assistive technology assessment and assignment processes. Some of those researchers and students are now successful professionals in psychotechnology. Furthermore, many authors who took part in writing chapters of the current book come from that experience of study and research.
However, the collaboration and friendship between Marcia and Stefano has not only led to the sharing of ideas and research projects, but has created a scientific network among Italian, American, and scholars from other nations who have formed the scientific community that has allowed such a large participation of authors in writing this work.

As editors of this handbook, let us now provide the reasons for this book, which organizes a key challenge for us: to develop an international ideal model of an assistive technology assessment process that gathers the most recent scientific developments in assessing and providing technical aids for an outcome that, if reached, would be a real success: the well-being of the person with a disability. This model, therefore, intends to express in an idealized and essential form, an assessment process carried out in a center for technical aid, since it provides such tools for assessment and the professional skill set that we define “psychotechnological.”

Of course, just for the fact that we speak of “challenge,” we reveal our awareness about the problems and limitations of an “international” ideal model. One of the unsolved problems, for example, is the difficulty, already met several times, to define the features of a center for technical aid. The modeling process of a center for technical aid is difficult if one takes into account the extraordinary variety of systems of regional and national health and social care, both public and private. This variety affects in different ways the specific characteristics that are found at any particular center. Furthermore, the different nature of the center for technical aid makes problematic the definition itself of the individual who is served by it: user, patient, client, or consumer? The user (for convenience we use this definition, a little more generic than the others) of a center for technical aid could be a patient of a physician (physiatrist) who operates in a national system of health care and sends him or her to a specialized facility, the center for technical aid indeed, for a more thorough assessment for obtaining a particular device. This assessment can be provided free of charge, if the center is part of a national health system, or paid for by a private health system or even out of the individual’s own funds [?]. Furthermore, the product chosen by the user could be sold by or procured directly from the center for technical aid or, alternatively, the device provision may be made later by other providers, external and independent from the center for technical aid.

These are just some of the issues discussed by the authors of this handbook. Other issues, in fact, are also addressed that are even more problematic from a scientific viewpoint. We refer to those that are intrinsically linked to the design of an international model. Because of the difficulty of finding an adequate and effective synthesis of the various models proposed by specific national systems of public health and welfare, the scientific community is facing an assistive technology delivery system, which will be increasingly individualized, due to the social and cultural diversity of users and the necessary adjustment of the center for technical aid’s functioning to the local health system. However, it should be noted that this particularization of the model is to clash with some trends that are aimed at promoting, instead, globalization (e.g., this occurs both in social and health policies of the European Community and in those of the World Health Organization). The internationalization of a model, indeed, is advantageous since it often emerges as a synthesis of experiences of regional models. Moreover, it offers the opportunity, by sharing a theoretical model and evaluation criteria, to share data essential to scientific research, planning, and evaluation of national and international policies and the verification of the quality of public services.

A goal that we set in writing the present project was to narrow the topics, trying to legitimate the choice made. In fact, our intention was not only to provide a theoretical text, which aims to develop an ideal model of assistive technology assessment processes, but to provide an operational tool able to outline both the applicability of the model itself as well as the main characteristics of a center for technical aid’s functioning, endeavoring to
provide a tool-kit for a “proper assessment,” and profiles of professionals acting within the center. Moreover, it even seemed essential to us comparing our model with some of the most advanced researches in technologies for rehabilitation and supports for independent living. However, we were well aware that a detailed description of all assessment tools useful in a center for technical aid, a presentation of all possible professional profiles working within and in collaboration with a center for technical aid as well as an overview of the latest technology devices for rehabilitation and independent living would have required an encyclopedia and not a handbook, much more operational, as is the current text. Therefore, and this could be read both as a limit and as well an advantage of this book, we have chosen, for each of the three areas mentioned—the tools of evaluation, evaluation experts in a center for technical aid and new technologies—the aspects of the current state of the art we judged to be the most representative or innovative. So, we not only identified for each topic the leading experts and invited them to contribute, but also, where possible, for each lead author to collaborate with coauthors to achieve a comprehensive, cross-cultural chapter. For this reason, the reader should not be surprised if he or she will not find mention of some professions among those that could be treated in such a handbook. We tried to give more prominence to the definition, training, and professional role of the new profession of psychotechnologist, as well as to highlight the professional profile of key allied health professions. Finally, we would like to stress that this handbook does not intend to model the assistive technology assessment process as a result of a mere academic mental exercise, but to provide examples of applications of it. This is emphasized for two main reasons: the theoretical view of the authors’ chapters and editors emerge from experimental research applied to rehabilitation and assistive technologies; the international ideal model of assistive technology assessment process has already been applied in centers for technical aid. Thanks to scientific and clinical collaboration, economic and operational support of the Centre for Technical Aid of Rome, Leonarda Vaccari Institute—which, in turn, is part of the Italian Network of Centres Advice on Computer and Electronic Aids and cooperates with the Institute for Matching Person and Technology and the Columbia University, with whom it shares the principles that underlie the assistive technology assessment process—it was possible to define the assessment model proposed in this handbook since the model is already operative in the Centre of Rome. This Centre offers a non-commercial advisory service and support on assistive technologies and computers for communication, learning, and autonomy. The service is free of charge for users who access it through the Italian National Health Service. Several scientific projects granted by the Institute are in progress at the Centre to verify not only the advantages of a systematic application of the Matching Person and Technology tools in the assessment process, but also the application of the assistive technology assessment process model. Some results will be presented and discussed in the chapters of this book.

Sincere thanks go to the authors of the chapters who have welcomed with enthusiasm our model, enriching in many parts the initial draft of this work and giving the work as a whole a widely applicable, current and credible content. Special thanks also go to the publisher, CRC Press, Taylor & Francis Group, who eagerly accepted the project and supported the long process of drafting and revising sections of the handbook. Again, special thanks is extended to the many peer-reviewers of the chapters, who played a generous and valuable role, both in the validation of scientific nature and quality of each contribution as well as representing the international scientific community in this area.

Marcia and Stefano
Preface to Second Edition

The first edition of the Assistive Technology Assessment Handbook (2012) was shaped by the publication of the first World Report on Disability in 2011, which provided the context for our chosen path to read the assistive technology assessment process in light of the biopsychosocial model of individual functioning, as proposed by the International Classification of Functioning, Disability and Health. When person and environment, individual functioning and context are integrated in the framework of an assistive technology assessment process, then the selection of the technology becomes more appropriate to the user and the user’s environment. This reduces the mismatch between the person’s needs and the demands of the environment. Consequently, these are powerful tools to increase independence and wellbeing.

The ideal model of the assistive technology assessment process was proposed in the first edition, based on Marcia J. Scherer’s Matching Person and Technology (MPT) model. Since the 1980s, Scherer has realized the importance of including personal factors in the selection process for an assistive technology. This rehabilitation approach was given a favorable reception by the scientific community and professionals. For this reason, we were happy to welcome the invitation of Michael Slaughter, executive editor of CRC Press, Taylor & Francis, to edit a second edition.

As in the first edition, this second edition was inspired by the initiative conducted by the World Health Organization and promoted by the General Assembly of the United Nations since September 2013. The United Nation’s requests were focused on the development of a global initiative to realize the obligations of the Convention on the Rights of Persons with Disabilities toward increasing access to assistive technology. In July 2014, the World Health Organization responded to that request by establishing a global initiative: the Global Cooperation on Assistive Technology (GATE).

Along with all of the authors of our chapters, we are very proud to have made a contribution to GATE’s activities, one of which is strongly focused on the assistive products service delivery model. Our ideal model of assistive technology evaluation and provision can be used by professionals to check the functioning and to (re-)conceptualize the phases of an assistive technology delivery system according to the biopsychosocial model of disability. The assistive technology assessment process model can be a useful driver for arranging the relationships among professionals and end-users, and for determining when a multi-perspective assessment of the match between the user and the technology product and assistive solution would be beneficial in the delivery process. It has been thought that this is a useful process of assistive technology assessment and delivery process for any kind of technology. The model outlines an ideal process which provides reference guidelines for evidence-based practice, steering both public and private centers who wish to compare, evaluate, and improve their own matching person and technology model.

It is imperative today that the field and profession of assistive technology avail of and encourage technological, medical, and cultural advances throughout the world. Organizing the myriad needs as well as opportunities in ways that maximize the well-being and life quality of the unique person with a disability requires a strong foundation from which to work and a framework to guide the process of providing assistive support. Our goal is to provide just one such framework for our colleagues to use, expand, and improve.

Marcia and Stefano
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Editors

Stefano Federici is a professor in general psychology and psychology of disability at the University of Perugia, Italy. He has been a very active researcher in assistive technology for the disabled over the past 15 years and has published extensively in this area. In addition to the first edition, he has also published several additional reference works in the field.

Marcia J. Scherer is a chaired and tenured professor at the University of Rochester and is a world class researcher in the field. She has published over 200 refereed papers in rehabilitation studies.
Contributors

Meera Adya
Burton Blatt Institute
Syracuse University
Syracuse, New York
and Washington, DC

Giulia Balboni
Department of Philosophy, Social and
Human Sciences and Education
University of Perugia
Perugia, Italy

Paulo Sérgio Siebra Beraldo
Clinical Research Division
SARAH Network of Neurorehabilitation
Hospitals
Brasilia, Brazil

Simone Borsci
Diagnostic Evidence Co-operative
Division of Surgery
Imperial College of London
London, United Kingdom

Marco Bracalenti
Department of Philosophy, Social and
Human Sciences and Education
University of Perugia
Perugia, Italy

Lucia W. Braga
Neurosciences and Neurorehabilitation
Division
SARAH Network of Neurorehabilitation
Hospitals
Brasilia, Brazil

Jaime Rosa Campeau
Department of Otolaryngology
University of Rochester Medical Center
Rochester, New York

Valentina Canonico
Atlas Centre–Associazione Sementera
ONLUS
Perugia, Italy

Simon Carson
Department of Physical Medicine and
Rehabilitation
University of Rochester Medical Center
Rochester, New York

Barbara Cordella
Department of Dynamic and Clinical
Psychology
Sapienza University of Rome
Rome, Italy

Fabrizio Corradi
Center for Technical Aid
Vaccari Institute for Disabled People
Rome, Italy

Gerald Craddock
Centre for Excellence in Universal Design
National Disability Authority
Dublin, Ireland

Michael P. Craven
Bioengineering Research Group
Faculty of Engineering
University of Nottingham
and
NIHR MindTech Healthcare Technology
Co-operative
Institute of Mental Health
University of Nottingham Innovation Park
Nottingham, United Kingdom

Desleigh de Jonge
LifeTec Australia
The University of Queensland
Brisbane, Queensland, Australia
Contributors

Louise Demers
Université de Montréal
and
Centre de recherche de l’Institut
universitaire de géiatrie de Montréal
Montreal, Quebec, Canada

Simone Donnari
Atlas Centre–Associazione Sementera
ONLUS
Perugia, Italy

Nancy Dukelow
Department of Physical Medicine and
Rehabilitation
University of Rochester Medical Center
Rochester, New York

Giovanni Fatuzzo
Atlas Centre–Associazione Sementera
ONLUS
Perugia, Italy

Stefano Federici
Department of Philosophy, Social and
Human Sciences and Education
University of Perugia
Perugia, Italy

Ingrid Lapa de Camillis Gil
Neurological Rehabilitation Division
SARAH Network of Neurorehabilitation
Hospitals
Brasilia, Brazil

Apeksha R. Gohil
Department of Occupational Therapy
School of Primary and Allied Health Care
Monash University
Melbourne, Victoria, Australia

Massimo Grasso
Department of Dynamic and Clinical
Psychology
Sapienza University of Rome
Rome, Italy

Francesca Greco
Department of Dynamic and Clinical
Psychology
Sapienza University of Rome
Rome, Italy

Katya Hill
School of Health and Rehabilitation
Sciences
AAC Performance and Testing
Teaching Lab
University of Pittsburgh
Pittsburgh, Pennsylvania
and
ICAN™ Talk Clinic of the AAC Institute
Carnegie, Pennsylvania

Melanie Hoyle
The University of Queensland
Brisbane, Queensland, Australia

Masaaki Kurosu
The Open University of Japan
Chiba-shi, Chiba, Japan

Sarah Kysor
Department of Physical Medicine and
Rehabilitation
University of Rochester Medical Center
Rochester, New York

Natasha Layton
La Trobe University
Summer Foundation
Bundoora, Victoria, Australia

Giulia Liberati
Institute of Neuroscience
Université Catholique de Louvain
Louvain, Belgium

Alessandra Lo Presti
Graduated in Psychology and Disability
Study
Rome, Italy

Trish MacKeogh
Central Remedial Clinic
Dublin, Ireland

Wendy L. Magee
Music Therapy Program
Boyer College of Music and Dance
Temple University
Philadelphia, Pennsylvania
Sheryl Maier  
Department of Otolaryngology  
University of Rochester Medical Center  
Rochester, New York

Amy Pacos Martinez  
Department of Physical Medicine and  
Rehabilitation  
University of Rochester Medical Center  
Rochester, New York

Claudia Mazzeschi  
Department of Philosophy, Social and  
Human Sciences and Education  
University of Perugia  
Perugia, Italy

Patrizia Mecocci  
Institute of Gerontology and Geriatrics  
Department of Medicine  
University of Perugia  
Perugia, Italy

Maria Laura Mele  
Department of Philosophy, Social and  
Human Sciences and Education  
University of Perugia  
Perugia, Italy  
and  
COGISEN  
Engineering Company  
Rome, Italy

Fabio Meloni  
Department of Philosophy, Social and  
Human Sciences and Education  
University of Perugia  
Perugia, Italy

Klaus Miesenberger  
Institute Integriert Studieren  
Johannes Kepler University Linz  
Linz, Austria

Damon Millar  
COGISEN  
Engineering Company  
Rome, Italy

Mansha Mirza  
Department of Occupational Therapy  
University of Illinois at Chicago  
Chicago, Illinois

Michael Morris  
Burton Blatt Institute  
Syracuse University  
Syracuse, New York  
and Washington, DC

William Ben Mortenson  
Department of Occupational Science and  
Occupational Therapy  
University of British Columbia  
and  
International Collaboration on Repair  
Discoveries  
Vancouver Coastal Health Research  
Institute (VCHRI)  
and  
GF Strong Rehabilitation Research  
Program, VCHRI  
Vancouver, British Columbia, Canada

Emanuele Pasqualotto  
Institute of Neuroscience  
Université Catholique de Louvain  
Louvain, Belgium

Chiara Pazzaglì  
Department of Philosophy, Social and  
Human Sciences and Education  
University of Perugia  
Perugia, Italy

Martina Pigliautile  
Psychologist  
Perugia, Italy

Katia Soares Pinto  
Pediatric Rehabilitation Division  
SARAH Network of Neurorehabilitation  
Hospitals  
Brasilia, Brazil

Christiaan Erik Rijnders  
COGISEN  
Engineering Company  
Rome, Italy
Contributors

Deepti Samant  
Burton Blatt Institute  
Syracuse University  
Syracuse, New York and Washington, DC

Marcia J. Scherer  
Institute for Matching Person and Technology  
Webster, New York

Christopher Stavisky  
Department of Physical Medicine and Rehabilitation  
University of Rochester Medical Center  
Rochester, New York

Aldo Stella  
Department of Philosophy, Social and Human Sciences and Education  
University of Perugia  
Perugia, Italy

Lorenza Tiberio  
Psychologist  
Rome, Italy

Michele Verdonck  
University of the Sunshine Coast  
Sippy Downs, Queensland, Australia

Thomas Wosch  
University of Applied Sciences Würzburg-Schweinfurt  
Würzburg, Germany

Andrea Gossett Zakrajsek  
School of Health Sciences  
Ypsilanti, Michigan

Susan Zapf  
Children’s Journey to Shine, Inc.  
Friendswood, Texas
Section I
The Assistive Technology Assessment Process Model and Basic Definitions

Stefano Federici and Marcia J. Scherer

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I.1 Introduction
As a part of the human condition, “Disability is complex, dynamic, multidimensional, and contested” (WHO and World Bank, 2011, p. 3). “Contested” refers to difficulties reaching a consensus in defining disability. There are multiple models of disability in operations and, often, in opposition. When talking about disability, there are many surrounding and supporting issues that become relevant such as individual functioning and its measurement, the existence of social barriers and a digital divide, objective quality of life and subjective well-being, activity performance and participation, human rights and disparities in wealth and health, and morbidity and mortality. Given the multidimensionality of disability, the International Classification of Functioning, Disability, and Health (ICF) aims to make clear that disability (and its correlated term “functioning”) must be understood as an umbrella term, “encompassing all body functions, activities and participation” (WHO, 2001, p. 3).
Disability is a multidimensional construct, and its measurement is multidimensional and cannot be held to a “gold standard” that is valid for all contexts and purposes (see Chapter 2, “Measuring Individual Functioning”). The only appropriate measure is the one that best suits the context, purpose, and person to which it is addressed, rather than the concept of disability in the abstract. Moreover, the variety of measurement tools and the flexibility to change the measurement procedures, adapting them to different people, contexts, technologies and other supports, and purposes, provide the most reliable scientific approach and clinical/practical solutions.

A well-known paradox in measuring disability arises from the fact that an individual’s understanding of their well-being may not accord with the evaluations of medical experts (Federici, Bracalenti, Meloni, and Luciano, 2017). Sen (2002) has noted the conceptual difference between perception and observation of health. There is often a discrepancy between an individual’s subjective view of their health, based on personal perceptions, and the views of doctors or professionals, which are based on objective data (Federici, Meloni, and Corradi, 2012). Albrecht and Devlieger (1999) state that the “disability paradox” implies that personal experience with disability is an important aspect of any assessment of disability; hence, assessments of it should combine objective observations with subjective, self-report data.

Madans and colleagues. (2002) identify, at the aggregate level, three main classes of reasons for measuring. Here, “providing services” (2002, slide 11)—including the development of programs and policies for service provision and their evaluation—is the first among the three classes. Particularly, the Assistive Technology Assessment (ATA) process can be viewed as one aspect of the first-mentioned class.

Assistive Technology (AT) plays a key and fundamental role in facilitating the social integration and participation of people with physical, sensory, communicative, and cognitive disabilities. We use the term AT, except where otherwise stated, as an umbrella term (WHO, 2004), with the meaning more commonly attributed to the “Assistive Technology device” term, as stated by the U.S. Assistive Technology Act (United States Congress, 2004) and acknowledged by the World Health Organization in the recent World Report on Disability (WHO and World Bank, 2011), as follows: “Any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities” (p. 101). This definition stresses that what make a device an assistive product, namely an AT, is who uses the product, rather than its intrinsic characteristics. Thus, mainstream/everyday/universal technologies such as smartphones and robots are considered ATs when they are used for enhancing capabilities and functioning of individuals with disabilities.

Furthermore, the International Standards Organization (ISO) has recently revised the definition of Assistive products for persons with disability, integrating the first definition of 1998 (ISO 9999) with the ICF’s concepts:

“any product (including devices, equipment, instruments and software), especially produced or generally available, used by or for persons with disability for participation, to protect, support, train, measure, or substitute for body functions, structures, and activities, or to prevent impairments, activity limitations, or participation restrictions” (ISO, 2016).

According to the ISO 9999, AT is a mediator, an interface that tends to reduce the mismatch between the person’s needs and the requests of the environment, neutralizing
barriers (promoting participation) and disability (reducing limitations) (e.g., ISO and IEC, 2008).

The ISO’s definition of assistive products was also discussed at the Global cooperation on Assistive Health Technology (GATE), a WHO initiative (http://www.who.int/disabilities/technology/gate/en/). GATE proposes a “positive approach” to change the definition using a more positive wording, for example, “any product (including devices, equipment, instruments, and software), especially designed and produced or generally available, whose primary purpose is to maintain or improve an individual’s functioning and independence and to facilitate participation”. In this definition, still under discussion, it is no longer the user of a product (the person with disability) that determines whether that product is an AT, but the purpose of use, that is, to promote well-being regardless of who uses it. In this manner, the AT tends to coincide with a “positive technology”, the final aim of which is to manipulate and enhance the features of personal experience, with the goal of increasing wellness and generating strengths and resilience in individuals, organizations, and society (Botella et al., 2012; Riva, 2013; Riva, Baños, Botella, Wiederhold, and Gaggioli, 2012; Wiederhold and Riva, 2012).

In sum, in line with previous definitions, a product is an AT either if the user of the product is a person with disability or if the purpose of the use enhances an individual’s functioning, independently of the user’s traits (with or without disability).

However, in order for an AT to achieve its purpose of reducing the mismatch between the person’s need and his/her environment and promoting well-being, a well-designed and well-researched sequential set of assessments, administered by professionals with relevant areas of expertise to match AT and person, is required (Scherer, 2005). The success of the matching is strongly affected by the evaluation protocol/model, as well as by the skills of the multidisciplinary team members (Federici and Borsci, 2016). For this reason, Section I of this handbook provides readers with useful guidelines for developing a set of tools for assessment of functioning and for disability screening in centers for AT evaluation and provision (Federici, Scherer, and Borsci, 2014). The ATA process borrows a user-driven working methodology from the Matching Person and Technology (MPT) model of Scherer (Scherer, 1998, 2017a, b Scherer and Craddock, 2002). Furthermore, the ATA ideal model embraces the ICF biopsychosocial model (WHO, 2001), aiming at the best combination of AT to promote the personal well-being of customers.

I.2 The Assistive Technology Assessment Process Ideal Model

The introduction of AT into the lives of people is a thoughtful and long-term process, which presupposes teamwork as much as professionalism, time, and experience. The aim of the ATA ideal model is to suggest guidelines to follow in order to obtain the desired results during the AT selection and assignment process.

This model, far from seeking to prefigure a “gold standard”, instead, sought to create a structure that allows one to build or change the existing processes so that they can consider more personalized variables, such as the nature of the person’s disability, the personal motivation and enthusiasm of both the person with a disability and their family members, the social and political context, and the availability of human and financial resources within user-driven processes, and do so in the context of the biopsychosocial model of the ICF.
The ICF (WHO, 2001) and the ICF-Children and Youth Version (ICF-CY; WHO, 2007) provide a unified standard framework for an ATA process in the centers for AT evaluation and provision, allowing them to seek the best match of user–AT solution, by using a comprehensive set of clinical measures, functional analysis (see Chapters 2 and 4), and psycho-socio-environmental evaluations (see Chapter 4). By the AT solution, we mean much more than providing a device to a person with a disability. It involves neutralizing barriers, improving the functioning of individuals, and promoting their well-being (AAATE, 2003). Consequently, delivering an AT solution entails an individualized combination of hard (actual devices) and soft (assessment, trial, and other human factors) assistive technologies, environmental interventions, and paid and/or unpaid care (Layton, Steel, and de Jonge, 2013).

As the ATA process model is a user-driven process, any activity of the AT service delivery must find a correspondence to a user action and vice versa. The users’ actions in the ATA process can be grouped into three phases (Figure I.1).

**FIGURE I.1**
Flow chart of ATA process ideal model in a center for AT: The ATA process ideal model can be read from the perspective of the user or from the perspective of the center for the AT service delivery. The User Action flow chart is on the left, and the procedures of the AT Service Delivery are on the right. The numbers refer to the phases and the letters to the steps for each phase. (From Federici, S., Scherer, M. J., and Borsci, S. 2014. *Technology and Disability*, 26(1), 27–38. doi:10.3233/TAD-140402.)
Phase 1 → The user seeks a solution for one or more forms of activity limitation or participation restriction by seeking assistance from a center for AT.

Phase 2 → The user checks the solution and tries and checks one or more technological aids provided by the professionals in a suitable evaluation setting (center, house, hospital, school, rehabilitation center, etc.)

Phase 3 → The user adopts the solution after obtaining the assistive device(s) from the public health system (or public/private insurance), receives training for the daily use of the AT, and receives follow up.

The ATA process ideal model can be used by professionals to check the completeness of the process used and to (re-)conceptualize the phases of an AT delivery system according to the biopsychosocial model of the disability stated by the ICF (WHO, 2001). Figure 1.2 displays the ICF model as it fits the ATA process model.

**FIGURE 1.2**
ATA process ideal model according to the ICF’s biopsychosocial model. The biopsychosocial model is displayed in the upper left region, and the ATA process flow chart is shown on the right. The solid line connects the components of Body Functions and Structure with phases 1 and 2 of the ATA process: The individual functioning and disability of the user are considered by the multidisciplinary team that evaluates the health conditions of the user. The dashed line connects the Activities component with phase 3 of the ATA process model: The matching process aims to support activity limitations and enhance individual functioning. The dotted line connects the Participation component of the ICF with the Environmental assessment process and phase 4 of the ATA process. (From Federici, S., Scherer, M. J., and Borsci, S. 2014. Technology and Disability, 26(1), 27–38. doi:10.3233/TAD-140402.)
I.3 AT Abandonment: The Service Delivery System in Different Countries

The most relevant studies on AT abandonment (Borg et al., 2012; Chen and Chan, 2013; Dijcks, De Witte, Gelderblom, Wessels, and Soede, 2006; Federici and Borsci, 2011, 2016; Federici, Meloni, and Borsci, 2016; Kittel, Di Marco, and Stewart, 2002; Kylberg, Löfqvist, Horstmann, and Iwarsson, 2013; Löfqvist, Slaug, Ekström, Kylberg, and Haak, 2016; Phillips and Zhao, 1993; Scherer, 1996, 2005; Scherer, Cushman, and Federici, 2004; Scherer and Federici, 2015; Scherer, Sax, Vanbiervliet, Cushman, and Scherer, 2005; Verbrugghe et al., 2015; Verza, Carvalho, Battaglia, and Uccelli, 2006) have been conducted in different contexts with different national service delivery systems (Estreen, 2010; Mathiassen, 2010; Stack et al., 2009). In some cases, such national service delivery systems have been divided according to the model underlying the service delivery itself: medical-oriented model, social-oriented model, or client-oriented model (Stack et al., 2009). On the other hand, the service delivery process has been analyzed by others from the Public or Private Health Service point of view, so that we can distinguish between private insurance, donations, and direct acquisition (Estreen, 2010; Scherer, 2017c). In Table I.1, the service delivery systems and models of some countries are quoted, as an example from which the previously mentioned works originate:

We can observe that, in general, in European countries, a Public Health System is more diffused where the person with a disability is considered a patient/user. Inside these systems, the person who effects the matching does not sell AT, but acts as an intermediary between the patient/user and the AT vendors by providing an assessment and support service. In countries such as the United States and Australia, it may occur that the person with a disability is considered a client inside a Private System, to whom the assessment center for AT will sell products. The first model assures more neutrality in assessing the best AT matching; the second model fosters user-centered satisfaction with the best matched product. In general, when there is a Public System, the financing of some device categories is bound to a “prescription” and authorized by a specialist. Moreover, the doctor who prescribes must carry out many duties that, in reality, should be within the competence of other experts, such as engineers, psycho-technologists, psychologists, and psychotherapists. In the Private Service, on the other hand, the client may benefit from well-prepared professionals, but without having the necessary services at their disposal. Notwithstanding the diversity of service delivery systems (public/private), recent studies prove that both systems involve high AT abandonment percentages—between 12% and 38%—with some exceptions for certain types of devices, such as electric wheelchairs, for which the abandonment rates can be as low as 5% (Wressle and Samuelsson, 2004). The more optional the AT use is, the higher will be the nonuse and abandonment rate (Scherer, 2005). Moreover, both systems involve a high degree of user dissatisfaction and a large waste of money. All this induces the scholars of this sector to pursue a critical elaboration of ATA process models, which, starting from the modelling of the preexisting services, allows us to develop some guidelines in order to optimize the matching process (Ripat and Booth, 2005).

* ”Service Delivery refers to professional advice and treatment activities, as well as the physical delivery of the technical aid to the person with a disability, including training and setup if required. In the Assistive Technology industry, the term Service Delivery is used to identify the set of facilities, procedures and processes that act as intermediaries between the AT product manufacturers and AT end-users” (Stack et al., 2009, p. 28).
TABLE I.1
Service Delivery System and Model

<table>
<thead>
<tr>
<th>Country</th>
<th>Service Delivery System†</th>
<th>Service Delivery Model§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Private system</td>
<td>Consumer‡</td>
</tr>
<tr>
<td>Austria</td>
<td>Public system and private system for self-employed</td>
<td>Social and medical</td>
</tr>
<tr>
<td>Denmark</td>
<td>Public system (health and municipalities)</td>
<td>Social</td>
</tr>
<tr>
<td>Finland</td>
<td>Public system (health)</td>
<td>Medical</td>
</tr>
<tr>
<td>France</td>
<td>Public system</td>
<td>Medical, social, and consumer</td>
</tr>
<tr>
<td>Germany</td>
<td>Private system and partially public system</td>
<td>Medical and social</td>
</tr>
<tr>
<td>Greece</td>
<td>Public and private system</td>
<td>Medical and consumer</td>
</tr>
<tr>
<td>Italy</td>
<td>Public system (health)</td>
<td>Medical and social</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Private and public system</td>
<td>Medical and social</td>
</tr>
<tr>
<td>Norway</td>
<td>Public system (municipality)</td>
<td>Medical</td>
</tr>
<tr>
<td>Spain</td>
<td>Public system (health and social by regions)</td>
<td>Social, medical, and consumer</td>
</tr>
<tr>
<td>Sweden</td>
<td>Public system (health and county councils and municipalities)</td>
<td>Medical</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Private and public system (health and social)</td>
<td>Medical, social, and consumer</td>
</tr>
<tr>
<td>United States</td>
<td>Private system</td>
<td>Social, medical, and consumer</td>
</tr>
</tbody>
</table>

Note: In almost all cases, the AT for schools in the private system is managed with a public service delivery system.

† Survey performed between 2010 (Estreen, 2010) and 2011 by the Leonarda Vaccari Institute in Rome, Italy.
§ Stack et al. (2009)
‡ Free market model in which there is no intermediary between the patient/consumer and his or her solution (Stack et al., 2009).

I.4 Presentation of the Chapters of Section I

The chapters presented in this section aim to discuss both features and different aspects of the ATA process ideal model, in order to set up a standard structure that can be shared among the centers for AT that aim to reduce both the abandonment and disuse of obtained ATs. Particularly, in Chapter 1, titled “Assessing Individual Functioning and Disability”, the authors present an overview of the historical evolution of different models of disability, from the medical to biopsychosocial, in order to explain the theoretical background underlying the ATA process model. The biopsychosocial (or universal) model embraced by the ICF is deepened here: from this novel perspective, the concepts of “functioning” and “disability” are redefined in reference to the complex interaction between personal and environmental factors. Under the lenses of this holistic model, the authors aim to explain the function of assistive solutions, which are conceived, here, as a mediator between the multidimensionality of the specific health conditions of an individual and their effective functioning in the ATA process model.
A close examination of the role of individual functioning, and how to measure it, is presented in Chapter 2, “Measuring Individual Functioning”. The authors discuss both issues and principles related to the measurement of individual functioning, paying special attention to its application to the ATA process. Starting from a discussion of the complexity of the definition of disability, the authors suggest different guiding principles to help professionals working in centers for AT in choosing and applying the set of measures that better fit with the objectives of the ATA process model. Different measures for clinical, functional, and psycho-socio-environmental factors are suggested here for the different evaluation steps of the ATA process model. Different tools and techniques are presented for facilitating the multidisciplinary team-building process, through the characterization of each profession required during the assessment (and measurement) process, with the ultimate aim of ensuring the well-being of the user.

In Chapter 3, titled “Measuring the Assistive Technology MATCH”, the problem of measurement in the matching process between user and AT is discussed. In the first paragraph, the authors focus on the description of two models, the MPT model (Figure I.3; Scherer, 1998, 2005) and the ICF model, in order to provide a comprehensive overview of the main standard frameworks of measures and tools currently being used. The aim of this study is to explain how the ATA process model is integrated with the MPT model to achieve the best AT assistive solution, because they both share a user-driven approach under the biopsychosocial model of the ICF.

![FIGURE 1.3](image)

(See Chapter 3, Figure 3.1; Chapter 6, Figure 6.1; Chapter 14, Figure 14.7 for the gray version). The matching person and technology model. The “Match of Person and AT” (the smallest circle) indicates the AT solution that increases the quality of life and well-being. (From Scherer, M. J. 2005. Living in the State of Stuck: How Technologies Affect the Lives of People with Disabilities (4th ed.). Cambridge, MA: Brookline Books.)
The relations among environment, accessibility, usability, and sustainability between a user and an AT are explained in Chapter 4, titled “Assessment of the Environments of AT Use: Accessibility, Universal Design, and Sustainability”. In this chapter, a user experience model and the environment evaluation model are discussed as two of the main important steps in the ATA process model. Moreover, the Environmental Assessment in the ATA process is both introduced and exemplified as a step-by-step decision-making process, set up by the multidisciplinary team for collecting data about the environment(s) of use, in which the users put the AT to work.

Chapter 5, titled “Measuring the Impact of AT on Family Caregivers”, concludes this section. It provides an overview of the literature about the impact of AT on informal caregivers of children and adults, and describes the relationship between the outcomes for assistance users, their informal caregivers, and the related assistive solutions. This chapter aims both to provide recommendations for practice and to suggest future developments in this field through two hypothetical illustrative vignettes.

I.5 Conclusion

The AT Assessment is a user-driven process through which the selection of one or more ATs for an AT solution is facilitated by the comprehensive utilization of clinical measures, functional analysis, and psycho-socio-environmental evaluations that address, in a specific context of use, the personal well-being of the user through the best matching of user and AT solution. As the AT solution represents the outcome of a user-driven process aimed at the improvement of individual functioning, it can be considered as a mediator of quality of life and well-being in a specific context of use. For these reasons, it is important to underscore that the AT solution does not coincide with a technology product, because the former is a complex system in which psycho-socio-environmental factors and assistive technology interact in a nonlinear manner, by reducing the activity limitations and participation restrictions through one or more technologies.

The definition of ATA represents the core definition of this handbook, summarizing the properties of the ATA process model. All the chapters in Section I refer to this definition and follow a guiding reference model, which is presented in Figure I.1.

References

The Assistive Technology Assessment Process Model and Basic Definitions


1

Assessing Individual Functioning and Disability

Stefano Federici, Marcia J. Scherer, Fabio Meloni, Fabrizio Corradi, Meera Adya, Deepti Samant, Michael Morris, and Aldo Stella

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1.1 The Universal Model of Disability

The origins of the biopsychosocial model date back to the proposal, which is put forward by psychiatrist George Engel in 1977, to integrate the dominant social and psychological variables within the medical model:

The dominant model of disease today is biomedical, and it leaves no room within its framework for the social, psychological, and behavioural dimensions of illness. A biopsychosocial model is proposed that provides a blueprint for research, a framework for teaching, and a design for action in the real world of health care (1977, p. 130).

Engel made the leading theoretical contribution for building the biopsychosocial model, which is identified in von Bertalanffy’s general systems theory (von Bertalanffy, 1950). According to this approach, the unifying principles in the scientific context are not a reduction of a scientific phenomenon, but the organization that explains it. It is not sufficient to divide a scientific phenomenon into simpler units of analysis and to study such units one by one; it is necessary to study the interrelations among these units. We contrast this with the old scientific method, which refuses all forms of teleology and is based on linear causality and relations between an independent variable and a dependent variable. We present an approach that examines the interrelations among many variables, some of them unknown, and which considers the organicistic characteristics of life, by considering concepts such as order, organization, differentiation, and orientation to a purpose. As a result, human beings are also observed as systems, ecologically embedded into multiple systems (Gray, Duhl, and Rizzo, 1969). In the biopsychosocial model, the definition of the
state of health or illness is therefore the outcome of the interaction of processes that operate at the macro-level, for instance, the existence of social support for depression, and the processes that operate at the micro-level, such as biological or biochemical derangements.

Thus, it is impossible, from this perspective, to isolate disability from the functioning of an individual and vice versa or, rather, to hypothesize one without the other, not only at the level of social organization but also at the level of a single individual. Disability implies functioning and vice versa. When Zola, in “Toward the Necessary Universalizing of a Disability Policy” (1989), expresses hope for the demystification of the “specialness” of disability and the admission that “people with a disability have long been treated as an oppressed minority” (p. 19), he assumes a conception of disability that is fluid and contextual: “Disability is not a human attribute that demarks one portion of humanity from another (as gender does, and race sometimes does); it is an infinitely various but universal feature of the human condition” (Bickenbach, Chatterji, Badley, and Üstün, 1999, p. 1182). The issue of disability for individuals “is not whether but when, not so much which one, but how many and in what combination” (Zola, 1993, p. 18).

There is not, according to Zola’s approach, which is close to the biopsychosocial model, a dichotomy between ability and disability. Rather, there is a continuum in which complete ability or complete disability represents nothing but borderline cases that are only possible in theory. The unique borders for dividing this continuum should have political and economic purposes and produce functional distinctions in order to redistribute resources within society. Evidently, we are talking about boundaries that could be criticized and may be modifiable over the course of time. According to Zola, developing “universal policies” is a matter of urgency that recognizes an indisputable fact: the entire population is “at risk” owing to the extraordinary concomitance of chronic illnesses and disability (1989, p. 1). Beyond a universal perspective, we seriously risk creating and perpetuating a model of segregated and separated society, which is also characterized by a progressive accentuation of inequalities:

Only when we acknowledge the near universality of disability and that all its dimensions (including the biomedical) are part of the social process by which the meanings of disability are negotiated will it be possible fully to appreciate how general public policy can affect this issue. (Zola, 1989, p. 20).

The rapid ageing of the world population, now more than ever before, confirms what Zola claimed. In most of the World Health Organization’s (WHO) recent documents, the correlation between the spread of disability as a condition and the progressive aging of the population is dramatically shown:

Life expectancy is increasing in most countries in the Region and the populations are therefore ageing rapidly. In 2050, one third of the population is projected to be 60 years and older. […] Whereas much of old age is a healthy period, there may be ill health, which leads to disability and dependence, especially in late old age (WHO, 2011, p. viii);

Global ageing has a major influence on disability trends. The relationship here is straightforward: there is higher risk of disability at older ages, and national populations are ageing at unprecedented rates (WHO and World Bank, 2011, p. 35).

Moreover, disability belongs to the human condition not only on a biological level, but also on a cultural one, because “across the world, people with disabilities have poorer health outcomes, lower education achievements, less economic participation and higher rates of poverty than people without” (WHO and World Bank, 2011, p. xi). According to the recent
World report on disability, it is estimated that between 110 and 190 million people (from 2.2% to 3.8%) have considerably significant difficulties in functioning (WHO and World Bank, 2011, p. 44).

1.2 Classification, Declaration and International Definitions of Functioning and Disability

In the International Classification of Functioning, Disability, and Health (ICF; WHO, 2001), conceptually founded on the biopsychosocial or universal model, an interactive model (holistic) is proposed. In this model, a person’s functioning and disability are considered the product of the dynamic interaction between health conditions and contextual factors, which include personal factors as well as environmental ones. In the ICF, concepts such as “functioning” and “disability” are defined in reference to the relation between an individual and their context, or rather the complex interaction between personal and environmental factors: “A person’s functioning and disability is conceived as a dynamic interaction between health conditions (diseases, disorders, injuries, traumas, etc.) and contextual factors” (WHO, 2001, p. 8).

It is impossible to talk about a person’s functioning and disability as if they live in a social, cultural, political, and economic vacuum. This vacuum is filled by the introduction of the contextual factors in the ICF’s biopsychosocial and inter-relational model of disability. The multidimensionality of the ICF is guaranteed by the fact that contextual factors are a basic and integral component of the human functioning model based on this classification, alongside body functions and structures, as well as activity and participation. The positive aspects of the relationship between an individual and their context are defined by the umbrella term “functioning,” by which we mean all nonproblematic or positive aspects of health and health-related individual conditions. On the other hand, all negative aspects that characterize the relationship between an individual and their context are defined by the umbrella term “disability”. In the classification, both terms have a neutral meaning (or rather are meant as traced back to their original semantic value), immune from any possible social-cultural biases, which justifies their use as “umbrella” terms.

Overall, the ICF individuates four components related to human functioning and its restrictions: the Functioning and Disability components, subdivided into (i) Body Functions and Structures; (ii) Activities and Participation, as well as the Contextual Factors components; which encompass (iii) Personal and (iv) Environmental Factors. Each component consists of different constructs or qualifiers and is subdivided into domains and categories at different levels. Health and health-related states may be classified using an alphanumeric code system: \( b = \) Body Functions, \( s = \) Body Structures, \( d = \) Activities and Participation, and \( e = \) Environmental Factors. Separated by a dot on the right of the alphanumeric codes, the ICF requires the use of one or more qualifiers, which denote, for instance, the magnitude of the level of health or severity of the problem at issue (WHO, 2001, Annex 2).

In accordance with the biopsychosocial model and the ICF, the Convention on the Rights of Persons with Disabilities, adopted on December 13, 2006 by the General Assembly of the United Nations resolution (hereafter Convention), recognizes the following:

Disability is an evolving concept and that disability results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their
full and effective participation in society on an equal basis with others... [and hopes for
the following:] (a) Respect for inherent dignity, individual autonomy including the free-
dom to make one’s own choices, and independence of persons; (b) Nondiscrimination;
(c) Full and effective participation and inclusion in society; (d) Respect for difference
and acceptance of persons with disabilities as part of human diversity and humanity;
(e) Equality of opportunity; (f) Accessibility; (g) Equality between men and women; (h)
Respect for the evolving capacities of children with disabilities and respect for the right
of children with disabilities to preserve their identities (UN, 2006, Preamble).

By founding a concept of disability on the basis of the international value of human
rights, the universal value of the Convention seems to have heeded the wishes of the
late Irving Zola regarding the need for a shared approach to policies on disability at
the international level. From this perspective: “human rights are applicable to everyone,
and to everyone equally, independently of all contingent differences between people—
race, religion, language, culture, geographical location, and so on, including disability”
(Bickenbach, 2009, p. 1112). The unique criterion to be recognized as a beneficiary of human
rights is, precisely, that of belonging to the human race. Nonetheless, it is undeniable that
such a perspective questions several practical issues concerning its application to different
human cultures. The concepts of disability and functioning are socially constructed or,
rather, the meanings of both terms are enriched with different values and denote cross-
cultural differences:

What it means to be disabled, in short, fundamentally includes what it means to be
viewed as disabled by others, and this is contingent on features of one’s society, system
of economic exchange, culture, language and many other things besides (Bickenbach,
2009, p. 1112).

Thus, risks of incommunicability or mutual misunderstanding between individuals and
institutions from different social, cultural, and political contexts are anything but unreal-
istic. The possibility of such incommunicability is manifested, at a theoretical level, in the
opposition of two different radicalisms: on the one hand, the absolutism of rights and, on
the other hand, cultural relativism. For political reasons, the Convention avoided adopting
clearly defined terms or excessively binding statements in defining disability. Nonetheless,
it seems clear that the Convention is based on the ICF, both from an epidemiological and
an operational viewpoint: indeed, both the ICF and the Convention share.

The core idea [...] that disability is the outcome of, often extremely complex and little
understood, interactive relationships between intrinsic features of the person (which, in
the ICF are understood as aspects of the person’s health state) and features of the overall
context in which person lives, works, and interacts with others. Environmental factors,
the constituent elements of this context, are not only natural and physical, but also atti-
tudinal, structural, political, social and cultural (Bickenbach, 2009, p. 1121).

Precisely, considering the complex interactions involved in the disability concepts pre-
ented by both the ICF (2001) and the Convention (UN, 2006), as well as, more recently, by
the World report on disability (WHO and World Bank, 2011), it is possible to overcome the
aporia of radically opposed approaches:

As cultural differences are examples of environmental factors that are productive
of kinds and levels of disability it is essential to take them into account in practice.
A health practitioner cannot understand the nature and severity of the disability of a client without understanding the client’s environmental context, including his or her cultural differences. Whether these differences actually make a difference in either the nature or severity of the disability is a practical and empirical question that needs to be answered on a case-by-case basis (Bickenbach, 2009, p. 1121).

In other words, the conflict is not in the contents, namely it does not concern the rightness of both engaged positions, but rather the political and/or ideological radicalism of both:

I argue that the conflict between universalism of rights and cultural sensitivity exist only if these positions are expressed in extreme form: rights absolutism and cultural relativity. If more sensibly spelled out—in the form of progressive realisation of rights and situational sensitivity of difference—there is no conflict at all. Indeed, these more reasonable positions are mutually supportive (Bickenbach, 2009, p. 1111).

It is now an unquestioned fact that the seriousness of a disability, as well as the level of an individual’s functioning, are largely determined by the context in which the individual lives. Cultural sensitivity, given the universal foundation of human rights, is an operative horizon to which all professionals of rehabilitation should pay attention.

The necessity of better measurements of the effects of environmental factors, in order to improve the rehabilitation outcome and, therefore, the well-being and satisfaction of a person with a disability and the level of quality of life achieved, has led to the implementation of more and more accurate models of functioning. Concerning this, it is of great importance that the 2002 American Association on Mental Retardation’s (AAMR) Definition, Classification, and System of Supports, the 2002 System (Luckasson et al., 2002), aimed to pick out a shared assessment model of assistive technologies. Beyond the specificity of the intellectual disability (preferred term to “mental retardation”), the relevance of the 2002 System’s model lies in the fact that “support” is considered as a basic element of mediation between the multidimensional features of disability (i.e., in this specific case, intellectual disabilities) and individual functioning. The 2002 System recognizes the biomedical, functional, and ecological aspects of disability as a common basis, as does the ICF. Both tools, by defining disability in terms of a functional and ecological outlook, represent the raising of a novel paradigm that has “its focus on functional skills, personal well-being, the provision of individualized supports, and the concept of personal competence (i.e., enhanced through skill acquisition, environmental modification, and/or use of prosthetics)” (Schalock and Luckasson, 2004a, p. 137).

In the 2002 System, the basic factors are represented by human beings, the environment, and supports. These factors explain the condition of disability and individual functioning. In particular, the dimensions by which human functioning is defined are as follows: intellectual abilities; adaptive behavior; participation, interaction, and social roles; health; and context. The supports, defined as “resources and strategies that aim to promote the development, education, interests, and personal well-being of a person and that enhance individual functioning” (Schalock and Luckasson, 2004a, p. 142), are integrated in the 2002 System in relation to four aspects: first, the individual functioning is the result of the interaction between the disability dimension and supports; second, giving supports to people improves their independence, relationships, social participation, and global well-being; third, the assessment and selection of supports are conducted by considering the aspects and domains of a person’s daily life; and finally, the supports defined as “services” are one type of support provided by professionals and agencies. Moreover, the concept
of support, like others, is culturally determined and, therefore, subject to cultural variability in relation to both the importance of rehabilitative practice and use, even though Schalock and Luckasson highlight that its “conceptual and practical link to assessment is widely observed” (2004a, p. 143). It is, thus, through the relationship that entails individualized support to the assessment process that we can reach the goal of a diagnosis, namely, the intervention; so that the primary purpose of diagnosis is intervention (Schalock and Luckasson, 2004a, p. 143).

1.3 Where Individual Functioning and Disability Are Assessed: Assistive and Rehabilitation Technology Service Delivery Models

The Global Cooperation on Assistive Health Technology (GATE; http://www.who.int/phi/implementation/assistive_technology/phi_gate/en/) affirms that to improve access to high-quality affordable assistive products globally, the initiative has to focus on four interlinked activities (4P):

- **Policy**: assistive technology policy framework
- **Products**: Priority Assistive Products List
- **Personnel**: assistive products training package
- **Provision**: assistive products service delivery model

A novel one “P” the GATE is going to add to the four: People or users. These five GATE’s activities (5P) embrace and promote an assistive technology (AT) terminology and a service delivery model based on the ICF’s concepts that break from the “medical model/devices/technology,” to enhance human functioning in order to ensure inclusion, full participation and well-being (see the GATE’s Concept Note document in the website cited above). It is an innovate paradigm that shifts the AT vision focused only on preventing or treating a disease or compensating an injury to participation and well-being.

The current literature base demonstrates that the appropriate strategy for the design and distribution of AT depends on many factors including the availability of personnel, raw materials, and device parts and the interaction of all these factors can complicate AT service delivery models. Health-care workers and policy makers need a knowledge base in the extant methods that AT may be provided to end users to improve their well-being and participation. The issue is multivariate and complex and a variety of models have begun to be developed that encourage innovation and service delivery. The extensive variety of models may be captured in six overarching categories, but each of these categories is general and comprised of many more subcategories of models. In addition, these categories are not perfectly discrete, but rather there are hybridized or “multimodal” types of models that overlap. Nevertheless, the following six overarching categories are an important method to conceptualize the universe of transferring AT to persons with disabilities (Adya, Samant, Scherer, Killeen, and Morris, 2012): (i) Charity/Donation Model—Mass distribution of free recycled or low-cost AT; (ii) Community-based Rehabilitation Model—Providing services for independence and integration through the use of local resources in collaboration with community stakeholders; (iii) Individual Empowerment Model—Matching the person with the appropriate AT and facilitating empowerment through
personal construction of AT, using available materials, do-it-yourself instructions, and home-based solutions; (iv) Entrepreneurship Model—Local entrepreneur or foreign entity designing a solution to match an identified need, developing distribution networks, and commercializing the solution; (v) Globalization and Large Scale Manufacturing Model—A product already developed or in development locally or in developed regions is transferred to resource-limited environments through multiple methods, such as workshops and factories; and (vi) Universal Design in Public Use Infrastructure—Building accessibility into mainstream products, such as cell phones, open source software, and universally designed devices. Each of these is briefly reviewed.

**Charity-Based Models:** Charity-based programs have been used for decades as a method to provide individuals with material products that they could not access owing to their socioeconomic and environmental conditions. Past programs have engaged in mass distribution of different types of AT including mobility devices and hearing aids. Charities engage in different activities such as developing low-cost prototypes available for free; fundraising to finance the delivery of AT; and refurbishing and recycling old AT devices. Although mass distributions of AT can be helpful at times, such as when a conflict or disaster results in a large number of acquired disabilities, they often involve products designed with the one-size-fits-all approach that cannot be customized to the needs of the consumers and their environments, or have low-quality designs that can lead to secondary injuries and wounds.

**Community-Based Rehabilitation (CBR) Models:** CBR was conceptualized and promoted by the WHO and related UN agencies in the early 1980s as a method of providing services to people with disabilities in developing countries who had no access to quality rehabilitative facilities, physicians, and other qualified personnel. The original rationale behind CBR was to circumvent the need for expensive institutional care and a lack of government support by providing cost-effective rehabilitation services to people with disabilities within their own homes and communities. Although its inception focused on the need for medical rehabilitative care, it has evolved owing to a realization that rehabilitation aimed at promoting independent functioning has to respond to the need for securing equal rights and access to services such as education, employment, health services, and public services and facilities. As CBR works on the principle of finding solutions through locally available resources, most AT delivered through CBR programs is designed to be affordable, made with locally available materials, and appropriate to the environment of the consumer.

**Individual Empowerment Models:** In individual empowerment models, consumers “partner” with providers in product evaluation and selection as professionals strive to individualize services, help people achieve their self-determined goals, and ensure people are included in all aspects of community life. To achieve a good match of person and technology and improved rates of optimal assistive technology use, it is important that the potential technology user be paired with a well-informed provider.

**Entrepreneurial Models:** Entrepreneurial models promote the availability of AT through commercialization, and this transfer of technology can occur using either top-down or bottom-up approaches. In the top-down entrepreneurial model, the technology solution is brought into the local market by a foreign or external entity. Top-down distribution of AT can also include local franchising and adaptation to the local culture.

**Globalization Model:** Globalization models refer to the expansion of multinational and international companies into novel markets in resource limited environments to create novel supply chains for the delivery of technology solutions that may or may not be adapted to local needs. Manufacturing in most globalization models is performed in-country at a large scale. Solutions can be designed in collaboration with international, national, and
local designers. It has to be noted that this model is mainly suited for the one-size-fits-all solutions, even when they are adapted to local context and needs.

**Universal Design Models:** The universal design approach is based on the understanding that designing products to match a mythical average of human abilities and conditions is in conflict with the fact that all human users are diverse and experience different personal and environmental circumstances. Inaccessible mainstream products and services designed with a focus on a narrow subset of human functioning, such as information and communication technologies (ICT), medical equipment, and physical infrastructure can impose significant barriers on people with disabilities and people who are aging. Universally designed public use products and infrastructure are also necessary to ensure that people with disabilities have equal access to all activities irrespective of the existence of AT since many times individuals cannot use mainstream technologies that do not match their AT devices.

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1.4 Assessing Individual Functioning within a Rehabilitation Process

The international scientific literature presents a wide variety of rehabilitation models from different authors. Some of these models—generally elaborated in the last decade—are conceptually compatible with the universal approach to disability, the biopsychosocial model, and the ICF. The assessment process, as a full evaluation of functioning and disability of an individual, can be considered as an aspect of any rehabilitation process, so that any rehabilitation model encompasses an assessment model too. For this reason, before presenting the assistive technology assessment (ATA) process model of assessment, it is useful to explore the most relevant models of rehabilitation described in the international scientific literature. Below, some of the most important contributions to the conceptualization of a rehabilitation process are briefly described, with a special focus, where possible, on the stage of the assessment.

Gracey, Evans, and Malley (2009) proposed grounding rehabilitation intervention in terms of a “Y-shaped” theoretical model. The starting point of the authors is to identify a biopsychosocial approach to assessment, formulation, and rehabilitation after acquired brain damage. The result is an original theoretical synthesis of existing work drawn from rehabilitation and psychotherapy studies that is also helpful in clinical use. The process of adaptation and reintegration in society is determined by overcoming the social, personal, and interpersonal discrepancies—represented by the two branches of the Y—that often follow a traumatic event. The Y-shaped model is so-called because the progressive move toward a novel awareness and acceptance of existing health conditions is graphically represented by the conjunction of the two branches of the Y-shaped model. The process of awareness and resolution of discrepancies made by the client must be supported in order to consolidate their post-injury sense of self and their psychological growth. This part of the path is represented by the vertical trunk of the Y-shaped model. During the process, the client can discover the aspects of continuity with the pre-injury self and can develop novel adaptive and personal meanings, arising as a result of the injury and related experiences.

Gracey et al. (2009) suggest that, at the very top of the Y-shaped model, it is possible that many clients will experience a discrepancy by trying to maintain a sense of identity through the negation of the difficulties. This leads, in the long run, to the loss of
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relationships and social networks. Customers often also deny the presence of difficulty with rehabilitation professionals. In the Y-shaped model, social and interpersonal factors can play a role in overcoming personal discrepancies, in reaching a novel awareness, and in developing coping resources. Nevertheless, findings from many studies suggest that focus on rehabilitation may go beyond compensation for deficits and, perhaps, should more explicitly incorporate a focus on growth and personal meaning.

In the Y-shaped model, the key phases of the process of rehabilitation correspond to (i) the development of safety; (ii) understanding of, engagement with, and reduction of social, interpersonal, and intrapersonal discrepancies; and (iii) supporting psychological growth. For each key phase, the authors (Gracey et al., 2009) identify the social, interpersonal, cognitive, and emotional variables involved, as well as the corresponding rehabilitation activities and strategies. In conclusion, the authors believe that the meaning of life experiences is a key to well-being; psychosocial outcome measures that focus solely on the amount or level of activity might not reflect meaningful personal change for the individual.

Steiner and colleagues (2002) proposed the Rehabilitation Cycle (Rehab-CYCLE), a modified version of the Rehabilitation Cycle developed by Stucki and Sangha (1998). It leads the healthcare professional through a logical sequence of activities to achieve successful problem solving or individual goals. The Rehab-CYCLE identifies the patient’s problems and needs and relates the problems to relevant factors of the person and the environment. It is useful for defining therapy goals, for planning and implementing interventions, and for assessing the effects.

In order to have a conceptual framework for ordering and understanding what disease means to a patient, the authors (Steiner et al., 2002) developed an extension of the Rehab-CYCLE (Stucki and Sangha, 1998), which they called the “Rehabilitation Problem-Solving Form” (RPS-Form). The RPS-Form consists of a single data sheet that is based on the ICF. It is divided into three parts: (i) a header, for basic information; (ii) an upper part, for describing the patient’s perspective; and (iii) a lower part, for the analysis of the healthcare professionals. The RPS-Form is designed for distinguishing the perspectives held by the patient and those of the healthcare professional. The patient’s view is recorded in the upper part of the form, denoted with “Patient (or Relatives): Problems and Disabilities,” and the healthcare professional’s views are noted in the lower part, denoted with “Health Professionals: Mediators Relevant to Target Problems.” The rehabilitation team attempts to identify those characteristics of the patients or their environment that caused or contributed to their problems.

The multiple interactions between patient and environment, as well as between all components of the patient’s organism, require thinking about in terms of causal networks, rather than in terms of straight lines, where A causes B, which, in turn, leads to C. When it is unclear whether a variable is directly responsible for a disability or whether it is an element that contributes to certain processes involved with the disability, the RPS-Form uses the term “mediator” to describe such variables (Steiner et al., 2002). The main task of the rehabilitation team is to discern the target mediators (i.e., those mediators supposed to have the greatest potential to solve the target problems) through the analysis of the RPS-Form, as a basis for the team to discuss each case in the framework of the ICF Model of Functioning and Disability.

In 2002, the AAMR released its Mental Retardation: Definition, Classification, and Systems of Supports (Luckasson et al., 2002), in which human functioning and intellectual abilities are described as being influenced by five factors: (i) intellectual abilities (intelligence); (ii) adaptive behavior; (iii) participation, interaction, and social roles; (iv) health;
and (v) context. Intelligence is defined as “a general mental ability that includes reasoning, planning, solving problems, thinking abstractly, comprehending complex ideas, learning quickly, and learning from experience” (Luckasson et al., 2002, p. 51). Adaptive behavior is defined as “the collection of conceptual, social, and practical skills that have been learned by people in order to function in their everyday lives” (Luckasson et al., 2002, p. 73). Participation and interaction concern the person’s degree of commitment in daily activities and their involvement in the surrounding environment. Social roles regard the set of activities that are considered normal for a specific age group. The definition of health, meant as a state of complete physical, mental, and social well-being, is in line with the one determined by the WHO (1948). Finally, the context is a concept adapted from the Bronfenbrenner’s theory (1979), and it describes the relationships that the person is involved, including “the person, family, and/or advocates; the neighborhood, community, or organization providing education or habilitation services or supports; and the overarching patterns of culture, society, larger populations, country, or sociopolitical influences” (Schalock and Luckasson, 2004a, p. 142).

The 2002 System suggests the multidimensionality of intellectual disability (ID) and assigns a central role to the supports as mediator between the multidimensional aspects of ID and individual functioning. In the 2002 System, “supports are defined as resources and strategies that aim to promote the development, education, interests, and personal well-being of a person and that enhance individual functioning” (Schalock and Luckasson, 2004a, p. 142) so that individual functioning is determined by the interaction of the supports with the five dimensions listed above. The main purpose of the supports is to enhance personal outcomes related to independence, relationships, contributions, school and community participation, and the personal well-being of people with ID, and the assessment process is based on various kinds of everyday life activity. An important aspect of the assessment process in the 2002 System is represented by the clinical judgment, defined as

A special type of judgment rooted in a high level of clinical expertise and experience that emerges directly from extensive data. It is based on the clinician’s explicit training, direct experience with person with whom the clinician is working, and familiarity with the person and the person’s environment, including his/her family (Schalock and Luckasson, 2004a, pp. 143–144).

### 1.5 Assessing Individual Functioning and Disability in the ATA Process Model

In the ATA process ideal model, the assessment is defined as “a user-driven process through which the selection of one or more ATs for an AT solution is facilitated by the comprehensive utilization of clinical measures, functional analysis, and psycho-socio-environmental evaluations that address, in a specific context of use, the personal well-being of the user through the best matching of user and AT solution” (Section I).

Consistent with the ICF model of functioning and disability, the 2002 System, and the ATA process model, the individual’s well-being is the rationale of intervention, which is guaranteed by the best match between the user and the support or AT. Under the lens of the ICF biopsychosocial model by the means of which the user’s request and the AT
solution is provided (Figure 1.1), the assessment process evaluates the individual’s functioning through clinical measures, functional analysis, and psycho-socio-environmental evaluations.

In particular (Figure 1.2), in the “User data collecting” phase, the diagnosis has a central role in the assessment, because it is in relation to the diagnosis that the following setup for matching and assessing tools is designed. However, it is only at the meeting with the user (“matching process,” Figure 1.2, phase 3) that it is possible to observe the individual’s performance, to evaluate their functioning in the most relevant aspects of daily life, and to personalize the support by making reference to the socio-environmental characteristics, qualities, or barriers (environmental assessment process) within the user’s life. Finally, the user support and follow-up procedures allow us to assess functioning recursively and to constantly weigh the outcome of assistive solutions in relation to the users’ needs and the changes faced in the functioning domains of everyday life (Figure 1.2, phase 4).

Thus, the role of mediation played by supports and AT solutions between the multidimensionality of the specific health conditions of an individual and their effective functioning in the ATA process seems quite evident. This is not to disregard, as a metadimension process, the dynamic interaction in the ATA process model between objective (Section I, Figure 1.1, “AT Service delivery” column) and subjective (Section I, Figure 1.1, “User Actions” column), or, rather, between the objective and subjective functioning measurements. The features of this dynamic, within the assessment process, tie the rehabilitation professionals to find solutions that consider the social and cultural context of an individual.
An ATA process model that is consistent with the ICF, in that it emphasizes the individual’s well-being and the best match between the user and the AT solution, is required, and is thus proposed in this chapter. This requires a user-driven process through which the selection of one or more technological aids for an AT solution is facilitated by the comprehensive utilization of clinical measures, functional analysis, and psycho-socio-environmental evaluations.
1.7 Summary

This chapter is divided into three main sections. Section 1.1 focuses on which individual functioning measures should be used, with a focus on the principle stating that disability is a multidimensional construct and does not have an underlying principle of measurement valid for every assessment. Additionally, the only guiding principle for a proper measurement is the clarity of the purpose of the measurement. Section 1.2 focuses on how to measure individual functioning, by indicating some guiding principles for choosing and applying a set of measures and by suggesting some tools that fit these principles. Section 1.3 suggests some measurement tools for an ATA process used in a center for technical aid.

References


2

Measuring Individual Functioning

Stefano Federici, Fabio Meloni, and Fabrizio Corradi

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2.1 Individual Functioning Measures

2.1.1 The Best Measure: Is There an Elixir of Measurements That Will Turn an Assessment into Gold?

In June 2001, the UN International Seminar on the Measurement of Disability brought together a large number of experts in disability measurement from developed and developing countries to review the current status of the methods used in population-based data collection activities to measure disability in national statistical systems (UN, 2001; Weeks, 2016). The seminar developed recommendations and priorities to advance work on the measurement of disability. In particular, the seminar improved the principles and standard forms for the global indicators of disability for use in censuses and helped to build a network of institutions and experts, given the broad consensus on the need for population-based measures of disability for countrywide use and international comparisons. The UN International Seminar experts selected the International Classification of Functioning, Disability and Health (ICF; WHO, 2001) as the basic conceptual model. Their
work emphasized the fact that the ICF model has established the need for a common language that not only allows a common understanding and use by operators belonging to different professional areas, but is also easily applicable to remarkably different environmental contexts, “resolving the apparent tension between respecting cultural and linguistic differences in the meaning of health and providing the scientific basis for an international common language of health” (Üstün, Chatterji, Bickenbach et al., 2001, p. ix; see also Üstün, Chatterji, Mechbal, Murray, and WHS Collaborating Groups, 2003; Üstün, Chatterji, Villanueva et al., 2001; Üstün, Chatterji, Villanueva et al., 2003).

The real problem encountered by the experts was, paradoxically, the complex definition of disability (Üstün, Chatterji, Bickenbach, Kostanjsek, and Schneider, 2003): In the ICF, in fact, disability arises out of activity limitations and restrictions on participation that are determined by the interaction between body function and structural impairments and a disadvantageous context (environmental and personal factors):

> Since only one or two of these dimensions of disability are reflected in measures in any given survey [...] the data will only capture a portion of the population, those who exhibit the specific aspects of disability the questions represent. (Altman and Gulley, 2009, p. 544)

In a complex model such as this,

> each domain represents a different area of measurement and each category or element of classification within each domain represents a different area of operationalization of the broader domain concept. To generate a meaningful general prevalence measure one must determine which component best reflects the information needed to address the purpose of the data collection. (Mont, 2007, p. 4)

The “definitional paradox” (Madans and Altman, 2006, slide 19) affecting the definition of disability is due to the operational nature of the disability concept according to which any theoretical definition implies an aporia, while any operational meaning is determined by the purpose of the research. Indeed, the outcome of the interaction between a person’s state of health and contextual factors, the sum of personal and environmental components, can be described at three levels: (i) body, as impairment of body functions or structures; (ii) person, as activity limitations measured as capacity; and (iii) society, as participation restrictions measured as performance. For each of these levels, it is possible to identify more than one “operational” definition of functioning and disability: The ICF, in fact, does not provide a single, unequivocal, operational definition, and consequently, does not point to specific measurement tools. The main consequence is that different operational definitions lead to different and sometimes incoherent assessments:

> Specifically, we are concerned with the similarities and differences in the populations identified as disabled when the conceptualization of disability, the resulting questions, and the methods used to code and analyze the data differ from one set of questions to the next. In addition, we are concerned with disability prevalence estimates when the same sets of questions are asked in two different national populations. (Altman and Gulley, 2009, p. 544)

Therefore, there are many different aspects for which the operational measures of disability may vary according to the prevalent notion of disability, the purpose of measurement and application, the characteristics of the disability investigated, and also, “the
definitions, question design, reporting sources, data collection methods, and expectations of functioning” (WHO and World Bank, 2011, p. 21). Moreover, all of these factors make comparisons of data at the national and international levels very difficult. In any case, the need for updated estimates on the worldwide prevalence of disability has led the World Health Organization (WHO) and the World Bank to jointly produce the first ever *World Report on Disability* (2011). This report is based on two large data sources: the WHO *World Health Survey* of 2002–2004 (Üstün, Chatterji, Mechbal et al., 2003; WHO, 2002–2004) from 59 countries and the WHO *Global Burden of Disease: 2004 Update* study (WHO, 2008). The first is the largest multinational health and disability survey ever to use a single set of questions and consistent methods to collect comparable health data from across countries; the second is an overall assessment of the health of the world’s population, providing exhaustive estimates of premature mortality, disability, and loss of health from different diseases, injuries, and risk factors, drawing on the available WHO data sources and on information provided by Member States.

The *World Health Survey* and the *Global Burden of Disease*, “based on very different measurement approaches and assumptions, give global prevalence estimates among the adult population of 15.6% and 19.4% respectively” (WHO and World Bank, 2011, p. 29). The *World Report on Disability* makes some recommendations in order to improve the availability and quality of data on disability, including: (i) adopt the ICF “as a universal framework for disability data collection” (WHO and World Bank, 2011, p. 45); (ii) improve national disability statistics; (iii) improve the comparability of data; and (iv) develop appropriate tools and fill research gaps, with particular suggestions for developing “better measures of the environment and its impact on the different aspects of disability” (WHO and World Bank, 2011, p. 46) and for coupling the evaluation of disability experience with the measurement of the “well-being and quality of life of people with disabilities” (WHO and World Bank, 2011, p. 47).

Moreover, in the field of measurement, the crucial point is not to find the right answer, but to answer the right question, and as Zola (1993) conveyed, any attempt to identify standard measures on disability reflects, more than anything else, the effort to consider disability as a fixed and dichotomous entity, and not, as the universal model of disability states, a fluid and continuous experience. Indeed, only in a purely theoretical manner might one find in an individual either a full disability or a full ability. In the biopsychosocial model, disability is no longer considered as an identity that defines people or social classes, as in the medical and social models. In the medical model, disability is a negative characteristic belonging to an individual that defines the gap between them and normal standard health. Conversely, the social model identifies disability as a social class of individuals in whom the majority recognizes a stigmatized status of minority (Goffman, 1963; Hahn, 1985). In the medical model, people have a disability because an illness or an impairment is attributed to them, and they are called “people with disability;” or much easier, they are entirely identified with the illness (e.g., Down, deaf, blind, etc.); in the social model, people are disabled because they are stigmatized by the prejudices of society, and one may talk about them as disabled people (not “with disability”) or as oppressed (not “with oppression”) (Oliver and Barnes, 1998). The biopsychosocial model moves from the person to the person’s functioning, overcoming a causal inference of disability as a result of both the impact of disease or other health conditions (WHO, 2001) and a social disadvantage. According to this view, disability is just a way of functioning, expressed by positive wording as the “ability to do” in specific contexts and health conditions.

Individual functioning is also related to the interrelation between a specific environment, personal features, and health conditions: “The issue of disability for individuals […]
is not whether but when, not so much which one but how many and in what combination” (Zola, 1993, p. 18). Disability is not a set of immutable characteristics that define one person over another, nor is it predictable by a medical diagnosis because it is not a direct consequence of disease, but instead, a multidimensional process that lasts a lifetime and involves the physical, psychic, and social spheres of the individual:

Having a disability is not a fixed status, but rather a continually changing, evolving, and interactive process. It is not something that one is or is not, but instead is a set of characteristics everyone shares to varying degrees and in varying forms and combinations. (Zola, 1993, p. 30)

The World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0; Üstün, Kostanjsek, Chatterji, and Rehm, 2010), as an example of a measure that adopts the ICF’s conceptual framework, is a psychometric questionnaire on self-perceived disability that assesses the individual functioning in the “here” of daily life activities and the “now” of the last 30 days, independent of any background disease or previous health conditions (Üstün et al., 2010, p. 5). Although disability is neither a fixed concept (i.e., etiologically determined by a diagnosis or immutable in time) nor dichotomous (i.e., ability and disability are not mutually exclusive), this does not mean that it is immeasurable: “Instead, its conception, measurement, and counting differs validly with the purposes for which such numbers are needed. The clearer the outcomes we seek, the clearer it will be what conceptions and measurements are necessary” (Zola, 1993, p. 30).

Disability is also a multidimensional construct, as its measurement is multidimensional. Therefore, the correct answer to the question posted in the section header is that the elixir of measurement is found when we orient the focus of the research not just on the theoretical definition of disability but also on the clearness of the purpose of our measurements. In other words, you will just measure what you want to find. Indeed, according to the uncertainty principle, the more precisely one property is measured (i.e., capacity), the less precisely the other can be measured (i.e., performance). Thus, with disability being a multi-property object of measurement, one could not measure all the properties at the same time with the same tool. As a consequence, the best researcher is one who has clearly defined the property of disability to be measured and the tool required to measure it. For all these reasons, an elixir of disability measurement is not even desirable. In fact, having a variety of measuring tools and the flexibility to change the measurement procedures, adapting them to different people, contexts, and purposes, is the most reliable scientific approach.

2.1.2 Fitting Measure for the Purpose of the Assistive Technology Assessment

The purpose of measurement is the guiding principle behind the specification of an operational definition and the choice of a coherent set of measurement tools. Madans and colleagues (2002) identified three major classes of purposes at the aggregate level in their research, asking general census questions on disability in the international context: (i) to provide services, including the development of programs and policies for service provision and the evaluation of these programs and services; (ii) to monitor the level of functioning in the population; and (iii) to assess the equalization of opportunities. The Assistive Technology Assessment (ATA) process ideal model (see Section I) can be viewed as an aspect of the purpose described in point (i). Madans and colleagues stated that the “provision of services at the population level includes, but is not limited to, transportation, rehabilitation, providing assistive devices, long term care” (2002, slide 11) and that the
fulfillment of this aim “requires detailed information about the person and the environment, as in the case of rehabilitation” (slide 11; see also Madans and Altman, 2006, slide 6). Questions about the need for assistive technology (AT) solutions and problems with accessibility are therefore at the heart of the assessment. Apart from all of this, the ultimate aim of the ATA process model is to “address, in a specific context of use, the personal well-being of the user through the best matching of user and AT solution” by means of “clinical measures, functional analysis, and psycho-socio-environmental evaluations” (see Section I).

2.1.3 From the Measures to the Purposes (Well-Being), from the Purposes to the Measurers (Multidisciplinary Team)

This statement indicates two orders of questions that need to be addressed: (i) the nature of the “well-being” concept and measurement, and (ii) how to “team up” professionals at the center for AT evaluation and provision. With regard to (i), it is plain that the nature of the well-being variable is merely subjective; in fact, it “measures ‘what people say’ rather than ‘what people do’. It is true that self-reported well-being has potential shortcomings such as response bias, memory bias and defensiveness” (Uppal, 2006, p. 525). Nevertheless, “subjective data have proved to be stable and useful” (Uppal, 2006, p. 525), and “there is increasing acceptance of patient-reported outcomes for those constructs where one’s subjective reality cannot be objectified (e.g., feelings, pain, energy levels, perceived health and so on)” (Kayes and McPherson, 2010, p. 1011). As part of this discussion, it is important to point out that, even today, both in the literature and in the different classifications of disability that have succeeded over time, there is no space for the inner world of the individual. In particular, a few authors have focused on the difference between the objective and the subjective dimensions of functioning and disability.

For example, if people can not play golf because of impairment (capacity limitation within activity limitation) or because of environmental obstacles (participation restriction), the MEANING of that fact will be quite different from person to person. For a lifelong regular golfer it would be disastrous, but for a person, otherwise similar, who has never played it, the fact itself that he is not playing golf would not be essential. It follows that evaluation of meaning or satisfaction (which are both subjective) of the objective activity or participation is indispensable especially for items other than common basic survival needs. (Ueda and Okawa, 2003, p. 598)

However, what is the subjective experience of functioning and disability? Ueda and Okawa defined it as follows:

a set of cognitive, emotional and motivational states of mind of any person, but particularly of a person with health condition and/or disability. It is a unique combination of, on one hand, a disability experience, a reflection (influence) of existing health conditions, impairments, activity limitations, participation restrictions and negative environmental factors (obstacles) into the person’s mind (negative subjective experience), and on the other hand an experience of a positive nature, which includes, among other things, the psychological coping skills developed, often unconsciously, in order to overcome these negative influences (positive subjective experience). (2003, p. 599)

The assessment of a subjective experience is a focal point in identifying the best AT solution for a given user, and its misunderstanding or underestimation has a major role in abandonment (Elliott, Kurylo, and Carroll, 2002; Scherer, Sax, Vanbiervliet, Cushman,
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and Scherer, 2005). It must also be highlighted that the subjective dimension of functioning and disability does not coincide with the objective dimension, that is, the one currently coded by the ICF. The relationship between the subjective and objective dimensions of functioning and disability is interactive and bidirectional. However, the two dimensions are relatively independent of each other. At present, although it is not possible to introduce a comprehensive codification of subjective experience, this dimension should be carefully considered in the ATA process model. The attention, however, must be twofold. On the one hand, ignoring the subjective dimension can lead to inaccurate assessments and inappropriate assignments, whereas on the other, as argued by Sen, one must bear in mind that “[t]he internal view of health deserves attention, but relying on it in assessing health care or in evaluating medical strategy can be extremely misleading” (2002, p. 861).

With regard to (ii), the choice of a set of measurement tools specifically for the purposes of the ATA process model facilitates the multidisciplinary team-building process by means of the characterization of each professional required during the assessment (and measurement) process. In the ATA process model, the two points are strictly linked. We agree with Kayes and McPherson’s statement that “a critical evaluation of one ‘objective’ measure highlights a number of potential limitations suggesting that the apparent willingness to adopt ‘objective’ measures with little questioning may be misguided” (2010, p. 1011). Objective measures, in fact, “are not necessarily invariant across populations” and often produce outcomes that “lack clinical relevance” (Kayes and McPherson, 2010, p. 1013); moreover, the administration method can be affected by the subjectivity of the practitioner as well.

All things considered, it seems that more than “simplistic dichotomy” among objective vs. subjective measures can be useful in determining whether or not a measurement tool is “fit for [its] purpose.” In the ATA process model, the ultimate aim of ensuring the well-being of the user is achieved through the use of many different instruments (clinical measures, functional analysis, and psycho-socio-environmental evaluations). These tools are both subjective and objective, but in any case, a professional who can interpret the results is always required. For these reasons, many different professionals are involved in the ATA process for both each type of user and each step of the process.

In the body function and structure evaluation step—the medical diagnosis analysis—the team consists of a physician, a psychologist, and a cognitive therapist, and an optometrist, audiologist, pediatric specialist, and geriatrician when the user’s age or impairment calls for them. In the activity evaluation step, a psychotechnologist, an occupational therapist, an architect, and an engineer are primarily needed. Finally, the support and follow-up phases allow us to evaluate the performance of the user (participation step) by means of a multidisciplinary contribution from a cognitive therapist, a special educator, an occupational therapist, a psychologist, a consumer support person, a speech language pathologist (if needed), and a physiotherapist (see Section I, Figure I.2).

2.1.4 What Is Measured versus Who Measures: Balancing the Power of the Assessment

Apart from all of this, the entire ATA process model is “user-driven”: Subjective measures are not only considered in the activity or participation evaluation steps but also in the medical diagnosis analysis, even though making a diagnosis is traditionally characterized by the prevalence and precedence of the objective measurement. Nevertheless, we agree with Mezzich (2002), who cited Lain Entralgo (1982): “Diagnosis is more than identifying a disorder (nosological diagnosis) or distinguishing one disorder from another (differential diagnosis); diagnosis is really understanding what is going on in the mind and body of the
person who presents for care” (quoted in Mezzich, 2002, p. 162). In other words, we make a claim for a comprehensive diagnosis that “aims to combine the best of objective scientific categorical diagnosis with the unique features, including the strengths and resources as well as difficulties, of individual patients” (Fulford and Stanghellini, 2008, p. 10).

There is another big issue with giving such importance to the user’s subjective perspective in measurement. As Brown and Gordon claimed:

Measurement and assessment, occurring within both research and clinical service contexts, typically involve an imbalance of power between professionals and persons with disabilities. Power is evidenced in who controls decisions about measurement and whose perspective—the subjective values of the measured person or the objective or normative values of the measurer—is given primacy. (Brown and Gordon, 2004, p. S13)

The imbalance of power “can affect the ‘something important’ that is at stake in measurement because the failure to share power can produce less useful measures” (Brown and Gordon, 2004, p. S13). Ordinarily, the imbalance is determined in the selection, use, and interpretation of measures that usually incorporate the preferences and perspectives of the professionals, but not of the user.

In this context, the person who is measured can have very different positions on many aspects of functioning with regard to the person who measures. For example, the measure “may agree that income is important to his or her QOL but disagree with the societal or normative assumption that a higher income is better” (Brown and Gordon, 2004, p. S14).

The point being questioned is the professional–user relationship. The ATA process model can amplify the relationship’s imbalance, because the presence of a multidisciplinary team in which each of the professionals carries out their values and preferences exponentially increases the shadow over the disabled person’s point of view. Such a risk can be avoided by adopting a user-driven approach or person-centered planning (Gzil et al., 2007; Holburn and Vietze, 2002; Leplege et al., 2007; Menchetti and Sweeney, 1995; Schalock and Alonso, 2002; Steiner et al., 2002), which places the disabled “at the center of a planning effort, often including a planning group (or circle) comprised of service professionals, family members, and people from the community” (Brown and Gordon, 2004, p. S14).

From a professional point of view, namely from this handbook’s perspective, a central role in the empowerment of who is measured is played by the psychologist as an expert in human relationships (see Chapter 8, “The Psychologist”). The psychologist not only administers measures and interprets test results but also plays a key role in both counterbalancing the professional–disabled relationship by paying attention to the powerless at each stage of the assessment process and makes easier connections between the different perspectives of the team of professionals.

### 2.2 How to Measure Individual Functioning

The purpose of this handbook is not to precisely define a default set of measurement tools: That would contradict what we wrote above. We take responsibility for both pointing out some guiding principles for choosing and applying a set of measures and for suggesting some tools that, together, we believe fit these principles.
2.2.1 Guidelines for Measurement and Assessment

The guiding principles are provided in the following:

1. The ultimate purpose of the ATA process ideal model is the enhancement of the subjective well-being and the quality of life (QOL) of the user through the best match with an AT solution.

2. A comprehensive diagnosis needs both a value-based approach (Fulford and Stanghellini, 2008) and an evidence-based one, and an idiographic personalized formulation (Mezzich, 2002) together with a standardized assessment.

3. When assessing a set of measurements, it would be best “to sacrifice reliability for validity” (Fulford and Stanghellini, 2008, p. 12).

Those of us who have worked for several decades to improve the reliability of our diagnostic criteria are now searching for new approaches on understanding of aetiological and pathophysiological mechanisms—an understanding that can improve the validity of our diagnoses and the consequent power of our preventive and treatment interventions. (Kupfer, First, and Regier, 2002, p. xv)

The reliability of diagnostic tools is an essential issue, but does not guarantee in itself the validity of the treatment, which is the primary purpose of rehabilitation professionals.

4. The user functioning evaluation should encompass objective and subjective measures for any health or health-related domain.

5. Throughout the measurement and assessment process, the multidisciplinary team should pay attention to the “power balance”: (i) in user–professional relationships; and (ii) in mutual relations between professionals.

The measurement tools that we suggest can be roughly classified into two types: subjective and objective. The subjective measures are those that collect and evaluate the subjective perspective of the users on their functioning; the objective ones are those that measure the user’s functioning from the perspective of the professionals to the extent that they make reference to standardized normative values. Although the ICF Checklist (WHO, 2003), any ICF Core Set, and the Vineland Adaptive Behavior Scales II (VABS-II; Sparrow, Cicchetti, and Balla, 2005) can be considered as objective measures, the WHODAS 2.0 (Federici, Bracalenti, Meloni, and Luciano, 2017; Üstün et al., 2010), the Matching Person and Technology Model (MPT; Scherer, 1998; Scherer and Craddock, 2002), the Canadian Occupational Performance Measure (COPM; Law, Baptiste, McColl, Polatajko, and Pollock, 2005), and the Support Intensity Scale (SIS; Thompson et al., 2004) facilitate evaluations of the subjective perspective of the user.

2.2.2 Measurement and Assessment in the ATA Process Model

In Figure 2.1, four orange shapes highlight the steps in the ATA process for which a measurement and/or assessment are/is required.

From the ATA process ideal model perspective, all these tools can be classified according to the assessment stage in which they are administered. Following the ATA process model (Figure 2.1) step by step, in the “User data collection” stage (step 1), in order to reach a
comprehensive diagnosis and assessment, both standardized and idiographic, the user will provide an ICF Checklist and/or the ICF Core Set related to their specific condition, drawn up by a physician, and the self-administered WHODAS 2.0 and Survey of Technology Use (SOTU, from MPT tools). At this stage of the ATA process model, the professionals have not yet met the user, so the psychologist plays a key role during the “Multidisciplinary Team Meeting” by reading and interpreting all the data provided (step 2) in order to both evaluate the individual functioning profile and set up the “Matching Process.” At the time of the “Matching Process” (step 3), the VABS-II, the Assistive Technology Device Predisposition Assessment (ATD-PA), and the SIS are administered to the user. The “Matching Process” step is when the very first time users meet the professionals of the center in order to evaluate their activity limitations, operationalized as “capacity,” and to assess the best match with an AT solution. Finally, in the “User Support” and “Follow-up” stages (step 4), the
team and the user evaluate the participation together, operationalized as performance, and continually check the user’s need to adjust the match or for a novel match.

2.2.3 Monitoring Individual Functioning in the Context of an AT Use: The Outcome of the ATA Process Model

The outcome analysis represents the focal point of the AT solution matching process and is conducted by the multidisciplinary team of a center for AT evaluation and provision. It is fundamental to point out some of the factors that can convey important information about the pertinence of an AT solution in order to replace, update, and support its adoption by the end-user and prevent its abandonment (Federici and Borsci, 2016; Federici, Meloni, and Borsci, 2016). The outcome can be analyzed by means of the clinical diagnosis, the functional state, the quality of life, the cost, the satisfaction (DeRuyter, 1995), and the comfort (Weiss-Lambrou, Tremblay, LeBlanc, Lacoste, and Dansereau, 1999). In particular, the analysis of two multidimensional constructs enables different degrees of intensity to describe the user’s experience of AT: satisfaction (Demers, Weiss-Labrou, and Ska, 2000) and comfort (Kolcaba, 1992).

Satisfaction is a positive attitude toward psychosocial factors concerning subjective perceptions, evaluations, and comparison processes (Linder-Pelz, 1982). The user can describe this kind of positive attitude toward health care services, products, and providers, and toward individual health conditions (Weiss-Lambrou, 2002). Comfort can be a physical sensation, a psychological condition, or both things simultaneously (Pearson, 2009), and it can generally be reported as a pleasant and positive sensation (Kolcaba and Kolcaba, 1991). Another parameter to consider is the environment of use, which involves the user’s characteristics and the objectives the user wants to reach with the adoption of the AT. An environmental investigation focuses on the person–environment system, while the user interacts with the given technology (Rust and Smith, 2006).

Different studies have highlighted the fact that there are high rates of AT abandonment of up to 75% (Garber and Gregorio, 1990; Gitlin, 1995; Phillips and Zhao, 1993; Tewey, Barnicle, and Perr, 1994). However, the causes of abandonment are rarely due to the features of the device (functioning, manageability, etc.), but they do concern the absence of the users’ involvement and/or their caregivers in the matching process (Borg et al., 2012; Federici et al., 2016; Scherer, 1996; Wielandt, Mckenna, Tooth, and Strong, 2006).

The evaluation process of AT matching must be a user-centered process, and moreover, it must aim to identify the best correspondence between the individual user needs and the features of a particular technology available in a given historical period (Gelderblom, Driessen, Evers, and Claus, 2009). Abandonment can also be due to AT that is no longer necessary, for example, because of a user’s recovery. Some authors have suggested the use of “discontinuity” to describe a possible result of the AT matching process, remarking in this manner that the term “abandonment” has a purely negative connotation, whereas the term “discontinuity” generally has a neutral connotation (Lauer, Longenecker Rust, and Smith, 2006). However, given that only a very low percentage of users no longer need to use AT because their health/physical condition has improved—as Federici et al. (2016) recently surveyed—the appropriate use of “abandonment” (with a negative emphasis) rather than, for example, “discontinuance” should be adopted in reference to AT nonuse.

For all these reasons, some of the evaluation tools that are able to analyze technical aid matching and that are based on the ICF (Scherer, 2005a; Scherer and Craddock, 2002) and the client-centered approach have been proposed. The models mentioned highlight the
fact that the more we focus on the object (the AT), the more we move away from a good match. In this manner, the problem of a good match lies more in the matching process, rather than only in the technology product itself: Indeed, it is fundamental to involve both users and caregivers in the AT matching process (Long, Huang, Woodbridge, Woolverton, and Minkel, 2003). Starting from this perspective, it is possible to distinguish between AT as a tool and AT as a service (AAATE and EASTIN, 2012; Federici and Borsci, 2016). In order to facilitate both the use of AT and the possibility of examining the chosen technology, it is important to create an assistance network around the user within the evaluation process.

The “Consortium model” describes a matching process centered on the participation of users and caregivers (Long et al., 2003). In this model, the user’s family and health workers intervene at the start of the matching process (“Evaluation, identification of outcomes”), taking a fundamental role in the following attainment of a good match between the user and the AT, whereby the match is only a component of the outcome.

Verza, Carvalho, Battaglia, and Uccelli (2006) also suggested a model focused on the involvement of the users, their families, and their rehabilitation teams. They highlighted four main reasons for explaining the AT abandonment phenomenon:

- A change in health conditions
- Rejection of the AT
- Inadequacy/absence of information and training
- Inappropriateness of the AT.

It follows that a careful outcome analysis of an AT is fundamental for a good match.

### 2.3 Suggested Measurement Tools for an ATA Process

In this section, we briefly describe some suggested tools to employ during the phases of an ATA process. The tools proposed and described below are from the following two major types: measures of individual functioning and outcome measures. The former tools are recommended for the first three steps of the ATA process model (Figure 2.1, orange shapes 1–3) and the latter for the fourth step (Figure 2.1, orange shape 4).

#### 2.3.1 Measuring Individual Functioning in an AT Matching Process

The *ICF Checklist* (WHO, 2003) was developed as a practical tool to elicit clinicians’ overall impressions of a patient’s condition. It allows the functioning profile of a subject to be described based on 128 codes selected among the thousands forming the entire ICF (WHO, 2001). The *ICF Checklist* is not a proper instrument for measurement or assessment: it provides the possibility of “opening” the codes on the basis of identifying a person’s functional problem, and at the same time, establishes whether or not, and in which measure, the environment acts as a barrier or a facilitator for the person’s activities. The *ICF Checklist* is administered to both patients and their caregivers. It is structurally divided into four parts: the introductory part, which includes biographical data, the ICD-10 code (WHO, 1992), and a specification of the information source; the first part contains a list
of codes of body functions (b) and body structures (s); the second part contains a list of codes for activities and participation (d); and finally, the third part contains a list of codes relating to environmental factors (e).

An ICF Core Set (condition-specific) can be defined as

A selection of ICF domains that includes the least number of domains possible to be practical, but as many as required to be sufficiently comprehensive to cover the prototypical spectrum of limitations in functioning and health encountered in a specific condition. (Stucki et al., 2002, p. 281)

In contrast, a generic ICF Core Set allows a comparison of health across conditions, as its domains represent “the most relevant domains to include the least number of domains possible to be practical, but as many as required to be sufficiently comprehensive to cover the general spectrum of limitations in functioning and health” (Stucki et al., 2002, p. 281).

The VABS-II (Sparrow et al., 2005) is designed to assess the adaptive level of personal and social functioning of any individual, disabled or not. In other words, the VABS-II measures adaptive behavior, namely “the collection of conceptual, social, and practical skills that have been learned by people in order to function in their daily lives” (Luckasson et al., 2002, p. 73). The assessment of adaptive behavior is made from a developmental perspective, and the scales are normalized on samples of males and females aged from 0 to 90. There are currently four versions of the VABS-II: the Survey Interview Form, the Parent/Caregiver Rating, the Teacher Rating, and the Expanded Interview Form (Sparrow et al., 2005). The Survey Interview Form is administered to a parent or caregiver in a semi-structured interview format (recently translated in Italian by Balboni, Belacchi, Bonichini, and Coscarelli, 2016). The open-ended questions allow more in-depth information to be obtained and facilitate the relationship between the interviewer and the respondent. The Parent/Caregiver Rating Form differs from the Survey Interview in that it uses a rating scale format and is the best choice when time or access is limited. The Parent/Caregiver Rating Form is a good tool for progress monitoring when the initial assessment has been made through the Survey Interview Form. The Expanded Interview Form has more items than the Survey Interview Form and is indicated for ages 0–5 or to implement specific planning for low functioning individuals. The Teacher Rating Form assesses adaptive behavior in students. It has a questionnaire format and is completed by the teacher or caregiver. This form differs from the Survey Forms in that it also covers content that a teacher would observe more easily in a classroom. The VABS-II is administered by a psychologist in a semi-structured interview format. The VABS-II has good concurrent validity with both the Stanford-Binet test and the Wechsler Intelligence Scale for Children. The VABS-II is a useful tool for assessing adaptive behavior in intellectual and developmental disabilities, autism spectrum disorders, attention deficit hyperactivity disorder, post-traumatic brain injury, hearing impairment, dementia, and Alzheimer’s disease.

The MPT is a model and a “set of person-centered measures, all of which examine the self-reported perspectives of adult consumers regarding strengths/capabilities, needs/goals,
preferences and psychosocial characteristics, and expected technology benefit. There are separate measures for general, assistive, educational, workplace, and healthcare technology use” (Scherer and Craddock, 2002, p. 125; see Chapter 3, “Measuring the Assistive Technology Match”).

The MPT instruments consider the environments in which the person uses the technology, the individual's characteristics and preferences, and the technology's functions and features. All of these components are analyzed and considered because even though a specific technology or a set of technologies may seem to be the best choice for a particular person, the absence of adequate support or some traits of the personality profile of the customer can cause the failure of the match. The MPT is a user-driven process, and an assessment of the degree of agreement between the user's perspective and that of the provider is planned. Moreover, the quality of life of the customer is a factor that orient the assessment of the influence experienced by the customer when using a specific technology. In the measurement process carried out by the MPT instruments, early recognition of an inappropriate match is crucial. This will limit the phenomenon of abandonment of the aid and reduce the feelings of disappointment and frustration related to this. The MPT set includes the Worksheet, the SOTU, the ATD-PA, the Educational Technology Predisposition Assessment (ET-PA), the Workplace Technology Predisposition Assessment (WT-PA), and the Health Care Technology Predisposition Assessment (HCT-PA). The tools included in the MPT are in a duplicate format, one for the technology user and another for the provider of the technology (counselor, therapist, teacher, employer, or trainer). In the ATA process ideal model, the use of the SOTU and the ATD-PA is particularly recommended. The SOTU helps identify technologies that an individual feels comfortable with or has success in using so that a novel technology can be built around existing comfort or success. This instrument explores the type of technology that clients already use, their experiences, both past and present, and their points of view on the technology currently being used. Furthermore, the SOTU values some personal and social characteristics of the user. The client and the provider each fill a version independently. However, the provider responds by trying to figure the answers of the client. After administration, the client and the provider discuss the critical discrepancies between the two filled forms. The ATD-PA is useful for selecting the most appropriate AT solution. Each ATD-PA (ATD-PA-Client and ATD-PA-Provider) is divided into two parts: The first part must only be filled once, whereas the second part must be filled for each technology. In the client's form version, clients are required to self-evaluate their capacity and performance and some personality traits. Furthermore, clients indicate their feelings about using a particular AT. For the provider's part, the provider must (i) list the factors and the extent to which they can be an incentive or an obstacle to the use of a specific technology; (ii) assess whether or not the client's resources are tailored to the characteristics of the specific technology; and finally (iii) evaluate what personality traits of the client are particularly implicated in the use of the specific technology.

The WHODAS 2.0 (Federici et al., 2017; Üstün et al., 2010) evaluates disability from a different viewpoint than that of the normal tools of measurement. In fact, while the ICF Checklist was developed as a practical tool to elicit clinicians' overall impressions of a patient's condition and to record information on functioning and disability, the WHODAS 2.0 rates the nature of a disability directly from the patient's responses. Therefore, the ICF Checklist offers an external (objective) view on disability, while the WHODAS 2.0 offers an internal (subjective) one. The WHODAS 2.0 assesses the limitations to activities and the restrictions in participation that are experienced by an individual, independent of a
medical diagnosis. Particularly, the instrument is designed for evaluating the functioning of the individual in six activity domains:

1. Cognition—understanding and communicating (six items).
2. Mobility—moving and getting around (five items).
3. Self-care—hygiene, dressing, eating, and being alone (four items).
4. Getting along—interacting with other people (five items).
5. Life activities—domestic responsibilities, leisure, work, and school (eight items).
6. Participation—joining in community activities (eight items).

There are several different WHODAS 2.0 forms, each of which has been structured in relation to the number of items (6, 12, 24, 12 + 24, and 36), the mode of administration (self-administered or administered by an interviewer), and the user who is to be interviewed (subject, clinician, or caregiver). In any case, the WHO recommends the use of the 36-item form, administered by an interviewer, for completeness. The participants who are interviewed are asked to indicate the level of “difficulty” experienced (none, mild, moderate, severe, and extreme) by considering the manner in which they normally perform a given activity, including the use of any support and/or help provided by a person (aids). For every item that receives a positive answer, the next question asked is the number of days (“in the last 30 days”) for which the interviewee met such a difficulty, in terms of a 5-point ordinal scale: (1) Only 1 day; (2) Up to a week = from 2 to 7 days; (3) Up to 2 weeks = from 8 to 14 days; (4) More than 2 weeks = from 15 to 29 days; (5) Every day = 30 days. Then, the participants are asked how much the difficulties interfered with their life. The respondents should answer the questions according to the following references:

1. Degree of difficulty (the increase in effort, discomfort, or pain, or slowness, or any differences in general)
2. Health conditions (disease or illness, or injury, or mental or emotional problems, or problems related to alcohol, or problems associated with drug abuse)
3. The last 30 days
4. The average between “good” and “bad” days
5. The manner in which they normally perform the activity.

Items that refer to activities not experienced within the last 30 days are not included (for further information, see Federici et al., 2017; Federici and Meloni, 2010a,b).

The COPM (Law et al., 2005) is an individualized, client-centered measurement tool intended to detect changes in a client’s self-perception of occupational performance over time. The COPM allows the users to formulate individualized purposes for occupational therapy and to voice their feelings about the appropriateness of their performances, their satisfaction with participation, and the importance of each goal in their lives. The specific focus of the COPM on client-identified problems is intended to facilitate collaborative goal setting between the therapist and the client. The COPM is administered through a semi-structured interview.

Once clients have identified their problems, they rate their perceptions of the importance of each activity on a scale from 1 to 10. From this list, clients choose up to five problems they wish to focus on during occupational therapy. For each problem, clients
then rate performance and satisfaction with performance, again using a scale from 1 to 10. Higher ratings indicate greater importance, performance and satisfaction. The performance and satisfaction scores of the selected activities are summed and averaged over the number of problems, to produce scores out of 10. (Carswell et al., 2004, p. 211)

The COPM is used as an assessment tool in occupational therapy. After an initial assessment of the client and after a period of therapy, the interview is re-administered. If there are changes in scores that exceed a value of two, the change is considered clinically significant. “Since its initial publication in 1991, the COPM has had two subsequent editions published and has been officially translated into 20 languages. It is in use by occupational therapists in over 35 countries throughout the world” (Carswell et al., 2004, p. 210).

The SIS (Thompson et al., 2004) is a standardized assessment tool developed by the American Association of Intellectual and Developmental Disabilities (AAIDD) that measures the patterns and intensity of support that an individual needs. More than a diagnostic test, it is a useful tool for setting up an individualized user-centered plan. The development of the SIS is compatible with the official definition of “intellectual disability” drawn up by AAIDD in 2010. This definition no longer contains the term “mental retardation,” as was in use until the penultimate definition of 2002 (Schalock et al., 2007). This change reflects the transition from the perception of disability as a “deficit” to another centered on optimizing functioning. The last definition given dates back to 2010: “Intellectual disability is characterized by significant limitations both in intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills. This disability originates before age 18” (Schalock et al., 2010, p. 1). The SIS completes the 11th edition of the “Definition, Classification and Systems of Support for People with Intellectual and Developmental Disabilities,” edited by the AAIDD: a tool that allows the theoretical definition of the support-based model to be translated into practice. The support-based model is conceptually compatible with the ICF (Schalock et al., 2010). The ICF domains of body functions (impaired intellectual functioning) and activities (limitations in adaptive behavior) directly relate to the AAIDD definition of intellectual disability. In the two systems, the person is entirely considered within the context of the person’s capacities and the expectations and supportive resources of the environment. The major difference is that the ICF is a general model of disability, whereas the AAIDD System is specific to intellectual disability. The SIS consists of three sections that measure the pattern and intensity of support in six life activity domains (home living, community living, lifelong learning, employment, health and safety, social activities), in protection and advocacy activities, and in 16 exceptional medical conditions and 13 challenging behaviors. In total, 57 various life activities are measured. The tool is administered as a semi-structured interview with the user and at least other two people who preferably live with the user, such as a parent and/or a caregiver. Any other respondents should have observed the person in one or more environments for a substantial period of time. The scale ranks each activity according to frequency, amount, and type of support. Finally, a support intensity level is determined based on the Total Support Needs Index, which is a standard score generated from the scores for all items tested by the scale.

2.3.2 Measuring the Outcome of an AT Matching Process

The main goal of the multidisciplinary team, after AT provision, is to measure and constantly monitor the effectiveness, efficiency, and safety (appropriateness) of the AT-user match in order to (i) provide support to users; (ii) guarantee their greatest level of autonomy
over time; and (iii) justify the resources used. The “[e]fficacy of an AT device is determined by the effect resulting from its use in comparison to the effect claimed beforehand” (Gelderblom and de Witte, 2002, p. 91).

In order to explain the reasons why an AT is used, disused, or abandoned and to verify the evolution over time of the AT solution, and moreover, to create and improve intervention programs for the rehabilitation field, it is necessary to identify and analyze the source of the user’s satisfaction/dissatisfaction and comfort/discomfort. In general, an analysis of the results obtained by the matching process is fundamental for choosing the best solution if any problem occurs during the evaluation process.

Over the last few years, some tools aimed at measuring the outcome of assigned AT have been designed. However, the corresponding research field is growing slowly, and the tools currently being used do not analyze every aspect of the AT matching process because they are only able to investigate some of the dimensions correlated with the quality of life (e.g., satisfaction, comfort, etc.). Among the most frequently used measuring tools, we can include the MPT (Scherer, 1998; Scherer and Craddock, 2002) and the COPM (Law et al., 1990, 2005).

The Quebec User Evaluation of Satisfaction with Assistive Technology 2.0 (QUEST; Demers, Monette, Lapierre, Arnold, and Wolfson, 2002) measures the user’s satisfaction with the use of an AT. It can be administered to adolescents, adults, and elderly people with physical or sensory disabilities. The theoretical background of the instrument is the MPT model (Scherer, 1998). Several years of implementation and research have confirmed its psychometric reliability and validity as an outcome measure of the user’s satisfaction with the assigned AT. The QUEST does not evaluate the performance of users with a device, but rather measures their satisfaction with the features of the device, as well as the specific features of the services related to the technology and the match. The tool is not only useful for professionals and researchers but also for AT designers, manufacturers, and retailers. The questionnaire is self-administered and requires approximately 10–15 minutes to complete. The minimum writing skills needed are the ability to mark the answer on a points scale and to write a comment. The three main objectives of the QUEST are the following: (i) to assess the degree of satisfaction that the user attributes to the eight items relating to the device and to the four items relating to the services; (ii) to identify the sources of satisfaction or dissatisfaction of the user; and (iii) to determine which aspects of satisfaction are considered most important by the user in evaluating the assistive device. The 12 items about satisfaction are divided into two parts: Eight items are related to the device (size, weight control, safety, durability, ease of use, comfort, and effectiveness), and four items are related to the services. Each item is scored by using a 5-point Likert scale ranging from 1 “not satisfied at all” to 5 “very satisfied.” In order to explore the reasons for user satisfaction/dissatisfaction, there is a space for comments next to each item. After the 12-item list, users choose the three most important aspects for their satisfaction from within another list of 12 items. The QUEST, depending on the context, can be completed by the evaluator or by the user if the evaluator is sure about the user’s understanding of the items. If the users do not have the motor, sensory, or cognitive skills required to complete the questionnaire, the professional can interview them by asking them to verbally answer or to indicate the number chosen on the enlarged protocol sheet. If the users are aged 0–12 years, a parent or a caregiver may answer in their place. The QUEST provides three scores: one for the device, one for the services, and a total score. The total score is useful for comparisons with other satisfaction measures and for determining the weight of each subscale score on overall satisfaction. Each score can vary from 1.00 = completely unsatisfied to 5.00 = completely satisfied. The evaluation fails if the user does not answer more than six items.
The Psychosocial Impact of Assistive Devices Scale (PIADS; Day and Jutai, 1996; Jutai and Day, 2002) is a self-report questionnaire designed for assessing the effects of an assistive device on functional independence, well-being, and quality of life. The PIADS is composed of three sub-questionnaires that focus on (i) ability, which measures users’ perceptions of their own competence; (ii) adaptability, which measures users’ willingness to explore novel experiences; and (iii) self-esteem, which investigates users’ emotions, such as happiness, security, and confidence. The sub-questionnaire focusing on ability is composed of 12 items that investigate the effectiveness of general skills (feeling of adequacy, efficiency, personal ability, etc.). The sub-questionnaire on adaptability consists of six items that aim to investigate the users’ predisposition toward taking risks and trying novel experiences, and their perceived feelings of well-being. The sub-questionnaire on self-esteem is composed of eight items that are related to the general feelings of emotional health, self-esteem, happiness, strength, and control. This questionnaire can be used for assessing the impact of the AT and the rehabilitation processes. It can also be used to evaluate the impact of aids, regardless of time limits, and as a comparison tool between devices and users. The PIADS can be administered to both adults and children over the age of approximately 10 years old. The completion time is approximately 5 minutes. The participants are asked to read a list of words or phrases describing how the use of an assistive device may affect their life. Each item is rated on a 7-point Likert scale from $-3 = \text{Strongly untrue}$ to $+3 = \text{Strongly true}$ to indicate the level by which they feel influenced by the AT. Unlike most of the elements, which have positive values, three items, confusion (5), frustration (10), and embarrassment (21), have a negative rating score. The participants are asked to fill the questionnaire by ticking the box that best represents the level by which they feel influenced by using the assigned aid. The PIADS can also be used for evaluating the user’s expectations of the device. The questionnaire is either filled by the user or a caregiver, and can be examined manually or with a specific table to help this process.

The Individual Prioritised Problem Assessment (IPPA; Wessels et al., 2002) is an instrument that assesses both the effectiveness of the AT provision and “the extent to which problems identified by an individual assistive technology user in his or her daily activities have been diminished as a result of the provision of assistive technology” (Wessels et al., 2002, p. 141). The instrument is user centered, as it assesses the effectiveness in relation to the operations considered relevant by the user. The IPPA allows variations over time to be checked. After the opening interview, a follow-up telephone conversation is held after at least three months following the provision of an AT. The initial interview lasts about 10–30 minutes, while the follow-up talk takes less than 15 minutes. During the initial interview, the user has to “identify the problems that he or she experiences in everyday life and that he or she hopes are eliminated or diminished as a result of an AT provision” (Wessels et al., 2002, p. 142). The user is then asked to identify up to seven problems, and for each of these, to complete an IPPA questionnaire. For each problem, the scores are assigned using a 5-point Likert scale, where the scores reflect the importance given by the customer/user to the activities and the difficulty associated with their execution. The total score is calculated by adding the sum of the “Importance” scores to the “Difficulty” scores for each problem and dividing the result by the total number of issues. The value obtained is “the total average perceived inconvenience experienced by the client with respect to the problems associated with daily activities” (Wessels et al., 2002, p. 142). The higher the score, the more individuals perceive their life as being disturbed by these problems. The IPPA score is recalculated during the follow-up interview when the user reassigns a “Difficulty” score for each problem reported in the initial interview. The problem keeps the importance value that was assigned during the first interview. The difference between the total IPPA score
before and after the supply of AT indicates the “efficacy” of the match and highlights any changes in the perceived discomfort about the problems reported. The scores also indicate the level of satisfaction the customers/users have regarding their initial expectations.

The Family Impact of Assistive Technology Scale (FIATS; Ryan et al., 2006) measures the multidimensional effects of an assistive device on families who have young children with disabilities through eight related constructs (grouped into subscales) that include child autonomy, caregiver relief, child contentment, performing activities, parent effort, family and social interaction, caregiver supervision, and safety. These constructs analyze the areas of child and family life that AT can affect, such as the level at which children can perform activities independently (autonomy), the manner they interact with others (family and social interaction), and any requests for attention from family members (supervision). Parents fill the FIATS, indicating their agreement/disagreement levels with 64 items through a 7-point Likert scale. The FIATS also contains elements of an independent subscale (technology acceptance) to measure the general receptivity of parents to AT devices for their children. The 64 elements are divided into nine subscales. The final FIATS score is calculated by the sum of the averages of the eight subscales. Increasing scores indicate a positive overall impact on the lives of children and families, and decreasing scores suggest a negative effect on the lives of children and families (for further information on the use of FIATS, see Chapter 5, “Measuring the Impact of Assistive Technology on Family Caregivers”).

The Assistive Technology Use Follow-up Survey (ATUFS) measures the users’ experiences with their AT device. An Italian version was developed by Federici and colleagues (Federici and Corradi, 2012; Federici, De Luca, and Corradi, 2012; Federici et al., 2016) from the original English version by Scherer (2005b). ATUFS 1.1 is a 17-item questionnaire designed to capture the respondents’ experience with an AT device they are using or the reasons for having abandoned an AT device. Use is assessed with item 2: “Are you presently using this device?” (response options: “no”, “yes”). This item records abandonment, regardless of whether the user has stopped using the device or has never used it. If the users responded positively to the question about current use, the interview then proceeds by investigating the users’ autonomy when using the device, that is, how often they need help when using the device and how often they use the device in a public context, respectively. Responses are given on a Likert scale ranging from 1 (every time) to 5 (never). The other nine items investigate the user’s experience with the AT in three domains of daily life: well-being and comfort (e.g., “To what degree [does/did] the device enhance your well-being?”), personal care (e.g., “To what degree [does/did] the device help you to take care of your health?”), and participation (e.g., “To what degree [does/did] the device help you to keep in touch with others?”). Responses are given on a Likert scale ranging from 1 (not at all) to 5 (a lot). This section of the questionnaire concludes with item 16, an open question about what might improve the usefulness of the user’s current AT device.

If the respondents indicated at item 2 that they were no longer using the device, the interviewer moves from item 4 to item 17, which consists of a scale with 21 subitems investigating the reasons for abandonment; it covers the following reasons: ineffectiveness, unreliability, difficulty of operating the device (items 1, 6, 7, 9, 12, 13, 14, and 20); preference for, or necessity of human help (items 2 and 8); characteristics of the milieu (item 3); changes in functional capacity (items 4 and 5); interference with daily activities (item 17); negative attitudes (item 18); maintenance costs (item 19); alternative solutions (item 21); appearance or size of the device (items 10, 11, and 16); inadequate training or support (item 15).
In the following Table 2.1, the above-suggested measurement tools for an ATA process are summarized according to two axes: vertically, the general characteristic of the measure (objective/subjective); horizontally, the step of the ATA process model in which the use of each measure is recommended.

### TABLE 2.1
Suggested Measurement Tools to Adopt in an ATA Process

<table>
<thead>
<tr>
<th>ATA Process Model</th>
<th>Objective</th>
<th>Subjective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: User data collection</td>
<td>ICF Checklist</td>
<td>WHODAS 2.0</td>
</tr>
<tr>
<td></td>
<td>ICF Core Set</td>
<td>MPT (SOTU)</td>
</tr>
<tr>
<td></td>
<td>VABS-II</td>
<td></td>
</tr>
<tr>
<td>Step 2: Multidisciplinary team meeting</td>
<td>(Psychologist’s evaluation of the individual functioning profile)</td>
<td></td>
</tr>
<tr>
<td>Step 3: Matching process</td>
<td>MPT (ATD-PA, professional form)</td>
<td>MPT (ATD-PA, consumer form)</td>
</tr>
<tr>
<td></td>
<td>SIS</td>
<td>COPM</td>
</tr>
<tr>
<td></td>
<td>COPM</td>
<td></td>
</tr>
<tr>
<td>Step 4: Follow up</td>
<td>MPT (ATD-PA, professional form)</td>
<td>MPT (ATD-PA, consumer form)</td>
</tr>
<tr>
<td></td>
<td>QUEST</td>
<td>PIADS</td>
</tr>
<tr>
<td></td>
<td>IPPA</td>
<td>FIATS</td>
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<tr>
<td></td>
<td>ATUFS</td>
<td></td>
</tr>
</tbody>
</table>

In the following Table 2.1, the above-suggested measurement tools for an ATA process are summarized according to two axes: vertically, the general characteristic of the measure (objective/subjective); horizontally, the step of the ATA process model in which the use of each measure is recommended.

### 2.4 Conclusions

In this chapter, we faced a twofold open question regarding the measurement of individual functioning, that is, what does individual functioning measure, and how should it be measured? The first part is focused on the bigger issue of what variables are used as estimates when measuring functioning and disability, whereas the second part deals with the guidelines and tools for measuring individual functioning. These issues arise from the nature of the concept of disability; in other words, it is a complex construct and a “multidimensional experience [that] poses several challenges for measurement” (WHO and World Bank, 2011, p. 21).

A comparison of different national and international reports on disability over the course of time shows that each measurement is different and gives rise to dissimilar estimates on the prevalence of the phenomenon, not only between different countries but also within the same country and at the same time. Many different aspects can cause the operational measures of disability to vary according to the prevalent notion of disability; the purpose of measurement and application; the investigated characteristics of disability; and “the definitions, question design, reporting sources, data collection methods, and expectations of functioning” (WHO and World Bank, 2011, p. 21). For all these reasons, the *World Report on Disability* (WHO and World Bank, 2011) made some recommendations in order to improve the availability and quality of data on disability, including (i) the adoption of the ICF as a universal framework for disability data collection; (ii) the improvement of national disability statistics; (iii) the improvement of the comparability of data; and (iv)
the development of appropriate tools in order to fill the research gaps. With regard to the latter point, the World Report on Disability suggested the development of “better measures of the environment and its impact on the different aspects of disability” (WHO and World Bank, 2011, p. 46) and the coupling of the evaluation of the disability experience with the measurement of the “well-being and quality of life of people with disabilities” (WHO and World Bank, 2011, p. 47).

Additionally, another crucial point in the field of measurement further complicates the issue. According to Zola (1993), any attempt to identify standard measures for disability reflects the effort to consider disability as a fixed and dichotomous entity more than anything else. Conversely, Zola’s universal model of disability indicated that disability is a fluid and continuous experience. According to Zola’s point of view, the World Report on Disability repeatedly stressed this point by using the word “experience” in relation to disability and by emphasizing a subjective dimension that is not reducible and not due to the level of objective measurement of functioning and disability. Disability is not a set of immutable characteristics that define one person over another or that are predictable by a medical diagnosis, because it is not always a direct consequence of disease; instead, it is a multidimensional process that lasts a lifetime and involves the physical, psychological, and social spheres of individuals. Because it is a multidimensional construct, its measurement should also be multidimensional. Therefore, an underlying principle of disability measurement is not even desirable. Instead, a variety of measurement tools and the flexibility to change the procedure of measurement in order to adapt them to different people, contexts, and purposes provide the most reliable scientific and clinical approach.

In this chapter, we followed the approach stating that the purpose of the measurement is the guiding principle for the specification of an operational definition and for the choice of a coherent set of measurement tools. Indeed, it does not define a default set of tools, but points to some guiding principles in choosing and applying a set of measures and in suggesting some tools that fit the ultimate purpose of the ATA process model, that is, “to address, in a specific context of use, the personal well-being of the user through the best matching of user and AT solution” via “clinical measures, functional analysis, and psycho-socio-environmental evaluations” (see Section I). The tools proposed and described in this chapter are from the following two major types: measures of individual functioning and outcome measures. The choice of the tools presented is intended to provide measures that allow the attainment of objective and comparable data in approaches that most effectively capture the subjective dimension of the experience of disability.

2.5 Summary

This chapter is divided into three main sections. Section 2.1 focuses on what individual functioning measures should be used, with a focus on the principle stating that disability is a multidimensional construct and does not have an underlying principle of measurement valid for every assessment. Additionally, the only guiding principle for a proper measurement is the clarity of the purpose of the measurement. Section 2.2 focuses on how to measure individual functioning by both pointing out some guiding principles
for choosing and applying a set of measures and by suggesting some tools that fit these principles. Section 2.3 suggests some measurement tools for an ATA process used in a center for technical aid.

References


Measuring Individual Functioning


3 Measuring the Assistive Technology MATCH

Fabrizio Corradi, Marcia J. Scherer, and Alessandra Lo Presti

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3.1 Introduction

The World Health Organization (WHO) Disability and Rehabilitation Action Plan 2006–2011 (2006) reports that about 10% of the world population experience some form of temporary or permanent disability. This document highlights that the assistive technology (AT) may be a helpful aid for people with disabilities “to increase their level of independence in their daily living and to exercise their rights” (WHO, 2006, p. 5). To achieve this goal, it is necessary to further enhance the development, production, distribution and support to use AT. In particular, the objectives of the WHO are in the following:

- Support Member States to develop national policies on AT
- Support member states to train personnel at various levels in the field of AT, particularly, in prosthetics and orthotics
- Promote research on AT and facilitate transfer of technology


Different studies show an average rate of about 30% of abandonment of AT within the first year of use, realizing that rates vary depending on the type of AT (Dijcks,
De Witte, Gelderblom, Wessels, and Soede, 2006; Kittel, Di Marco, and Stewart, 2002; Phillips and Zhao, 1993; Scherer, 1998; Scherer, Cushman, and Federici, 2004; Scherer, Sax, Vanbiervliet, Cushman, and Scherer, 2005). A study (Federici and Borsci, 2011) found approximately 25% AT abandonment in a local public health system and 12% of abandonment in a rehabilitation project. As the authors explain, such a high rate of abandonment/discontinued use can be traced back to not focusing on the user and/or the service delivery process did not foresee a required support before the device was delivered (Federici and Borsci, 2011, 2016; Judge, 2002; Lauer, Longenecker Rust, and Smith, 2006; Phillips and Zhao, 1993; Scherer and Craddock, 2002). Furthermore, a recent survey on the abandonment of AT in Italy showed that 17.9% of the sample were no longer using their assigned AT device within 7 months of issue and 40% of this group reported that they had never used the device (Federici, Meloni, and Borsci, 2016).

It must be realized, however, that only 5%–15% of the population who could benefit from ATs use them (WHO, 2006). The WHO hopes for a wider range of people that would benefit from such aids in order to achieve both functional benefits and participation in desired life situations (WHO, 2002). People not receiving the AT that could benefit them combined with evidence of AT abandonment, highlights the fact that matching is not occurring. Thus, there is a need to perform a matching process that carefully follows an assignation model that encourages centers for technical aid to perform a systematic assessment at each step of the matching process, including post-delivery support and assistance. The need of an assignation model is connected at least with two main objectives:

1. Minimization of financial losses, which would allow more people to take advantage of appropriate technologies
2. The provision of assistive solutions that best fit a user’s needs, achieving participation goals

Although a wide number of AT tools and frameworks have been developed, they tend to focus on AT outcome by, for example, the measurement of user satisfaction and/or performance of the assigned AT (see Chapter 2). Thus, standardized procedures and measures for the match and the assignation of AT at the time of AT selection are still required. While some individuals refer to the International Classification of Functioning, Disability and Health (ICF) as a tool that can assist the professional during the matching process (Karlsson, 2010); Bernd, Van Der Pijl, and De Witte (2009) considerations, the ICF checklist is a generic measure that is not developed for the purpose of assessing and addressing AT needs. A recent analysis of this issue (Bernd et al., 2009) reports a lack of reliable models and tools, which can be applicable to the process of selecting AT. In fact, most of the studies on this field are literature reviews or an attempt to develop a valid model of evaluation and do not follow any experimental design criteria. The only validated instrument that is currently mentioned in the literature is the Matching Person and Technology (MPT) model (Scherer, 1998). Starting from these considerations, the “Assistive Technology Assessment” (ATA) process model has been developed with the aim of identifying the optimal process to increase both the quality of the match of provided/supplied/purchased AT and users’ realization of benefit from its use (Federici, Scherer, and Borsci, 2014; see Section I). Under this perspective, the ATA process model is able to identify the steps required to achieve the optimum match by involving different professional skills and tools for the following activities: clinical analysis, the AT matching process, environmental analysis, the assessment of outcome, and evaluation of the match of the user and selected AT over time (Scherer et al., 2012). However, the two perspectives adopted by the MPT and the ATA process models are
different: the MPT process describes what should be measured, whilst the ATA process shows how a center for technical aid must be structured to allow the appropriate match between user and AT. Nevertheless, both models share the objective of promoting the personal well-being of the users by ensuring that the AT fits with their needs.

3.2 Measuring the Assistive Technology Match

The MPT is the most published model that is specific to AT assessment. The MPT model (Scherer, 1998) argues that the characteristics of the person, environment, and technology should be considered as interacting when selecting the most appropriate AT for a particular person’s use.

3.2.1 The ICF and Other Outcome Measures

The ICF; (WHO, 2001) offers a model to guide and integrate the complex aspects of assessment for AT: the biopsychosocial model, to which the MPT model refers. The ICF conceives disability as the product of the interaction between the individual’s characteristics and those of the physical and social environments. The disability is now defined as a variation of human functioning along three dimensions: impairments (the organic or psychological deficit), limitations in activity, and restrictions in participation. In particular, the ICF does not classify people, but describes situations of each person in terms of health domains and domains associated with it (such as education and work). For the first time, the WHO model of disability considers environmental factors, classifying them systematically, allowing the correlation between health and environment, and coming to the definition of disability as follows: a health condition in an adverse environment. Information obtainable by ICF is useful not only to study disability, but also to identify appropriate interventions. For example, if the problem is impairment, assistance will be focused on the individual; if the problem is related to a restriction of participation because of discrimination, then the intervention will be directed to the elimination of social and/or environmental barriers, changing barriers in the environment and also providing facilitators, so as to improve performance in everyday life.

Although the ICF was not particularly developed to guide AT assessment, the literature shows that it lends itself as a descriptive model for the ATA process. The ICF captures the complex aspects of the impact of AT, and it can assist the professional in decision making (Bernd et al., 2009). Assessment processes based on the ICF will assist professionals to understand the intended individual’s need, facilitate collaboration across agencies, and prioritize goals for intervention. The WHO defines AT as any device or system that enables a person to perform a task that would otherwise be considerably difficult to execute and which facilitates a task being performed (WHO, 2004; see Section I). AT includes both devices and services. AT services are defined as a service that supports AT assessment, acquisition, and device use (Bausch and Ault, 2008).

Furthermore, the ICF components are well integrated in combination with some assessment instruments, such as the ICF checklist mentioned earlier. It is compatible with the Canadian Occupational Performance Measure (COPM; Law, Baptiste, McColl, Polatajko, and Pollock, 2005), the Individually Prioritized Problem Assessment (IPPA; Wessels et al., 2002) and the Goal Attainment Scale (Karlsson, 2010). The ICF checklist is a practical tool
to elicit and record information on the functioning and disability of an individual: it elicits what capabilities and limitations the users experience in activities and participation related domains. It has a list of mental functions, sensory function and pain, voice and speech functions, respiratory system, etc. The checklist assists the service provider to know if more specific function assessment will be required. The COPM was developed for capturing the client’s individual occupational performance, it is not AT specific, but looks at the needs of the AT user from a client-centered perspective. Applied with other instrument it has been found to be a useful tool for the ATA process (Bernd et al., 2009; see Chapter 2). The GAS was introduced for evaluating mental health services; currently, it is used in pediatrics, rehabilitation, and mental health. It measures the change in response to individual goal-setting. The IPPA is a generic instrument to measure the effectiveness of any assistive technology provision. In sum, the COPM, GAS, and IPPA are sensitive to measure change; a combination of these instruments, along with the ICF checklist, offers service providers additional evidence-based solutions for outcome measure in assistive technology, as an alternative or complement to the MPT (Karlsson, 2010).

The only AT model based on specific evidence, developed to match the ICF and its checklist as found in the literature, is the MPT model (Bernd et al., 2009; Scherer and Craddock, 2002), specifically the measure, Assistive Technology Device Predisposition Assessment (ATD PA), where each item has been mapped to the ICF. The MPT fills a gap that considers the interactions among device characteristics, its user, and the environment. In addition to the COPM, GAS, and IPPA, the literature suggests the use of the Quebec User Evaluation of Satisfaction with Assistive Technology 2.0 (QUEST; Demers, Monette, Lapierre, Arnold, and Wolfson, 2002) and the Psycho-social Impact of Assistive Devices Scale (PIADS; Day and Jutai, 1996; Jutai and Day, 2002) when evaluating contextual factors such as device features and the enhancement of user’s well-being, but none of these have each of their items mapped to the ICF (see Chapter 2).

### 3.2.2 The Matching Person and Technology Model

The MPT model is a “user driven” and collaborative model, as it is based on technology selection achieved by a partnership of the person with a disability and a professional or team of professionals in order to create a dialogue and make manifest different perspectives of the person’s needs and appropriate supports. For the first time, the person with a disability is explicitly involved in AT selection. The traditional one-way process from provider to consumer (medical model) is replaced with an approach acknowledging that the provider is a key element of the environmental influences on AT selection and realization of benefit (social model). Key influences on the selection of the most appropriate AT for any given person is distributed among the following interdependent and interactive elements for achieving a match that is as appropriate as possible (Figure 3.1: see Section I, Figure I.3 for the color version):

1. **Milieu/Environment** or the characteristics of the architectural, built, physical, social, cultural, and attitudinal contexts in which the assistive technology is used
2. Characteristics relating to temperament, **Personality** and preferences of the user
3. Salient features of the assistive **Technology** itself

Furthermore, the MPT model contributes to the promotion of G.O.O.D. professional practice as shown in Table 3.1.
The MPT process and measures assess the individual predisposition to the use of assistive technology (or other forms of technology) and attempts to assess the extent to which the AT is likely to be accepted and used. It is through a series of worksheets completed by the user and professional (which identify relevant factors related to the environment, technology, and person) that the professional gains information to ascertain the critical factors that influence the acceptance and use of the AT being considered. The goal is to prevent AT nonuse (abandonment) and inappropriate use by gathering information, integrating it, and utilizing it to select the most appropriate AT and mediate between the needs expressed by the user and those related to the environment of use. For example, use can be forecast to be partial or reluctant owing to environmental factors, but good in respect to technology features and characteristics of the person; thus, the environment in which the AT will be used may require modification so that the person can get the most satisfaction and functional gain with the AT. Environmental features extend beyond physical access, often including economic resources and social support. Therefore, in the AT selection process, it is essential to involve from the beginning all the people who will be affected by the use of AT (user, caregivers, family members, employers, classmates, etc.).
The MPT perspective emerged from concern about AT abandonment. In the 1980s, scholars began to address the rehabilitation problems related to AT abandonment. The rehabilitation professionals have, therefore, begun to seriously study the problems of those who use AT and why they use them and those who do not and why they abandon or discard them.

Most of the research on AT use and abandonment considered several factors such as cost of equipment, physical abilities required for use, demography, product safety, and reliability. Particularly, there are three areas of study: (1) the personal characteristics of users and acceptance of technology, (2) the product features preferred by consumers, and (3) the inquiries about the AT use. Zola (1982) found that consumers prefer devices that promote independence associated with psychological and social freedoms, not only physical functioning. In addition, a number of personal factors that may affect the AT use and its acceptance, such as motivation, awareness of disability, goals of life, and effort–reward ratio, have been identified. Devices that allow users to complete important tasks are more likely to be used. In most studies, acquisition cost, durability, reliability, ease of use, security features, aesthetics, ease of repair, handling/portability, and good instructions were the most important features for a good AT.

Typically, the factors associated with the person are combined with the technology and environmental features. Phillips and Zhao (1993) reported an abandonment equal to 29.3% for AT, identifying four factors that are significantly related to AT nonuse and abandonment by users regardless of the type of disability:

1. Change in user needs
2. AT was easy to obtain
3. Low performance of the assistive technology
4. Lack of consideration of the user’s opinion when selecting the assistive technology

The highest abandonment rate occurred with mobility aids and mainly in the first year of operation, or after five years, implying an impact both at the individual level in terms of frustration and depression and at the entire health system level in terms of loss of funds and funding (Federici et al., 2016; Verza, Carvalho, Battaglia, and Uccelli, 2006).

Zimmer and Chappell (1999) examined the receptivity of 1400 elderly people in the Canadian province of Manitoba to specific technologies in order to develop an appropriate model of understanding. The authors found that receptivity is influenced by the following factors: predisposition, need, and social support, as well as the individual's level of concern for problems that could be mitigated through the use of technology. However, on closer analysis the results showed that the primary concern is home security. Older people often cope with chronic functional problems that limit their activities and their independence. The technology, therefore, acting on the practical difficulties of the elderly, can be an opportunity to improve their quality of life and a method of coping with disability.

Few studies investigated the use of AT by children (the pediatric population). However, in most children with disabilities, the use and abandonment of assistive devices are often influenced by other people close to them, such as parents, teachers, and therapists (Caudrey and Seeger, 1983).

Although there are many models in the AT literature, none of these were proved capable of predicting AT use. Lenker and Paquet (2004) proposed a holistic conceptual model,
user-centered, that predicts the AT use in terms of its perceived benefits and considers it a decision-making process that occurs and is shaped over time and not in a moment. The use of AT has an impact on the user, the environment, and the use of the technology, but at the same time, the AT impact predicts its future use.

Similar results were obtained from Verza et al. (2006), who demonstrated how a multidisciplinary approach to the evaluation of patients with multiple sclerosis who require AT can reduce AT abandonment. These authors identified four factors of abandonment: deterioration of physical state, nonacceptance of aid, failure/lack of information and training, and AT inadequacy. Most of the equipment that was abandoned was done immediately or within the first year of use.

The predisposition to the use of technology is multifaceted and includes the needs, abilities and preferences, previous experiences with technology, personality factors, expectations, and many other variables. A cross-cultural analysis (Federici, Scherer, Micangeli, Lombardo, and Olivetti Belardinelli, 2003) confirmed the hypothesis of a relationship between self-representation of disability (assessed with the World Health Organization Disability Assessment Schedule 2.0 [WHODAS 2.0]), coping strategies (measured by the Coping Inventory for Stressful Situation (Endler and Parker, 1999)), and the individual predisposition to the use of AT (assessed with the Survey of Technology Use [SOTU]).

In all studies, we highlight the central role of the user during the entire process of AT selection (aid assignment), by informed choice, trial use, then the use of technology in order to produce a noticeable advantage in terms of efficiency, satisfaction, acquisition of greater autonomy, and improving the quality and way of life (Lenker and Paquet, 2004). The complexity of matching user and technology requires a person-centered approach and, thus, a more complete assessment of the user before the AT selection/assignment. In addition, a better training of professionals and service providers and an appropriate training of users on the ATs will facilitate decisions regarding the AT assignment, thus reducing the likelihood of AT abandonment.

Indeed, the need to assign an AT that enhances the individual skills and quality of life often clashes with the nonuse or abandonment of AT or with the nonoptimal use of it (Scherer and Federici, 2015).

The MPT is the first theoretical model that has focused on the involvement of the person with a disability in the process of assigning the aid. Because the lived experience of disability is subjective and unique, there is need for a comprehensive user-centered evaluation that gives the user the opportunity to express preferences and individual and psychosocial characteristics (Scherer, 2005).

According to Scherer (2002), only through a thorough evaluation, the following could be identified:

- The need to change the environment or support from others to enable the use of the AT
- The impact of related limitations
- The balance between the functional capabilities and limitations
- The need for training and the identification of contexts for trial use (home, school, and work)
- The most cost-efficient AT for the user in terms of usability and aesthetics
- The extent to which the AT satisfies the needs of the consumer at follow-up and the existence of any unforeseen and undesirable side effects.
The ultimate goal of the selection/assignment process is to improve the performance and quality of life of the individual, where a quality lifestyle and wellness indicates “the entire universe of human life domains, including physical, mental and social features that constitute what may be called a good life” (ICF, 2001, p. 188). If the aid does not perform this function, it will not, or rather should not be, used.

3.2.3 The MPT Process and Measures

Table 3.2 below lists the MPT process and measures with their intended purpose. It endeavors to follow the G.O.O.D. principles.

The measures in Table 3.2, particularly the ATD PA, have been consistently found to be reliable and valid (Gatti, Matteucci, and Sbattella, 2004; Goodman, Tiene, and Luft, 2002; Scherer and Cushman, 1995; Scherer and Sax, 2009; Vincent and Morin, 1999). Significant correlations were found with the following factors: quality of life, mood, support from others, motivation for AT use, program/therapist reliance, self-determination/self-esteem (Scherer et al., 2005), Environmental Factors of the ICF (Scherer and Glueckauf, 2005), Satisfaction with Life Scale (SWLS), Brief Symptom Inventory (BSI) (Scherer and Cushman, 1995), and psychosocial aspects (Brown, 1997; Brown and Merbitz, 1995).

3.2.4 MPT Model and ICF

The different measures in the MPT process are compatible with the ICF and allow the assessment of relevant domains affected by the use of technology. Table 3.3 lists the major domains of the ICF, some examples of AT and other forms of support, and the most appropriate MPT measure for the evaluation of each ICF domain (based on Scherer and Glueckauf (2005)).

3.2.5 Different Versions of Matching Person and Technology

Indeed, to provide relevant measures for the various interests and needs of people with disabilities across age groups, there are separate versions.

The evaluation process for Matching Assistive Technology and Child (MATCH) was designed by Scherer (1997) within the MPT model to provide a person-centered approach for the assessment of individual predisposition to the use of AT by infants and children between 0 and 5 years of age with a separate version for those children of school age.

The MATCH process consists of a series of tools designed for those who aim to obtain a better match between the child and support in the form of technologies: producers and evaluators of AT, social and family care centers, coordinators of centers for technical aid, psychotechnologists, therapists, and parents. Other adaptations of the MPT are designed to address specific disabilities or specific areas of evaluation, for example, Cognitive Support Technology Predisposition Assessment (Scherer et al., 2012).

3.3 The Assistive Technology Assessment Process

AT plays a crucial role in supporting the social integration of people with disabilities. The AT matching process involves a sequential and articulated series of assessments
### TABLE 3.2
MPT Assessment Process and Forms

- **Step One:** *Initial Worksheet for the MPT Process* is organized by areas in which persons may experience loss of function (e.g., speech/communication, mobility, hearing, and eyesight) or have important strengths. It identifies initial goals and areas to strengthen through the use of a technology (or other support/strategy) or environmental accommodation. Potential interventions supportive of the goals are written in the space provided on the form. When a novel technology is being introduced to a person, it is better to work from an area of strength. Each item should be addressed, regardless if a professional believes it is relevant for this individual or not. You never know what connection will be triggered or what observations will be recollected that will affect later decision making.

- **Step Two:** *History of Support Use* is used to identify supports used in the past, satisfaction with those supports, and why a novel type of support may be better than alternatives. It is organized according to the same areas of functioning as the initial worksheet in step one.

  Although steps one and two focused on the “separate parts” of the individual, it is believed that unless each area is addressed, key barriers to optimal technology use may be missed. For example, when you focus on communication and are about to recommend a device that requires very good vision, and that has not been assessed, there may be problems if the person does have significant vision loss. The goal is to emphasize the entire person and do a comprehensive assessment considering the entire person, environments of support use, and so on, but to achieve this by considering in turn the many parts that comprise the whole and their relationship to one another.

- **Step Three:** *Specific Technology Matching*. The individual completes his or her version of the appropriate form depending on the type of technology under consideration. The modular nature of the assessments allows for the use of one, two, or more forms as well as sections of forms. The individual versions of the *Assistive Technology Device Predisposition Assessment and Cognitive Support Technology Device Predisposition Assessment* have the option for computerized scoring with interpretive guidelines.

  - **General:**
    - *Survey of Technology Use-Individual*
    - *Survey of Technology Use-Professional*
    A 29-item checklist inquires into the respondent’s present experiences and feelings toward technologies. The questions ask individuals to list all of the different technologies they use and feel comfortable, the idea being that the introduction of a novel technology should build upon and capitalize on existing comfort and skill. Individuals are also asked to provide information about areas regarding their general mood and preferences and social involvement that have been found in research to impact a favorable predisposition toward technology use. The professional version is identical to the students’ version.

  - **Assistive:**
    - *Assistive Technology Device Predisposition Assessment-Individual*
    - *Assistive Technology Device Predisposition Assessment-Professional*
    The ATD PA inquires into individuals’ subjective satisfaction with key body functions (9 items), asks individuals to prioritize aspects of their lives in which they desire the most positive change (12 items), profiles individuals’ personal factors and psychosocial characteristics (33 items), and asks for individuals’ opinions regarding their expectations regarding the use of a particular type of assistive device (12 items). The scales are the labeled view of capabilities, subjective quality of life, family support, support from friends, mood and temperament, autonomy and self-determination, self-esteem, and readiness for technology use. The final section allows for the comparison of competing devices and rates the device and person match. The ATD PA (professional form) allows the professional to determine and evaluate incentives and disincentives to the use of the device by a particular person.

  - **Cognitive Support:**
    - *Cognitive Support Technology Device Predisposition Assessment-Individual*
    - *Cognitive Support Technology Device Predisposition Assessment-Professional*
    The CST PA is structured like the ATD PA above, but it has additional six items in body functions focused on Specific Mental Functions:
      - Paying attention, not getting distracted
      - Remembering information about people or events

(Continued)
TABLE 3.2 (Continued)
MPT Assessment Process and Forms

- Educational:
  
  *Educational Technology Device Predisposition Assessment-Student*
  *Educational Technology Device Predisposition Assessment-Teacher*

  The ET PA is a 43-item form designed to assess student and educator perspectives in four key areas: (1) educational goal and need, (2) particular educational technology under consideration, (3) psychosocial environments in which the technology will be used, and (4) student learning style and preferences.

- Workplace:
  
  *Workplace Technology Device Predisposition Assessment-Individual*
  *Workplace Technology Device Predisposition Assessment-Employer*

  The 28 items in the WT PA address key characteristics of the technology being proposed, the person or employee, and the workplace.

- Health care:
  
  *Healthcare Technology Device Predisposition Assessment-Professional*

  The 42-item HCT PA is a checklist addressing the characteristics of the particular health problem, health-care technology, likely consequence of HCT use, personal issues, and attitudes of significant others toward the course of treatment.

  Each of the individual forms may serve as a guide for an oral interview if that seems more appropriate for the situation. The professional completes the professional version of the same form and identifies any discrepancies in perspective between the professional’s and the individual’s responses. These discrepancies then become a topic for discussion and counseling.

- Step Four: The professional discusses with the individual those factors that may indicate problems with his or her acceptance or appropriate use of the technology.

- Step Five: After the problem areas (barriers, limitations) have been noted, the professional and individual work to identify specific intervention strategies and devise an action plan to address the problems.

- Step Six: The strategies and action plans are committed to writing, for experience has shown that plans that are merely verbalized are not implemented as frequently as written plans. Written plans also serve as documentation and can provide the justification for any subsequent actions such as requests for funding or release time for training.

- Step Seven: A follow-up assessment is conducted to determine any adjustments or accommodations required to the technology and to inquire into realization of benefit, goal achievement, and whether the individual consumer has changed priorities. The measures in Step Three: Specific Technology Matching are used at baseline/initial assessment and then again at follow-up to determine change over time for a particular person.

Conducted by experts with different professional skills, a successful matching process is determined by both the assessment protocol model and the skills of the multidisciplinary team. The matching process occurs in centers specialized on AT in which a team of experts plays a mediating role between AT and the person with a disability. In Western countries, this process is characterized by two seemingly opposing models: in one, more prevalent in some European countries (e.g., Italy), the person who needs an AT is considered as a user/patient; on the other model, more common in Anglo-Saxon countries, the person is rather a consumer or customer. This difference is related to differences in policies towards assistance services: in the first case, in fact, the center does not sell products but it only provides assistance and evaluation services; in the second case, the center for technical aids may also manufacture and sell the AT that it provides. Compared to the second model, which emphasizes the centrality of customer satisfaction, the first model grants a more neutral approach in the evaluation and the assignation of the technology. The ATA process model describes both the skills and functions of the multidisciplinary team involved during the matching process and their mutual interaction. The ATA process model can be read both from the user’s point of view and from the point of view of the center for technical aid (see Section I).
### TABLE 3.3

List of Major Domains of ICF, of Some Examples of AT and Other Forms of Support, and of Most Appropriate MPT Measure for the Evaluation of Each ICF Domain

<table>
<thead>
<tr>
<th>ICF Activities and Participation</th>
<th>Examples of AT and Other Supports</th>
<th>MPT Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning and applying knowledge:</strong> Learning, applying the knowledge that is learned, thinking, solving problems, and making decisions</td>
<td>Note taking, real-time captioning services, personal digital assistant (PDA) and laptop computers, audio recording devices, computer software, and electronic calculators</td>
<td>SOTU, ET PA, CST PA, MST</td>
</tr>
<tr>
<td><strong>General tasks and demands:</strong> Performing single or multiple tasks, organizing routines, and handling stress</td>
<td>Personal assistance, service animals, timers, and memory aids</td>
<td>ATD PA Sections B and C</td>
</tr>
<tr>
<td><strong>Communication:</strong> Communicating by language, signs, and symbols, including receiving and producing messages, carrying on conversations, and using communication devices and techniques</td>
<td>Sign language interpreters, electronic and manual communication devices, computer input and output devices, modified telephones and text messaging devices, radio and television adaptations, and signaling and alerting devices</td>
<td>Initial worksheet, history of support use, ATD PA Section B, HT PA</td>
</tr>
<tr>
<td><strong>Mobility:</strong> Changing body position or location or transferring from one place to another, by carrying, moving, or manipulating objects; by walking, running, or climbing; and by using various forms of transportation</td>
<td>Manual and power wheelchairs, canes and walkers, transfer boards, vehicle modifications, lifts, relief maps, and global positioning system (GPS)</td>
<td>ATD PA Sections A and B</td>
</tr>
<tr>
<td><strong>Self-care:</strong> Caring for oneself, washing and drying oneself, caring for one’s body and body parts, dressing, eating, and drinking, and looking after one’s health</td>
<td>Modified eating utensils, nonslip mats, robotic devices, buttonhooks, liquid soap dispensers, and electric toothbrushes</td>
<td>ATD PA Sections A and B</td>
</tr>
<tr>
<td><strong>Domestic life:</strong> Acquiring a place to live, food, clothing, and other necessities; household cleaning and repairing; caring for personal and other household objects; and assisting others</td>
<td>Bottle and can openers, tilt tables, modified lighting, support bars and rails, and remote—or voice—activated environmental controls</td>
<td>ATD PA Sections A and B</td>
</tr>
<tr>
<td><strong>Interpersonal interactions and relationships:</strong> Basic and complex interactions with people (strangers, friends, relatives, family members, and lovers) in a contextually and socially appropriate manner</td>
<td>Manual and electronic communication devices, life skills coach, and sexual aids</td>
<td>ATD PA Sections B and C</td>
</tr>
<tr>
<td><strong>Major life areas:</strong> Tasks and actions required to engage in education, work, and employment and to conduct economic transactions</td>
<td>Remote control devices, customized workstations, structural modifications, and alternative computer access</td>
<td>ATD PA Sections A and B, other MPT measures</td>
</tr>
<tr>
<td><strong>Community, social, and civic life:</strong> Actions and tasks required to engage in organized social life outside the family, in community, social, and civic areas of life</td>
<td>Signaling and alerting devices, noise reduction devices, adapted recreational and leisure devices, and transportation accommodations</td>
<td>ATD PA Sections A and B, other MPT measures</td>
</tr>
</tbody>
</table>
The ATA is a user-driven process through which the selection of one or more AT devices for an AT solution is facilitated by the comprehensive utilization of clinical measures, functional analysis, and psycho-socio-environmental evaluations that address, in a specific context of use, the personal well-being of the user through the best matching of user and AT solution (Scherer et al., 2012).

ATA under the lens of the ICF Biopsychosocial Model (see Section I) is provided in the following:

- The ICF biopsychosocial model is our lens for viewing the ATA process.
- The user (request) seeks a solution for one or more ICF components: Body Functions and Structures (health conditions), Activities, and Participation, all within the Context consisting of Personal and Environmental Factors.
- The user request triggers the user-driven process.
- The user-driven process begins with the ATA for an AT solution.
- The AT solution is facilitated by the comprehensive utilization of clinical measures, functional analysis, and psycho-socio-environmental evaluations.
- The user request is satisfied with the best matching of user and AT solution (including user well-being and realization of benefit from AT use).

The center for technical aid verifies the user’s satisfaction and realization of benefit by activating support and follow-up. User well-being continues as long as the solution, with support and follow-up, remains a good match (Scherer et al., 2012).

3.3.1 The ATA Process in the Center for Technical Aid and in the Rehabilitation Project

The ATA is the ideal process recommended for a public or private center for technical aid. However, some studies highlight significant data concerning the AT matching in the rehabilitation arena (Federici and Borsci, 2011; Verza et al., 2006). Federici and Borsci (2011) have conducted a survey on a large scale on satisfaction with and use of AT within specific public paths (center for technical aid) and within the rehabilitation project. Such a survey highlights a very definite difference between the two processes, showing significantly different abandonment rates: in case of specific paths, the abandonment rate is around 25% (i.e., below international averages that show rates of about 30%, even though it is in line with them if we consider that the AT studied are only hearing aids and stair lifts). On the other hand, in case of rehabilitation projects, the abandonment rate decreases to 12%. Moreover, within specific paths without a dedicated rehabilitation service, there is great variability as far as the assignment processes are concerned, highlighting the existence of many possible processes in the assignment of AT. The ATA process model allows a general standardization of processes, which indicates essential elements in a successful matching path (Federici et al., 2015). Actually, according to the analysis of Federici and Borsci (2011), it is clear that they lack some indispensable steps in attaining a good match between user and AT. In particular, all processes registered in the area do not consider as part of the assignment process a follow-up assessment service that is able to manage use-related problems and users’ frustrations. The lack of follow-up services is one of the main factors that may cause the abandonment of aids/AT in the research centers.
According to another study conducted in the area of rehabilitation, another relevant factor emerges concerning a low abandonment rate (Verza et al., 2006): a reduction of 28% (9.5% up to 37.3%) was credited to the intervention of a multidisciplinary team (physical therapist, occupational therapist, physician in physical medicine and rehabilitation, and psychologist) and the direct involvement of user and his/her home environment in the AT matching process.

In the same study, the possibility is considered of a further reduction in abandonment by using measurement tools of predisposition to AT such as the MPT. The importance of the main role of the home and personal environment in the use of the matched technology (Aid/AT) and an outcome of a satisfactory experience with the AT has also been indicated by Pasqualotto, Federici, Simonetta, and Olivetti Belardinelli (2011).

The ATA process sets out the guidelines for the process assignment of an AT and calculates both the intervention of a multidisciplinary team by the involvement of the user and his/her environment and the assistance services as well as recurrent follow-ups, strictly related to the possibility of the need to reassess the used AT.

### 3.4 The Matching Person and Technology Model and the Assistive Technology Assessment Process Model

The MPT process allows the measurement and evaluation of the matching between user and AT, through the different measurement tools in the MPT package (SOTU, ATDPA, CSTPA, ETDA, WTPA, and HCTPA). The ATA process model, instead, is a system of organizing the AT assignment within a center for technical aids and allows professionals to view and manage step by step the articulation of the path that the user follows to achieve the optimum match. In part, the MPT process coincides, or rather is to operate within the ATA process model, because both have as their objective the optimal matching of user and AT, except that the MPT process is an assessment method and includes matching measures, while the ATA process model is a functioning process that guides an AT assignment. The ATA process model may, thus, accompany the successful development of a matching process through the MPT tools. The model underlying the MPT and the ATA process is the same, namely a “user-centered” model that is based on a biopsychosocial model of disability (i.e., the ICF). However, the outlook is different: the MPT process describes what should be measured, and the ATA process model indicates how a center for technical aids is set up in the management of matching user and AT. Particularly, the ATA process model provides information and guidelines regarding the setting, the professionals to which the user must contact, the collection of information, the center of technical aids management, the multidisciplinary team involved in the matching process, etc. Within this structured and multidimensional setting, the MPT fits as a model, an assessment tool, and “outcome measure” of the match achieved. The MPT model underlying the ATA process allows the use of a series of measures that provide a person-centered approach able to identify the best AT that fits the user’s needs: this goal can be reached through a collaborative approach in which the user and professional of the multidisciplinary team cooperate during the evaluation processes. Within the ATA process model, the different items provided by the MPT can be effectively used by the multidisciplinary team to determine the expectations of the user/customer and define the aims (Initial Worksheet and History of Support Use), carry out surveys on the technologies used and analyze in this manner the related users’
satisfaction (SOTU), and carry out assessments of the AT user's predisposition to use and AT (ATD PA).

In this manner, the ATA process model is able to guide the work within a center for technical aids and allow professionals to regularly monitor all the factors that would promote the user/customer's personal well-being through the best combination of their needs and the assistive solution. The ATA process model would allow, at the same time, obstacles to be identified and overcome that could have a negative impact on the assignation process such as the following:

- Lack of financial resources for the purchase, evaluation, testing, and training of AT
- A multidisciplinary team composed of professionals who have not been previously trained to cooperate with the matching process and assist the AT user
- Processes built that do not consider user/customer's needs, priorities, preferences, and participation in the choice of the AT

The MPT model aims to help professionals to obtain the best match by using different measures that have been validated within the biopsychosocial context (Scherer and Sax, 2009). Both process and measures would contribute to the promotion of user personal well-being by identifying the best AT within a well-defined process, with trained professionals and in a completely user-driven model.

### 3.5 Conclusion

According to Scherer (2002), only through a thorough evaluation, the following could be identified:

- The need to modify the environment or support for AT use
- The impact of limitations on the performance of activities and participation in desired life roles and settings
- The balance between functional capabilities and limitations
- The need for training and the identification of contexts for trial use (home, school, and work)
- The most cost-efficient AT/aid for the user in terms of usability and aesthetics
- The extent to which the AT/aid satisfies the needs of the consumer and the existence of any undesirable side effects through a follow-up evaluation.

The ultimate goal of the assignment process of an AT is to improve the functioning and quality of life of a person with a disability, and many such individuals, where quality of life and wellness indicates, in a general sense, “the universe of domains of life, including physical, mental and social features which constitute what may be called a good life” (ICF, 2001, p. 188). If the AT does not perform this function, it will not, or rather should not, be used. Using the MPT tools within the ATA process model could help professionals achieve a better matching between user and AT and, thus, a reduction in AT abandonment.
3.6 Summary

In this chapter, the ATA model has been presented. The ATA model outlines an ideal process that provides reference guidelines for both public and private centers for technical aid provision, allowing them to compare, evaluate, and improve their own matching model. The actions required by the ATA process model to centers for technical aid can be divided into four fundamental steps: access to the structure and activation of the process, evaluation and activation of the AT selection, delivery, and follow-up. The ATA model is a user-driven process through which the selection of one or more AT is facilitated by the utilization of comprehensive clinical measures, functional analysis, and psycho-socio-environmental evaluations that address, in a specific context of use, the personal well-being of the user through the best matching of user and AT solution. As the ATA process model and the MPT model and accompanying measures share a user-driven working methodology and embrace the ICF biopsychosocial model, they can be integrated within a path aiming for the best combination of AT to promote the personal well-being of users.

References


Measuring the Assistive Technology MATCH


4

Assessment of the Environments of AT Use: Accessibility, Universal Design, and Sustainability

Mansha Mirza, Andrea Gossett Zakrajsek, and Apeksha R. Gohil

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4.1 Introduction

The role of the environment in inhibiting or supporting full societal participation of people with disabilities is increasingly being acknowledged. Theoretical frameworks of disability such as the social model (Oliver, 1990) and the International Classification of Functioning, Disability, and Health (ICF; World Health Organization [WHO], 2001) recognize the role of the environment in “producing” disability, albeit to varying extents. Even the preamble of the United Nations (UN) Convention on the Rights of Persons with Disabilities affirms that disability results from the interaction between individuals with impairments and environmental barriers (UN, 2006).

Furthermore, research studies have repeatedly underscored the dynamic relationship between environmental factors and the community participation of people with disabilities (Egilson and Rannvieq, 2009; Verdonschot, de Witte, Reichrath, Buntix, and Curfs, 2009). In addition, there is a robust body of literature demonstrating that conflict between assistive technology (AT) and its context of use is an important contributor to AT nonuse and abandonment (Day, Jutai, Woolrich, and Strong, 2001; Dijcks, De Witte, Gelderblom, Wessel, and Soede, 2006; Kittel, Di Marco, and Stewart, 2002; Lauer, Longenecker, and Smith, 2006; Philips and Zhao, 1993; Scherer, 2002; Scherer, Cushman, and Federici, 2004; Scherer, Sax, Vanbiervliet, Cushman, and Scherer, 2005; Soderstrom and Ytterhus, 2010).
In light of this evidence, any assistive technology assessment (ATA) process would be significantly incomplete without a systematic consideration of how the user’s environment influences the acceptance of AT, its utilization, and the user’s participation in various life activities.

This chapter provides a rationale and framework for incorporating the environment within the ATA process. In the past, some AT manuals and guides have addressed this area with a primary focus on microenvironments such as the home, school, and workplace (Church and Glennen, 1992; Mann and Lane, 1991). In this chapter, we take a broader view of the environment and understand the environment to comprise physical, social, cultural, legislative, and economic components. However, our goal is not to prescribe specific measures and tools for evaluating each of these components. Instead, we offer an innovative model for considering the environment within the ATA process more broadly and holistically and along the three dimensions of accessibility, universal design, and sustainability.

This chapter is divided into three sections. In Section 4.2, we introduce the concepts of accessibility, universal design, and sustainability, and describe two models depicting the interaction between these concepts. In Section 4.3, we discuss how an environmental assessment framework incorporating these three dimensions can inform the ATA process and illustrate a step-by-step evaluation of the environment to support decision making within the ATA process. Finally, in Section 4.4, we provide an example illustrating how the concepts and processes described in Sections 4.2 and 4.3 can be applied within an actual case.

### 4.2 Accessibility, Universal Design, and Sustainability: An Overview

Examining the environment in terms of accessibility, universal design, and sustainability offers a framework for making the ATA process more comprehensive, relevant, and in line with contemporary and future conceptual and geopolitical trends.

#### 4.2.1 What Do We Mean by Accessibility, Universal Design, and Sustainability?

Traditionally, assessments and interventions targeting the environment have tended to draw upon the concept of accessibility. In the United States, the first structured guidelines codifying accessibility of the built environment, known by the acronym ADAAG (Americans with Disabilities Act Accessibility Guidelines), were created in 1990 (U.S. Access Board, 2004). Likewise, other countries around the globe have developed accessibility standards, some of which are informed by legislation (Dion et al., 2006). In Europe, through work of the European Institute for Design and Disability (EIDD Design for All Europe) network, the Build for All Reference Manual was created in 2006 to organize and promote accessibility within the built environment (Build-for-All Project, 2006). Build-for-All aims to “enable all people to have equal opportunities to participate in every aspect of society. To achieve this, the built environment, everyday objects, services, culture, and information—in short, everything that is designed and made by people to be used by people—must be accessible, convenient for everyone in society to use and responsive to evolving human diversity” (Build-for-All Project, 2006; EIDD Design for All Europe, 2004).

Although these standards and policies were primarily geared toward promoting accessibility for people with disabilities, the current international trend has progressed toward a
broader definition of the population that could benefit from “accessible” environments. This broadening definition of the user population is expressed in the philosophy of universal design (UD). Universal design is a term used to describe the designing of all products and the built environment in an inconspicuous manner to be both aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life (Mace, Hardie, and Place, 1991). Elsewhere, it has been defined as a movement that approaches the design of the environment, products, and communications with the widest range of users in mind (Knecht, 2004) and as a process of embedding choice for all people in design (Salmen, 2008).

Whereas accessibility is viewed as the removal of barriers and addition of special features particularly for use by people with disabilities, universal design is viewed as providing environments that can be fully experienced by all people. Accessibility is based on assumptions of particular barriers for a specific group of people. Conversely, universal design is viewed as a framework for developing solutions to satisfy the anticipated needs of all end-users (Knecht, 2004).

In addition to accessibility and universal design, sustainability is the third dimension that we propose as essential for evaluating the environment. Sustainable design refers to the design and production of objects or buildings in methods that are economical and that minimize harmful effects for the natural environment (Birkeland, 2002). For the purpose of this chapter, we have broadened the definition of sustainable design to also encompass the notion of adaptable usage such as the use of products or environments over time, and across changing functional abilities and demands.

Although AT professionals and consumers are familiar with the concepts of accessibility and universal design, the notion of sustainable design remains an unchartered territory, yet one that is becoming increasingly significant within the context of global climate change and resource scarcity. Sustainability is an important concept to consider when designing products and environments for people with disabilities particularly because of recent speculation that this population is likely to be disenfranchised from the global movement addressing the central problem of climate change facing our society (Lovelock, 2010).

Several examples highlight the need for considering accessibility, universal design, and sustainability in conjunction when designing new buildings. A recent case study of three green-certified public buildings in Malaysia revealed that while the buildings satisfied the local standards for sustainability and green design, they were inaccessible for people with physical and sensory disabilities. Authors of the case study advocated for regulatory action and incentives so that accessibility standards are enforced alongside green design standards, in compliance with national disability legislation (Yiing, Yaacob, and Hussein, 2013). In a similar example from the UK, a researcher with cerebral palsy investigated the accessibility of a sustainable housing project in Nottinghamshire. The research revealed that eco-living features created access barriers for people with disabilities. For example, opening and closing triple glazed windows, so designed to control temperature, was challenging for people with poor dexterity and strength. Similarly, higher thresholds built for the purpose of heat retention and air tightness made spaces inaccessible for people with mobility impairments. Based on these findings, the author argued that accessibility for people with disabilities is overlooked when building spaces that are energy efficient and environmentally friendly (Bhakta, 2014).

Thus, there is a dire need for the literature to guide the design of spaces that are both sustainable and accessible for a diverse range of users. By incorporating the three concepts of accessibility, universal design, and sustainability within a single framework, this chapter offers an environmental assessment framework that is comprehensive, innovative, and relevant to contemporary trends and demands.
4.2.2 Interaction between Accessibility, Universal Design, and Sustainability

When assessing the environment along the dimensions of accessibility, universal design, and sustainability, it is important to understand that these three dimensions do not operate in isolation but instead overlap and intersect (Gossett, Barnds, Mirza, and Feidt, 2009). The point of intersection between all three dimensions represents the “ideal” design solution for the product or environment being considered—a solution that achieves the highest degree of accessibility, universal design, and sustainability. A visual illustration of this point is presented in Figure 4.1.

The intersection model allows one to simultaneously place each decision or design element of the product/environment under consideration in relationship with the three dimensions and to judge it against its approximation to the ideal center. Although the “ideal center” represents the main goal of any design process, previous research (Gossett et al., 2009) has shown that the ideal solution is difficult to achieve. Instead, in most situations, there exists a tenuous relationship between these three desired features pulling the design solution in divergent directions. At these times, the solution eventually adopted reflects a tradeoff among the three features of accessibility, universal design, and sustainability. A visual illustration of this point is presented in Figure 4.2.

In Figure 4.2, the dimensions of accessibility, universal design, and sustainability each exist along their own continuum. Each design decision can be evaluated in terms of universal design, accessibility, and sustainability, falling into various places on the three continua. Evaluation on these continua can help to focus a decision on a critical deciding factor. Both the intersection and continuum models can play an important role in guiding environmental assessments and informing decisions during the ATA process. An environment that falls in the ideal center of the intersection model will have the following characteristics:

- It will facilitate the optimal functioning of a particular AT prescribed to a particular user with a disability (accessibility), thereby promoting the utilization of the prescribed AT by that user. For example, the optimal functioning of a wheelchair and consequently the user’s ability to enter and use a building is contingent on the presence of a ramp (accessible) or stairs (inaccessible) at the building’s entrance.

![Figure 4.1](image)

**FIGURE 4.1**
Intersection model of conceptual dimensions of accessibility, universal design, and sustainability.
It will seamlessly accommodate the AT as part of its layout or architecture (Center for Universal Design, 2008). For example, a building entrance that is level with the sidewalk and textured to allow cane detection eliminates the need for a separate entrance for users of walkers, canes, and wheelchairs, thereby seamlessly incorporating individuals with a wide spectrum of functional abilities. Most people strive to conform to normative standards of functioning and appearance because we are socialized to minimize or hide our differences (Scherer, 2002). This indicates that aesthetic considerations play an important role in AT acceptance. Therefore, a universally designed environment that aesthetically and inconspicuously supports AT use can minimize potential stigma and promote the uptake and acceptance of the prescribed AT by the user.

It will support AT use across changing needs, the changing functional status of the user, and across changing weather conditions. It will be easy and economical to maintain and will minimize any negative impact on the natural environment (sustainability). Device adjustability, affordability, and ease of maintenance and repair are important features that contribute to long-term AT use (Scherer, 2002). However, the extent to which an AT can be adjusted and maintained with ease will be determined to a great extent by its context of use. For example, a height-adjustable worktable that can accommodate pediatric and adult-sized wheelchairs can support the user across the growth curve. Similarly, a carpet that is safe for use with walkers and wheelchairs can support an aging user with declining functional mobility. In addition, if both the worktable and the carpet in the above example can be cleaned with nonchemical agents, they will be easier and economical to maintain without degrading the natural environment.

Thus far, we have introduced the three dimensions of accessibility, universal design, and sustainability, and described the dynamic interaction between them. The following section describes an environmental assessment framework that is based on these three dimensions and illustrates its incorporation within the ATA process.
4.3 Environmental Assessment in the ATA Process Based on the Concepts of Accessibility, Universal Design, and Sustainability

Incorporating the three conceptual dimensions of the environment as discussed above, one has the potential to maximize user participation and satisfaction, thereby affording assistive solutions to users. It is important to note that an assistive solution is the outcome of a user-driven process that aims to improve the user’s functioning, quality of life, and well-being in his/her contexts of use. Rather than focusing on AT alone, the assistive solution represents a holistic solution, considering the user needs, the environment(s) of use, and the AT.

The environment represents an important component of the assistive solution and can be evaluated along the dimensions of accessibility, universal design, and sustainability, described in Section 4.2. An evaluation of the environment along these dimensions must include the following criteria:

- An evaluation of the environment against applicable national/regional accessibility guidelines and design standards
- An evaluation of social, cultural, political, and economic components of the environment and their potential impact on AT use
- A user-driven evaluation of how different environments support/hinder the user’s participation in various life activities with and without the recommended AT
- A determination of possible universal design and sustainable strategies for adapting the environment for optimal and flexible AT usage over the long term

Under the auspices of these four criteria, we present and discuss an environmental assessment (EA) (Üstün et al., 1997) process that provides a method of systematically choosing AT that matches the user’s needs while considering the three dimensions of the environment: accessibility, universal design, and sustainability. As an ongoing component of the ATA process, the overall aim of this EA process is to help practitioners obtain the best possible match among the user, AT, and environment to arrive at an assistive solution that will optimize user participation and satisfaction in the context of use.

4.4 The Environmental Assessment Process: An Overview

As depicted in Figure 4.3, the EA process should ideally be conducted collaboratively between the AT user and a multidisciplinary evaluation team within a center for technical aid. Acknowledging that the environment is antecedent to the AT and crucial for determining the limits of AT use and functionality, the EA occurs at the beginning of the ATA process, particularly during the user data collection phase. When a user arrives at a center for technical aid seeking an assistive solution, the multidisciplinary team must initiate a systematic process in which they, together with the user, reflect on the environment(s) where the proposed AT will be used and evaluate each environment along the dimensions of accessibility, universal design, and sustainability.
When evaluating the environment for accessibility, the multidisciplinary team may ask questions around what accessibility guidelines and mandates are operant at the national and local levels that inform design and modification of buildings, facilities, and programs for people with disabilities. Examples of such guidelines and mandates include the AADAG in the United States and Build-for-All in Europe, as described previously in this chapter. The team may then discuss implications of these accessibility guidelines with the user during the EA process. For example, a multidisciplinary team may use knowledge of physical access laws when evaluating a workplace and seeking an assistive solution with a user who has physical access needs. On the basis of the results of their evaluation, they might need to collectively decide whether the workplace environment needs to be modified to support AT functioning, and consequently the user’s productivity, and the extent and costs of modifications required. A knowledge of local policies governing accessibility will also help to determine whether the AT and environmental modifications will be publicly or privately funded, a key factor in determining the feasibility of the proposed assistive solution.

Universal Design is the second dimension to consider when collecting data for the EA process to arrive at an assistive solution. Universal Design represents an aim for the built environment to be both aesthetically pleasing and usable to all (Mace et al., 1991). In order to evaluate the environment along this dimension, seven principles were originally identified by the Center for Universal Design (1997). Two new principles were added...
by Jon Sanford, one of the contributors to the original seven principles (Sanford, 2009). The resulting nine principles of universal design include the following:

1. Equitable use
2. Flexibility in use
3. Simple and intuitive use
4. Perceptible information
5. Tolerance for error
6. Low physical effort
7. Size and space for approach and use
8. Social integration (i.e., the design provides opportunities for individuals to participate in activities with others)
9. Contextual integration (i.e., specific design features are aesthetically, socially, and culturally compatible with the overall design)

To complement the above principles, Steinfeld and Maisel (2012) developed eight goals of universal design. These goals are intended to connect universal design guiding principles with community participation outcomes of users in alignment with the ICF. The eight goals of universal design are described below (Steinfeld and Maisel 2012):

1. Body fit—Accommodating a wide range of body sizes and abilities
2. Comfort—Keeping demands within desirable limits of body function
3. Awareness—Ensuring that critical information for use is easily perceived
4. Understanding—Making methods of operation and use intuitive, clear, and unambiguous
5. Wellness—Contributing to health promotion, avoidance of disease, and prevention of injury
6. Social integration—Treating all groups with dignity and respect
7. Personalization—Incorporating opportunities for choice and the expression of individual preferences
8. Cultural appropriateness—Respecting and reinforcing cultural values and the social and environmental context of any design project

The nine principles and eight goals of universal design can guide environmental evaluations by considering the needs of multiple users who may require assistive solutions to participate fully in a given space. This is particularly important when considering assistive solutions for communal settings such as schools, which involve multiple users in various capacities, such as students, parents, and administrators. In this example, multiple users of the school could collaborate with a multidisciplinary team of professionals to explore an assistive solution that would be usable to all patrons and visitors of the school. This assistive solution would reflect decisions made regarding AT, the environment, and the users while embedding choice for all people in the design (Knecht, 2004). For instance, classrooms would be designed so that multiple users with a broad spectrum of functional abilities would benefit from assistive solutions that support full participation for all: AT would support various learning styles; desks and tables would be adaptable to satisfy the
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physical and sensory needs of all students, teachers, and parents; and auditory systems would support communication for all participants in the classroom. Incorporating universal design philosophy into the EA process offers more inclusive assistive solutions. The universal design philosophy also offers a pragmatic method to evaluate environments that most people use in their daily lives but ones that are seldom considered when making AT decisions, such as train stations, airports, schools, museums, and places of worship.

In addition to considering accessibility and universal design to support assistive solutions, it is important for the user and multidisciplinary team to evaluate sustainability within the physical, social, economical, ecological, and temporal contexts during the EA process. In order to evaluate the environment for sustainability specific to environmental impact, some cities, townships, and private authorities have created their own standards. For example, in the United States, the Green Building Council has developed a green building certification system, entitled Leadership Energy and Environmental Design (LEED). This system offers a useful framework for evaluating and rating new and retrofitted construction in terms of energy efficiency and use of resources and materials that are locally available and easy to maintain. The LEED rating criteria allow projects to achieve a certified, silver, gold, or platinum rating that is based on the incorporation of sustainability components into design (U.S. Green Building Council, nd). Although LEED’s recognition extends internationally, other sustainability standards offer similar methods of rating “green” design, such as the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom, Greenstar in Australia, the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan (Parker, 2009), Green Mark in Singapore, and the Green Building Index (GBI) in Malaysia (Yiing et al., 2013).

We propose that standards of accessibility, universal design, and sustainability be applied to both the environment and AT when considering an assistive solution. For example, information may be collected from a user who experiences mobility impairment while at home. During this data collection process, the user and multidisciplinary team can discuss both current and future needs to arrive at an assistive solution incorporating both the AT and the environment into a single “sustainable” solution. In this case, the user may be prescribed a wheeled mobility device made of recycled materials and a ramp constructed of locally grown resources. Additional recommendations may be made to install nonskid flooring that is easy to clean and maintain with nonchemical-based solutions to further minimize any negative environmental impact of the assistive solution.

Considerations of sustainability during the EA process must focus not only on solutions that are ecologically sound and environmental friendly but also on choosing solutions that will meet the user’s changing needs over a period of time, ideally a life span. For example, consider the evolving needs of a student with gradually deteriorating vision who is transitioning to college. While thinking about changing needs of this student over the life span, a multidisciplinary team seeking an assistive solution would need to evaluate what would be a better AT for this student: a computer with built-in screen magnification or a computer installed with screen reading software. The final solution would depend on the rate of vision decline and the extent to which alternative learning formats are supported in the college environment.

A potential framework for guiding this “life-span” understanding of sustainability is the evaluation guide for livable communities developed by the American Association of Retired Persons AARP Public Policy Institute in the United States (2005). This framework can be used for broadly evaluating the environment and its dynamic interaction with life-span functional changes. Although it was created for aging populations living in urban and suburban United States and would need to be adapted for other age groups
and cultures, it may be a useful resource for determining common environments of use and evaluating these environments to satisfy the needs of users throughout the life span.

The above examples identify frameworks, guidelines, and rating systems that address each of the three dimensions of accessibility, universal design, and sustainability individually. More recently, guiding frameworks and rating systems have been developed that address multiple dimensions simultaneously. For example, Sandler (2016) developed an accessibility and green design checklist with the Washington Court Housing Survey. The checklist can be used by multiple stakeholders, such as consumers, architects, and developers, to design sustainable, energy-efficient homes that are also accessible for people of all ages and abilities. Another example is the AWARE Manual for Sustainable Accessible Living, which provides building standards and contractor requirements for all residential projects awarded federal funds through the City of Columbus and Franklin County, Ohio. The manual incorporates elements of green design and universal design and is intended to encourage development of homes that are energy efficient and accessible across the life span (City of Columbus and Franklin County, 2013). Similarly, the Green Home Institute, a U.S.-based nonprofit organization, has developed a third party verified accessibility certification program called Zerostep. This program is incorporated within the organization’s Greenstart Homes Certification to help developers build homes that satisfy both accessibility and sustainability standards (Little, 2015).

Thus, there is a growing recognition that multiple dimensions of the environment need to be considered when designing spaces that are usable by diverse individuals while also conserving natural resources. However, existing frameworks and checklists do not offer much guidance on evaluating the environmental dimensions of accessibility, universal design, and sustainability in the context of AT solutions. To this end, we suggest a step-by-step decision-making process that can be used for evaluating both AT and the environments in which it may be utilized.

### 4.4.1 The EA Process: Step-by-Step Decision Making

The EA process offers a guide for the user and multidisciplinary team to effectively evaluate and determine the best assistive solution for the user’s needs. An evaluation of the environmental dimensions of accessibility, universal design, and sustainability, along with an assessment of the user’s needs and features of the proposed AT, occurs in step 1 of the EA process, as indicated in Figure 4.3. It is at this step that an ATA occurs, the user’s needs and desires are assessed, and the environment is evaluated for its impact to support or obstruct full participation for the user. In the EA process, the three dimensions of accessibility, universal design, and sustainability are explored for impediments and opportunities within the environment.

Upon completing the environmental evaluation in step 1, if there is a match between the environment, the user, and the AT (step 2), the assistive solution is achieved, the EA process ends, and the evaluation is discussed by the multidisciplinary team and user in the ATA process. If a match does not occur at this point in the EA process, possible modifications may be made to the environment (step 3) or the user and multidisciplinary team may reassess the interactions among the environment, user, and AT in a new matching process, thereby determining the impact of this process on the user (step 4). At this point, options to achieve the match are evaluated for the most effective and efficient assistive solution (step 5). This solution may involve modifying the environment to achieve maximal accessibility, universal design, and/or sustainability (step 6); changing the AT to match the user’s needs (step 8); or making changes to both the environmental dimensions and AT (step 7). This
step-by-step decision-making process might need to be repeated for each environment or context where the intended use of the AT would occur.

This decision-making process may be further supported by the matrix depicted in Figure 4.4. The matrix includes specific criteria for each dimension of accessibility (eight user participation goals), universal design (nine principles of universal design), and sustainability (three criteria pertaining to energy efficiency, life-span approach, and environmental impact). Different AT products and environmental modifications may be considered against the suggested criteria for each dimension.

An optimal AT solution would be the combination of AT and environmental modification that satisfies maximum number of criteria for each of the three dimensions of accessibility, universal design, and sustainability. Although each of these three dimensions is individually useful in evaluating the environment in the EA process, it is the intersection of accessibility, universal design, and sustainability that supports optimal design decisions to enhance the assistive solution for a user. It is in this intersection that AT supports the individual user to fully participate in life (accessibility), is seamlessly incorporated into the environment and useful to all users (universal design), and has a low environmental impact (sustainability).

The following section describes a case study in which an EA process informed by the dimensions of accessibility, universal design, and sustainability was applied in a real-life context to achieve the best assistive solution for multiple users.

4.4.2 Case Evaluation: Considering Accessibility, Universal Design, and Sustainability within the EA Process

To more fully understand the EA process and the role of accessibility, universal design, and sustainability, we share the following case study that resulted from a research project exploring the intersection of these three dimensions of the environment (Gossett et al., 2009). This project started in an effort to document and analyze the decisions that a cross-disability organization named Access Living of Metropolitan Chicago (Access Living) was making during the design of a new-construction building. Disabled advocates established Access Living in 1980 to advocate for disability rights, pride, and dignity for people with disabilities. An overall goal of Access Living in designing the new-construction building was to develop a space that was universally designed while maximizing accessibility and sustainability within the design. The dimensions of accessibility and universal design were
imperative in the project because most users of the future building included staff and consumers with a wide range of disabilities. Sustainability was also important for the project in order to pursue the goal of using “green design” to create environmentally responsible construction in accordance with architectural trends and standards in the city (Kibert, 2008). Specific details related to the research project are published elsewhere (Gossett et al., 2009). However, a case example of the decision-making processes involved in designing a conference room within the new building is described here. This case example offers a discussion of interrelated aspects of the environment, AT, and users’ needs within the EA process.

At the beginning of the design process, a multidisciplinary team of architects, disability advocates, and rehabilitation professionals collaboratively assessed the following: (1) users’ needs for an assistive solution, with users being defined as all staff and consumers of Access Living services; (2) aspects of access, universal design, and sustainability that may/may not be afforded by the environment; and (3) AT options that may contribute to specific needs of individuals using the environment.

Through this initial evaluation process, it was determined that the access needs of users of the conference room included the following:

- A large room enough to accommodate large numbers of people using various forms of AT, such as electronic communication devices, wheelchairs, and other mobility devices
- Ease of communication for people who are deaf/hard of hearing and options for recording and captioning meetings
- Lighting to satisfy multiple needs such as focused lighting for sign language interpreters, task lighting for people with low-vision, and nonglare lighting for people with light-sensitivity
- Electrical outlet options for powering various AT equipment such as real-time interpretation devices, power wheelchairs, and computers
- Objects within the environment (tables, chairs, etc.) that offered flexible use and ease of movement throughout the space.

In addition, needs related to sustainability included steps to

- Limit environmental impact of materials and construction procedures
- Identify energy-saving elements that need to be built into the design during construction, as opposed to incorporating these after construction
- Consider long-term needs of the user, including the changing needs of individual users of the space as well as changing needs of the organization, Access Living (this would offer sufficient flexibility to accommodate changes in staff members, organizational processes, and systems over time)

At the time of this project, the eighth and ninth principles of universal design had not been proposed. Therefore, the original seven principles of universal design (Center for Universal Design, 2008) were also used for guiding the environmental evaluation as follows:

- *Equitable use*: The design should satisfy the needs of all people who would use the space and all conference purposes, such as small and large group meetings, teleconferences, and presentations.
- *Flexibility in use*: Features of the room should be usable for various purposes.
Assessment of the Environments of AT Use

- **Simple, intuitive use**: AT and objects should be easy to use and accommodate a wide range of literacy and language needs.

- **Perceptible information**: Users should be able to effectively and efficiently understand the information shared, and activities conducted in the room and features of the room should support alternative forms of communication.

- **Tolerance for error**: Hazards should be limited and use of objects/technology in the room should be intuitive.

- **Low physical effort**: People and objects should be able to freely move around the space with minimal physical effort.

- **Size and space for approach and use**: Design of the room should include adequate space for all to easily enter, exit, and navigate the room.

This evaluation process allowed the multidisciplinary team to develop plans incorporating both environmental modifications and AT into the building’s design to work toward optimal assistive solutions for all users. Decisions made during this process were based on the intersection of the three dimensions of the environment: accessibility, universal design, and sustainability. AT was incorporated into the conference room design in methods that decreased costs, targeted long-term needs of the users, maximized accessibility for individual users, and was usable to the greatest extent possible for everyone. The conference room was designed to support and accommodate various types of AT, including video conferencing capability, electronic communication systems, variance of lighting options achieved through overhead lighting and task lighting, manual and power wheelchairs, other types of mobility aids, and augmentative and alternative communication devices. Multiple outlets were installed at wall and floor levels to allow for powering of these various devices.

Furniture included in the designed conference room consisted of chairs and tables made of recyclable materials with powder-coated paints and water-based adhesives. This furniture was also made using volatile organic compound (VOC)-free manufacturing processes. Use of VOC-free manufacturing processes reduces vapor pressures that negatively affect the environment and human health. In addition, the chairs offered flexibility in use, such as removable armrests and seats, which can be folded out of the way. Chairs and tables also offered wheeled capability and could therefore be moved around the room simply and intuitively with low physical effort.

The conference room was also designed in terms of equitable use so that it was sufficiently large to accommodate groups of people with various mobility devices and communication needs who may meet for various reasons. Communication was an important consideration in designing a conference room. The room was designed to abide by the acoustical standards prescribed by ADAAG, making use of microphone options to support communication needs and accommodation of large groups (U.S. Access Board, 2004) (Center for Universal Design, 2008). Light-harvesting options were also used for maximizing natural light in coordination with artificial light to minimize the energy costs and maximize applicability to various users.

The case example of the conference room described earlier demonstrates how considerations of accessibility, universal design, and sustainability within the environment can be combined with evaluation of users’ needs and knowledge of AT features to arrive at an appropriate assistive solution. This case example can be appraised by reflecting back on the intersection model (Figure 4.1) and the continuum model (Figure 4.2) introduced at the beginning of this chapter. All three dimensions (accessibility, universal design,
and sustainability) were considered during the EA process when designing the conference room. Each design decision informed by the EA process can be evaluated in terms of whether it fell within the ideal center depicted in Figure 4.1. If it did, then it could be said that an ideal assistive solution was achieved. If not, then we need to determine where the decision fell along the three bars of the continuum model depicted in Figure 4.2. To illustrate this point further, we describe two instances: one in which the design decision achieved the ideal center and one in which the decision initially fell outside of the ideal center, suggesting tradeoffs among the dimensions of accessibility, universal design, and sustainability. While appraising the case example in this manner, it is important to bear in mind that within this example, the term “user” refers to the collective of staff and consumers of Access Living.

Let us first consider the conference room seating furniture. When this furniture is rated separately on each bar of the continuum model, it consistently falls on the higher (left) end of each bar. As a universal design element, it rates well because of its ergonomic design that demands low physical effort, flexibility in terms of use as a result of adjustable height, and flexibility in terms of storage as a result of stackability. In terms of sustainability, it rates well because of its recyclability and low emission qualities, and because it is locally manufactured using VOC-free manufacturing processes. In terms of accessibility, it rates well because of the additional feature of adjustable armrests that allow for easy transfers from other surfaces such as wheelchairs. Therefore, considering all the three elements together, this furniture falls in the ideal center on the intersection model and represents an appropriate assistive solution for the various people expected to use the conference room.

A contrasting example is the communication system designed for the conference room. The original design of the communication system made use of microphone capability and an audio frequency induction loop. In terms of accessibility, this design decision rated well because it conformed to standards of communication access recommended for people who are deaf/hard of hearing under the ADAAG and adequately supported assistive technologies required by this group such as hearing aids. In terms of universal design, the communication system did not rate as well because it would be distracting and would pose challenges to people with cognitive disabilities, people attempting to negotiate parallel conversations, and people with hearing sensitivities. In terms of sustainability, the communication system required additional materials but was included in the original design, necessitating few postconstruction modifications. Thus, the original design of the communication system entailed gains in the accessibility continuum (particularly for deaf/hard of hearing users) through a tradeoff with gains in the universal design and sustainability continua. As a result, the communication system in the conference room would fall outside of the ideal center on the intersection model. In other words, the communication system, as originally designed, would offer an assistive solution for deaf and hard of hearing users but not for people with cognitive disabilities and hearing sensitivities.

In the end, Access Living decided against installing the audio frequency induction loop for multiple reasons. The system did not satisfy local fire safety regulations. Second, the organization’s internal research revealed that deaf and hard of hearing users could use portable devices such as personal amplifiers and wireless sound transmitters and receivers as alternatives. Thus, the final design decision for the conference room’s communication system was more favorable along the universal design continuum.

A final point to bear in mind about this case example is that it describes the EA process for an environment that was in its development stage. This situation offered
a perfect opportunity to modify the environment in a manner as to approximate the ideal center at the intersections of accessibility, universal design, and sustainability to support the participation of multiple users and their varied AT needs. However, such situations are rare, and in most cases AT users have to contend with preexisting and predesigned environments. Nonetheless, the EA process described in this chapter would be just as valuable when applied to such situations because it would guide decisions about modifying the environment(s) or the AT or both to optimize the assistive solution for the user.

4.5 Conclusions

In this chapter, we highlight the importance of assessing user environments in the ATA process along the three conceptual dimensions of accessibility, universal design, and sustainability. To this end, we present a model and decision matrix that can be useful in identifying the optimal assistive solution for users. This assistive solution is one in which the ideal center can be achieved by modifying the environment, changing the AT to match the user’s needs, or making changes to both the environment and AT. However, this process never occurs without considering the interaction between AT, the user, and the environment. Often, the goal of achieving the ideal center is elusive, and decisions are made that may incorporate one of the three concepts of the environment over the others. However, the final decision ultimately depends on the contingencies of the situation and the needs of the user.

4.6 Summary

This chapter discusses the role of the environment in inhibiting or supporting full societal participation of people with disabilities and provides a rationale and framework for incorporating the environment within the assistive technology assessment (ATA) process. In this chapter, the environment of AT use is viewed broadly as encompassing physical, social, cultural, legislative, and economic elements. Based on this broad definition, the first part of this chapter proposes a model for assessing the environment within the ATA process along the three intersecting dimensions of accessibility, universal design, and sustainability. By evaluating the environment along these three dimensions, one can strive to achieve the “ideal” design solution, which will enhance the match between the AT, the user, and his/her environment. The second part of this chapter offers a step-by-step decision-making process to guide the multidisciplinary team to effectively evaluate the environment as an ongoing component of the ATA process. Furthermore, within this ATA process, we offer a decision-making matrix to support the assessment of specific criteria of accessibility, universal design and sustainability. The overall objective of this environmental assessment process is to help practitioners arrive at an assistive solution that will optimize user participation and satisfaction in the context of use. This chapter concludes with a case study exemplifying the environmental assessment process in practice.
Acknowledgments

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References


Assessment of the Environments of AT Use


Measuring the Impact of Assistive Technology on Family Caregivers

Louise Demers and William Ben Mortenson

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5.1 Introduction
In general, it is understood that assistive technology (AT) has the potential to enhance the functioning of users. Moreover, in the process, it allows them to be less dependent on the assistance of others (Federici, Scherer, and Borsci, 2014; Federici, Tiberio and Scherer, 2014). For the vast preponderance of ATs, this secondary assumption is not buttressed by systematic evidence (Henderson, Skelton, and Rosenbaum, 2008; McWilliam, Diehl-Jones, Jutai and Tadrielli et al., 2000). To create an enhanced understanding of the impact of AT on caregivers, we require the following: (1) better empirical evidence; (2) an improved conceptual understanding of the inter-relationship of outcomes between assistance users and family caregivers, and (3) more developed and refined measurement tools.
To address these needs, this chapter has the following goals:

1. To provide an overview of current literature that explores the impact of AT on family caregivers (i.e., unpaid friends, family, and acquaintances) of children and adults.

2. To offer theoretical contributions that explicate the relationship between AT interventions and outcomes for assistance users and their family caregivers and describe an AT provision process that is inclusive of the assistance users and their family caregivers.

3. To describe two measures in this area and discuss plans for their future development.

By addressing these goals, this chapter will provide clinicians and researchers with an up-to-date understanding of progress in this area and suggestions about how to implement these developments into practice. We have provided two hypothetical vignettes to illustrate more vividly the content of this chapter.

The first vignette is about Charlie, an eight-year-old boy with Duchene muscular dystrophy. He lives in a two-story bungalow with his mother, Susan, his father, Harold, and his five-year-old sister, Lisa. He has difficulty in going up the stairs, walking outside the home, and has problems with fatigue. So, his parents carry him while going to places outside the home, because when he walks he becomes too tired to do activities. The parents have restricted Charlie’s and their own activities to reduce the need to carry him to places, but they both report intermittent back pain and ongoing muscle soreness. At school, he can participate in classroom activities, but has difficulties going to and participating in activities outside the classroom.

In the second vignette, Bob depicts a 75-year-old man with osteoarthritis in both knees. He lives with his wife Jean who is a 70-year-old woman who is relatively healthy. They live in a one-floor apartment with level entry. Bob is having increasing problems moving around because of knee pain and has had several falls when his left knee “gives out.” He is currently waiting for joint replacement surgery and uses a cane. Jean helps Bob get up from low surfaces, helps Bob donning and doffing his socks, and does most instrumental activities of daily living (IADL) tasks around the house, but does not drive. Bob will drive Jean to go shopping, but typically waits for her in the car or sits and has coffee while she shops. He is currently following an exercise program recommended by a physical therapist to try to reduce potential deconditioning. Jean has stopped social visits with her friends, so she can be available to help Bob and keep him safe around the home and reports that she feels tired all the time.

We will draw upon these vignettes to provide a human face to the conceptual and methodological material that follows.

This chapter begins with an overview of current research in this area, with a specific focus on the impact of AT on family caregivers. The next section introduces three conceptual models to help explicate the relationship between AT interventions and outcomes for family caregivers. The first model describes how the personal assistance strategy of individuals with disabilities, which may include AT, affects themselves and their family caregivers simultaneously. The second model illustrates how AT can moderate caregiver’s primary and secondary stressors in a manner that influences their participation, health, and quality of life. The third model portrays an AT intervention process that is inclusive of assistance users and their family caregivers. The penultimate section introduces two
tools that measure the impact of AT interventions on family caregivers of children and adults. In the final section, we illustrate the steps of our AT intervention process and the use of two measurement tools based on the vignettes of Charlie, Susan, Harold, and Bob and Jean.

5.2 Main Text
5.2.1 Overview of Current Literature

5.2.1.1 AT and Human Assistance

Assistive device use is common among children and adults with disabilities. According to the Participation and Activity Limitation Study (PALS), a population-based health survey, half of the Canadians with disabilities under the age of 15 years and nearly two-thirds of those 15 years or older used assistive devices (Statistics Canada, 2008). A survey of adult consumers of California-independent living centers found that device use increases with age (Kaye, Yeager, and Reed, 2008). Despite the use of these devices, unmet need appears to be a problem. According to PALS, one-quarter of Canadians with disabilities under the age of 15 had none of the AT they required, and 30% required additional equipment. Of those 15 years and older, 10% had none of the AT they required, and 29% required additional equipment (Statistics Canada, 2008). Agree, Freedman, Cornman, Wolf, and Marcotte (2005) found that 72% of older people with activities of daily living (ADL) limitations who used AT also relied on family care, whereas only 54% of non-AT users relied on family care. Similarly, 26% of AT users and 12% of nonusers relied on formal care. Further analysis indicated that AT use was substituted for personal care only for individuals who were unmarried, and those with more high school education. In contrast, individuals with cognitive impairments were less likely to substitute AT for informal or formal personal assistance.

Family caregiving is extremely common and may have detrimental consequences for the care provider. In the United States, 43.5 million family caregivers, such as Jean, Susan, and Harold assist individuals who are ill or disabled (NAC and AARP Public Policy Institute, 2015). Family caregivers of older adults are frequently either spouses or adult children (Department of Health and Human Services, 1998), whereas caregivers for children are typically their parents. Around 8 million Canadians provide care to family members who have a long-term disability, in which 28% of the population is aged 15 and older (Turcotte, 2012). As the number of older adults, aged 65 and older will double in Canada in the next 20 years (Statistics Canada, 2005), family caregivers will likely experience increased demands. In order to maintain the quality of life of those they help, caregivers may experience a great deal of stress that can lead to their physical or emotional burnout (Egbert, Dellmann-Jenkins, Smith, Coeling, and Johnson, 2008). In Canada, 34% of regular family caregivers (those providing more than 2 hours per week of care) report feeling depressed (Turcotte, 2012). In the United States, three out of five co-residing caregivers and more than nine out of ten caregivers who provided more than 21 hours of care each week reported having high burden levels (NAC and AARP Public Policy Institute, 2015). The potential for burnout poses a challenge to Western health-care systems, as family caregivers provide their unfunded assistance four times more frequently than formal caregivers (Agree, Freedman, and Sengupta, 2004). In the case of providing care for people with Alzheimer’s,
it has been estimated that, in 2011 alone, family caregivers provided a total of 19.2 million hours of unpaid care (Alzheimer’s Disease International, 2016). The replacement value of family caregivers’ unpaid contributions has been estimated to be $25 billion annually in Canada (Hollander, Liu, and Chappell, 2009) and $470 billion annually in the United States (Reinhard, Feinberg, Choula, and Houser, 2015). In the United States, this is more than triple the amount that Medicaid pays out for these long-term support services (Grossman and Magaña, 2016). This value excludes the loss of economic productivity associated with the time spent by providing care and emotional and physical burden. In Canada, more than one-quarter of employed family caregivers reported that they need reduction in their hours of work owing to their caregiving duties (Turcotte, 2012). In the United States, the cost of family caregiving to employers has been estimated to be $33.6 billion annually (Metlife Mature Market Institute, National Alliance for Caregiving, 2006). A meta-analysis found that caregivers have significantly higher stress and depression and significantly lower subjective well-being, self-efficacy, and physical health than non-caregivers (Pinquart and Sörensen, 2003).

A principal reason for providing AT is that it reduces dependency on human assistance and decreases caregiver burden. However, despite the use of AT, activities and social participation are likely to remain restricted to some extent, particularly for persons with moderate and severe levels of impairments (Fuhrer et al., 2006). There are three main patterns of assistance: (1) the use of AT alone, (2) AT combined with human assistance, and (3) human assistance alone. Harold and Lisa use the third pattern of assistance with Charlie as they carry him to places rather than using AT. Bob uses the first pattern of assistance when ambulating with his cane. Bob and Jean use the second pattern of assistance for shopping, as Bob uses his cane to get to the car so he can drive his wife to the store, but does not buy things himself. Indeed, considerable data exist indicating that both AT and human assistance are used by users to enhance their participation (Agree et al., 2005; Allen, Foster, and Berg, 2001; Østensjø, Carlberg, and Vøllestad, 2005; Taylor and Hoenig, 2004).

5.2.1.2 Caregivers of Assistance Users

To appreciate the impact of AT on participation, one must understand how provision of AT may affect the human help that is provided. Recognition of the essential role of caregivers in preserving or enabling participation of assistance users began with the emergence of family-centered care in pediatrics (Dunst, Trivette, Davis, and Cornwell, 1988) and continued with broadening of term client to include family members in definitions of client-centered practice (Townsend et al., 1997). Some scholars have recommended a shift from a patient-focused approach to a patient-and-caregiver approach in the field of AT (Demers, Ska, Desrosiers, Alix, and Wolfson, 2004; Gooberman-Hill and Ebrahim, 2006; Pettersson et al., 2005). Unfortunately, in current clinical practice, the inclusion of caregivers in the AT provision process is rather hit or miss and scant attention has been paid to the effect of AT on assistance users’ human helpers, particularly family caregivers (Henderson et al., 2008; McWilliam et al., 2000). Two systematic reviews that have explored the impact of AT on users’ informal caregivers were published (Marasinghe, 2016; Mortenson et al., 2012). Although the level of evidence of included studies was low, these reviews found that AT provision was generally associated with the reduced hours of care and perceived burden; however, in some cases, AT altered or at times added to caregiver burden.

Some qualitative research has explored the impact of assistive device use on caregivers. Among caregivers of individuals with stroke (Pettersson et al., 2005; Rudman, Hebert, and Reid, 2006), studies have indicated that caregivers had ambivalent feelings about assistive
devices. Although most participants were grateful for the benefits that these devices provided, their use was sometimes accompanied by anxiety about the possibility of injury, accessibility issues, and the social stigma experienced by some individuals who use AT in the community. In contrast, qualitative studies with children and parents have found manual (Glumac, Pennington, Sweeney, and Leavitt, 2009) and power wheelchairs (Wiart, Darrah, Hollis, Cook, and May, 2004) to be generally beneficial.

Cross-sectional studies based on national survey data have examined the relationship between AT use and family caregiving. Data from some of these studies suggest that the use of AT helps caregivers by substituting for some of the physical and emotional effort entailed in supporting an individual with disabilities (Agree et al., 2005; Agree et al., 2004; Agree and Freedman, 2000; Allen et al., 2001; Allen, Resnik and Roy, 2006). Although these studies suggest that AT has a positive impact on family caregivers, there are two principal limitations. The studies rely on cross-sectional data, which limits the development of causal explanations. Furthermore, the impact of AT use on caregivers is inferred from responses to considerably few queries, principally dealing with the number of hours of assistance provided. This excludes the measurement of other important outcomes, such as reduced physical demands on helpers, diminished psychological stress, and satisfaction in providing help. The neglect of such potential outcomes results in an incomplete portrayal of the benefits of AT for caregivers.

Other cross-sectional studies have explored AT use and family caregiver assistance. Chen, Mann, Tomita, and Nochajski (1999) examined how physically impaired assistance users \((n = 20)\) involved caregivers in accessing or using their assistive devices, and how assistance users and caregivers perceived the value of AT. Their results indicated that AT might reduce the dependence of assistance users on human assistance and some of the perceived burden on family members and friends. In a descriptive study, Messecar, Archbold, Stewart, and Kirschling (2002) identified 47 home modification strategies including the use of assistive devices, providing assistance, and making changes to the home environment that were used by caregivers of community dwelling elders with a variety of impairments. Kane, Mann, Tomita, and Nochajski (2001) interviewed 30 caregivers about their perceptions of device use. The caregivers indicated that devices were generally beneficial for assistance users but were not always covered by insurance. Among a subsample of individuals with spinal cord injury that had a decline in physical function over the last five years, half required additional assistance with activities of daily living (Thompson 1999). Among these individuals, family members were the primary form of assistance; however, the use of AT increased over time (Thompson, 1999). The internal validity of the above studies is constrained by their use of descriptive rather than experimental designs and by their small sample sizes. Furthermore, in several of these studies, the relationship among the assistance user, assistive device usage, and the caregiver was not explicitly examined.

Intervention studies have demonstrated positive results for caregivers. Two uncontrolled intervention studies have suggested that AT interventions can be beneficial to caregivers. Using a single subject research design, Rigby, Denise, Schoger, and Ryan et al. (2001) found that provision of a rigid pelvic stabilizing bar for children with cerebral palsy reduced caregiver assistance with some repositioning during the day. Ryan and colleagues found that provision of two special-purpose, seating devices was associated with significant improvements for children and their parents; whereas, removal of the devices was associated with a return to baseline scores (Ryan et al., 2009). A recent, randomized controlled trial found that family caregivers reported significantly decreased burden with the dyad-identified activities following the provision of AT (Mortenson et al., 2012).
Generally, there are three main limitations with research in this area. First, cross-sectional research designs do not enable causation to be established. Second, the impact of AT is often measured in terms of hours of care, which is a considerably crude metric. For example, if a caregiver reallocates time saved through the use of AT to other, perhaps more enjoyable caregiving tasks, this change would go unmeasured. Third, outcomes reported in the current literature often provide insufficient detail to capture all the benefits of providing AT interventions. More studies, such as those by Ryan et al. (2009) are required to develop a complete understanding of the impact of AT interventions on family caregivers.

5.2.2 Conceptual Frameworks on the Impact of AT on Caregivers and Users

In this section, we introduce three conceptual models to help understand the relationship between AT interventions and outcomes for family caregivers. In the first model, we describe how an assistance user’s personal assistance strategy that frequently includes the use of AT impacts themselves and their family caregivers. In the second model, we demonstrate how AT can alter caregivers’ stressors so that their participation, health, and quality of life can be facilitated. In the third model, we describe a family caregiver inclusive AT intervention process.

5.2.2.1 Conceptual Framework 1

Based on research and clinical work in this area, we developed conceptual framework 1 to examine the impact of an AT intervention on the assistance user–caregiver dyad (Demers, Fuhrer, Jutai, Lenker, and Deruyter, 2007; Figure 5.1). The framework starts with a mobility related AT intervention, which alters the personal adaptive strategy (assistance solution in the Matching Person and Technology model; Scherer, 1998; see Chapter 3). An assistance user’s adaptive strategy consists of two possible components: (1) AT, which includes assistive devices and special equipment, and the services rendered to provide them, and/or (2) the assistance of others, composed of informal support from family caregivers and/or formal support. This framework has parallels with the Matching Person and Technology model, in that it acknowledges that selection of assistive devices is facilitated by using context-specific clinical measures, functional analysis, and psycho-socio-environmental evaluations (see Chapters 3). This framework extends the Matching Person and Technology model by indicating how the presence of a caregiver creates the potential for a variety of assistive strategies to reduce activity limitations and participation restrictions, which may include caregiver assistance, use of assistive devices or a combination of the two. The conceptual framework highlights the concomitant effects of an AT intervention on the person with a disability and on his or her caregiver. Caregivers like Jean, Susan, and Harold may have few, if any, opportunities to modify their role unless a novel AT or a novel method of using available AT is actually adopted by the assistance user. The framework indicates how an inclusive assistance strategy can also be beneficial for the user’s family caregivers. Accordingly, AT use is a vital determinant of benefits such as enhanced activity, participation, psychological functioning, device satisfaction, and well-being of the user and his or her caregiver.

With conceptual framework 1, AT intervention alters the personal adaptive strategy particularly the manner and extent of concerted human help with activity, and, in some instances, entirely eliminates the need for that assistance. The altered helper-related activities encompass (1) the physical and psychological components that are identified in
the literature on caregivers (Demers et al., 2009; Hoenig, Taylor, and Sloan, 2003), and (2) the interaction between AT and personal assistance (Agree et al., 2005; Allen, Foster, and Berg, 2001; Chen et al., 1999; Hoenig et al., 2003; Verbrugge and Sevak, 2002). The physical component includes perceived physical difficulty, frequency of help, and number of hours of help. The psychological component of the altered helper-related activities includes participative necessity, satisfaction in providing help, and emotional difficulty.

This framework resonates with the assistive technology assessment (ATA) process model (Federici et al., 2014a,b; see Section I) in which it identifies the caregiver as a critical component of the environmental milieu, but also emphasizes how an assistance solution that carefully considers the user’s environmental context can also influence that context, particularly in terms of its impact on user’s family caregivers.
5.2.2.2 Conceptual Framework 2

Demers et al. (2009) developed conceptual framework 2 for better understanding the impact of AT on the AT user’s caregiver. According to this framework (Figure 5.2), the primary and secondary stressors of a caregiver have a direct influence on the caregiver’s outcomes, which include quality of life, physical and psychological health, and social participation. Primary stressors are directly related to the caregiving provided (e.g., types of assistance, number of tasks, time required, safety, and physical effort). Secondary stressors are related to the long-term impact of primary stressors on the caregiver and include role overload, decreased free time, and home modifications required to accommodate an assistance user. Several factors help mediate the relationship between stressors and caregiver outcomes. These include personal resources, coping strategies, and self-efficacy. Other factors can moderate the relationship between stressors and caregiver outcomes by altering the method in which care is provided. AT is one moderating factor that, depending on the device type, and amount and manner of use, can decrease the areas of assistance provided, decrease time required, reduce caregiver physical effort, and improve safety. Background and contextual factors also moderate caregiving outcomes. Improvements in social support, environmental accessibility, living arrangement, and quality of relationship can decrease primary stressors, by reducing caregiving or perceived stressors that can facilitate positive caregiver outcomes.

![Figure 5.2](image_url)

**FIGURE 5.2**
In applying conceptual framework 2 to the first vignette, it is evident that carrying Charlie is a primary stressor for Susan and Harold that involves intense physical effort and associated safety issues. The need to carry Charlie results in secondary stressors as this decreases the amount of time they have for other activities. In terms of outcomes, despite their existing personal resources and coping strategies, and a supportive social environment, the stress of caregiving has reduced Harold and Susan's social participation, physical health, and quality of life. As Charlie will continue to grow larger and less physically able, these outcomes are unlikely to improve unless moderating or mediating factors can be altered.

In the second vignette, Jean experiences multiple primary stressors given all of her caregiving tasks. These likely contribute to secondary outcomes that include role overload, and decreased free time. Despite the moderating influences of background and contextual factors and Bob’s use of a cane, Jean experiences decreased social participation and reduced physical and psychological health. Until Bob recovers from his surgery, which will not be for several months, it is probable that Jean’s outcomes will continue to decline unless moderating or mediating factors are changed in some manner.

5.2.2.3 Conceptual Framework 3

Given the inter-related outcomes of assistance users and their family caregivers, it seems logical that family caregivers should be included as key players in the AT prescription process. Rather than involving family caregivers in an *ad hoc* manner, based on our work in the area, we recommend working with assistance users and their family caregivers using a five-step process (described in Table 5.1). Conceptual framework 3 was developed as part of an experimental study to ensure that the intervention was safe, feasible, and relevant to the targeted individuals (Demers et al., 2016a,b). To develop this model, we used an iterative process that involved delineating the intervention in consultation with clinicians, assistance users and caregivers, and preliminary testing of the intervention with two dyads. This approach is congruent with the ATA process (Federici et al., 2015), but explicitly acknowledged the role of the family caregiver in this process and is not

TABLE 5.1

<table>
<thead>
<tr>
<th>Step</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification and assessment of the</td>
<td>Agree on the choice of problematic activities, and the aspects of those activities that make them problematic. Perform baseline measurements and assessments</td>
</tr>
<tr>
<td>problematic activities with involvement</td>
<td></td>
</tr>
<tr>
<td>of the caregiver</td>
<td></td>
</tr>
<tr>
<td>Identification of possible strategies</td>
<td>For caregivers and users to make a joint decision to adopt a strategy linked to the ATs, they need to be sensitive to the advantages and disadvantages and take into account: their beliefs and values towards technology; possible impacts on the physical and social environment; skills required and their actual skills</td>
</tr>
<tr>
<td>Choice of most appropriate ATs solution</td>
<td>Decide on strategies related to ATs</td>
</tr>
<tr>
<td>Training</td>
<td>For caregivers and users to become competent in using the strategies related to ATs with targeted activity</td>
</tr>
<tr>
<td>Evaluation of the AT solution</td>
<td>To help caregiver’s and user’s motivation to continue using the strategies related to ATs</td>
</tr>
</tbody>
</table>
necessarily based on a center for technical aid. According to this model, the process begins with identification and assessment of problematic activities that have been selected cooperatively by the assistance user and his or her family caregiver(s). After the identification of potential strategies, the best potential strategy is identified for trial implementation by the user/caregiver dyad. Following AT provision and training, desired outcomes are reassessed. The process will continue until an appropriate solution is found or all options have been exhausted.

Although the steps in this model are linear, the advent of novel problematic activities or environmental changes may require alternation of the process midstream. Furthermore, based on the evaluation of the AT solution, earlier steps may be revisited. Sometimes novel devices may be trialed; however, other times, novel strategies may be examined or alternative problem activities may be identified. Moreover, with the existence of multiple problematic activities, each step may occur at different times. The steps of this process will be illustrated with the vignettes after the introduction of relevant measurement tools in Section 5.2.3.

5.2.3 Measurement Tools Addressing AT Impacts on Family Caregivers

Currently, there are two tools that measure the impact of an AT intervention on family caregivers: (1) the Caregiver Assistive Technology Outcome Measure (CATCOM) for caregivers of adults, and (2) the Family Impact of Assistive Technology Scale (FIATS) for children and their parents.

5.2.3.1 Caregiver Assistive Technology Outcome Measure

The CATOM is an 18-item outcome measure with a structured interview format. It was constructed based on a conceptual framework of outcomes for caregivers of assistance users (Demers et al., 2009). The CATOM measures the caregiver’s perception of the impacts of AT in his or her life. It may also be used for assessing the change between assessment and reassessment after an AT-related intervention. The measure is used for recording the activities that caregivers provide assistance and for identifying the most demanding one. The measure has three parts (Table 5.2). The first part identifies and enumerates all of the care recipient’s activities for which the caregiver provides assistance and the forms of assistance given, the second part (13 items) measures the caregiver’s frequency (5 = never to 1 = almost always) of elements of burden associated with a dyad-identified activity, and the third part (4 items) captures the caregiver’s perceived burden of all of the assistance they provide and overall quality of life. The second part can be administered for each activity that is selected for intervention. In a preliminary evaluation of the CATOM, the reliability, standard error of measurement (SEM), and minimally detectable change (MDC) were calculated. The resulting interclass correlational coefficients for parts 2 and 3 of the CATOM were 0.89 (95% CI 0.64–0.96) and 0.86 (95% CI 0.60–0.95), respectively; the SEM and MDC for part 2 were 3.02 and 8.35, respectively, and for part 3 were 1.35 and 3.73, respectively (Mortenson et al., 2015a,b). The 13 domains that are measured with the CATOM are presented in Table 5.1.

Since the first edition of this text, two additional versions of the CATOM have been developed. The multiple-problem CATOM (MP-CATOM) is an adapted version of the initial CATOM that is described above. The main difference between the two measures is that the MP-CATOM allows for tracking of the effects of multiple problematic activities as opposed to a single problematic activity (Demers et al., 2016a,b). The second part of the
MP-CATOM (items 1–14) is concerned with classifying the specific activities that caregivers provide support for as well as measuring the frequency of caregiving and the perceived burden associated with the identified problematic activities and has a Cronbach’s alpha of 0.861. The third part of the MP-CATOM (items 15–18) measures overall burden and has a Cronbach’s alpha of 0.812.

The power wheelchair CATOM (PW-CATOM) was developed for capturing the specific burden related to provision of power wheelchair assistance. The PW-CATOM is an 18-item measure. In the second part (items 1–14), caregivers rate the burden they experience in regard to six different aspects of power wheelchair specific activities: transfers to and from the wheelchair, wheelchair maintenance, propelling a wheelchair inside, transporting wheelchair (up/down stairs/into/out of vehicle), getting around outside with wheelchair, and operating special wheelchair features (tilt in space, elevating leg rest, recline). Part three (items 15–18), similar to the other versions of the CATOM, addresses the overall perceived burden that caregivers experience. Excellent test–retest reliability was reported for the PW-CATOM as well as excellent internal consistency (Mortenson et al., 2017).

5.2.3.2 Family Impact of Assistive Technology Scale

The FIATS is a 55-item tool that measures parent’s perceptions of the impact of assistive device use on children and on themselves (Ryan et al., 2006). The FIATS covers eight domains (\( n = \text{items per domain} \)): child autonomy (5), caregiver relief (9), child contentment (9), doing activities (child has control over own actions) (5), parent effort (8), family and social interaction (child interacts with others) (4), caregiver supervision (7), and parent’s concerns about safety (8). Parents indicate their degree of agreement or disagreement with each item using a seven-point rating scale, where lower scores indicate better outcomes. The scale was developed with the researchers in consultation with five clinical content experts, and seven parents reviewed the preliminary items to establish content and face
validity (Ryan et al., 2006). The internal consistency of each domain ranges from 0.64 to 0.92 with an overall Cronbach's $\alpha$ of 0.94 (Ryan, Campbell, and Rigby, 2007). The interclass correlational coefficient (ICC) for each domain range from 0.77 to 0.92 and the overall ICC is 0.92 (95% CI 0.86–0.95) (Ryan et al., 2007). Examples of three supervision questions include “I have little time to get chores done around the house;” “I’d like my child to be as independent as possible;” and “It is easier to play with my child when someone is holding him/her.” An example of a family/social interaction question is as follows, “My child socializes with others at mealtime.”

The original FIATS was adapted and evaluated for responsiveness with regard to augmentative and alternative communication (ACC) systems (FIATS-ACC). The FIATS-ACC required the addition of communication-focused subscales. The measure is an 89-item tool that covers thirteen domains; the seven child-related domains are as follows: behavior, communication, contentment, doing activities, education, self-reliance, and social versatility; the six parent- and family-related domains are as follows: caregiver relief, energy, family roles, finances, security, and supervision (Delarosa et al., 2012). The scoring system of the FIATS-ACC is consistent with that of the original FIATS in which parents rate their agreement on seven-point rating scales, where lower scores indicate better outcomes. An initial evaluation of the FIATS-ACC found that it had acceptable internal consistency and test–retest reliability (Delarosa et al., 2012).

### 5.2.3.3 Examples of Outcome Measurement with Vignettes Based on the Process for Identifying Appropriate Assistance Strategies and AT Provision Updating and Training for Assistance Users and Their Family Caregivers

#### 5.2.3.3.1 Vignette 1

**Step 1**: In concert with the clinician, Charlie and his family decided to improve Charlie’s independent mobility.

Table 5.3 provides baseline assessment data using the FIATS regarding their current strategy. For the sake of brevity, description of specific assessments of his physical and cognitive, perceptual status, and postural control are omitted here. As can be noted at the baseline in Table 5.3, Susan and Harold are quite concerned about Charlie’s autonomy and his performance of activities and about their effort (involved in carrying him places) and limited caregiver relief. Family/social interactions and supervision are less of a concern.

<table>
<thead>
<tr>
<th>FIATS Domain</th>
<th>Baseline</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomy</td>
<td>Score</td>
<td>Mean</td>
<td>Score</td>
<td>Mean</td>
<td>Score</td>
<td>Mean</td>
<td>Score</td>
<td>Mean</td>
<td>Score</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>5.6</td>
<td>21</td>
<td>4.2</td>
<td>14</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiver relief</td>
<td></td>
<td></td>
<td>48</td>
<td>5.3</td>
<td>48</td>
<td>5.3</td>
<td>32</td>
<td>3.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contentment</td>
<td></td>
<td></td>
<td>40</td>
<td>4.4</td>
<td>38</td>
<td>4.2</td>
<td>26</td>
<td>2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doing activities</td>
<td></td>
<td></td>
<td>26</td>
<td>5.2</td>
<td>27</td>
<td>5.4</td>
<td>14</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort</td>
<td></td>
<td></td>
<td>46</td>
<td>5.8</td>
<td>42</td>
<td>5.3</td>
<td>20</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family/social interaction</td>
<td></td>
<td></td>
<td>12</td>
<td>3.0</td>
<td>13</td>
<td>3.3</td>
<td>10</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td>30</td>
<td>3.8</td>
<td>40</td>
<td>5.0</td>
<td>24</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervision</td>
<td></td>
<td></td>
<td>22</td>
<td>3.1</td>
<td>30</td>
<td>4.3</td>
<td>22</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (Total range 55–385) Mean range =8–56</td>
<td>252</td>
<td>36.2</td>
<td>259</td>
<td>36.9</td>
<td>162</td>
<td>23.2</td>
<td>14</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Step 2: Their current strategy of moving Charlie is becoming untenable for Susan and Harold, because as Charlie grows, his parents are finding it increasingly difficult to carry him to long distance. Although Charlie can still walk, if he walks far he becomes considerably fatigued so this option is no longer realistic. The parents have resisted using AT, because of the stigma associated with its use, perceived accessibility issues, and some denial about his diagnosis; however, at this point, they feel that the benefits would outweigh the disadvantages.

Step 3: There are a variety of options to choose including the use of a walker, a manual wheelchair, or power mobility. Given the progressive nature of Charlie’s condition and growing concerns about his lack of independence, Charlie and his parents decided that they would like to trial power mobility for community mobility.

Steps 4 and 5: Following a two-week trial of an appropriately fitted power wheelchair, the parents are somewhat ambivalent about the impact of the device. They are storing the power chair in the garage, and Charlie is able to access it independently, but with difficulty given the stairs, he needs to use. They like how the chair gives Charlie more autonomy, but are more worried about his safety as he has had several minor accidents in the chair and they feel they need to supervise when driving the chair as a result. Earlier, they used to drive Charlie to school, but since they do not have a lift for their car, they have been accompanying him to school in the power wheelchair, but this takes additional time from their day as it takes over 15 minutes and they are not sure how they will deal with inclement weather. Charlie can get into the school and into his classroom, but not the washroom. He has hit the walls and doorframes several times with the footrests of his chair. School staff is worried about the potential for property damage, injury to other students, and issues of what could happen with the wheelchair when Charlie enters the bathroom and leaves it in the hallway.

Steps 4 and 5 repeated: Difficulties identified in step 5 at two weeks suggest that additional training is required; therefore, steps 4 and 5 are repeated. With two additional weeks of training and reprogramming of the chair, with special modes to facilitate indoor and outdoor mobility, Charlie has become much safer driving the wheelchair and the family has purchased a wheelchair lift so that they can take the chair to school using the car. Charlie has been driving around his home independently, and taking part in more activities as a result. Charlie is driving better at school, and teachers have educated other students about the need to leave Charlie’s chair alone when it is in the hallway. These changes increase the parent’s perceptions of Charlie’s autonomy, decrease their safety concerns, reduce their effort, and facilitate caregiver relief as noted below.

Revisiting Step 1 in the future: Given the progressive nature of the Charlie’s diagnosis, over time other changes will be required to enable facilitate his ongoing mobility. This will likely include a lift in the home, or moving to a level entry home. The school will need to modify the bathroom to allow Charlie to access it with his power chair. Alternative power wheelchair control switches and environmental control systems might be necessary.

5.2.3.3.2 Vignette 2

Step 1: Based on the process outlined above in conjunction with their clinician, Bob and Jean have decided to make it safer and less painful for him to (1) get around and (2) perform bathroom transfers. They observed if (3) he could become more independent on dressing and putting on his shoes and socks. As described in previous chapters, various assessments of the user can be used to help determine the most appropriate AT interventions and evaluate the outcomes for Bob, but will not be described in this chapter.
In looking at the impact on Jean, the baseline assessment using the MP-CATOM provides the following results regarding the current assistance strategy for their three main issues (presented in Table 5.4). At the baseline, Jean generally has more frequent concerns with the caregiving she provides.

**Step 2:** Following the baseline assessment, various strategies for his issues are considered for his mobility and bathroom transfers. Although Bob is independent for ambulation with a cane, his falls are grave concern for Jean and helping him from the floor is a taxing physical burden, particularly because he is taller and heavier than Jean. Therefore, providing physical assistance to Bob, particularly when he falls is not sustainable for a long term. They would like to find a strategy that prevents him from falling. For his dressing of his lower extremities, Jean is their current strategy of choice, but they explored methods to see if he can become independent with this activity again.

**Step 3:** To facilitate mobility, several AT strategies are considered; however, balance problems and instability of his right knee necessitate the use of a standard walker for ambulation. To facilitate bathroom transfers, they decided to have a higher toilet seat so that it is easier for Bob to sit down. To make this transfer easier, they tried some toilet armrests so that Bob can use his arms to help him raise and lower himself. For the bathtub, a variety of options are considered. Although it would be possible to have a bath chair in the tub, they are worried that he might fall getting over the side of the tub. Instead, they used a tub transfer bench that extends outside the tub with a tub grab to facilitate bathroom transfers. In terms of dressing options, they decided to trial a flexible sock aide to facilitate donning socks and a long handled shoehorn and reacher are trialed to facilitate donning and doffing shoes and socks.

**Step 4:** The clinicians bring the devices for trial and, over the next two weeks, practices using them with Bob and Jean.

**Step 5:** Although Bob is able to put his socks and shoes on with difficulty with assistive devices, he and Jean decided that it is easier for Jean to put on his socks and shoes because as Jean indicates, “it is much faster and not that much of bother.” He decides to keep the reacher as it enables him to take his shoes off by himself and pick things up off the floor. At this point, scores on the MP-CATOM indicate that Jean experiences less burden; however, she is experiencing more burden related to the three main issues. This is potentially due to her continued worry that Bob may fall when ambulating his walker.

Four months later (three days after discharge from the hospital), the **Assistance Users/ Caregiver Dyad AT Process Model** was applied again.

**Step 1:** Mobility and bathroom transfers remained important issues for him after discharge from the hospital.

<table>
<thead>
<tr>
<th>MP-CATOM Construct (range)</th>
<th>Baseline</th>
<th>Two Weeks</th>
<th>Four Months</th>
<th>Six Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Mean</td>
<td>Score</td>
<td>Mean</td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP-CATOM Part 2: Burden</td>
<td>49</td>
<td>3.5</td>
<td>52</td>
<td>4.0</td>
</tr>
<tr>
<td>to Three Main Issues</td>
<td>(14–70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>15</td>
<td>3.8</td>
<td>14</td>
<td>3.5</td>
</tr>
<tr>
<td>MP-CATOM Part 3: Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caregiving Burden (4–20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Step 2: The same potential strategies existed.

Step 3: No novel additional equipment was required to be considered, and he used all of his equipment after being discharged.

Step 4: Additional training was required to ensure that he could use all of the equipment following his surgery.

Step 5: Jean’s re-evaluation with the MP-CATOM indicates that her burden for the selected issues has increased compared to her two-week scores, but have not returned to base-line levels. Her overall burden is worse than baseline as Bob felt pretty sick after his surgery and she had to perform many additional caregiving duties.

Step 5 repeated two months after surgery: Bob is walking much better, however, so has now returned to using only a cane. As he cannot flex his knee to more than 90 degrees, he continues to use the bath bench and the raised toilet seat. Particularly, now he is waiting for his right knee to be replaced. Jean is still a little worried about his safety given his problems with his other knee. She provides less physical assistance, although she still helps with his shoes and socks. Her overall caregiving burden has decreased substantially. In this regard, the surgery and assistive devices have reduced her caregiving burden.

The Assistance Users/Caregiver Dyad AT Process Model will likely need to be reapplied in the future. Depending on how Bob recovers from his next knee replacement, Jean may experience increased caregiving demands that might be addressed via assistive devices or perhaps require the involvement of formal caregivers. At some point, Jean might experience a health-related issue. Therefore, it is possible that their roles might be reversed and Bob might become a care provider for Jean in some manner.

5.2.4 Future Directions

Considerable investigation should be performed for better understanding the impact of AT on family caregivers. Conceptual models should be proposed to help understand how AT use impacts the lives of family caregivers and controlled experimental research, like a study currently in progress by the authors, is required to provide causal evidence of their effectiveness (Mortenson et al., 2009). Tools such as the FIATS and CATOM are promising; however, additional research is required for further validating and refining them. Mixed method designs may be required to simultaneously evaluate the effectiveness of AT interventions quantitatively and to understand the active ingredients, social processes, and contextual factors that influence the outcomes of these interventions on family caregivers qualitatively. Additional investigation is required to conceptualize and evaluate how AT simultaneously influences informal and formal caregiver outcomes, and econometric studies are necessary to examine the cost effectiveness of AT interventions.

5.3 Conclusion

Research to understand the impact of AT on family caregivers is still in its infancy. It is commonly assumed that AT will provide a trickle-down effect that will reduce the burden
associated with informal caregiving. Currently, most research that has explored the relationship between AT use and family caregiver outcomes has used cross-sectional survey or qualitative data, which does not permit such a causal claim to be made. Some studies have indicated that some devices may reduce the hours of care provided, but devices that are more complex may have a less clear-cut influence on caregiver outcomes.

Based on the conceptual model we have developed and our clinical experiences, we suggest that for AT interventions to be successful long term they should consider carefully the influence and perspectives of family caregivers, because outcomes for assistance users and their caregivers are inter-related. Assistive solutions that may be beneficial for the assistance user in the short term, but negative for the family caregiver are not self-sustaining. Similarly, an assistance solution that has only a direct benefit on the caregiver by decreasing physical burden (e.g., using an electric rather than a mechanical lift) may create an indirect benefit for the assistance user as it makes the family caregiver less difficult and more available.

The FIATS and CATOM are two promising measures for capturing the impact of AT interventions on family caregivers; however, additional research is required to refine them and further test their psychometric properties. Given the stage of development of research in this area, mixed methods research studies may provide invaluable data about the impact of AT on family caregivers from a variety of perspectives. By developing a thorough understanding of the impact of AT on assistance users and their family caregivers, interventions that are more suitable can be offered and funding that is more appropriate can be sought.

5.4 Summary

In this chapter, we have provided an overview of research that has explored the impact of AT on family caregiver. We have offered family caregiver specific models that help explicate how AT may impact family caregivers and described two measures that are intended to capture this effect. We have proposed that the process of AT provision should explicitly acknowledge the role of the family caregiver. With two vignettes, this chapter provides examples of how these measures could be used for capturing the impact of AT on family caregivers. We have provided suggestions for future work in this area.

Acknowledgments

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Section II

Assessment Professionals

Working on the Multidisciplinary Team

Marcia J. Scherer and Stefano Federici

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II.1 Introduction

How disability is diagnosed and treated differs according to age at onset and type of disability. Developmental disabilities, which occur in infancy and childhood, are typically diagnosed after behavioral and maturational anomalies are observed and are then confirmed medically. Acquired disability can occur at any time in the life span, and treatment is often initiated in a hospital emergency room. Disability associated with a degenerative condition, typically associated with advanced age, is generally managed by primary care physicians, neurologists, gerontologists, and family members.
II.1.1 Treating Developmental Disabilities

Developmental disabilities such as Down Syndrome or cerebral palsy cannot be “cured”. However, interventions applied as early as possible can make a great deal of difference in current and future functioning. Orthopedic and neurological impairments can be surgically corrected or medically managed. Often, children with developmental disabilities undergo many treatments during their initial development with the goal of strengthening or extending the use of existing capabilities (Scherer, 2005). All disabilities can be greatly helped with advances in technology.

The goal today is to help children with developmental disabilities to participate in life by playing with other children, attending school and being a valued member of the family and community. This requires that the right blend of technologies, supports, and accommodations are provided in light of the student’s needs and strengths (Scherer, 2005). In-school interventions may include physical and occupational therapy, speech therapy, and the administration of medications that control seizures, relax muscle spasms, and alleviate pain. This may also include braces and other orthotic devices, communication aids such as computers with voice output, and a wide variety of additional products designed to minimize functional limitations and allow the achievement of academic goals and participation in the full academic curriculum and school activities.

Although students with developmental disabilities have educational and physical challenges, their potential is unlimited. The key is to identify abilities and strengths and strengthen them while managing limitations and match students with the opportunities and supports necessary to achieve lives of productivity and quality.

II.1.2 Treating Degenerative Disabilities

The situation is somewhat different at the other end of the life span for those individuals who have a degenerative cause of disability. Until recently, when an aging person was observed putting things in the wrong places and then forgetting where they put them, not performing personal care activities, and saying and doing inappropriate things, then that individual likely moved in with adult children or other relatives to be cared for and monitored. That still occurs today, but just as frequently the individual’s primary care physician may recommend the family to consider assisted living or a nursing home.

In some manner, we have situations the reverse of what they were traditionally. The families of infants and children with developmental disabilities now assume a major portion of caregiving because placing their child in an institution would be viewed by today’s society as acting irresponsibly. At the same time, options for caregivers of aging persons with dementia increasingly include placement in specialized facilities that, in spite of efforts to lower the staff–patient ratio and create an attractive and homey atmosphere, are institutions for all practical purposes.

II.1.3 Treating an Acquired Disability

Once the person is stabilized medically, they may receive medical rehabilitation designed to strengthen the remaining capabilities and compensate for those that have been lost. Psychosocial issues (financial, family, housing, or school/work) are viewed with the objective of returning the individual to prior roles and community participation (Scherer, 2012).

Rehabilitation centers can be embedded within a larger medical center or in a freestanding rehabilitation facility. Rehabilitation encompasses not only the therapy provided but
also everything else that occurs on the unit including nursing care, monitoring of behavior, nutritional assessment and planning, and non-pharmacological strategies and techniques employed to foster the optimal environment for recovery. As a result, the therapy for patients occurs 24 hours per day on the unit and provides the opportunity to carry over treatment, strategies, and training all day long and observe the recovery process more closely to adjust to a patient’s needs more effectively. Even the physical structure and environment of the unit itself is often used for facilitating the management of patients. For instance, limiting the points of access onto and off the unit often deters patients from wandering into unsafe areas. Additionally, low stimulation settings help decrease agitation and irritability. All of these aspects of management facilitate recovery and help minimize the use of medications and their side effects.

Clinical information, the results of laboratory testing, as well as imaging, all aid in the determination of disability. The evaluations performed by occupational and physical therapists, speech language pathologists, psychologists, and so on are equally important. Information from a variety of standardized assessments and tests are used to help determine and guide treatment planning from acute care to community (re) integration.

Outcome measures used for determining the effectiveness of medical interventions and rehabilitation continue to focus primarily on changes over time in body functions and structures. Moreover, when quality of life is addressed, it is apt to be limited to health-related quality of life (e.g., Maas et al., 2010). A recent study reported, however, that health-related quality of life measures are predominantly measures of function that results “in a bias against people with long-standing functional limitations not related to current health” (Hall, Krahn, Horner-Johnson, and Lamb, 2011, p. 98).

As stated by Wilson (2006), improved methods of evaluating rehabilitation that relinquish the dependence on traditional outcome measures that frequently fail to identify the real needs of patients and families are required. It remains the case that considerably less attention is provided to the following:

- The lifestyle and daily routines, preferences, and goals of individuals with disability and their family members
- A person’s predisposition to benefit from some interventions over others
- The match of expectations of benefit with realization of benefit from the chosen interventions
- Social and environmental factors impacting benefit

True to a biopsychosocial approach, rehabilitation should begin with an understanding of the current physical, cognitive, emotional/behavioral, and psychosocial functioning of the individual. This requires a rehabilitation team comprised of individuals from the diverse areas of specialty including neuropsychology, rehabilitation psychology, psychiatry, occupational therapy, speech language pathology, social work, and vocational rehabilitation counseling. Specialists in sensory loss, such as audiologists and optometrists, may also be included. A key member of the team to include at the outset is the assistive technology specialist. Personal assistance and support from technologies, as well as environmental restructuring and the use of cognitive and behavioral strategies, are important resources. Case managers and disability advocacy organizations can help obtain further appropriate services for those in the community such as transportation, financial management, and housing assistance.
II.2 Presentation of the Chapters of Section II

The structure, level of intensity, and services available for rehabilitation can vary widely from one area to another, whether comparing facilities, cities, states, and countries. As one illustration, a review of traumatic brain injury rehabilitation, by a research team in Singapore (Chua, Ng, Yap, and Bok, 2007), listed the following as comprising the multidisciplinary rehabilitation team:

- Person with a disability
- Family or caregivers of the person with a disability
- Rehabilitation physician or physiatrist
- Rehabilitation nurse and rehabilitation technicians
- Allied health professionals: physiotherapist, occupational therapist, speech and language pathologist, clinical psychologist, neuropsychologist, social worker, and counselor
- Paramedical health professionals: dietician, orthotist, and rehabilitation engineer
- Other medical specialists: for example, ophthalmologist, gastroenterologist, and neurologist
- Vocational rehabilitation services and counselors
- Volunteers from support or spiritual groups (p. 34)

The Joint Committee on Interprofessional Relations Between the American Speech-Language-Hearing Association and Division 40 (Clinical Neuropsychology) of the American Psychological Association (2007) also provided a list of professionals comprising the brain injury “interdisciplinary team”:

- Besides the patient and caregivers, interdisciplinary teams may include, but are not limited to, the following professionals: speech-language pathologist, clinical neuropsychologist, audiologist, rehabilitation psychologist, behavioral specialist, dietitian, educator, occupational therapist, physical therapist, primary care physician, psychiatrist, physiatrist, rehabilitation nurse, social worker, case manager, therapeutic recreation specialist, vocational rehabilitation counselor, and paraprofessionals. (3–4)

The Joint Committee (2007) states that

- When cognitive, communication, emotional, and psychosocial domains are affected, the team should include at least a clinical neuropsychologist or rehabilitation psychologist, and speech-language pathologist. Team membership will vary with the age of the persons served, the type of impairment, the stage of recovery, and the special training of team members. (p. 4)

The guidelines proposed by the Association for the Advancement of Assistive Technology in Europe (AAATE) and the European Assistive Technology Information Network (EASTIN) (2012) recommend the multidisciplinary team approach as the most appropriate in the assistive technology (AT) selection process. Because the prescription of AT must not be based upon a medical model, only a multidisciplinary team approach can provide a holistic evaluation of the users’ needs. The AAATE and EASTIN (2012) states that
Selection of assistive equipment should not be based upon a strict medical approach. In the selection process medical, functional, social and other aspects should be taken into account. According to this, a partnership approach and multi-disciplinary assessment are the most appropriate. (p. 18)

Thus, even though there can be variability in the structure, level of intensity, and services available for rehabilitation, there is also considerable consistency in the above views of the rehabilitation team, from Singapore to Europe and US.

The eight chapters presented in this section focus on and describe the role of many professions in the rehabilitation of persons with disabilities and their match with appropriate ATs.

Each of the above chapters has been written by international experts in their area of specialty. What unites these authors is not only their commitment to optimal rehabilitation outcomes, but their perspective of the biopsychosocial approach to the AT evaluation, selection, and provision.

II.3 Conclusion

The best rehabilitation outcomes are achieved when individuals with shared perspectives, but representing different areas of knowledge and skill, pool their expertise to derive interventions that satisfy the personal, psychosocial as well as physical needs, and preferences of the individual with a disability. This teamwork also should be brought to bear on the selection and provision of assistive solutions. Each of the contributors to this section describes how this can be achieved from the viewpoint of their training and practice.

References


6

Assessment of Assistive Technology for Individuals with Cognitive Impairments

Christopher Stavisky, Jaime Rosa Campeau, Simon Carson, Nancy Dukelow, Sheryl Maier, Amy Pacos Martinez, and Sarah Kysor

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6.1 Introduction

Our ability to meaningfully and effectively interact with the world around us is dependent on the successful interface of cognitive processes with the surrounding environment. With the breakdown of one or more of these processes, our ability to function independently may become disrupted.

In a time of great advances regarding technology in our day to day lives, technology has the potential to increase independence and success with daily activities for individuals with cognitive impairments. There is a great deal of research to support the efficacy of external aids and/or assistive technologies on increased independence and life participation for individuals living with cognitive impairments (Sohlberg and Turkstra, 2011). As
Before we are able to carefully select, train, and implement the most optimal assistive technologies and techniques to best serve these individuals, it is imperative that we first complete a comprehensive and patient-centered assessment to create a clear profile of each individual, including areas of cognitive challenges and strengths, physical abilities related to device use, prior technology/device experience and preferences, individual goals and expectations, and environmental considerations and supports. This assessment may include standardized and non-standardized procedures, the latter being particularly valuable in individuals with cognitive deficits, in order to outline the individual’s demands and abilities within functional contexts.

In this chapter, we will do the following:

1. Discuss application of guiding theories to cognitive evaluation and treatment with particular regard to assistive technology
2. Review members of the interdisciplinary assessment team and describe each discipline’s assessment protocol
3. Provide an example of a collaborative program
4. Discuss future considerations

6.2 Theoretical Frameworks Guiding Assistive Technology Assessment for Individuals with Cognitive Impairments

The process of assessment and intervention for assistive technology for individuals with a cognitive impairment can be guided by various cognitive and assistive technology frameworks. Two frameworks highlighted in this chapter include Distributed Cognition (Hutchins, 1995) and Matching Person and Technology (Scherer, 1998, 2012; Scherer and Craddock, 2002). These frameworks were selected because they address the interaction of the individual with a piece of technology serving as a cognitive support tool in daily activity contexts. The following is an overview of these theories and application to the assessment of assistive technology for individuals with a cognitive impairment.

6.2.1 Distributed Cognition

Distributed Cognition (1995) is a cognitive theory that views cognition as a system of interactions between an individual and his/her environment, including other individuals and objects. Distributed Cognition is different from other more traditional cognitive theories because of two distinguishing principles. The first is that Distributed Cognition views cognition and cognitive processes wherever they are occurring (i.e., within an individual's environment and/or within a particular context), and accounts for the functional interactions between the individual(s) and environmental objects allowing the cognitive processes to occur. In other words, Distributed Cognition has a different conceptualization, or unit of analysis, of cognition, compared to traditional cognitive theories. Traditional cognitive theories often view the boundaries of the individual, or the cognitive processes that occur within an individual to be cognition. Distributed Cognition suggests that cognition extends beyond the boundaries of
the individual, and includes the functional interaction of the cognitive processes, individual, and the items and/or people in the environment. In this sense, the unit of analysis is the functional performance of the individual within his/her environment and with the use of the necessary tools. The second principle that differentiates Distributed Cognition from other traditional approaches to cognition is that Distributed Cognition accounts for cognitive events that are broader than cognitive processes and the use and manipulation of symbols within a particular individual. That is, Distributed Cognition posits that cognition can be broader than the specific cognitive processes that are facilitated and occurring within the human brain and its respective structures responsible for particular cognitive domains (e.g., memory, attention, executive function, etc.) (Hollan, Hutchins, and Kirsh, 2000).

Distributed Cognition posits that cognitive abilities are facilitated and executed with the use of environmental artifacts, or tools, that assist the individual with receiving the information necessary to complete a task. For example, the cognitive ability of remembering information for a task happens because an environmental tool provides information to the person, and then the person recalls and processes the information, which then allows the person to initiate, execute, and complete the task. According to this theory, cognition is a socio-technical system. The system is comprised of a person and contextual factors that also include the people and objects with whom/which the person interacts. Distributed Cognition emphasizes that cognition occurs through the interaction of three factors: the socio-technical system itself, the structures of the system (e.g., the personal and contextual factors in the system), and the coordination of the system. A disruption in any of these factors can affect cognition (Hutchins, 1995).

This theory has a direct application in the use of assistive technology for individuals with a cognitive impairment. Because this theory supports the idea that cognition can be a collaborative function of the individual and also the support tools in his/her context and environment, it supports the assessment and treatment approaches focused on the improvement of cognition function with the use of cognitive compensatory strategies and cognitive support tools involving the use of technology.

### 6.2.2 Matching Person and Technology

The Matching Person and Technology (MPT) model (Scherer and Craddock, 2002) allows for synchronization between the person and their technology, in accordance with the World Health Organization (WHO) International Classification of Functioning, Disability and Health (WHO, 2001). This model (Figure 6.1: see Section I, Figure I.3 for the color version) is focused on a holistic view that views the sum of the parts as greater than the entire system and is presented as a layered circle with the match of the person and the technology with all other factors surrounding it in layers. The three primary layers are the person, the environmental factors, and the technology. Without considering all the three areas, as well as an ongoing cycle of evaluation and adjustment in an ecologically valid and therapeutic environment, success with technology is restricted (Scherer, 2005; Scherer and Craddock, 2002, see also Chapter 3).

The first layer of the circle is the person. This level considers personal factory with the focus including body functions, body structures, activities/participation, personal and psychosocial needs and preferences, expectations/goals, routines, and functional needs. These areas focus on what the person would like to do, if they have the necessary skills to utilize the technology, what their expectations are related to technology, and their goals and their support. For example, if the individual goal is to use a keyboard but they lack the range of motion of the necessary arm, this would need to be considered (see Chapters 2 and 14). The
environment is the next layer and includes cultural, attitudinal, physical, political, and economic factors (Chapter 4). These areas focus on the expectations of others surrounding the person, the cultural experiences the individual has had, as well as the physical environment that will have an impact on the technology that can be used. For example, if the individual comes from a culture where high technology, such as computers are not accepted and there is no electricity, a computer may not be a feasible option. The outermost layer is the technology. It is not only electronics that are considered in this level, but other pieces of low technology such as a notebook. This focuses on the technology available, what it does to satisfy the individual’s needs, cost, appearance, and overall utility. For example, if the individual would like to have an environmental control unit for the home is one that satisfies their needs developed for a price, then that can be paid (Scherer, 2012).

The MPT model proposes a seven-step process to complete in order to successfully match the individual with the correct technology (see Chapter 3). Each step is focused on success with the chosen technology, and there are a variety of forms that can be utilized. The first step is assessing the person’s abilities and focusing on where the loss of function has occurred. Second, the individual’s history of use of technology as it relates to cognitive prosthetics. The third step is titled specific technology matching, and it allows the individual to begin to identify technology for use through the use of a variety of assessments. The professional assisting will also complete the forms, as the fourth step should discuss both results with the individual as well as aspects that demonstrate problems with what was chosen. For steps five and six, specific treatment strategies are chosen and an action plan is put into place. Step seven is a follow-up assessment after obtainment of the technology to allow for the ongoing cycle of evaluation and insuring an appropriate match. Forms or assessments previously used in step three may be used again as a comparison and a
6.2.3 Additional Theoretical Considerations

Because of the importance of context when completing an assessment of assistive technology for individuals with a cognitive impairment, it is often appropriate to select assessments that target the cognitive and activity demands of individuals within their contexts. The context in which an individual participates should be an integral part of the assistive technology assessment for a person with a cognitive impairment because cognitive functioning can vary in differing environments. Two reasons for this include the following: (1) the cognitive demands and activity demands on the person can change in different environments, and (2) the ability of a person to use cognitive strategies, such as assistive technology, differs when the control that the person has over the environmental changes (Nygård and Kottorp, 2014). An approach often employed in the field of neuropsychology that is also appropriate to guide the selection of assessments that target the cognitive needs within the individual’s context is described as a flexible battery approach. This approach allows for variation in the quantity and type of assessments selected for the client based on the assessment needs of that particular client. A benefit of using this approach is that it affords the clinician to use assessments that match the needs of the client, rather than following a firmly structured assessment battery protocol. This approach can be employed by all disciplines contributing to the assessment of appropriate assistive technology for individuals with a cognitive impairment. A consideration of the disciplines should be the validity of the assessments, including internal validity, external validity, and ecological validity, to ensure that the selected assessments are appropriately targeting the needs of the client.

6.3 Professionals Involved in Assistive Technology Assessment for Individuals with Cognitive Impairment

In order to fully and appropriately assess an individual for the use of assistive technology as cognitive support tools and prosthetics, multiple lenses of cognition and function are beneficial. Therefore, the team of health-care professionals who can offer different insights into these areas can lead to a successful and appropriate match of technology for an individual to use and assist with cognitive performance. The following is a selection of health-care professionals included in this process, and a description of their roles.

6.3.1 Neuropsychologist

The role of the neuropsychologist in traditional cognitive rehabilitation settings has historically been the provision of assessment and rehabilitation services to individuals. Neuropsychological evaluations can be conducted within inpatient and outpatient settings. For instance, evaluations can be conducted to assist in differential diagnosis, evaluate treatment efficacy, assist in legal matters, do research, or assist with care management (Lezak, Howieson, and Loring, 2004). Populations commonly served in regard to outpatient neuropsychological evaluations include those with neurological damage, such
as individuals suffering from stroke or those with multiple sclerosis or traumatic brain injury. Typical outpatient batteries are quite extensive, and measure performance in multiple cognitive domains, including memory, attention/concentration, language, visuospatial, executive function, premorbid function, and psychological function. While evaluations are flexible and tailored to each individual, with examiners selecting tests appropriate for both answering the referral question and the limitations of the individual, there are certain measures commonly used for assessing these domains. Below are measures used frequently in neuropsychological evaluations:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>Trail Making Test Part A (Army Individual Test Battery, 1944)</td>
<td>Quickly connecting numbers in sequential order</td>
</tr>
<tr>
<td>Executive Function</td>
<td>Trail Making Test Part B (Army Individual Test Battery, 1944)</td>
<td>Quickly connecting and alternating between numbers and letters in sequential order</td>
</tr>
<tr>
<td>Language</td>
<td>FAS/Animals (Spreen and Strauss, 1998)</td>
<td>Phonemic and semantic verbal fluency, respectively</td>
</tr>
<tr>
<td>Visuospatial</td>
<td>Clock Drawing Task (Spreen and Strauss, 1998)</td>
<td>Drawing of different elements of a clock</td>
</tr>
<tr>
<td>Memory</td>
<td>Wechsler Memory Scale—Fourth Edition (WMS-IV), Flexible Approach (Wechsler, 2009)</td>
<td>Measure of visual and auditory memory by immediate and delayed recall of story and design elements</td>
</tr>
<tr>
<td>Psychological Functioning</td>
<td>Personality Assessment Inventory (PAI; Morey, 1991)</td>
<td>Self-report of personality and psychological symptoms</td>
</tr>
<tr>
<td>Overall Cognitive Functioning</td>
<td>Mini-Metal State Examination (MMSE; Folstein, Folstein, and McHugh, 1975); Rancho Los Amigos Levels of Cognitive Functioning Scale (Hagen, Malkmus, and Durham, 1972)</td>
<td>Measure of impairment across several cognitive domains; Assessment of cognition and behavior following a closed head injury</td>
</tr>
</tbody>
</table>

Inpatient populations participating in neuropsychological evaluations are typically hospitalized within an acute care facility, and undergo an abbreviated testing battery with limited assessments. These evaluations are generally composed of a small number of measures with the goal of understanding overall cognitive functioning across multiple domains. The inpatient neuropsychological evaluation seeks to assist with treatment planning for the individual and to address concerns such as ability to return to work, need for accommodations, and tracking of cognitive improvement/recovery over time.

Within an outpatient cognitive rehabilitation model, the role of the neuropsychologist is to highlight each individual’s cognitive profile. That is, the neuropsychologist is responsible for utilizing a battery of assessments with the goal of obtaining a global “cognitive snapshot,” or an overview of functioning across several cognitive domains. This differs from the speech–language and occupational therapy evaluations, which often provide more in-depth information regarding the impact of cognitive deficits on functioning, such as communication deficits and performance of activities of daily living, respectively. The neuropsychological evaluation identifies each individual’s overall cognitive strengths and weaknesses, which can then be used for guiding the development and implementation of later strategies within occupational and speech therapy, including those utilizing assistive technology. The identification of cognitive strengths and weaknesses can be useful in the development of effective treatment strategies by utilizing cognitive strengths to improve...
domains that are impaired (Golden and Vicente, 2013). Importantly, neuropsychological evaluations can also identify psychological diagnoses, such as anxiety and depression, which can further magnify cognitive deficits. Particularly, in contrast with both occupational (see Chapter 10) and speech–language (see Chapter 13) therapies, the neuropsychology service typically satisfies with each individual on only one occasion for a single evaluation. Once this evaluation is conducted and information regarding the individual’s cognitive profile has been communicated to team members, the neuropsychologist serves as a subject matter expert for the team (e.g., knowledge of disease process, quality of life, and the impact of mental health on treatment outcomes). The neuropsychologist uses this knowledge to assist with treatment planning and treatment evaluation for each individual.

The battery of test measures for an outpatient cognitive rehabilitation program is chosen with the purpose of guiding treatment planning. The evaluation consists of a standard battery that is used with each individual, as well as an initial interview to collect data regarding the presenting problem and psychosocial and medical history. This screening battery was designed to capture each individual’s functioning across several cognitive domains in order to identify strengths and weaknesses relevant for treatment planning. Certain factors, including goals of the examination, psychometric properties of the measures, the ability to perform repeat evaluations, and time (Lezak et al., 2004) were considered when the Integrative Cognitive Rehabilitation Program (ICRP) test battery was created. Given the brief amount of time with each individual (60 minutes), tests were selected that could be administered quickly, but were psychometrically sound and had the ability to measure function across cognitive domains.

An example of an outpatient cognitive rehabilitation program test battery includes the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), Form A (Randolph, Tierney, Mohr, and Chase, 1998); Trail Making Test Part A and B (Army Individual Test Battery, 1944); and the Beck Depression Inventory—Fast Screen for Medical Patients (BDI-FS; Beck, Steer, and Brown, 2000). The RBANS, which was developed as both a screening measure and an assessment of cognitive decline in older adults, consists of 10 subtests and produces scores for five different cognitive domains: Immediate memory, delayed memory, language, attention, and visuospatial/constructional (Randolph et al., 1998). The RBANS requires individuals to complete tasks such as recalling a list consisting of several words, judging the orientation of lines, quickly producing members of a particular semantic category (e.g., fruits and vegetables), and copying a complex figure. Derived from age-based norms, raw scores from each subtest are converted into scaled scores and percentile groups, as well as Index Standard Scores, to allow for classifications (e.g., low average, average, high average). Requiring only about 30 minutes to administer, this cognitive screening measure helps to develop an overall cognitive profile of each individual.

The battery also includes the Trail Making Test (Army Individual Test Battery, 1944), a timed measure consisting of two parts. Part A is a measure of processing speed in which individuals are presented with a page of numbers (1–25) and are instructed to quickly connect the numbers sequentially. Part B is a measure of executive function, a domain excluded from the RBANS. The individual is presented with both numbers and letters, and is required to quickly alternate between numbers and letters (e.g., 1, A, 2, B). Time taken to complete each part of the test is recorded and converted into T-scores using norms based on age, sex, years of education, and ethnicity (Heaton, Miller, Taylor, and Grant, 2004).

As a measure of psychological functioning, the BDI-FS (Beck et al., 2000) is used. This is a seven-item, multiple-choice self-report screening measure for depressive symptoms. Individuals endorse an item associated with a numerical value (0–3), and these values are summed to create a total score, which is then classified in terms of severity
(i.e., minimal, mild, moderate, or severe symptoms of depression). This brief test of psychological functioning can help to identify any contribution depression that may have on cognitive functioning, and caution the examiner to possible obstacles to treatment efficacy.

Overall, this battery produces scores in the cognitive domains of memory, language, attention, visuospatial function, executive function, and processing speed, as well as psychological functioning. This provides the neuropsychologist with an overall cognitive profile that can help to identify strengths and weaknesses. The individual's functioning within each domain is communicated to occupational therapists and speech–language pathologists to be used in the development of treatment strategies with assistive technology. The obtained neuropsychological data can be utilized to document and track cognitive change/progress, identify areas of clinical concern that may also need to be addressed and treated, and finally to assist with treatment planning and treatment evaluation with the cognitive rehabilitation team.

6.3.2 Occupational Therapist

Occupational therapy (OT) is function-based, focusing on activities of daily living (ADLs), instrumental activities of daily living (IADLs), and work/school performance (deJonge, Wielandt, Zapf, and Eldridge, 2012; see Chapter 10). The role of the occupational therapist in the assessment of assistive technology for a client participating in cognitive rehabilitation follows that of an overall occupational therapy process outlined in the Occupational Therapy Practice Framework (American, 2014). The process includes an assessment of the individual's current level of function and needs, intervention focused on the use of the assistive technology to assist the individual by compensating for the cognitive impairments, and the targeting of outcomes, which includes measuring whether or not the outcomes of the intervention satisfy the performance outcomes or goals set in collaboration between the individual and the therapist.

Within the functional model of cognitive rehabilitation, the purpose of occupational therapy is to work with individuals with a cognitive impairment toward developing and using compensatory strategies to assist the individual with improving performance with daily activities and function. Assistive technology has a role in this process because technological devices may serve as cognitive support tools for these individuals with cognitive impairments (Gillespie, Best, and O'Neill, 2012). An evaluation by an occupational therapist is a crucial step in the development of cognitive compensatory strategies for cognitively impaired persons, as it allows the clinician to understand the individual's cognitive strengths and barriers to daily function, as well as appropriate technology that may match the strengths and satisfy the needs of the barriers. Three major components are included in the occupational therapy evaluation: a cognitive domain assessment, a function assessment, and an assessment for appropriate assistive technology. The following provides a description of each of these assessments.

Occupational therapy as a profession has several grounding theories that lend themselves to the use of adaptive technology integration into the performance of activities of daily living and instrumental activities of daily living. It is not just the occupation (everyday life activities) that the occupational therapist must analyze but the client factors, performance skills, performance patterns, and context/environments as well. The Ecology of Human performance Model by Dunn, Brown, and McGuigan (1994) provides a framework for considering the effect of context, which they describe as how a person views their world. The person, in all areas, is viewed in conjunction with the task they are completing.
Assessment of Assistive Technology for Individuals with Cognitive Impairments

to establish a context. A task is defined as those objective behaviors needed to accomplish a goal. In order to assess these in a logical and objective manner, the authors propose that the interaction of the task and the person be viewed in stages—establish/restore, alter, adapt, prevent, and create. The use of technology as a cognitive prosthetic for cognitive rehabilitation lends itself to this type of structure and fits closely with the use of the Matching Persons with Technology theory. The client uses adaptive technology not just in the clinic or treatment area but in the home and community context as well. The desktop computer that allows for the maintenance of lists in the home environment may no longer be functional in the context of the grocery store. If this is not considered, the client may not have the desired success or outcome.

The Model of Human Occupation (MOHO) was first established by Gary Kielhofner (2002) and has been since revised to keep in pace with the changing need of clients. MOHO explains how meaningful daily activities (occupations) are motivated, organized into everyday life patterns, and performed in the context of the environment. It is considered an open system model with input and output and processing in between. The output is viewed as an occupation, and the input is the other factors noted in the American Occupational Therapy Association framework. How the individual processes the information is ever changing and is not considered the same for each individual. As processing is occurring, feedback is received and further processing occurs, ideally with adjustments as required or with the knowledge that success was achieved. In cognitive rehabilitation, the individual would like to be independent in a bill pay task (volition). The occupational therapist provides and instructs in a spreadsheet to complete (performance), that they complete once a week at 5:00 p.m. on Sunday (pattern). They realize that the task needs to be completed more frequently and then alters to establish a twice weekly pattern (Kielhofner, 2002).

The field of occupational therapy has a variety of assessments that examine cognitive domains relating to function. One of such assessments is the Cognitive Assessment of Minnesota (CAM) (Rustad et al., 1995). The CAM tests various cognitive domains, including attention span, remote memory, orientation, immediate memory, basic language, temporal awareness, discrimination, visual memory and sequencing, auditory memory and sequencing, recent memory, thought processing, concrete reasoning, foresight and planning, mental flexibility, safety and judgement, insight, and abstract reasoning. The assessment contains normative values based on data from 200 individuals. This particular cognitive assessment is guided by theoretical frameworks suggesting that neuro-training can occur in the human brain after an insult to the cognitive system occurs because of neuroplasticity.

One alternative occupational therapy assessment is the Executive Function Performance Test (EFPT) developed by Baum, Morrison, Hahn and Edwards (2003) at the Program in Occupational Therapy at Washington University Medical School. The EFPT assesses three executive function components (task initiation, task execution that includes organization, sequencing, and judgment/safety, and Task completion) while completing four functional tasks. The focus is what an individual is capable of and the amount of assistance they will need to achieve success with the task. It will also assist with the determination of which executive functions are impaired. The tasks include simple cooking, telephone use, medication management, and bill payment. A standardized cueing system is used to allow for a variety of individuals to complete the tasks (Baum et al., 2008). Each type of cue is assigned a score that allows for the provision of three overall score—executive function component score, task score, and a total score. The time required for completion is also recorded.
The results of the standardized assessment(s) provide information for the occupational therapist about cognitive domains that are working well for the individual, as well as the domains demonstrating impairment. Both sets of information should be carefully considered by the occupational therapist. The cognitive strengths can provide guidance to the occupational therapist regarding potential cognitive compensatory strategies that the individual will be successful using. For example, if the individual scores high for visual memory, this individual may be successful with the use of cognitive strategies that highlight visual memory (such as memory notes or a calendar with written text). The areas of cognitive impairment should be considered because they demonstrate the domains that should be compensated, or addressed, in cognitive rehabilitation.

The second component of evaluation for the occupational therapist is a function assessment. The function assessment can be completed in a variety of ways, including nonstandardized and standardized assessment. Nonstandardized assessments include either demonstration of functional performance for activity participation, or a description of functional abilities. Standardized assessments involve the use of a standardized tool to assess the individual’s functional capabilities relating to cognitive performance. Ideally, the standardized assessment is demonstrated for providing valid and reliable results based on empirical evidence. An example of a standardized functional assessment is the Patient Competency Rating Scale (Prigatano et al., 1986). This is a 30-item five-point Likert scale questionnaire that asks individuals to rate their performance in a variety of daily tasks and situations, including ADLs, IADLs, emotional regulation, and social participation.

The third component of the evaluation is the assessment of appropriate assistive technology for the individual. This can include an assessment for assistive technology preferences, as well as consideration for the individual’s cognitive strengths. An example of an assessment of assistive technology preferences follows the theoretical framework of Matching Persons and Technology (Scherer and Craddock, 2002; see Chapter 3). A crucial component of the cognitive assessment when evaluating for appropriate assistive technology to be used as a cognitive compensatory strategy or support tool is the suitability to the individual’s cognitive processes. An appropriate cognitive compensatory strategy or support tool should do exactly as the name suggests: assist the individual with cognitive compensation or support the cognitive abilities in order to improve performance for a task. Through the standardized cognitive assessment completed by the clinicians and professionals who are part of the cognitive rehabilitation team, particular and specific cognitive deficits can be identified. The cognitive compensatory strategy or support tool should either compensate for the cognitive deficit(s) identified or support intact cognitive domains and processes to the extent that the individual experiences improved performance and function in the targeted task or activity. For example, if short-term memory is identified upon standardized testing as a cognitive deficit, an appropriate cognitive support tool may be a smart device capture tool system that affords the individual opportunities to quickly capture and store information from activities and tasks that may otherwise be lost. A cognitive compensatory strategy can be considered as a process that an individual engages to improve the cognitive performance with a task. In the above example, the individual employs a cognitive compensatory strategy when he/she uses the capture tool to store the information presented during the activity or task. In other words, the cognitive compensatory strategy focuses on the implementation of a process to improve cognitive performance with a task, and the cognitive support tool is a form of medium that allows the individual to manage the information (i.e., storing the information, retrieving the information, etc.).
6.3.3 Speech–Language Pathologist

The speech–language pathologist (SLP) is responsible for assessing and treating cognitive and communication deficits within the realm of cognitive rehabilitation (see Chapter 13). Although speech pathology is the sole “owner” of communication rehabilitation, there is some overlap with occupational therapy as to the treatment of cognitive impairments. An evaluation by a speech–language pathologist first involves an interview to screen for the types of deficits that may be present (cognitive, receptive or expressive language or both) and to determine how to effectively evaluate these deficits. The formal evaluation then allows the SLP to identify the individual’s strengths and weaknesses in order to develop patient-centered goals and strategies for intervention. The components of this evaluation include an assessment of cognitive domains, a more in-depth, targeted assessment of language (as warranted), a functional assessment, and an assessment of potential low-tech assistive technology.

There are numerous assessments within the field of speech–language pathology that can be used for assessing cognitive function. The Cognitive-Linguistic Quick Test (CLQT) (Helm-Estabrooks, 2001) is one of these assessments. The CLQT was developed for use with English- or Spanish-speaking adults with acquired neurological dysfunction, ages 18–89. It provides a standardized scoring system that permits analysis of language, visuospatial planning skills, and conceptualization of time. This evaluation is criterion-referenced and contains nine subtests, each of which can be linked to 2–3 of the cognitive domains that are assessed by the test including attention, memory, executive function, language, and visuospatial skills.

Scores are then tallied to develop cognitive domain scores that can be categorized based on normative values by age ranges to determine a numerical severity of impairment, corresponding to within normal limits, mild, moderate, and severe deficits. The severity rating for the five cognitive domains are then averaged to provide a composite severity rating. Additionally, further assessment of performance can be completed through calculation of Z-scores in order to obtain task-specific percentile scores. This is particularly useful for individuals who demonstrated difficulty with particular tasks, but may have achieved a cognitive domain score that was within normal limits.

The targeted language assessment can involve administration of selected subtests from standardized language assessments, or administration of an entire language assessment. This determination is made through identification of the primary deficit that is impacting the individual’s function—is language the primary deficit or is it a secondary deficit. The CLQT provides some assessment of receptive language in terms of the individual being able to follow the directions of the test, as well as expressive language through the confrontation naming subtest and generative naming subtest. If additional testing is required for higher level language, the Boston Naming Test (BNT) (Kaplan, Goodglass, and Weintrob, 2001), which requires the individual to name 60 picture items, may be more revealing and can offer insight into the individual’s stimulability to multiple cueing techniques or a full length assessment of both receptive and expressive language such as the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass, Kaplan, and Barresi, 2001) or the Western Aphasia Battery—Revised (WAB-R) (Kertesz, 2007).

The BNT consists of a stimulus picture set of 60 drawings of objects that become increasingly less familiar and difficult to name. If the individual is unable to name a pictured object, he or she is given a stimulus cue (e.g., “an animal”), followed, if required, by a phonemic cue (e.g., “be-”). If the individual is still unable to name the picture, he or she
is finally presented with a written choice of four words to choose. Response latency is also recorded, that is, the amount of time between the presented stimulus item and the individual’s response. An individual’s score is calculated using the number of responses that were reached without the need for a phonemic cue.

The current edition includes an appended Apraxia Assessment, as well as options for short form or extended testing. Individual subtest scores are documented on the Subtest Score Summary Profile to provide a visual profile of performance on each of the subtests, grouped by the domain of function. The summary profile, along with the Rating Scale of Speech Characteristics are used to develop a diagnostic summary of the level and type of aphasic impairment. The Score Summary Profile displays raw scores, spaced to correspond with the appropriate percentile value.

The WAB-R (Kertesz, 2007) is an individually administered test designed to comprehensively evaluate an English-speaking adult or teenage child’s language function following an acquired neurological disorder. The test measures both linguistic and nonlinguistic skills. Composite scores that can be obtained are the Aphasia Quotient, Language Quotient, and Cortical Quotient. The full battery is not required for all individuals; however, the verbal subtests are required for obtaining the Aphasia Quotient. In addition to inferring the lesion location and etiology, the results can help to determine the presence, severity, and type of aphasia; measure a level of performance to serve as baseline for detecting change; and provide a comprehensive assessment of the individual’s language strengths and deficits to appropriately guide therapeutic planning.

The speech–language pathology functional assessment can be a separate assessment in itself, and/or it can involve behavioral observations identified during formal testing. For example, during administration of the CLQT, the speech–language pathologist can attend to the time it takes the individual to complete each task to determine if the individual is trying to work very quickly, but making mistakes; if the individual is taking time to check his or her work; if the individual is working excessively slowly and trying to determine the factors that may influence this; and if time pressure is a factor in the individual’s performance. Other observations that can be made during formal testing include the following: whether the individual can self-monitor for errors, and, if they can, are they able to problem solve through fixing those errors; whether the individual does better with verbal vs. visual processing and memory; if attention may be impacting the individual’s ability to encode material into memory and manifesting as a memory deficit; how the individual organizes language (i.e., with generative naming—does the individual attempt to name by category, by first letter, etc.); and the individual’s approach or use of strategies to aid with problem solving or executive function tasks. Similarly to occupational therapy, a standardized functional assessment such as the Patient Competency Rating Scale (Prigatano et al., 1986) can also be used. This provides information related to both cognitive and communication strengths and weaknesses.

The final step in the evaluation process would be to consider if assistive technology is an appropriate intervention and the individual’s needs and preferences related to assistive technology. In a more focused assessment of language, the speech–language pathologist may assess an individual for low- or high-tech devices to aid in communication (i.e., communication notebooks, Lingraphica or Dynanox device, etc.). In assessments more targeted toward cognitive strengths and weaknesses, the focus of the technology assessment for the speech–language pathologist is more on low-tech solutions targeting organization, attention, and memory, with the occupational therapist providing assessment and implementation of high-tech solutions (i.e., electronic calendars, apps, etc.).
Some examples of the low-tech solutions would be alarms, calendar systems, notebooks or audio recorders, folder and filing systems, etc. The low-tech assessment is completed by identifying where the individual's cognitive breakdowns are occurring, and determining the individual's preferences for various types of low-tech solutions. For example, if the individual is missing appointments, the factors that influence this may be (1) awareness and recall of the date, time, and location of appointments; (2) awareness of when he/she needs to leave for the appointment; (3) attending to time on the day of the appointment to ensure that the individual leaves at the appropriate time; (4) having transportation arranged ahead of time, etc. If the individual is not aware of appointments or do not recall them, then using a calendar (wall vs. pocket) and setting up “rules” for how and when to record information in the calendar and when to check the calendar may be a helpful low-tech solution. If the individual is aware of the time, but is missing appointments because they are not scheduling sufficient time to travel to the appointment, then creating a daily schedule template to be completed the night before in order to preplan travel time may be an effective solution. If the individual does not attend to the clock throughout the day and “loses track of time,” then setting a timer or having an alarm on a watch or other device might be the most appropriate low-tech solution. If the individual has transportation issues, developing a template for scheduling and confirming transportation ahead of time (preplanning) may be an appropriate alternative. In each of these scenarios, low-tech solutions are offered and discussed with the individual to determine feasibility. Once a solution is selected then it is tailored toward the individual’s specific needs by creating “rules” for how to use the technology that will allow the individual to have the greatest success. Technology is then trialed at home by the individual, results are discussed with the clinician, and changes are made in the type of technology, or how it is used to further improve the individual’s functional performance.

6.3.4 Other Tests

The assessment of individuals with cognitive–communication disorders after traumatic brain injury can prove challenging to speech–language pathologists. It was with this knowledge that The Academy of Neurologic Communication Disorders and Sciences Practice Guidelines Group dedicated a specific writing committee to the topic, with the objective of evaluating the evidence base for standardized and nonstandardized evaluation and to provide guidelines for clinicians to identify valid and reliable tools. The following seven tests were found to satisfy the most established criteria for validity and reliability with this clinical population (Turkstra et al., 2005a,b):

- American Speech Language Hearing Association Functional Assessment of Communication Skills in Adults (ASHA-FACS) (Frattali, Thompson, Holland, Wohl, and Ferketic, 1995)
- Functional Independence Measure (FIM; Uniform Data System for Medical Rehabilitation) (Keith, Granger, Hamilton, and Sherwin, 1987)
• Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (Randolph et al. 1998)
• Test of Language Competence—Extended (TLC-E) (Wiig and Secord, 1989)
• Western Aphasia Battery—Revised (WAB-R) (Kertesz, 2007)

The authors also advise on the limitations of current standardized assessments, and urge clinicians to consider testing within a “broader framework that considers evaluation of the person’s pre-injury characteristics, stage of development and recovery, communication-related demands of personally meaningful everyday activities and life and communication contexts” and to collaborate with other professionals who also evaluate cognitive function (Turkstra et al., 2005a,b).

6.4 Assistive Technology and Collaborative Cognitive Rehabilitation Programs

Using a team approach to evaluate a person’s functional status and cognitive abilities is ideal to appropriately and successfully recommend assistive technology for cognition. At the University of Rochester Medical Center in New York State, the ICRP (https://www.urmc.rochester.edu/physical-medicine-rehabilitation/patients-families/services/integrative-cognitive-rehabilitation.aspx) has developed a team approach for providing cognitive rehabilitation. ICRP was founded in 2011 when an individual who was observed by neuropsychology was found to have needs that traditionally would not warrant cognitive rehabilitation. The individual, a young and highly functioning professional, had sustained a mild stroke that resulted in executive dysfunction making return to work difficult without supports in place to assist him in daily performance. Following the neuropsychological evaluation, speech–language pathology was consulted for cognitive strategy development and occupational therapy was consulted for technology implementation of functional strategies for work related tasks. The collaboration of these three professionals during evaluation, strategy development, and technology implementation marked the starting point of what has become a successful interprofessional team. The team, which has expanded to include multiple providers from occupational therapy, speech–language pathology, and neuropsychology has worked extensively since 2011 to develop tools and processes for individual evaluation and intervention, as well as process development to foster a team approach to patient care and open channels of communication.

The role of each discipline in the cognitive rehabilitation process is defined; however, there can be a great deal of overlap between disciplines that can make a team approach challenging at times. To reduce duplication of services, it is essential that providers communicate regarding the evaluation findings as well as the intervention approach in order to provide complimentary services for optimal individual outcomes. An important aspect of the successful team approach is to define tools and roles for each discipline that will ensure a comprehensive approach to the treatment plan. ICRP utilizes intake templates for gathering functional and cognitive performance information. Furthermore, specific assessments have been selected by the disciplines that are complimentary and not redundant for individual assessment. By standardizing the process,
individuals are provided with a comprehensive program that is consistent between providers.

A potential downside to over standardizing a program is the loss of individualized intervention. Each individual does not always fit the standard intake measures and assessments that the team has chosen. For this reason, the ICRP team has developed a pathway approach to assessment that allows deviation from the typical process. The intake measures are sufficiently flexible to allow for individuals of varying functional status, and there can be some variation in cognitive assessments administered. The individual's role with the ICRP team is vital, as the process would not work without individual goals and active engagement with the program. ICRP has developed an intervention menu that the providers and individual can work with as a method to improve individual engagement in the process. Furthermore, the intervention menu works for both high tech and low-tech intervention strategies. Allowing the individual to direct the type of strategies and how they will be used often increases success.

Individuals who choose to use assistive technology for cognition often benefit from a wide range of strategies. To ensure therapy remains goal directed, it is essential that a thorough evaluation be performed by all disciplines including an assessment of assistive technology to improve the success of use. For individuals who choose to use assistive technology, the occupational therapist often takes the lead role in strategy implementation, often including strategies developed by other disciplines as well.

Individuals participating in ICRP who choose technology as the mode for cognitive compensatory strategies benefit from a wide array of possible uses. The providers most often choose programs such as calendars, reminders, alarms, to-do lists, checklists, notepads, auditory cues, and other visual cues to assist individuals with functional tasks. The continuously changing technology environment and advanced application settings allow for many possibilities of cognitive compensatory strategies. Appendix A provides a theoretical model for working with individuals with cognitive impairments focused on the development and use of assistive technology for improved cognitive performance with daily activities.

6.5 Case Example

Joe is a 23-year-old male collegiate level assistant sports coach. He began experiencing cognitive difficulties after he was hospitalized with viral meningitis and encephalitis. He also had a history of depression and anxiety and multiple sports concussions. During his initial evaluation, his subjective complaints were the following: delays in processing information and communicating responses, poor memory, difficulty managing complex emails, inability to multitask, and difficulty regulating incoming information resulting in cognitive overload.

6.5.1 Neuropsychology Assessment

Neuropsychological testing was conducted with Joe utilizing the following measures: Advanced Clinical Solutions Test of Premorbid Functioning (ACS TOPF; Psychological Corporation, 2009); BDI-FS; Boston Naming Test—Second Edition (BNT-II); California Verbal Learning Test—Second Edition (CVLT-II; Delis, Kramer, Kaplan, and Ober, 2000); FAS/Animal
Naming; Personality Assessment Inventory (PAI); Rey Complex Figure Test (RCFT; Osterrieth, 1944; Rey, 1941); Trail Making Test (A and B); Wechsler Abbreviated Scale of Intelligence—Second Edition (WASI-II; Wechsler, 2011); Wechsler Memory Scale—Fourth Edition (WMS-IV), Flexible Approach; Wide Range Achievement Test—Fourth Edition (WRAT-IV; Wilkinson and Robertson, 2006); and Wisconsin Card Sorting Task, Computerized Version (WCST; Heaton, Chelune, Talley, Kay, and Curtiss, 1993).

An estimate of premorbid functioning (TOPF) revealed High Average functioning with commensurate IQ scores (WASI-II: FSIQ = 113; 81st percentile). Academic screening measures also reflected strong academic functioning (WRAT-IV Reading: 99th percentile; WRAT-IV Sentence Comprehension: 91st percentile; WRAT-IV Spelling: 91st percentile; WRAT-IV Math computation: 91st percentile). Intact performance was noted on measures of simple attention (Trails A), executive functioning (WCST), and confrontation naming (Boston Naming). In contrast, Joe demonstrated mildly reduced verbal fluency (FAS and Animal Naming). Additionally, his memory scores evidenced significant variability across administered memory measures. He demonstrated a High Average performance on measures of verbal memory for story information (Logical Memory), with reduced recall. On a second measure of verbal memory/verbal learning (CVLT-II), he evidenced mildly reduced encoding of information (Trial1); however, he benefitted from repetition and rehearsal of information. His visual memory was slightly reduced on the RCFT. Additionally, his performance on the RCFT reflected reduced visual memory (immediate and delayed recall) and was significant for poor planning and reduced organization of visual details and general visual design. Results of two administered mood inventories (PAI and BDI) were indicative of clinically significant concerns, reflecting elevated anxiety and possible depression. Clinical interview findings revealed concurrent concerns regarding insomnia, reduced frustration tolerance, mood-based changes, and concern regarding his perceived changes in functioning. Recommendations included education and counseling regarding concussion recovery, increased mental health support (initiation of outpatient counseling services), and cognitive rehabilitation involvement to address areas/domains of weakness (language fluency, visual planning/organization, memory encoding support, and normalizing of his deficits).

6.5.2 Speech–Language Pathology Assessment

Joe was assessed using the BNT and the CLQT. Joe was able to name 49/60 pictures on the BNT, which indicated a mild deficit in naming given he scored greater than 1 deviation below the mean for his age (mean: 55.3, standard deviation 3.8). On the CLQT, Joe scored within normal limits for all five cognitive domains—attention, memory, executive function, language, and visuospatial skills. Further assessment of his performance using task-specific percentile scores revealed that he scored at or above the 50th percentile for all tasks, which is normal. Despite these findings, he was experiencing functional cognitive and communication breakdowns at work; therefore, therapy was recommended to target information management and processing as well as facilitatory strategies for word retrieval. The low-tech cognitive prosthetics that Joe and the clinician determined together would be most helpful for information management and processing were the following: (1) creation of templates for repetitive tasks, such as a team travel itinerary that could easily be modified for each game; (2) use of spreadsheets to manage and organize information required for planning team travel (i.e., costs, addresses, and confirmation numbers for busing, hotels, meals, etc.); (3) use of binders with sections to organize information on current players and recruits, etc.
6.5.3 Occupational Therapy Assessment

Joe was assessed using a modified version of the Patient Competency Rating Scale (Prigatano et al., 1986) and the CAM (Rustad et al., 1995). Based on the results from the modified version of the Patient Competency Rating Scale, Joe presents with delays in processing and communicating responses, memory difficulties, difficulties managing work emails, delayed information processing, difficulties regulating cognitive overload, and difficulties with multitasking. The results of the CAM indicated that Joe demonstrated moderate difficulties with auditory recall and recognition, safety and judgment, and abstract thinking. Joe demonstrated severe difficulties with visual memory and sequencing and moderate concrete problem solving. While considering these findings, and Joe’s work as a collegiate basketball coach, which required him to complete work in multiple locations, the occupational therapist employed guiding principles from the MPT model (Scherer, 2012; Scherer and Craddock, 2002) to determine appropriate technology and cognitive support tools for Joe. The occupational therapist collaborated with Joe about his cognitive support tool preferences, and determined that Joe would benefit from a low-technology cognitive support tool to capture and store information, including paperwork, that Joe would need for his daily work tasks. The tool that Joe preferred to satisfy these needs was a combination calendar and notebook that also had a folder to store and carry paper documents. Because of his difficulties with communication, memory, and cognitive overload, it was also determined that Joe would benefit from use of a high-technology cognitive support tool to quickly capture and store information that he received from conversations and quick interactions with other individuals throughout the work day. The tool that Joe opted to satisfy this need was a smartphone that included a note-taking application and voice recording feature.

6.6 Summary

This chapter provided an overview of the assessment of assistive technology for individuals with cognitive impairments. This chapter discussed application of guiding theories to cognitive evaluation and treatment with particular regard to assistive technology, reviewed members of the interdisciplinary assessment team and described each discipline’s assessment protocol, and provided an example of a collaborative program. In particular, this chapter introduced a multidisciplinary program that was developed to better manage the functional deficits of individuals with mild to moderate cognitive impairment. The aim of the program is to provide function-based, compensatory interventions with an assistive technology focus. The program capitalizes on the expertise of multiple scopes of practice collaborating as a team to provide assessment and individualized treatment to improve individual outcomes and work toward individual autonomy. The program highlights patient-focused care and integration of disciplines to provide an individualized assessment of cognitive strengths and weaknesses and to identify a unique and tailored treatment approach that emphasizes collaboration and incorporating the individual’s family and support the system in the process. Assistive technology measures and techniques are selected based on individuals’ preference and comfort with technology and knowledge of environmental considerations and supports.
Appendix A: The Integrative Cognitive Rehabilitation Program Theoretical Model

References


Assessment of Assistive Technology for Individuals with Cognitive Impairments


The Special Educator

Susan Zapf, Trish MacKeogh, and Gerald Craddock

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7.1 The Role of the Special Educator in Assistive Technology Assessment

The World Health Organization (WHO) and the United Nations Global Disability (UNGD) reports estimate that individuals with disabilities account for 15% of the world population. They identify approximately 150 million children with disabilities in the world (WHO, 2011), with an estimated 93 million children classified in the moderate to severe disability range and over 13 million children classified in the severe disability range. The United Nations Convention on the Rights of Persons with Disabilities, The American Disabilities Act, and The Individuals with Disabilities Education Act advocate the right of all children to be included in the general education system and to receive individualized support services and accommodations required for successful participation. The definition of special education varies worldwide as many countries use a social classification system similar to the International Classification System of Functioning, Disability and Health (ICF) addressing the child’s ability to participate across the educational domain, while other counties focus on a medical model for education based on specific categories of impairment or disabilities (WHO, 2001).

Although service terminology may vary across counties, the intent to support students with disabilities should be a global priority with a focus to remove barriers and provide facilitators such as technology tools and service delivery that can impact the students’ participation in the community. Although changes in legislation have provided a positive

* In the educational setting, the student is the consumer for assistive technology; therefore, in this chapter, student will be used instead of client/consumer. Student will refer to a person between the ages of 3–21.
shift to include the consideration of Assistive technology (AT) in the student’s educational plan, there still remains a deficiency in many countries for children with disabilities to have access to needed AT that can assist with meeting their educational plan and participation in daily activities. The WHO reports that only 5%–15% of individuals with disabilities have access to AT in many developing countries. Bouck (2016) reported that only 7% of secondary students with an Individualized Education Plan (IEP) reported having access to AT in a national longitudinal study-phase 2 conducted in the United States. Of concern in this report was the fact that students with higher incidence of disabilities reported less access to AT supports (<5%) in the educational setting (Bouck, 2016). The WHO (2010) promotes the training of educators and various other personnel in AT to improve access for technology. Moreover, it specifies access to AT should be at an affordable cost, testifying it as a right and an important component to inclusive education. The special educator can play a vital role in providing technology access and implementation of tools to be used with students in the educational setting.

An important responsibility of special educators is to develop an IEP for each student who requires learning support. The IEP is a collaborative process, which focuses on the abilities of each individual student, their desired goals tailored to the student’s individual needs and abilities. The consideration for AT devices and AT services should be embedded within the IEP (TATN, 2009). The Texas 4-Step model is a process that can guide the special educator through the consideration process of AT aligned with the development of the student’s educational plan. The first step is to identify the student’s current academic achievement and functional performance level aligned to the national standards. This step aligns with the needs analysis step in an assistive technology assessment (ATA) process, to identify areas of strength for the student and areas of need that may require an AT solution. The second step is to identify the goals and objectives, what is expected that the student can achieve. The third step is to determine if any of the tasks involved in the students’ education plan will be difficult for the student to achieve and subsequently decide if an AT solution or AT service is needed. The final step is to determine if AT solutions/services are needed, and this step can be accomplished through gathering needed information in the assessment process and trial of AT solutions (TATN, 2009).

The special educator is a crucial member on the AT team. Special educators work with students on a daily basis and are able to identify the student’s strength and needs in the area of academic performance. As stated above, the needs assessment is the first step in the ATA process. The special educator is in the best position to identify students’ area of need related to specific academic performance, and can assist in determining the students’ predisposition and personal characteristics related to the successful integration of AT. Working with students on a daily basis, special educators have the opportunity to become familiar with personal characteristics of students and can help identify predispositions that can support or hinder the student’s use of AT.

AT has long been recognized as a tool for enabling independence and access for individuals with disabilities (Chun-Huanh, Sugden, and Beveridge, 2009; Hemmingsson, Lidstrom, and Nygard, 2009; Østensjø, Carlberg, and Vollestad, 2005; Quinn et al., 2009; Watson, Ito, Smith, and Anderson, 2010; Zapf, Scherer, Baxter, and Rintala, 2016). With the national trend of including children in special education into regular education classrooms in the United States, 75% of children with disabilities are spending at least 49%–80% of their time in regular education classes; a significant increase over the past 10 years (Swanson, 2008). It is essential that teachers design classrooms to allow for curriculum access—for example, the student can obtain information (written, oral, and graphic)—and provide information in a suitable and appropriate means for all children. While curricular
access is paramount, it is also important that children have the opportunity to perform a variety of social, academic, and personal care tasks/activities that impact functional participation in the educational setting. AT can facilitate successful participation for many children with disabilities.

In Ireland, the National Council for Special Education (NCSE) carried out a national stratified replacement random sampling procedure on the type of AT used in education comprising students from 5 years to 18 years of age. The technologies covered were Visual aids and devices, Audio systems, Communication devices, Software, and Control devices/accessories. The final sample examined the views of 100 students and their parents in terms of their experiences of acquiring and using AT as well as their perceived impact of the AT on their education. Seventy percent of students reported that their educational needs had been met by their AT. Students reported they engaged better in class as they could hear instruction and see text more clearly with the use of visual and hearing technology. For others, the use of software allowed them to keep up with the class by easily taking down notes, while others stated, doing tests were easier when using a laptop. However, 20%–30% of the students reported that the impact of AT had not been positive and consistently identified the need for support and training in the use of technology as key barriers (Wynn et al., 2016). The responses from these students implies the importance of AT service provision, and special educators are crucial in the successful implementation of AT to support students in the educational setting.

7.2 Assessment and Service Delivery Considerations in Special Education

Research has shown that the most effective implementation of AT begins with a child-centered ATA and service plan. (Wissick and Gardner, 2008; Zapf et al., 2016). The AT evaluation should involve a comprehensive individualized assessment of the child’s progress on current goals, the child’s tasks, environment in which the AT will be used, past experiences with the use of AT and other supports, and the child’s predisposition to the use of alternative or additional supports (Scherer and Sax, 2010; Scherer and Zapf, 2008; Zapf et al., 2016). Each child has a “predisposition” that can influence the use of AT. Such predispositions depend on personality characteristics, subjective well-being, and views of physical capabilities, experience, future expectations, social acceptance, financial, and environmental support for technology use (Louise-Bender Pape, Kim, and Weiner, 2002; Scherer, 2005). In addition, assessing and conceptualizing the patterns and degree of the child’s disability becomes a crucial component. Special educators can help the AT team identify the student’s predisposition, specific skills, past technology use, and abilities that can support the use of AT for the student. The NCSE study of AT provision advocates the adoption of a biopsychosocial approach to assessment based on the WHO ICF model, the involvement of parents and student, and moving away from diagnosis as a basis for the allocation of resources.

The importance of a “good match” between the student and the technology has been found to be an essential element to the successful use of AT. One specific assessment process that has been effective in identifying predisposition characteristics and AT tool characteristics that influence and impact a person’s general AT use is the Matching Person and Technology (MPT) model and assessments (Scherer, 1998, 2005; Craddock and Scherer, 2002). The MPT consists of measures validated for use by both young people
and adults with disabilities (see Chapter 3). The Matching Assistive Technology to Child-Augmentative Communication Evaluations Simplified (MATCH-ACES) was developed under the theoretical framework of the MPT and uses similar constructs but is designed for the pediatric population in the educational setting (Federici, Corradi, LoPresri, and Scherer, 2009; Scherer, 1997, 1998; Scherer and Zapf, 2008; Zapf, McBride, and Scherer, 2014; Zapf, 2012). Using the MPT evaluation forms in the assessment of 45 students, Craddock (2006) found that the MPT model guided the assessment process. Particularly, the MPT process was found to be a student-centered assessment that involved the students in the identification, selection, and acquisition of AT. Craddock also found that each dimension of the MPT framework, the environment, the technology, and the person, played a defining role in the assessment process and the success of AT outcome use for students in secondary education. Zapf et al. (2016) analyzed the predictive validity of the MATCH-ACES assessment on 35 students in five school districts and found significant Wilks’ Lambda in the MATCH-ACES predisposition scales indicating a strong predictor model in the AT use group classification. Particularly, the model found that the predisposition factors of student need motivation, flexibility, persistence, and teacher interest and willingness to use technology influenced AT outcome use. The MATCH-ACES assessment was also found to have good internal consistency within the predisposition scales. The AT teams reported that the assessment had good clinical utility, was student-centered, and provided streamlined assessment that was aligned with the AT consideration process.

In tandem with the MPT the IEP is a collaborative process, which focuses on the abilities of each individual student, their desired goals, and tailored to that student’s individual needs and abilities. It is based on a client focused social and participatory service delivery model in AT (Craddock and McCormack, 2002), that emphasizes the active participation of the service user in the selection of appropriate equipment and in the ongoing evaluation and decision-making processes. Part of this European funded program was the development and training of a novel profession called Technology Liaison Officers (TLO). These were adults with disabilities who received training and third level qualifications in AT. They were based in the community and their role was to support both families and teachers in accessing, understanding, and using AT. The overall focus of the program was a bottom-up approach enabling the local personnel to define the issues involved in a service delivery system (Scherer and Craddock, 2002). Person-centered planning begins by establishing individual’s prioritized needs in collaboration with a team consisting of the individual’s support network, family, close friends, teachers, and AT specialists.

The success of students with disabilities using AT is related, amongst other factors, to the AT knowledge and skills of special education teachers (Scherer and Craddock, 2002; Scherer and Zapf, 2008; Zapf, Scherer, Baxter, and Rintala, 2016); however, findings indicate that AT training at the teacher training level may not be adequately addressed. Approximately one-third of undergraduate special teacher licensure programs, 28% of initial postbaccalaureate licensure programs, and less than 25% of master’s degree programs require AT coursework. Many graduates are leaving special education teacher preparation programs without the critical knowledge, skills, and dispositions necessary to address the AT needs of their students (Judge and Simms, 2009).

In a study commissioned by Inclusion International, Laurin-Bowie (2009) surveyed 750 teachers and 400 parents from 75 countries and found that the EFA (Education for All UNESCO, 2009) mission was not working for children with disabilities, particularly for those with intellectual impairments, due to lack of administrative follow-up on implementation of EFA goals and education of staff. The study defines quality inclusive
education as requiring positive and enabling attitudes for inclusion, supportive and trained teachers, adaptable curriculum and assessment, and accessible and supportive schools. In Ireland, in a study by Work Research Center (2015), it was found that there was a 45% unmet technology need for children with intellectual/learning disabilities. Age was the most frequent predictor of unmet demand with children and younger adults with intellectual disabilities comprising the bulk of need for ATs in this cohort. A later report by the National Disability Authority found that the use of AT for people with Autistic Spectrum Disorder (ASD) is in its infancy and future research in this area must be recommended (NDA report, 2014). Edyburn (2015), a leading specialist in AT, believes that it is essential that the field engage in collecting and evaluating data to determine the efficacy of the interventions in order to understand the effort and cost necessary to scale-up the benefits. An initiative is underway in Ireland to support research into AT for children and adults with intellectual disability, and the Assistid program (Assistid, 2016) is funding research across a number of AT areas from designing apps and virtual reality programs for collecting information about the current use of AT and barriers that people face when attempting to access or use AT and raising awareness of the potential that AT has to transform lives of people with intellectual disabilities. In particular, research has been undertaken into AT outcomes for children and adapting the Irish MPT tool as a multimodal ATA tool for children with mild to moderate intellectual Disability (ID) and ASD through a Universal Design framework. Exploring the nature of how children with ID learn means that traditional data collection techniques may not be sufficient to investigate how technology and AT can support their needs. Ruddock and Flutter (2004) argue that text-based tools often position the child as a passive object of research and do fully understand a child with an intellectual disability “lived experiences” and their multiplicity of abilities and needs. It is intended to adapt the Institute for Matching Person and Technology (IMPT) tool as a multimodal tool on a digital platform and the project is commencing its pilot study (Assistid, 2016).

A significant change in the approach to technology within education is required if AT is to be included as an essential tool for students with disabilities. Information and communication technologies (ICT) considered a ubiquitous tool within the classroom and AT as a tool for students with disabilities to fit into the existing structures. Novel technologies can vastly increase access and learning opportunities for students; yet, this technology has not been fully utilized within the educational setting. An educational system is required where there is not one “typical” learner but a variety of learners each provided with adequate supports. Change can occur at many levels but in particular, in the classroom setting where the teacher could view technology as a means for creating a collaborative learning environment and support students in their educational goals.

One of the more significant findings in research on the use of ICT in education is the extent to which ICT can support the inclusion of students with Special Educational Needs (UNESCO, 2009). Currently, in many countries, the predominant practice is to withdraw pupils from the classroom for supplementary teaching with a support teacher. However, this reliance on individual supplementary classes on a withdrawal basis has been criticized as contrary to the principle of integration in teaching and learning, and an inclusive system of education withdrawal prevents interaction among students with and without special needs (Buli-Holmberg and Jeyaprathaban, 2016; Markussen, 2004). The NCSE study recommended that Universal Design for Learning (UDL) is appropriate in responding to the increasing overlap between mainstream ICT, ICT for learning, and AT. The report recommended an audit of the current AT identification and acquisition process using a UDL framework that could form the basis for a more user-friendly, proactively transparent, and
administratively efficient approach to AT provision. It is commonly known that it is more cost-effective to make an inclusive environment at the start rather than paying for costly adaptations.

In a study conducted with post-primary school students over a two-year period, Craddock (2006) found that ICT and AT played critical roles in augmenting participation of the students at both social and educational levels. The use of these technologies acted as an important catalyst in the educational process and environment for students with disabilities and was one of the factors that led to the fulfillment of the students’ goals. In particular, the students reported that the AT gave them the opportunity to show that they had the ability and the skills that they knew they had but had not previously the means to demonstrate. In general, the students reported that AT increased their skills, their capacity, and their quality of communication. They were able to work better and faster and cover more of the curriculum. They felt that the technology enabled them to complete their education on an equal status with their peers. Craddock also found a number of factors that are associated with the students’ successful use of technology, including the following:

- Early intervention, the earlier the student is exposed to the technology, the more adapt the student is in its use and the more comfortable the student is with technology association
- Formal supports, this includes the support of teachers, principals and the entire school ethos, both in its inclusive support and understanding of disability but also the schools’ engagement with technology
- The comfort level of the teachers using technology within the school setting
- Educating teachers in technology
- Informal supports were also crucial, and this mainly referred to family and friends; in particular, the mother played a crucial role in obtaining the AT devices and also supporting the use of AT in the home

Similarly, Zapf et al. (2016) also found that teachers’ interest and comfort in using AT within the classroom were significant predictors in affecting students’ AT outcome use in the educational setting. They found that when these two predictors were removed from the second predictive analysis, the predictive model was found to be nonsignificant, indicating the effect that teachers’ interest and comfort in AT can have on students’ success of utilizing AT use within the classroom setting. Hemmingsson, Lidstrom, and Nygard (2009) used qualitative methods and interviewed students on their perception of AT use in the school setting. Students reported that they had a desire to use more AT than provided in the classroom and that AT was not available because their teachers are not integrating the AT into their lessons or AT was not available in their certain classrooms. The lack of follow-up support for teachers and students was also identified as a reason for nonuse of AT in the classroom. These issues are again identified in the NCSE study; a common theme from both parents and educators was the lack of training and support for both ICT and AT in the classroom. International and national guidelines identified in the NCSE study in Ireland highlighted common themes such as the need to involve parents and pupils; the need to provide access to relevant information; the need for training and support for all stakeholders; the need for an effective phased matching processes; and the need to integrate AT into a universally designed, inclusive education process (Wynn et al., 2016).
Teacher comfort level with AT is a critical factor in continued use and support for AT use among students (Zapf et al., 2016). Craddock (2006) found that the important factors to emerge in the satisfaction of student AT use were the following:

- The provision of supportive educational classrooms that included more imaginative layouts of classroom furniture versus the traditional column/row
- Low-tech ATs such as pencil grips and wedges, book stands, and magnifiers
- The integration of mainstream technology with AT such as the use of laptops with specialized software uploaded onto all systems that linked remotely to electronic interactive white boards.

Craddock also identified human factors that were critical, such as having classroom assistants working closely with the students and the teacher. In many instances, it was the support given by individual teachers that materialized as a critical factor in the successful use of AT. A study by Zapf et al. (2016) and Scherer and Zapf (2008) found a significant correlation between the variables of teacher/parent comfort and student motivation in AT use, indicating that the teacher/parent comfort may affect the students’ motivation in the use of AT. This finding supports the importance of using an assessment scale to assess the comfort level of the teacher/parent scale and its effect on the outcome use of AT. A study by Sze (2009) revealed that one of the most important predictors of successful integration of students with disabilities in the regular classroom is the attitude of general education teachers. The results confirmed the existence of a significant link between preservice teacher attitude and instructional practice. The success of instructional practice requires that general education facility be prepared to work with students with disabilities. Preservice special education courses have benefited preservice teachers in gaining an understanding of students with special needs, thus increasing their comfort level with diverse learners overall. In studies on the attitudes of general education teachers, it was also revealed that a lack of knowledge of disabling conditions affected the ability of these teachers to accept not only students with disabilities but also other students with special needs. Craddock (2006) identified teacher knowledge as an important factor in students’ effective use of AT at the post-primary level. The National Council for Curriculum and Assessment (NCCA) in its ICT framework final report (2007), piloted in 12 schools, concluded that teachers welcomed the framework, but lacked the infrastructure to implement it successfully. There was a view that ICT was undervalued in the classroom that was evidenced by out-of-date and inadequate equipment. The report recommended significant investment in ICT infrastructure, that ICT be embedded in the curriculum, assessment, and State examinations and that teacher training in ICT be made available.

Finally, Craddock (2006) found that unsuccessful AT users reported many reasons for nonuse, including a desire to “fit-in” that may be threatened by AT use, for example, being less inclined to use communication devices even though they can improve communication due to the perceived stigma. Assistive devices may effectively improve mobility, communication or accessibility, but if the device has a negative connotation because it brings unwanted attention and threatens the sense of “fitting in,” this sense of “fitting in” may be more important to the user than independence and/or sense of control. Similarity Zapf et al. (2016) found that students in the low user group had negative scores related to persistence on the predisposition scales, the teachers also had negative scores related to interest in using AT within the classroom setting. These findings again support the need for AT
training for special educators and the significant role played by special educators in the overall support of student AT use in the classroom.

### 7.3 Outcome Studies of AT in the Educational Setting

AT devices and tools are designed to improve a child’s performance and to remove barriers that can exist towards independence. Recent studies by Zapf et al. (2012) and Watson et al. (2010) found significant effect in IEP goal improvements in students who received AT devices and services from a trained multidisciplinary team based on pre- and post-performance scores. These authors also found that the AT intervention provided positive contributions to the students’ improvement in IEP mastery as compared with relative and supportive services and specific modifications to curricular tasks. The AT used in this study included written communication hardware and software, speech-generating devices, curriculum support software, and computer and switch access. Øien, Fallang, and Østensjø (2016) conducted a qualitative study on nine children with Cerebral Palsy (CP) and found that the students who considered their AT as part of their body schema identified their AT as facilitating participation in school activities and were more likely to use AT successfully within the classroom.

Increased independence in students’ functional abilities should be a primary focus when developing IEP. AT can be a catalyst in achieving independence to prepare students toward functional life goals. Østensjø et al. (2005) analyzed the effects of environmental modifications and assistive devices on 95 children diagnosed with CP. These authors found a substantial reduction in the need for caregiver assistance with indoor and outdoor mobility and the self-care skill of eating. They also found a strong association between the child’s independence and caregiver demands, indicating AT that supported independence could affect the amount of care required for the child. Likewise, educators in the NCSE study were asked to rate the AT impact on the educational participation of their pupils. In general, ratings were considerably positive with the exception of overall school involvement, and educators pointed to improved participation and interaction by pupils, better preparation of materials, improved reading and writing, and better educational outcomes. Teachers also noted improvements in the educational engagement of their pupils. Particularly, they cited improved interest in educational issues, improved participation and interaction in class, better preparation of materials, and lower levels of stress and higher levels of confidence among their pupils. AT also influenced academic progress in terms of improved literacy and numeracy, better overall educational outcomes, and an improvement in homework quality (Wynn et al., 2016).

### 7.4 Environmental Factors to Promote AT in the Classroom

Technology can play an important role in creating an inclusive classroom. The combined use of ICT and AT in the classroom can facilitate inclusive practices in education. Significant changes can be made to curriculum content, delivery, and organization of mainstream programs through the effective use of technology. An example of the ubiquitous use of...
technology can be found within the Inclusive Learning through Technology (ILT), which involved the integration of technology in four schools, two mainstream, and two special schools. This was achieved through the provision of a range of hardware and software technology including the following:

- The provision of laptop computers for each student
- Interactive whiteboards
- AT provision for individual students
- Wireless broadband access
- Microsoft Office Suite
- Inspiration (mind mapping software)
- Video conferencing facilities
- MP3 players for each student

Classrooms were provided with laptop computers equipped with wireless network capability and the latest technology and software to provide easier communication and exchange of information. The interactive whiteboards facilitated alternative teaching methodologies and supported teachers to move to a more interactive approach. The whiteboards also allowed for synchronized teaching between the schools and direct interaction between teachers and students across schools via a virtual learning environment. A variety of software resources were provided with the whiteboards including Internet access, Kidspiration (www.inspiration.com/Kidspiration), and access to the Atomic Learning site (www.atomiclearning.com). Concept mapping software was introduced in order to scaffold students’ thinking process. In addition to the technological inputs, teachers were provided with training in the thinking skills developed by Edward De Bono and more specifically the Cognitive Research Trust Thinking Techniques (CoRT, 2004) for use in the classroom. The thinking skills program aimed to provide students with tools to improve their learning strategies in a move away from a unidimensional or entire group instruction to a more differentiated and learner-centered approach. The objective was to develop the students’ ability to think critically, to apply their learning, and to enable more creativity and flexibility. In addition, teachers were introduced to the use of mind mapping as a learning tool and to theories that support differentiated instruction. Differentiated instruction requires personalizing the curriculum in order to satisfy the individual learning needs of students, to capitalize on their strengths, and enhance their capabilities. Teachers were trained to recognize the wide range of learning styles/teaching styles used in differentiated instruction in acknowledgement of the significant effect that learning styles have on the learning and teaching process.

Teacher training was a crucial feature of the ILT project based on the belief that each teacher involved had unique talents and potential that could be nurtured, with the ultimate aim of improving teaching and learning. All professionals involved in the project attended continuous professional development (CPD) training. All new teachers were provided with a copy of the ILT summer course; there were a variety of small group sessions about the thinking methodologies used in the project for all teachers involved, and technical support was offered in small group or on a one-to-one basis.

For students to become proficient in AT use, a teacher should have the skills and comfort in using technology to provide opportunity for use and success. As with all subject areas, certain students exhibit different levels of proficiency. In a study by Craddock (2006)
on the use of AT with teenage students, three discernable groups of students emerged, distinguishable by the type of technology they used, how they used it, and how satisfied and comfortable they were with it. They were typified as the novice, transition, and power users. The power users were using high-end technology, such as voice recognition, screen readers, and other voice output systems. They exhibited more than just a pragmatic adaptation to the technology; they displayed an emotional attachment evidenced by how the students defined themselves in relation to their technology. Their technology released in them hitherto hidden beliefs and abilities. The students described the devices as inextricably associated with their self-image, recognizing that the technology changed their self-identity. Their “cultural capital” was increased, with the use of high-end portable technologies that enabled them first to “fit in” and second to compete and, in a number of cases, outperform their nondisabled peers. A key factor in becoming a power user was the length of time they were using technology: often starting its’ use as a young child, from the ages of five or six.

The picture emerged quite differently for the students of the novice users group. They had little formal support outside of the curriculum. Their first introduction to high technology came much later. Surprisingly, none of these students had any experience of AT or knowledge that technology could have provided easier access to the curriculum. For the novice users, timing was a critical issue; it was difficult for them to assimilate a novel technology a few months before one of the most important examinations of their careers. However, a number of the novice group did achieve a competence with the technology. These students are characterized as “transition users.” They incorporated the technology at a pragmatic level, but the lack of identification with the technology left them in a transitional period that perhaps with time and consideration could lead them to become power users of the technology.

Craddock (2006)’s study supports the need for the special education teacher to become familiar with the students’ needs matched to AT throughout the educational continuum. The special education teacher should become familiar with the roles of AT in the student’ environments, including transitional stages between educational environments (elementary-to-high-school-to-college). The goal of education is to prepare a student to function successfully in the world, including the home, work, social settings, and the work environment. The special educator should become familiar with technologies that can enhance the student’s success in these settings. Transitional planning meeting are crucial to assure that the AT required for success is in place to optimize the student’s success. Special educators should understand the transitional process and act as facilitators to assure that the student continuously receives the required AT when transitioning into these novel environments.

7.5 Going Forward: Universal Design for Learning

A model of framing the integration of technology in the school context is Universal Design (see Chapter 4). Universal Design is a strategy, which aims to make the design and composition of different environments and products accessible and understandable to, as well as usable by, everyone, to the greatest extent in the most independent and natural manner possible, without the need for adaptation or specialized design solutions. The main thrust of the UDL model is to support teachers in creating and adapting lessons in order to increase access and participation for all students. One of the main ideas is that of “flexibility,” that
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is, offering multiple methods of presentation and participation to students and offering them different ways to show their understanding. In other words, getting the pupils to read a book and write answers into a workbook only reaches a certain percentage of pupils. Many students do not perform well with narrow parameters, but may work well when work is presented in a different manner. While UDL is not technology-driven per se, technology does offer some of the flexibility that benefits all learners. For example, text-to-speech software will help the student who is struggling to read. In addition, text can be enlarged and font or background colors changed to help a student who finds it hard to distinguish text.

7.6 Case Evaluation

Craddock (2003) discussed nine stages in the service delivery process of AT:

- Outreach
- Initiative
- Assessment
- Typology of the solution
- Selection
- Authorization for financing
- Delivery
- Training
- Management and follow-up

By applying the above model to students, we can observe how the key elements of the MPT model—personal characteristics, milieu, and AT solution—combine to enable clients to fully participate in school, family life, and community. Our case studies will look at two students: Zoey, a young female student entering the preschool program and followed through into the intermediate school; and John, a secondary student with plans to transition to college.

7.6.1 First Case Study

Zoey is a 36-month-old female toddler who was diagnosed with Autism Spectrum Disorder and a Speech and Language delay at age two. She was born at 34 weeks, identical twin pregnancy, and cesarean delivery. Zoey required oxygen for the first 72 hours, and had jaundice, with Apgar score of 6. She was admitted into Pediatric Intensive Care Unit for one week owing to oxygen deficiency, difficulty with feeding, and severe jaundice. She was discharged home to parents and referred for home therapy services to monitor progress and development. Zoey’s twin sister did not have signs of developmental or neurological delays. Therapy services maintained on a consultative basis from two months of age as medical conditions were stabilized, and Zoey was successfully taking a bottle. Zoey had a history of ear infections; at age two, Zoey was not communicating and parents expressed concerns with regression in behavior and social engagement. Early childhood
services provided direct therapy program services owing to delays in social engagement/joint attention, limited communication, and motor praxis concerns. The case for this chapter jumps to Zoey at age 36 months at her transitional IEP meeting, as she is to begin educational services through the Pre-School Program for Children with Disabilities (PPCD) under the Individuals with Disabilities Act (IDEA).

During Zoey’s transitional IEP meeting, her occupational and speech and language therapist from her early childhood intervention (ECI) program met with the school educational team (special education [SE] teacher, school administration, diagnostician, occupational therapist [OT], physical therapist [PT], and speech and language therapist [SLP]) to discuss her current strengths, needs, and plan for education. Zoey’s current level of performance and participation in the home is described as follows: Zoey is an attractive young girl who enjoys movement and music. She has a very supportive family who has been engaged in therapy sessions through the early childhood program. Zoey’s parents have noted some progress in her communication and motor skills but have recently read about the language acquisition through motor planning program (LAMP) to facilitate communication (Schlosser and Wendt, 2008) and have requested consideration of a device to aide with communication. During the PPCD program evaluation, Zoey demonstrated decreased joint attention and engagement. She was easily frustrated if she is not able to get her needs met and escalated with her behavior. Her parents and therapists stated that she can become upset and may try to hit others when she is not able to communicate. She is motivated with music and seeks continuous movement. She demonstrated full range of motion but has weak core strength and decreased trunk rotation. Zoey has limited sustained attention and requires a multisensory approach to learning through visual model/representation and verbal prompts. Although she is able to sit on a chair, owing to her movement seeking behavior and decreased core strength, she tends to fall out of her chair. According to the educational testing, Zoey’s motor skills appear to be at 30 months for gross motor skills, 24 months for fine motor skills, and 15 months for communication, although they believe her receptive communication skills are higher than her expressive communication. Zoey scored within 15 months for behavior and social engagement. Her parents have used picture book when requesting items with some success and have used a simple low-tech static screen device. They also use sensory strategies at home for calming, and have incorporated some cause and effect activities as she likes to listen to picture books. Her vision acuity/convergence are mildly impaired but corrected with glasses. She demonstrated visual scanning with both smooth pursuit and saccades.

Her ECI therapists discussed the current AT they used in the home setting, which includes the following: visual schedules, communication picture book, low-tech voice output device, finished/reward box, and weighted blanket. She loves music and is engaged in computer-based learning tasks that use music as a positive reward. She does have some difficulty with holding items in her hands owing to sensory sensitivity and refuses to hold writing utensils; however, she is interested in using her Ipad for coloring and playing educational games.

Zoey’s parents’ main concerns are her communication delay. They feel that she would be able to engage more independently if she could talk. The team has tried a low-tech augmentative and alternative communication device (AAC), which included a picture book and a nine-icon static screen display. The team felt that she was able to find the icons on her voice output device but the static screen was limiting to her. Zoey is in the stage of Novice User at the age of 36 months working towards transitional user at age five. She becomes more independent as she moves into a transitional to power user stage successfully at
10 years of age. This case will look at Zoey at the age of 36 months and then at 10 years using her AT in the educational setting.

**Stages of AT Service Delivery**

<table>
<thead>
<tr>
<th>Stages of the AT Service Delivery Model</th>
<th>Zoey, Age 36 months Novice User</th>
<th>Zoey, Age 10 years Transitional to Power User of AT</th>
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<tbody>
<tr>
<td>Outreach</td>
<td>The educational team (SE teacher, OT, PT, SLP, and school psychologist) attend regional meeting to stay abreast on current AT available, they are part of the school’s AT team. Information on possible solutions is shared at Zoey’s IEP meeting.</td>
<td>Seven years later Zoey is in the 4th grade. She participates in an inclusion classroom partial day and an Academic Learning (AA) Class to address language arts, math, and social skills training. Zoey has taken ownership of using her communication device and uses videos to share her activities with her family and friends. Her teachers have attended an AT training course on social engagement and are interested in video role modeling for peer engagement as Zoey is at a critical age for peer relationships.</td>
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<tr>
<td>Initiative</td>
<td>The educational team, ECI team, and parent discuss the need to do an AT assessment to help identify Zoey’s need for AT aligned to her current goals/objectives and to identify the best solution for communication and transitions.</td>
<td>Zoey, SE teacher, and parents attend the regional AT center to look at the current technology available. SE teacher meets with AT team to discuss current needs and issues regarding her current technology (her current device is three years old). It is also time for her three-year re-evaluation and the team is considering to re-assess her current technology plan.</td>
</tr>
<tr>
<td>Pre-assessment and Assessment</td>
<td>The AT team (SE teacher, OT/PT/SLP) observe Zoey in the PPCD classroom and have identified the area of need related to Zoey’s IEP. They have identified key predisposition factors of AT use in Zoey: high motivation and comfort with technology, willing to learn new strategies with multisensory cueing, and support in both the home/school setting. Areas that may impede her use of AT are related to sensory/behavior meltdowns, can be inflexible, and training needs for inclusion teachers.</td>
<td>The AT team (including the SE teacher) observe Zoey in her classroom. They meet at her re-assessment planning meeting and discuss her current skill level and progress on IEP with use of AT. They note that her AT use has been mostly successful, although she has demonstrated some increased frustration with writing tasks, and less use of her communication device in her inclusion classrooms, specifically her Language Arts classroom. At the meeting, her parents discuss interest in using a grant to purchase a new device through an Autism Foundation. They have expressed concern for her current communication system’s voice selection is not always conducive to her current needs. Although she is able to use more verbal communication, they feel Zoey has difficulty with expressing herself in a timely manner and would like a device application that satisfies all of her needs. They also discuss the need for her device to have word processing capability for her writing assignments, because this is a high focus area for the next year. The team identifies Zoey’s current success with AT and feel that an AT re-assessment to determine specific need areas and device features required on an ATD to help Zoey achieve her IEP goals.</td>
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Stages of AT Service Delivery (*Continued*)

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<td></td>
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In re-assessing her current predisposition factors, they found that Zoey is still motivated to use technology and is motivated to use her device to share about her interests and weekend plans. The team reported that she uses her device less in her inclusion classrooms but they have also noticed a lack in participation when she is in her language arts classroom.

The AT Team reviews the previous MATCH-ACES assessment and AT follow-up scores over the past three years to update Zoey’s current area of need related to IEP and her overall performance. Zoey has improved in her expressive communication skills, although she still has issues with speech clarity, pragmatic delay, and word retrieval for age-level conversations with peers, she does require the use of an AAC with more peer-age level set-up. Zoey also indicates that she does not like the voice of her device and expresses interest in a voice that sounds more like a “teenager.” The team discusses possible solutions for her communication application. The SLP provides feedback on expressive communication word bank that should be included on ATD. The OT recommends the need for a device that also includes video capability for role modeling and specific applications that can target social engagement. The OT also looks at the device compatibility with Word 365 online version for mobile devices, and Google Docs with word prediction extensions. Two device systems that have these features are tried.

Arrangement was for Zoey to trial the next level of high-tech AAC device; one device was on loan from the Regional AT Centre and the other device was available through the school’s AT loan library. She trialed two different devices that included the specific features outlined on the AT assessment device feature form. Zoey had progressed from an initial 20-icon to a 45-icon page and was able to navigate through dynamic pages. Both AAC devices were compatible with the school’s current network/computer system. SE teacher felt it was more compatible. After a four-week trial of each device, the team felt that there was a need to upgrade Zoey’s AAC device, as the device provided more language icon choices with appropriate peer conversation program capability, included video role modeling opportunity, and access to cloud-based word processing. The AT team recommended this option.

Although Zoey’s sensory needs have considerably improved, she still required the use of the weighted lap pad and fidgets at times related to increase stress, such as testing or large group activities. The IEP team agreed with the current recommendations.

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### Stages of AT Service Delivery (Continued)

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<tr>
<td>Authorization for financing</td>
<td>The IEP team agreed that the AAC device was essential for Zoey to achieve her IEP goals. Smaller light-weight AAC device was selected owing for portability needs, and the device capability matching Zoey’s needs. The SE teacher contacted the AT team, and the team sent the request for the device purchase.</td>
<td>The school owned the previous AAC device. The AT team and vendor discussed with parents the availability of an Autism grant they may want to pursue if they wanted to purchase the AAC device personally or the district would provide the device (and it would be owned by the school). The AT team had a similar device in storage that they could use in the interim, while they waited for the purchase of the novel device. The parents discussed options and wanted to try for the grant device first, and in interim use the district’s device.</td>
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<tr>
<td>Delivery</td>
<td>The AT team met with the SE teacher to deliver the device within a three-week time, and the AC loan was returned to the regional center.</td>
<td>The AT team met with funding agency and parents and completed the grant information for the AAC device. While the grant was waiting for approval, the AT team, SE teacher, parent, and Zoey set up the use of the Districts AAC device that was used with success in the trial as it was similar to the device that was being purchased. The grant process took four months for approval and delivery.</td>
</tr>
<tr>
<td>Training</td>
<td>The SLP and OT met with the SE teacher, regular-education teacher, Zoey, and her parents to set up the device and training. The OT and SLP worked together with SE teacher on programming the device and teaching strategies so that all staff and parents were consistent with helping Zoey use her device. SE teacher was responsible for carryover of the AT implementation and also to contact AT team for maintenance. The parents incorporated the device in the home setting. The SE Teacher, OT, and SLP attended regional training on the LAMP program to facilitate communication through the use of the AAC device use in the classroom.</td>
<td>The SLP and OT met with SE teacher, regular-education teacher, Zoey, and parents to set up the novel device when it arrived. The OT and SLP worked together with SE teacher and Zoey to incorporate the key phrases and words for both peer communication and academic-based lessons. The SE teacher continued to be responsible for the carryover of the AT implementation and also to contact AT team/parents for maintenance. The AT team worked with inclusion teachers, and the SE teacher was a liaison for questions related to the communication device. A data collection form was developed to target the use of her device in inclusion classrooms. The SE teacher and OT trained inclusion teachers on Zoey’s device and the features including word processing for writing, video use when required to explain the task with a visual model. The SE Teacher attended regional training on best practice for students with Autism.</td>
</tr>
<tr>
<td>Management and follow-up</td>
<td>The SE teacher and regular-education teacher (Zoey will be going into an inclusion kindergarten with support) meet periodically to discuss Zoey’s progress. AT team follow-up quarterly through email and observation checks.</td>
<td>The SE teacher documented the AT modifications that were required for state-testing. The SE teacher documented the equipment in IEP for transition to the next school. The OT and SLP continue to meet with SE teacher and regular-education teacher to discuss and support Zoey’s needs in the areas of communication, sensory, and social skills. The SLP continues with follow-up on communication programming needs with the SE teacher.</td>
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Stages of AT Service Delivery (Continued)

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<tr>
<td>The SE teacher and paraprofessionals continue to do activities to facilitate the use of the communication devices, and Zoey is using her device in both the school and home setting. Zoey also has been successful with utilizing her sensory strategies within the classroom. It is noted that there has been a decrease in her melt-downs with the incorporation and follow-through of the recommended AT. At the age of five, Zoey has been successful with her devices and started to take ownership of her device. She is moving toward developing skills as an AAC user and moving into the transitional user phase of AT.</td>
<td>At this time, Zoey is successfully using the device. She is able to navigate the word processing application, and word prediction to complete written assignments. She has become efficient with using her AAC device and an increase in oral statements and word use has been noted. She uses her AT tools through-out the day and she has accepted the AAC device as part of her persona. Her parents and SE teacher are very supportive and her AT devices and strategies are available in her classrooms.</td>
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7.6.2 Case 2: John

John is a young man with Athetoid CP. He attended his local mainstream primary school for seven years, then moved to a mainstream secondary college and progressed then to the third level education. The case study introduces John at the age of seven as a novice user of technology. The case study moves forward to when John is a young man of 17 and a power user of technology. Power and novice users refer to a study of students transitioning from second to third level education conducted by Craddock (2006). Three discernable groups of students emerged from the study distinguishable by the type of technology they used, how they used it, and how satisfied and comfortable they were with it. They were typified as the novice and power users with students progressing between the two stages characterized as transition users. The study also determined that students progressed to being power users of technology when they were introduced to technology at the primary level, had teachers who were comfortable with the technology, and had a supportive home environment.

John appeared to have an intuitive sense for AT, he was successful the first time he was introduced to AT, as he pressed the head switch for access that was attached to his wheelchair.

Stages of AT Service Delivery

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<thead>
<tr>
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<th>John, Age 17 Power User of AT</th>
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<tbody>
<tr>
<td>Outreach</td>
<td>Teacher visits annual AT conference trade show. Sees technology that maybe suitable for one of her students. Collects contact information of Local Technology Liaison officer (TLO)</td>
<td>Ten years later John is now in second level education, keeping up to date with new technology by searching the web and communicating with users on an online national user discussion forum.</td>
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Stages of AT Service Delivery (Continued)

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<tr>
<th>Stages of the AT Service Delivery Model</th>
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<th>John, Age 17 Power User of AT</th>
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<tbody>
<tr>
<td><strong>Initiative</strong></td>
<td>Teacher discusses with John’s parents about having an assessment for AT. Parents agree and fill out a pre-assessment form with the support of the local TLO.</td>
<td>John finds the Eye Gaze technology and shows the information to his teacher who in turn contacts the local Special Educational Needs Officer (SENO)</td>
</tr>
<tr>
<td><strong>Pre-assessment and Assessment</strong></td>
<td>TLO visits the school to see the teacher and observe John in the classroom and how he participates. TLO demonstrates and trials a selection of AT devices with John. Being only age 7, teacher, parents, and TLO invite AT Assessment Team to assess John in school</td>
<td>John is frustrated with current slow speed of his technology and feels an Eye Gaze system would help him speed up with his writing</td>
</tr>
<tr>
<td><strong>Typology of the solution</strong></td>
<td>AT Assessment Team assess John using the MPT. A number of devices are tried; however, John, having seen a number of the devices previously, is most interested in the round head switch that is easily attached to his wheelchair. He is delighted when he was able to type his own name for the first time on the computer screen.</td>
<td>Liaising with his teacher, SENO and local TLO John applies to trial a portable eye gaze system. There is a waiting list with varying times depending on need. However, eventually an outreach team assesses and offers an eye gaze system for trial and suggests the use of his existing system as a backup and portable device for movement between classes in school.</td>
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<tr>
<td><strong>Selection</strong></td>
<td>Arrangement agreed between John’s teacher and the TLO to have a loan of a desktop computer with the switch and the special software to trial for a month. TLO visits once a week to show the teacher and John some more features of the software. At the end of the month, TLO and teacher discuss with John and his parents and all feel this is a very good solution for John.</td>
<td>Trial of the Eye Gaze system is arranged with the local TLO; within three weeks, technicians from the assessment team provide John with a month’s trial of the system and finds his typing speed has doubled.</td>
</tr>
<tr>
<td><strong>Authorization for financing</strong></td>
<td>The TLO liaises with the rest of the assessment team and a recommendation is forwarded to the parents and the teacher for the school to submit to the Department of Education for funding. In the meantime, the loan period of the equipment is extended until novel equipment arrives. At the review, John is assessed using the MPT and the results show a good match.</td>
<td>SENO with technical support from TLO make a recommendation for the new EyeGaze equipment to the Department of Education. Within three months, the recommendation is passed and the EyeGaze system is ordered.</td>
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<tr>
<td><strong>Delivery</strong></td>
<td>Three months later the novel equipment arrives and the teacher with the support of the Local TLO assemble and test the equipment is working. The loan equipment is returned.</td>
<td>Equipment was delivered to the school, and John supports the teacher in installing the system on his laptop computer.</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>TLO works closely with John’s teacher to show how the novel system works and once a month for a half-year period the TLO spends an hour with teacher on demonstrating novel educational software that the teacher can use with John but also the rest of the class.</td>
<td>John being a Power User of Technology trains himself in using the new equipment and finds U-Tube videos of other users of the technology to help him speed up his writing. He is now six times faster in typing using his new system, and now he is looking forward to going to the third level education.</td>
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Stages of the AT Service Delivery Model

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<tr>
<th>Management and follow-up</th>
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<td></td>
<td>The teacher works with John on a six-month period over the next couple of years. Liaises with the TLO on novel software and some maintenance issues such as the switch, computer interface, and the ink cartilages for the printer.</td>
<td>John now uses Skype to contact the TLO if there are any maintenance issues. John works with the TLO and SENO on producing a SON specified to his AT needs and requirements for successful transition to the third level</td>
</tr>
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</table>

Note: The Systematic Template for Assessing Technology Enabling Mainstream Education (STATEMENT) project was funded under the European Horizon initiative (2006). Its purpose was to produce a Statement of Need specific to Assistive Technology for students progressing from second level to post-second-level education. This is similar to having a “passport” that empowers the student to transition to other institutions and present his/her passport to what they use and/or require to be successful users of AT in the new setting.

7.7 Conclusions

This chapter outlined the important role of the special educator in provision of AT within education. It was proposed that the special educator must feel “comfortable and interested” in the use of technology in order to support successful use of AT in the classroom. It was discussed that a successful AT assessment must include an understanding of the personal characteristics of the person and their predisposition for technology use. Furthermore, it is critical for the special educator to bring information regarding students’ needs to the interdisciplinary assessment team. To achieve teacher comfort in technology, training is essential and outlines the inclusive learning through technology as an example of technology integration and teacher training. This chapter also provides an insight into the successful and unsuccessful users of technology and outlines the factors that can determine use or nonuse of AT. Finally, as technology advances with and AT products increase with support from the mainstream market, the authors outline the next stage of technology provision within the classroom, Universal Design for Learning. Ultimately, providing an educational environment, where classrooms are designed to cater for all types of students regardless of their disability or special need, is optimal. It is imperative for the teacher to recognize that all students have varying ability, and it is a measure of their ability not disability that should determine how their education is supported. The classroom should provide a range of supports for any student who may have issues in accessing the curriculum, from reading difficulties to writing to understanding. A special educator should have the knowledge, skills, and competence backed up with the support of technologies to support all within the education environment.

7.8 Summary

This chapter describes the importance of AT to support students in education and the role of the special educator in the process of integrating AT for students with disabilities into the educational system. The special educator is essential in the AT assessment and
implementation process by providing knowledge of the students’ educational capabilities and supporting students in their daily academic activities using assistive technology. It is imperative that school administrators provide special educators opportunities for AT education and training in order to stay abreast on AT tools and implementation strategies. It is also vital that the Special Educator work alongside the educational team to provide support and knowledge as the student transitions through the stages of educational learning using AT.

Disclaimer

The views expressed by Dr. Ger Craddock are his own and are not of his employer the National Disability Authority.

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References


The Psychologist

Fabio Meloni, Stefano Federici, Aldo Stella, Claudia Mazzeschi, Barbara Cordella, Francesca Greco, and Massimo Grasso

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8.1 The Languishing Role of the Psychologist in Assistive Technology Assessment

Psychology itself is dead. Or, to put it another way, psychology is in a funny situation. My college, Dartmouth, is constructing a magnificent new building for psychology. Yet its four stories go like this: The basement is all neuroscience. The first floor is devoted
to classrooms and administration. The second floor houses social psychology, the third floor, cognitive science, and the fourth, cognitive neuroscience. Why is it called the psychology building? (Gazzaniga, 1998, pp. xi–xii).

Together with the neuroscientist Gazzaniga, we ask why the biopsychosocial model, one of the classifications of the ICF: International Classification of Functioning, Disability and Health (ICF; WHO, 2001), is labeled as such when it contains nothing psychological? We do not believe that psychology is defunct, but surely (clinical) psychologists risk not being able to find it in the World Health Organization’s disability model if it does not build a “floor” for psychology. Maybe it would not be so bad if the problem were just circumscribed to (clinical) psychologists’ occupation in the world. It is considerably bad if psychology perhaps has the tools to prevent the abandonment of assistive technology (AT) (Federici and Borsci, 2011, 2016; Federici, Meloni, and Borsci, 2016; Lenker and Paquet, 2004; Phillips and Zhao, 1993; Riemer-Reiss and Wacker, 2000; Scherer, Sax, Vanbiervliet, Cushman, and Scherer, 2005; Söderström and Ytterhus, 2010; Verza, Carvalho, Battaglia, and Uccelli, 2006; Waldron and Layton, 2008; Zimmer and Chappell, 1999) in order to guarantee a user-driven AT assessment (ATA) process through which the selection of one or more technological aids for an AT solution is facilitated by the comprehensive utilization of clinical measures, functional analysis, and psycho-socio-environmental evaluations that address, in a specific context of use, the personal well-being of the user through the best matching of the user and the AT solution.

In a search of the terms “psychologist role” and “disab*” or “rehabil*” in the “abstract” field of the main databases of scientific indexes such as the Cambridge Scientific Abstracts (CSA), PubMed, Medline, PsyArticle, PsyInfo, Eric, and Ebsco, from 1900 to date, the findings are astonishing: There are 69 products between 1973 and 2016. By eliminating studies referring to school psychologists or related only marginally to the (clinical) psychologist’s role in rehabilitation and AT assignation, the number of products is reduced to 49, comprising eight chapters in books and monographs, and 41 journal articles. Twenty-three of them were published in the 26 years between 1973 and 1999, and the remaining 23 in the last 17 years. We found just four conference papers (Federici, Corradi, Mele, and Miesenberger, 2011; Meloni, Federici, and Stella, 2011; Mitani et al., 2007; Nihei, Inoue, Kaneshige, and Fujie, 2007) in the Association for the Advancement of Assistive Technology in Europe (AAATE) conference proceedings by searching “psycholog*” in the title or in the abstract.

The international scientific literature has never given a clear definition of the role and competencies of the psychologist in the rehabilitation field. In the process assessment of AT, the psychologist’s role is given, but it typically seems to be narrowed down to the testing and diagnostic phases.

The professional skills of psychologists and their usefulness in the following are all issues of minor relevance in the AT scientific literature (Barry and O’Leary, 1989; Scherer, 2000):

1. Advocating the user’s request in the user-driven process through which the selection of one or more technological aids for an AT solution is reached
2. Acting as a mediator between users seeking solutions and the multidisciplinary team of a center for technical aid
3. Team facilitating among the members of the multidisciplinary team, and finally
4. Reframing the relationship between the clients and their families within the framework of the new challenges, limitations, and restrictions they face
Nevertheless, the recent advance of the biopsychosocial model in the social and scientific communities (Plante, 2005), the integration of objective and subjective measures in the diagnostic process (Federici and Meloni, 2010; Kayes and McPherson, 2010; Ueda and Okawa, 2003; Uppal, 2006), the recognized relevance of contextual factors, particularly the personal ones affecting the long-term success of AT matching (Nair, 2003; Scherer, Craddock, and MacKeogh, 2011; Scherer et al., 2005), and the increasing attention given to the “imbalance of power” (Brown and Gordon, 2004, pp. S12–S14) in the relationship between professionals and users all require a change in the attitudes and practices concerning the role of the psychologist in the entire process of AT assessment and provision.

It is reasonable to assume that the deafening silence on the psychologist’s role in the ATA process is largely owing to the absence of personal factor codes in the ICF.

8.2 Nothing about “Psycho” without Psychologists: The ICF and the Need for Its Revision

The second part of the ICF covers “contextual factors,” which are divided into two components: environmental factors and personal factors. The latter are not actually coded in the ICF framework, but are involved in the process of functioning and disability, and are comprised in the conceptual background of the Classification (Geyh et al., 2011). Personal factors are defined in the ICF as “the particular background of an individual’s life and living and comprise features of the individual that are no part of a health condition or health states” (WHO, 2001, p. 23). They include

- gender, race, age, other health conditions, fitness, lifestyle, habits, upbringing, coping styles, social background, education, profession, past and current experience, overall behavior pattern and character style, individual psychological assets and other characteristics, all or any of which may play a role in disability at any level. (WHO, 2001, pp. 23–24)

They encompass one domain (internal influences on functioning and disability) and one construct (impact of the attributes of the person) (Table 8.1). The domain is “what” the ICF classifies in each of its components at the highest semantic level (e.g., mental functions, structures of the nervous system, learning and applying knowledge, etc.). The construct refers to “how” each category is weighed in an operational manner by using specific qualifiers. For example (WHO, 2001, p. 217 Annex 2), the performance of a person (positive aspect: functioning qualifier to weigh) who lost a leg (body structure domain [cod. s750]; negative aspect: impairment qualifier [cod. s750.4]) in a work-related accident and since then has used a cane (environmental factor construct [cod. e1201; positive aspect; facilitator qualifier e1201.+3], but faces moderate difficulties in walking around (activity and participation construct; negative aspect: activity limitation qualifier [cod. d4500.2]) because the pavement in the neighborhood is very steep and has a very slippery surface (environmental factors construct: negative aspect: barriers qualifier [cod. e2100.–3]) is classified as “moderate restriction in performance of walking short distances”: cod. d4500.2.

In the previous vignette, the use of the aid, that is, the cane, reduces the impact of the physical impairment and the environmental barriers on the individual’s capacity
TABLE 8.1
An Overview of the ICF

<table>
<thead>
<tr>
<th>Components</th>
<th>Part 1: Functioning and Disability</th>
<th>Part 2: Contextual Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domains</td>
<td>Body functions and structure</td>
<td>Activities and participation</td>
</tr>
<tr>
<td></td>
<td>Body functions</td>
<td>Life areas (tasks, actions)</td>
</tr>
<tr>
<td></td>
<td>Body structures</td>
<td></td>
</tr>
<tr>
<td>Constructs</td>
<td>Change in body functions (physiological)</td>
<td>Capacity Executing tasks in a standard environment</td>
</tr>
<tr>
<td></td>
<td>Change in body structures (anatomical)</td>
<td>Performance Executing tasks in the current environment</td>
</tr>
<tr>
<td>Positive aspect</td>
<td>Functional and structural integrity</td>
<td>Activities and participation</td>
</tr>
<tr>
<td></td>
<td>Functioning</td>
<td></td>
</tr>
<tr>
<td>Negative aspect</td>
<td>Impairment</td>
<td>Activity limitation and Participation restriction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


and performance, although the individual’s capacity without assistance and/or in a standardized environment might be considered more severe (e.g., cod. d4500.2 3). This entire assessment process may be performed by a multidisciplinary team where a (clinical) psychologist might not be necessary, because competence in human cognition, emotion and behaviors, and social relations systems are not essential for classifying the person in the example or for assigning him the aid (the cane). According to such biosocial perspectives on functioning and disability classification, “psycho” remains merely a prefix to a word to say that the internal influences and the impact of the attributes of the person on functioning and disability are not considered, thus preventing the cultural and professional development of (clinical) psychologist figures even in the field of an AT assessment process. Universally, in a center for technical aid, the clinical psychologist does not belong to the center’s multidisciplinary team of professionals, often being present merely as an external consultant. Engineers, physiotherapists, and specialists in rehabilitation (e.g., speech and language pathologists, audiologists, optometrists, special educators, and occupational therapists) typically comprise the internal team of a center for technical aid and outline the current biosocial outlook on disability.

The ICF imputes the lack of codes for the personal factors to “the large social and cultural variance associated with them” (WHO, 2001, p. 9). However, the real novelty of the biopsychosocial model compared to the previous medical and social ones is precisely the presence of the “psycho” prefix between “bio” and “social.” The failure in coding, such an important component of the contextual factors 10 years after the ICF edition, given its distinctive value for the entire classification, creates a disturbing parallel between the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) of 1980 (WHO, 1980) and the ICF. In fact, the ICIDH aimed to describe and represent disability in terms of the social model, but ended up revealing a
substantial consistency with the medical model: similarly, the ICF seems to ignore the call to complexity implied in the biopsychosocial model, and is only, literally, an integration between the medical and social models, without a comparatively real qualitative leap. The psychological variables comprised in the ICF personal factors can make a substantial difference in the rehabilitation process; particularly, they play a central role during the AT assessment process. The lifestyle, the coping style, the social and cultural background, or the character style really determine the success in matching the person with the technology (Federici, Scherer, and Borsci, 2014; Scherer, 2005b). An appropriate psychological evaluation or a precise clinical intervention with the users and/or their significant human context over the course of the whole AT assignment process may prevent, for example, the abandonment of the AT solution provided, which is a big problem in the matching outcome (Federici et al., 2016; see Chapter 3). It is reasonable to assume that the lack of importance given to the “systemic” skills of the psychologist in the process of matching the person with the technology is largely due to the noncoding of personal factors in the ICF.

The ICIDH needed to be revised, as there was a need to include environmental factors in the coding scheme (Pfeiffer, 1998); today, we claim that the ICF needs revision, as there is an urgent need to develop the personal factors (see also Steiner et al., 2002). Moreover, as Geyh et al. (2011) discussed in concluding a literature review on the conceptualization of the personal factors component of the ICF, personal factors:

have not been studied extensively or are undervalued (Cruice, 2008; Lehman, 2003; Threats, 2007; Weigl, Cieza, Cantista, Reinhardt, and Stucki, 2008) […]. It is suggested that one aim of further research should be the development of PF categories within the ICF (Khan and Pallant, 2007). (p. 1097)

8.3 The Personal Factors of Functioning and Disability

The recent literature review, already cited in the previous paragraph—conducted by Geyh along with other eminent scholars of the ICF Research Branch and Classifications, Terminology and Standards Team of the WHO (Geyh et al., 2011) on the conceptualization of the personal factors component of the ICF—yielded 353 citations in 79 papers. Five hundred and thirty-eight statements about personal factors were classified. Authors, in addition to conceptual statements, have identified personal factors (Badley, 2006; Fougeyrollas, Cloutier, Bergeron, Cote, and St-Michel, 1999; Ueda and Okawa, 2003; Verbrugge and Jette, 1994; Viol et al., 2006). These authors have maintained that there is a need for standardization, pointing to “the potential of PF (personal factors) in enhancing the understanding of functioning, disability and health, in facilitating interventions and services for people with disabilities, and strengthening the perspective of individuals in the ICF” (Geyh et al., 2011, p. 1089).

An outline list of personal factors has already been provided by the ICF and the ICF-CY: “gender, race, age, other health conditions, fitness, lifestyle, habits, upbringing, coping styles, social background, education, profession, past and current experiences, overall behavioral pattern and character style, individual psychological assets” (WHO, 2001, pp. 23–24; 2007, pp. 15–16). A more comprehensive list of 238 examples of personal factors not named in the ICF definition was created by Geyh et al. (2011), who collected all those
named in 23 papers out of the 79 reviewed. Most of the listed 238 factors are found in just one paper (n. 199). Of the 39 remaining concepts, the consensus of more than five papers converges on only three concepts: self-efficacy (13), motivation (7), and personality (7). These findings prompted the authors to claim “a need for further standardisation in relation to personal factors as part of the ICF” (Geyh et al., 2011, p. 1099).

The contexts in which personal factors are most frequently mentioned are the rehabilitation of communication disorders and musculoskeletal conditions. In any event, there is universal agreement on the role of personal factors in all stages of the rehabilitation process (Geyh et al., 2011; Gutenbrunner, Ward, and Chamberlain, 2007; Steiner et al., 2002), especially “when the ICF was introduced as a framework for comprehensive, holistic and multidisciplinary assessment in a clinical context” (Geyh et al., 2011, p. 1097). But what about personal factors and assistive devices?

### 8.4 Personal Factors and AT Solutions

According to the authors of the above-mentioned reviewed literature (Geyh et al., 2011), personal factors are prevalently mentioned in papers related to occupational and vocational rehabilitation, psychiatric rehabilitation, rehabilitation counseling, and psychosocial care intervention; they are addressed in just four papers related to assistive devices (Barker, Reid, and Cott, 2006; Cruice, 2008; Henderson, Skelton, and Rosenbaum, 2008; Howe, 2008). In addition to these four papers, Stephens and Kerr (2000), Pape, Kim, and Weiner (2002) Scherer et al. (Scherer, 2005a, 2011; Scherer, Cushman, and Federici, 2004; Scherer and DiCowden, 2008; 2005), and Jahiel and Scherer (2010) have indicated that relevant personal factors have an impact on the use and abandonment of assistive devices, consistent with Philips and Zhao’s findings in 1993 in their famous research to determine how technology users decide to accept or reject assistive devices: Three out of four factors significantly related to abandonment—lack of consideration of user opinion in selection, easy device procurement, and change in user needs or priorities—were related to personal factors (Phillips and Zhao, 1993).

Notwithstanding the scarcity of the attention given in the international scientific literature to the role and competencies of the psychologist in the ATA process, it has been universally ascertained that personal factors are an essential and unavoidable dimension for the best matching of the user and device. This outlook has pushed scholars in the AT field to reword AT as AT solution, in order to stress that it is more than a technological device for a technical fix or to overcome a disablement (Roulstone, 1998). It involves “something more than just a device, it often requires a mix of mainstream and assistive technologies whose assembly is different from one individual to another, and from one context to another” (AAATE, 2003, p. 3).

A useful tool for identifying the personal factors that might play a decisive role in successfully matching user and AT is provided by the paper of Pape et al. (2002). In this review article, 81 publications were considered in an effort to individualize the meanings assigned to AT and how these personal meanings influence the integration of AT into daily activities (p. 5). In addition to each personal factor code retrieved from the literature reviewed, the paper offered a novel tool for seeking the meanings ascribed to AT by individuals. A topic guide implemented by questioning routes makes up a worksheet for the exploration of personal factors. The questions are classified under two main criteria: disability types and
8.5 The Psychologist in a Center for Technical Aid: The Specialist in Personal Factors

As stated by Scherer et al. (2011),

[p]eople’s predispositions to, expectations for, and reactions to ATD [assistive technology device] use are highly individualised and personal. These predispositions, expectations and reactions emerge from such influences as varying needs, abilities, preferences and past experiences with and exposures to technologies. Importantly, predispositions to use support (as well as realised benefits from use) also depend on one’s sense of well-being and satisfaction with current performance of activities and participation in daily life events (p. 812).

Out of all the professionals comprising the multidisciplinary team, psychologists are the ones who, in terms of curriculum and training, are the greatest experts in personal factors as they are conceptualized by the ICF, expertise that they only partly share with psychotechnologists (see Chapter 9). The skills of psychotechnologists are more focused on the technological side of matching the person with technology and less oriented to the clinical and psychological dimensions of human–technology interaction:

Psychotechnologists are experts in Information and Communication Technologies (ICT), in particular, in Human–Computer Interaction (HCI) and human factors. They analyze the relations emerging from the person–technology interaction by considering the following:

(a) All the psychological and cognitive components which […] are directly involved into the technological system as a fundamental and dynamic part of it, and (b) The possibilities of adapting and designing eSystems and eServices in an adaptable and accessible manner (eAccessibility). (Chapter 9).

Division 22 of the American Psychological Association, by reporting Scherer and colleagues’ (Scherer et al., 2004) entire entry in The Corsini Encyclopedia of Psychology and Behavioral Science (2004) noted that the “rehabilitation psychologist works with the variation factors. The first relates to four disability types: disability due to aging, acquired disability, congenital disability, and disability due to a progressive disorder. The variation factors relate to the type and morbidity of impairment, namely the peculiarities referable to the body factors: impairment type and degree, illness type and severity, origin and diagnosis of disability, and functional improvements. The authors then transformed the personal factor concepts emerging from the 81 papers reviewed using operationally probative questions. These probative questions involve psychological, cultural, and adaptation issues (Pape et al., 2002).

In spite of the scarcity of scientific works focusing on the relations between personal factors and the assignment of suitable AT according to a biopsychosocial perspective, the personal factors emerge as central to successful matching. Therefore, the most skilled professional profile in the knowledge of individual features and behavior is definitely that of the psychologist.
individual with a disability to address personal factors impacting on the ICF domains of activities and participation” (p. 802). Moreover, it illustrates most of the issues that should be investigated by a psychologist in a center for technical aid:

Neurocognitive status, mood and emotions, desired level of independence and interdependence, mobility and freedom of movement, self-esteem and self-determination, and subjective view of capabilities and quality of life as well as satisfaction with achievements in specific areas such as work, social relationships, and being able to go where one wishes beyond the mere physical capability to do so. (p. 802).

Since psychologists work on the adaptive changes on the human side of the person–environment polarity, they should take care to know the features and properties of the personal factors. One of the most relevant categorizations focuses on the personal factors that are changeable and that are not changeable (Geyh et al., 2011; Howe, 2008; Threats, 2003, 2007). Ethnicity, language, cultural background, gender, age, developmental level, sexual orientation, and sexual identity are all unchangeable personal factors that highly affect, in a given context, the relation of the user with a technology (Geyh et al., 2011; Howe, 2008; Threats, 2003, 2007). This distinction plays a central role, because the psychologist, according to humanistic and cross-cultural psychology principles (Olkin, 1999), promotes the users’ awareness of the individual resources on which they can operate in order to obtain the best person–technology matching and empowers the users’ well-being. In other words, the team of the center for technical aid operates not only to turn environmental barriers into facilitators, but also to motivate users to do the same in their adjustable individual resources. The psychologist encourages the users to explore their individual features and to leverage all their personal factors that can disclose an adaptive potential in a given context.

Another main distinction within personal factors concerns the difference between objective and subjective factors. As reported by Wade (2000), “the focus of rehabilitation is the patient’s activities, their behavior” (p. 115), but “the nature of a patient’s beliefs and expectations can influence the extent and nature of disability, and indeed may on occasion be the primary cause” (p. 117). The subjective dimension of functioning has been described by Ueda and Okawa (2003) as a combination of negative and positive subjective experiences situated at a “psychological–existential level” (p. 599). The subjective dimension is strictly linked with the objective one, interrelated and interacting, but also strongly independent of each other. Ueda and Okawa (2003) made a distinction between personal factors and the subjective dimension because they put almost all the traits proposed in the literature as belonging to personal factors within the objective level. Aside from whether or not any consideration of the subjective dimension of functioning is gathered by the personal factors of the ICF and the extent to which they overlap, there is no doubt that the “psychological–existential level” should be held in high consideration by the psychologist. In other words, objective and subjective dimensions are concerned from the different points of view of individual functioning: On the side of the professional, most of the ICF’s dimensions can be viewed as objective dimensions, for a codifiable and measurable individual functioning; on the side of the user, most of the ICF codes are relevant insofar as they are elements of subjective individual functioning or disability experience. Because the goal of the ATA process is user well-being, by providing the best match of user and AT solution, with human well-being as an outcome of a subtle equilibrium between the subjective and objective dimensions of health (Federici and Olivetti Belardinelli, 2006; Sen, 2002; see Chapter 2), the
The psychologist should pay significant attention to balancing the subjective and objective factors by mediating between the user's request and the multidisciplinary team's AT solution provision.

The psychologist should give special attention to the difference between body functions and personal factors. As reported by Threats (2007), there has been some confusion in the literature between those two components, and it is very important to make the right attribution, especially during the assessment stage. In a center for technical aid, this distinction may become particularly relevant when the professional measures the predisposition of the user to use the technology. Technology use was found to be influenced not only by factors associated with the user's environment and the characteristics of the technology but also by the nature and characteristics of the purpose of the use and by the personal characteristics of the user (Scherer, 1999, 2002). Properly encoding the predisposition to use the technology allows the identification of the solution that is the best match. For example, if a client with a palsy due to a car accident indicates a lack of confidence with technology prior to the incident and a continuation of that lack of confidence after the accident, this trait may be considered a personal factor. However, if the client reports a reduction in confidence in association with the onset of the palsy, this factor may be categorized within the body function component (Howe, 2008). From this point of view, the Matching Person and Technology (MPT) series of assessments (Scherer, 1999) is a useful measure to make the right attribution concerning the technology predisposition of the user:

The MPT model and accompanying assessment instruments address three primary areas to assess as follows: (a) determination of the milieu/environment factors influencing use; (b) identification of the consumer's needs and preferences; and (c) description of the functions and features of the most desirable and appropriate technology. (Scherer and Cushman, 2001, p. 127)

Two instruments within the MPT tool kit are particularly suitable for the psychologist's use: the Assistive Technology Device Predisposition Assessment (ATD PA) and the Survey of Technology Use (SOTU). The ATD PA is a self-report questionnaire with items on a 5-point scale and yes/no questions that measures an individual's predisposition to and readiness for ATD use. The follow-up version assesses the realization of benefits from the selected ATD and the reasons for situations of nonuse. The ATD PA was developed to help reduce inappropriate ATD recommendations and the frustration that often accompanies a poor match of person and device (Scherer et al., 2011). In addition, some of the areas investigated by the ATD PA (Section B: Well-Being, Quality of Life, and Section C: Psychosocial factors) offer insights for further investigations of the personal traits of the user (Scherer, 2005a). The SOTU is another MPT instrument designed for professionals considering providing an individual with any kind of technology, but who suspect that the individual may be reluctant to use it. The psychologist's purpose in administering the SOTU is both to detect if users feel that the use of technology threatens their well-being or self-esteem, and to help them discover the positive aspects of use (Scherer, 1999).

Concluding this section, we hold that the psychologist's profile in a center for technical aid is that of a specialist in personal factors, who, more than a rehabilitator, is an enhancer and an "empowerer" of personal awareness, a mediator and defending counsel for the personal and subjective factors in the multidisciplinary team of professionals.
8.6 Outlining the Psychologist’s Role in the ATA Process Model

Although we do not believe that psychology is defunct, as we held above in contradiction to Gazzaniga’s statement, modern psychology has assumed a paradoxical attitude toward disability that does not facilitate the formation of a clear role for the psychologist in the field of disability. On the one hand, Finkelstein’s (1998) autobiographical assertion about the risk of psychology imprisoning disabled people in their bodies “as being not-able” when he was “introduced to the concept of mental deficits in brain functioning” (p. 31) is certainly true if that brief mention of disability is raised only during the study of neurophysiology. What has been proven otherwise is that a defense of a discipline as “abnormal psychology” does not resolve Finkelstein’s assertion when it is claimed that the distinctions of normal and abnormal are not synonymous with good or bad. Consider a characteristic such as intelligence. A person who falls at the very upper end of the curve would fit under our definition of abnormal; this person would also be considered a genius. Obviously, this is an instance where falling outside of the norms is actually a good thing. (Cherry, 2010, para. 2)

This does not sound very convincing, but almost conveys: *excusatio non petita, accusatio manifesta.*

On the other hand, modern psychology has grounded its theory in the “school of suspicion” (Ricoeur, 1970, p. 28) of Freud. Abnormality reveals the structures and dynamics of human behavior. As an anachronistic anticipation, clinical and developmental psychology are founded on the bases of a universal model of abnormality. The cases of hysteria and neurosis gave Freud not only insights for developing a novel therapeutic methodology, but much more, for creating an ontogenetic human theory. The cognitive neurosciences observe the abnormal behavior of people with brain injuries in order to understand the normal nervous representation of mental processes, so that abnormality remains an exception in the normal human functioning (see the section “Cognitive Neural Science Integrates Five Major Approaches to the Study of Cognitive Function” in Kandel, 2000, p. 384); clinical and dynamic psychology, conversely, generalize the abnormal behavior because the mechanisms below, highlighted by mental illness, are shared by the entire human race. What Zola did in the 1990s by promoting a demystification of the “specialness” of disability (1989) and assuming a conception of disability that is fluid and contextual, modern clinical psychology had done one hundred years before. As a contemporary master of suspicion, indeed, Zola reaffirmed what was an acquired theory of clinical psychology, that the dichotomy between normal and abnormal “is not a human attribute that demarks one portion of humanity from another […] it is an infinitely various but universal feature of the human condition” (Bickenbach, Chatterji, Badley, and Üstün, 1999, p. 1182; see also: WHO and World Bank, 2011; Zola, 1989). The issue of disability for individuals “is not whether but when, not so much which one, but how many and in what combination” (Zola, 1993, p. 18). The clinical psychologists well know that it is not the basal mechanisms, that is, the body structures and functions, that make the difference among individuals, but the degrees and combinations of individual functioning.

So, in outlining the psychologist’s role in the ATA process model, we do not want to pour *new wine into old wineskins,* namely to create a new profile for psychologists from a psychology that is past. We would recover that which is owned by modern psychology: a

* An excuse that has not been sought (is) an obvious accusation.
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hermeneutic suspicion towards all assessment processes that transform users “as objects to code rather than human beings to support” (Duchan, 2004, p. 65). We outline a psychologist’s role grounded in psychology’s assumptions that the goal of any psychological support is not a technical fix of an abnormal functioning individual, but personal well-being. In plain words, the psychologist in the ATA process model will answer for a person-centered evaluation through which the selection of one or more technological aids is facilitated by the (self) awareness of the users and their milieu in which the AT solutions provided are only for the personal well-being of the users.

8.6.1 When the Psychologist Role Is Required in the ATA Process Model

According to the ideal model of an ATA process in a center for technical aid (see Section I), the phases in which the clinical psychologist’s competencies are specifically employed may be divided into six steps (follow the three blue hexagons with “ψ” in Figure 8.1):

![ATA process model flow chart](image)

FIGURE 8.1
ATA process model flow chart. Here, only the “AT Service delivery” column is shown. The three blue hexagons with a “ψ” indicate where the clinical psychologist’s competencies are particularly requested. See Section I, Figure 8.1, for the entire ATA process model flow chart.
1. **Acceptance and evaluation of the user's request** (ψ hexagon n. 1):
   
a. **User data collecting:** When the user provides data to the center for technical aid, the data are collected; then, the case is opened and transmitted to the multidisciplinary team. All the clinical measures, functional analyses, and psycho-socio-environmental evaluations provided by the user are analyzed by the clinical psychologist in order to (i) profile, within the limits of the data collected, the user according to a biopsychosocial and holistic perspective; and (ii) draw up a psychological report for the following multidisciplinary team evaluation.

   b. **Meeting with the multidisciplinary team:** The multidisciplinary team evaluates the user's request and data. The clinical psychologist's tasks at this stage are (i) to emphasize the unique and peculiar aspects of the case represented by the user in terms of personal factors and of the human and relational context of the user's life; (ii) to advocate the user's request in the multidisciplinary team; and (iii) to facilitate the team members' communications and solution seeking in the interest of the user.

2. **Promoting the AT solution** (ψ hexagon n. 2):
   
a. **AT solution multidisciplinary team evaluation:** The multidisciplinary team arranges a suitable setting for the matching assessment, and along with the user, assesses the AT solution proposed, tries the solution, and gathers outcome data. After the matching process, the multidisciplinary team evaluates the outcome. If successful, the team proposes an AT solution to the user and schedules a new appointment. If not successful, the process restarts. In this step, the clinical psychologist advocates the user's request, guaranteeing a user-driven assignment process through which the selection of one or more technological aids for an AT solution is reached. Active listening, empathy, and the ability to reformulate in a shared language the user's requirements are the main instruments employed by the clinical psychologist in this step. Furthermore, the psychologist might offer the opportunity to reframe the relationship between the user and the user's family within the framework of the new challenges, limitations, and restrictions they face with the introduction of a new AT.

   b. **User agreement:** The multidisciplinary team proposes the AT solution to the user, who evaluates whether or not the technological aid proposed by the professionals is a suitable solution. If yes, the user goes ahead with the process, but if not, the user exits the process without a solution for the request, or waits for novel technological products or professionals' solutions. The clinical psychologist may play a central role in this step, for example, by requesting that the user explore the reasons for the rejection, particularly if they are related to personal factors or factors depending on the context of human relationships. While the main objective of the ATA process is the best AT solution for the user, it is equally true that a sufficiently good solution is often better than no solution.

3. **User support and follow-up** (ψ hexagon n. 3): When the technological aid is delivered to the user, a follow-up and ongoing user support are activated. The clinical psychologist works to promote the well-being of the user by regularly monitoring the good quality of the match achieved in terms of the impact on the user's personal empowerment.
8.6.2 How a Psychologist Facilitates the Awareness of the User’s Context and the Multidisciplinary Team’s Perspectives

8.6.2.1 Methodology

In the model we propose here, we suggest that the person with the disability should be the focus of the intervention, being the real “protagonist” of the overall process. Some specifications are otherwise requested, depending on the specific features of the subject, by which we mean macro-features that can be used as guidelines to orient the methodology of working “with” the subject. These features are the age of the disabled subject and the type of disability. These variables overlap with other variables connected with the “time,” and thus, with the when during which the clinical psychologist operates, whether during the assessment phase, the evaluation of the user’s request, the phase of the promotion of the AT solution, or in the third moment, the phase of support and follow-up (see paragraph 6.1). From the methodological point of view, clinical psychologists have tools specific to their profession: the clinical interview and psychological tests (personality tests, performance-based personality tests, questionnaires, rating scales, etc.), tools that belong to the realm of psychological assessment for evaluating personality function in the case of disability.

The psychological assessment, having the specific aim of investigating and knowing the personal factors (psychological ones) that can mediate the choice, and then, the efficacy of the use of the AT chosen, will be conducted in a multi-method way (e.g., Hunsley and Meyer, 2003), thus using a multi-method assessment battery in order to maximize the validity of the individualized assessments (Meyer et al., 2001).

Moreover, in the area of psychological assessment, a relatively novel method of conducting evaluation has recently emerged that has also been applied in different fields (e.g., McInerney and Walker, 2002; Tharinger et al., 2009). It is called collaborative assessment and is mainly based on collaboration between the subject/s and the psychologist. According to Finn and Fischer (1997; see also Finn, 2003), in the collaborative approach to the assessment, the psychologist and the clients work together to develop a productive understanding, ensuring that the patients will get the most out of their assessment. In the last few years, in the field of therapeutic research, a novel paradigm called Collaborative Assessment has been devised. This approach, first devised in 1982 by Fischer in the United States, is based on the assumptions of collaboration between the psychologist and the client starting from the testing session. Its major features are as follows: collaboration, individualization of the assessment procedure (in the choice of assessment tools), and flexibility (different pathways for different clients). In the assessment conducted with a collaborative approach, the client is directly engaged: The psychologist asks for client feedback on the assessor’s integrated impressions. The findings are thereby tailored to the client’s words (APA, 2010). A recent meta-analysis showed that psychological assessment procedures—when combined with personalized, collaborative, and substantial test feedback—have positive, clinically meaningful effects on treatment, particularly regarding treatment processes, and improve the impact (Poston and Hanson, 2010).

We believe that this method of conducting assessments could guide the work of the clinical psychologist in a center for AT evaluation and provision with different clients.

PHASE 1—Acceptance and evaluation of the user’s request (ψ hexagon n. 1)

Children: Children with disabilities do not arrive at the ATA center alone, but with their parents or caregivers. For this simple but important reason, it will be
necessary to involve the parents (caregivers) in the evaluation process, both because they mediate the information with the child, and because they will be responsible for guaranteeing the sustainability and the use of the chosen AT solution. For this reason, we think that, with children, the search for a suitable AT solution is a task that should involve the entire family (see Chapters 5 and 13). The clinical psychologist will meet the parents together in a clinical interview, separately from the child, to give them the necessary time and space for freedom of expression without reciprocal influence. After the clinical interview and on the basis of what arises at that stage, tests will be used to gain a better understanding and objective knowledge of the aspects of the parenting function that can support, or hinder, the ambition of the ATA center for the child with disability. In general, the use of psychological tests in this phase will concern both the parents and the child. This psychological assessment phase, conducted with the use of a few tests, thus constituting a multi-method approach (e.g., Hunsley and Meyer, 2003), has the specific objective of investigating and ascertaining the personal factors (psychological ones) that can mediate the choice, and consequently, the efficacy of the technical aid.

Preadolescents and adolescents: What is stressed for children’s and parents’ (or caregivers’) involvement in the assessment phase is also true for this age group, but because the main goal of this age is the construction of self-identity in terms of self-autonomy, the involvement of the subject in the assessment phase is particularly important and delicate. Because self-efficacy is central to the adolescent’s psyche, the clinical psychologist will evaluate, through the use of the clinical interview and psychological tests—administered in a collaborative manner—the active participation of the subject to ensure that the adolescent is engaged in the process of the evaluation of the technical aid, also considering the impact it could have, particularly as regards the adolescent’s self-esteem and self-image. Parents will be involved as well, and will evaluate if and how their functioning facilitates or hinders the development of the adolescent in the presence of the technical aid.

Adults: Adult subjects with disabilities must be treated as persons. Depending on the specificity of the disability, the assessment of the subjects’ personal factors (psychological assessment) will be done with the use of the clinical interview and of psychological tests (in a multi-method approach), also using in this case a collaborative approach, enhancing the subjects’ active engagement and participation in the process, to choose the best technical aid. Through the clinical interview/s, the psychologist will be allowed to observe the personal and interior experience of the subjects with respect of the disability, to investigate the subjects’ representations of self with respect of the disability and expectations of the technical aid. The subjects’ availability regarding the use of the aid will be investigated, as well as the best choice of aid, the subjects’ wish for autonomy, and their self-efficacy. The use of psychological tests, proposed in a collaborative manner and according to a multi-method approach, will allow the psychological assessment to focus more effectively on the aspects of the subjects’ psychological functioning (personal and relational) that can hinder or support the use of the shared choice of the technical aid.

Older adults: Assessment of personal factors depends on the subjects’ level of autonomy, cognitive, and affective. If the subjects are autonomous and self-sufficient,
they will be regarded as if they are adults. In regards to older persons, we have
to consider their life perspective and the impact of the technical aid on this, in
terms of improving their quality of life. If a subject is not autonomous or self-
sufficient, the psychologist will consider and carefully evaluate the subject’s
context (caregivers). In this sense, personal factors will not be separate from
the contextual ones.

PHASE 2—Promoting the AT solution (ψ hexagon n. 2)

In this phase, the clinical psychologist, by the use of the clinical interview and
if required through tests, will observe the suitability of the choice in light of
what happened in PHASE 1. Working with the subject with the disability (and
with the family in the cases described above), the clinical psychologist gives
psychological support to the subject and, as in the assessment phase, detects
the presence of obstacles to the use of the chosen technical aid, difficulties in its
acceptance by the subject (or by the subject’s context), and detecting aspects of
the subject’s functioning that could interfere with the use of the aid. The clini-
cal psychologist observes, from the point of view of the subjects with disabili-
ties (e.g., efficacy, autonomy, mood, self-esteem, satisfaction), the impact the
aid has on their life (and life context), both in a positive sense (increment) and
in a negative sense (e.g., depressive mood, isolation, withdrawal, etc.). Active
listening, empathy, and the ability to reformulate the user’s requirements in a
shared language are the main instruments used by the clinical psychologist in
this stage, within the interview. Furthermore, the psychologist might offer the
opportunity to reframe the relationship between the users and their families
within the framework of the new challenges, limitations, and restrictions they
face with the introduction of a new AT.

PHASE 3—User support and follow-up (ψ hexagon n. 3)

In this phase, the clinical psychologist assesses the match between the subject
and the aid, together with the client. If PHASE 1 has been conducted rigor-
ously, with the psychologist listening carefully to the subject, it is probable that
this third phase will be a good outcome of the process. It is also possible that
in this case, events (external or internal) in the life of the subject may occur
that will necessitate a “revision”—a new assessment phase—to reframe the
first choice of an aid. Factors of change can also result from developmental
facts (e.g., for children with technical aids for learning disabilities). Using the
clinical interview as well as tests, the psychologist will conduct this phase as a
follow-up step in the process. We expect that particular attention will be paid
to the satisfaction of the subject, as a measure of the efficacy of the matching
intervention the psychologist and the client have conducted together. Quality of life will also be a measure that should be considered.

8.6.2.2 Goals

The role of clinical psychologists within ATA centers is mainly linked to their diagnostic
competencies and skills, and the planning of the intervention. These are clinical compe-
tencies: assess to know (in our model, assessing and knowing together), and to intervene,
if convenient, useful, and necessary.

The first goal is the identification of those aspects of psychological functioning (personal
factors) that promote and sustain the awareness of the subject with a disability and that are
supposed to mediate: (i) the choice of a certain technical aid; (ii) the acceptance of the aid; (iii) its use; (iv) its use over time; and (v) the possibility to change it (for another or none) if personality changes occur in the person and in case the aid is no longer useful or suitable. In this context, another aspect on which the clinical psychologist will work, compatibly with the cognitive psychological functioning of the subject with the disability, is the possibility of improving the reflective functioning of the subject with the aim of identifying the aspects of the self (of the present and of the future) that mediate the use and acceptance of the technical aid. The clinical psychologist will also detect and assess the clinical conditions significantly connected to the deficit that could hinder the intentional use of the aid (e.g., depression in a boy affected by an injury to the legs after a traumatic accident. The boy does not accept the wheelchair that could help him to improve his autonomy because he does not accept the limitation, and he is ashamed, feeling different from his friends. He withdraws, does not go outside his home, and does not accept the aid wheelchair, because it makes him feel different from others).

Tools used in the assessment phase can be used again in the follow-up phase as measures of the efficacy of the intervention. Other specific measures, such as the perceived quality of life, will be used to verify the efficacy of the intervention, measures directly taken by the subject with a disability (and/or by the caregivers) and measures taken by the psychologist (or by an external member of the team). Other measures concern the global evaluation of the subject’s autonomy, and more specific measures assess the change of the psychic function with respect to the technical aid used.

8.6.3 What a Psychologist Should Do in Promoting a User’s Request

In concluding this paragraph on the psychologist’s role in the ATA process model, we describe, in a guideline style, what a clinical psychologist should do in promoting a user’s request:

• Be an expert in the relational field: able to listen, receive, understand others
• Be aware of the idiographic approach, sensitive to individual differences in psychological functioning
• Have expertise and dynamic comprehension of the biopsychosocial variables of functioning, so that the hyphen between “bio-,” “psycho-” and “social” will not be a separator, but a connector. The perspective is that of interaction, something that is less valued by the ICF model
• Have a developmental perspective, not only when working with children but also with adults and older people. This allows them to appreciate the change always present in life (decremental or incremental; continuous or discontinuous)
• Be able to involve subjects actively in the psychological assessment process with the aim of improving their awareness of the personal factors that mediate the choice and use of the technical aid
• Be able to work with, depending on the subjects, the different people in their lives, respecting their roles and competencies
• Have clinical competencies: evaluation and planning of the intervention. The psychologist should be able to conduct an early assessment but also be able to evaluate the course of the process and to test its efficacy. We consider as an intervention the process of the choice of a specific aid, done together with and for a specific person with a disability, which has the specific features of psychological-personal-functioning
• Be able to use psychological tests and to conduct a psychological assessment through the use of tests in a multi-method way (using not just one instrument, but several, to ensure the incremental validity of the evaluation in order to appreciate the psychological functioning of the subject). Working on a team that includes a neuropsychologist, clinical psychologists with such competencies will orient their evaluation to the axis of psychological functioning with regard to relational functioning and emotional-affective functioning, being aware of their strong connection

8.7 Psychologist “Know Thyself” Psychologist’s and Professional’s Representations: New Advances

The biopsychosocial perspective considers the human complexity and its mutability better than others. In order to adopt this perspective, usefully combining the contributions of the professionals working on the team, there is a need to acknowledge the specificity and the asset value of interdisciplinary work (Telfener, 2011), despite the literature showing that the physicians’ and social workers’ identities are better defined than those of the psychologists. In fact, the psychologist’s professional identity tends to follow the physician’s or social worker’s model, depending on the context (Grasso, 2001), as has been highlighted (Cordella, Greco, and Grasso, 2011) by the Dynamic and Clinical Psychology Department of the Medicine and Psychology Faculty at Sapienza University in Rome.

8.7.1 Professionals’ Representations of Disability

The research has been performed in an Italian Vision Rehabilitation Center that serves the central and southern areas of the country and has worked in the field for almost one and a half centuries. It provides many services, including rehabilitation for blind and visually impaired people of all ages, with a multidisciplinary approach carried out by a variety of professionals making up the team. The aim of the study was to explore the professionals’ identity of the rehabilitation team using narrations (Freda, 2009) of their professional experiences in the rehabilitation of people with visual disabilities.

The interviews were audiotaped and integrally transcribed, and the transcripts underwent a text analysis performed with a computer software package, T-Lab (Lancia, 2004). T-lab performs a multivariate analysis aiming to classify the text according to word co-occurrence in order to identify the themes characterizing the interviews (Cordella, Greco, and Raso, 2014) and to infer the latent unconscious categories setting participants’ representations of their function, their patients with disability, and the rehabilitation process.

The results showed four different themes characterizing the professionals’ accounts that reflect the richness of the professionals’ skills and experiences. They highlighted their ability to deal with a large variety of problems connected with disability. Management, prevention, training, and education seem to be the goals of the rehabilitation process performed by the interaction of the multidisciplinary team. Moreover, the professionals working at the vision rehabilitation center were classified into four groups: physicians, paramedics, psychosocial workers, and Vision Rehabilitation Therapists (VRTs) (Table 8.2), and a cluster distribution in each group was ascertained to explore how it characterizes each profession.
The management theme mostly characterizes physicians and refers to the need to manage the working team. Their accounts seem to have contributed particularly to this cluster construction. Working on a multidisciplinary team determines the necessity to consider different needs and points of view for these professionals. A comprehensive vision rehabilitation service seems to imply the necessity to work on the professionals’ interactions. Working together is not just a resource, as it calls for an additional job in order to overcome issues connected with the multidisciplinarity. In this cluster, the target is the team itself, and the professional function is focused on management and coordination, working on the professionals’ needs, rather than those of the person with the disability, and the rehabilitation process is not a vision-specific process.

The theme of prevention characterizes the health professionals, the physicians, and the paramedics, although for the latter, it is the most relevant one. Paramedics focus particularly on disabilities associated with the visual one, paying particular attention to the consequences caused by the visual disability during child development. The patient is represented as a child with multiple disabilities, particularly mental disabilities, and the paramedical function does not deal directly with the visual disability, losing specificity.

It was interesting to note that psycho-social workers have an almost equal distribution in all clusters and are not particularly characterized by any of them. Although the group is heterogeneous and small, only one social worker and two psychologists, this may suggest that these professionals do not have a function specificity clearly distinguishing them from the others. It is likely that they focus on the plurality of disabilities affecting the young person, which necessarily requires a multidisciplinary approach, as the themes of management and prevention are slightly more represented, like other health professionals.

Accounts of the VRTs contribute mostly to the Training and the Education themes. In the Training theme, the function focuses on the AT training, independently from the needs of the user. The process is considered morally right, and the attention is focused on the professionals’ performance. In the Education theme, the function aims to support students

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<th>Professional Groups (First Data Analysis)</th>
<th>Vision Rehabilitation Team</th>
<th>Professional Groups (Second Data Analysis)</th>
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<td>Group</td>
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<td>VRTs</td>
<td>13</td>
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<td>Vision Rehabilitation Therapists (VRTs)</td>
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Accounts of the VRTs contribute mostly to the Training and the Education themes. In the Training theme, the function focuses on the AT training, independently from the needs of the user. The process is considered morally right, and the attention is focused on the professionals’ performance. In the Education theme, the function aims to support students
with disabilities in their studies in order to enable them get degrees or jobs. Visual disability determines limits that could hinder work and social integration. The VRTs’ function is to replace their patient’s deficient function. As the rehabilitation process seems to be focused on a particular moment in life, this theme does not consider the possibility of building new abilities. The substitution seems to be the only possibility to help the person with the disability, but it implies high personal involvement for these professionals.

Therefore, it is interesting to observe the following:

- The representations of people with disabilities focus on their deficiencies, rather than on their resources and enhancing them. They are not represented as independent, productive, self-effective, or able to solve problems (Greco, 2016). This representation does not help professionals to motivate their patients or help the patients to assume an active role. A few recent studies have suggested that taking responsibility for managing their own conditions, with support and advice from health-care professionals, is an important factor in the rehabilitation process for patients with chronic conditions (Bodenheimer, Lorig, Holman, and Grumbach, 2002; Girdler, Boldy, Dahiwal, Crowley, and Packer, 2010; Holman and Lorig, 2000). This is different from the professional teaching particular solutions or making changes to the patient’s home environment. Hence, to assume an active role in the process, people with disabilities need to be motivated. This novel paradigm in health care aims to provide the patients with the skills and resources to manage the practical, social, and emotional consequences of their disabilities and to seek specialist support when needed.

- Professionals often talk about children and young people, but the ability to deal with disabled adults of working age seems to be unexplored. In fact, restrictions related to disability often result in the loss of independence, which is often associated with a loss of social and economic status, and also implies a cost to society.

- Those who train in the use of ATs do not wonder what these aids represent for the person with a disability and how they will be used.

- Finally, psychosocial workers seem to have less professional function specificity. According to the literature, in some specific work environments, psychologists may confound their professional function with that of the psychotherapist, losing their professional specificity (Grasso, Cordella, and Pennella, 2016). Currently, in the disability area, the psychological function aims to support disabled people in facing the emotional difficulties arising from the loss of an ability. Although this is a useful function in the rehabilitation service, it is not the only one the psychologist can carry out.

- It is possible to widen the psychological area of intervention if we consider the psychological expertise as the ability to seize, interpret, and make the representations that mediate the relationship between individuals and their social/work environment more functional. Based on this approach, psychologists could facilitate the work of professionals and the multidisciplinary team (individuals), making the rehabilitation process of the disabled person more effective (work environment).

8.7.2 New Advancement: Psychologists’ Specificity and Professional Burnout

The presentation of the study to different congresses yielded an interesting reaction among the psychologists and professionals working in rehabilitation centers. The latter
told us about their professional experiences, noting that they were in line with the results, which could be extended to other types of disabilities. Working with disabilities calls for unavoidable personal involvement, which challenges professionals. In line with the literature, burnout is a problem characterizing health and social professionals working with disabilities and resulting in decreased work efficiency and high rates of staff turnover (Yang, Meredith, and Khan, 2015). Personal, social, and organizational factors are associated with this psychological distress (Kowalski et al., 2010; Zeidner, Hadar, Matthews, and Roberts, 2013). Moreover, the psychologists noted that the lack of professional specificity that emerged from the study could depend on the inclusion of psychologists in the wider category of psychosocial workers.

In considering the congress participants’ contributions, we repeated the analysis presented previously in order to explore: (a) the representations of the psychologists and (b) the emotional distress during the interview. To achieve this objective, a different professional group classification was made according to vocational training that identified five professional groups: physicians, paramedics, VRTs, psychologists, and others (Table 8.2, Second Data Analysis).

The results showed the same themes as those in the previous research: management, prevention, training, and education (Figure 8.2). Each of the themes is almost equally relevant in the rehabilitation process, as is shown in the pie chart of the Vision Rehabilitation Team, although professional groups are significantly associated with some of them ($\chi^2$, $df = 12$, $p > 0.0001$). The groups of physicians, paramedics, and VRTs are significantly characterized by the presence of specific themes and the absence of others in their interviews ($se > |2|$) (Sharpe, 2015). These professionals are particularly interested in specific activities: The prevention of the consequences of a visual disability on child development is the paramedic’s concern, prevention and team management are the physician’s interests, and the education and the AT training are the VRT’s concerns. These professionals find their specificity in one or two activities and are not interested in the others, which are significantly absent in their discussion ($se < -2$) (Figure 8.2).

**FIGURE 8.2**
Distribution of themes in the entire rehabilitation team and for specific professional groups.
The group of psychologists is not characterized by any of the themes in particular (se < |2|). This result could be caused by the small number of psychologists who participated in the study. Nonetheless, in line with the literature, psychologists could consider psychotherapy as their professional specificity. This activity is not specific to the rehabilitation process nor to the ATA process, although it could be useful in some specific cases.

In order to explore emotional distress during the interview, the activation of defense mechanisms was considered. We supposed that participants who are challenged by the topic of the interview would tend to be talkative or reticent (Cordella, Greco, Castellani, and De Nigris, 2015). This could be a defense mechanism allowing the reduction of the emotional distress arising from the stimuli. Professionals who face emotional distress in performing their jobs would be talkative or reticent when they are asked to talk about their professional experiences. The length of the interview (number of words) was considered in order to classify the interviews in three groups: reticent (first quartile, m_{length} = 704 words), no defense activated (second and third quartile, m_{length} = 1341 words), and talkative (fourth quartile, m_{length} = 3835 words).

The activation of a defense mechanism related to the emotional distress of the interviewee is significantly associated with the theme distribution ($\chi^2$, dL = 6, p > 0.0001) (Table 8.3), while the groups of professionals were not significantly characterized by the length of the interview ($\eta^2 = 0.37$). The management of the team was not a concern of the talkative participants. That is, those who produced a long interview had a significant absence of this theme (se = −2.2). Participants who did not activate a defense mechanism (medium length interview) were interested in the team management (Management theme, se = 2.4) and not in the educational process (Education theme, se = −2.1). Finally, the reticent participants were not concerned by any particular theme (se < |2|).

It seems that the more professionals face emotional distress, the more they focus on the person with the disability, disregarding the working team. This probably supports their isolation from the team, increasing the emotional tie with the patients, but also leading to emotional overload and potentially to professional burnout. Moreover, it could be difficult for the working team to collaborate with them. This could explain the congress participants’ comments. Further studies are necessary to verify the association between isolation from the working team, excessive personal involvement, and professional burnout.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Reticent CU%(se)</th>
<th>No Defense Activated CU%(se)</th>
<th>Talkative CU%(se)</th>
<th>All CU%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>26.3(0,3)</td>
<td>19.7(−2,1)</td>
<td>28.4(1,6)</td>
<td>25.1</td>
</tr>
<tr>
<td>Prevention</td>
<td>25.4(−0,2)</td>
<td>29.3(1,2)</td>
<td>24.3(−0,9)</td>
<td>26.2</td>
</tr>
<tr>
<td>Management</td>
<td>29.8(0,5)</td>
<td>33.9(2,4)</td>
<td>22.6(−2,2)</td>
<td>27.3</td>
</tr>
<tr>
<td>Training</td>
<td>18.4(−0,7)</td>
<td>17.1(−1,8)</td>
<td>24.8(1,8)</td>
<td>21.4</td>
</tr>
</tbody>
</table>

Notes: CU = Content Unit (text unit classified); se = standardized residual.
8.7.3 A New Approach in Psychological Practice

To understand how psychological practice could be useful in the ATA process in a center for technical aid, it is important to introduce the concept of representation. According to cognitivism, individuals categorize reality not only on the basis of their perceptions, but also based on beliefs related to the perceived object, which makes some similarities more important than others (Neisser, 1989). Therefore, there is a connection between culture and human cognition, in which the context influences the individuals’ perceptions, attitudes, and behaviors (Ugazio, 1989).

According to Moscovici (Farr and Moscovici, 1984; Moscovici, 1961), representation is a system of ideas, values, and practices that provides individuals with a code for social exchange and for categorizing and naming various aspects of their world. Therefore, it facilitates communication and orientates individuals in their social world, allowing them to master it. Representations are an approach to the interpretation and social sharing of knowledge. They are learned from the social context, and at the same time, are discursively constructed by individuals belonging to the context itself. Therefore, representations are the process and the result of social construction, constantly converted into a social reality, while continuously being reinterpreted, rethought, and represented.

Finally, Matte Blanco (1975) suggested that individuals categorize reality not only by means of a cognitive process, but also through an emotional one. Individuals facing reality categorize it emotionally and cognitively, which allows them to perceive the context as intentioned. For example, the child that bumps against the corner of a table and strikes it back attributes a negative intention to the table. Therefore, the child recognizes the object (table) because of the ability to categorize it cognitively, and at the same time, the child sets a behavior (striking the table back) through the ability to categorize it emotionally, representing it. Hence, each time individuals relate to an object (person, thing, service, technical aid, etc.), they categorize it cognitively and represent it emotionally depending on their own culture. Therefore, representations determine behaviors that can be more or less effective in achieving goals.

According to this perspective, psychological expertise is the ability to identify the individuals’ emotional representations, helping them to eventually understand how these representations can hinder goal achievement (Carli, 1993; Grasso, 2010; Grasso, Cordella, and Pennella, 2003; Grasso and Salvatore, 1997). For example, the child’s ability to avoid the table’s impact is granted by the ability to pay attention to the barriers surrounding the child, rather than by striking back at the table. Therefore, working on individuals’ representations allows for intervention in the problem (avoid bumping against the table) rather than on the behavior (striking back at the evil table) or directly on the object perceived by the individual as responsible for the problem (the evil table). Moreover, it helps individuals to relate effectively to their context, adapting to it.

8.7.4 Psychological Professional Practice Guidelines in the ATA Process

As claimed previously, psychologists have the skills to work on representations by making them more functional. Therefore, some guidelines about the psychological approach in the ATA process have been drafted here to better understand how to establish a practice according to the target. In fact, psychologists can usefully contribute to the professional team during the six steps of the ATA process, working on representations and thereby improving service effectiveness.
8.7.4.1 The User

Users who come to a center for technical aid have their own representations of the center and of the service provided, which sets their requests, behaviors, attitudes, and expectations. These representations will influence their relationships with the professionals of the center, hindering or facilitating their work. Hence, the psychologists could start their work from the incoming user’s request for technical aid. They should explore the needs that pushed the disabled users to ask for technical aid at that particular moment in their lives. If the professionals take the answer to the users’ requests for granted, the intervention will be focused on the users’ disabilities rather than on the representations they have of their problems. Accordingly, only the “bio” and “social” dimensions of disability are addressed, omitting the “psycho” dimension, which influences the way that the users build their own relationships.

The users’ representations of the services provided by the center determine their requests. In fact, two users with the same disability can represent their problems differently and expect a different reaction (service) from the center. Therefore, one of them could focus on the right the user has to obtain the technical aid because of the user’s disability, setting the request as a claim for damages and pretending reparation from the professionals. The other user could focus on a passive and dependent role because of an inability, limiting the user’s participation to an extreme degree, and complaining and distrusting the professionals. Both of these users would not benefit entirely from the service, and the professionals would probably face difficulties in working with them, being limited in their effectiveness by the users’ representations.

Integrating the ATA process with psychologists that are trained to seize, interpret, and make representations more functional could facilitate the professionals’ work and make it more effective. In fact, psychologists can work on users’ representations of the center for technical aid and of their disabilities, promoting a functional development of their representations to facilitate their active participation in the process.

8.7.4.2 The Family

Families also have their representations of the center and of the disability, which can hinder or facilitate the disabled user and increase or decrease the center’s effectiveness and the professionals’ work. Some families are overprotective, whereas others are less protective. They might have expectations that overestimate or underestimate the outcomes, which will condition their relationship with the disabled user and the professionals.

In fact, the relatives’ representations of the disability can facilitate or limit the disabled person’s independence, influencing their expectations of the disabled person’s abilities. In some rehabilitation centers for AT evaluation and provision, a day’s role play session has been set up to put relatives in the same condition as the person with the disability, helping them to face the same challenges. At the end of the day, the participants have an interview with a psychologist aiming to reorganize their representations of the disability. This process helps the relatives to develop a more functional representation, overcoming their fears about disability. Furthermore, it helps them to cooperate with the disabled user and with the professionals to solve the problems related to the disability.

8.7.4.3 The Professionals’ Multidisciplinary Team

Psychologists can also work on professionals’ representations of the center and of the disabled users, because such representations can hinder or facilitate the process and the
achievement of goals. In fact, as has been highlighted in the previously presented study, if the representation of the user is passive, the user's abilities are not considered, hindering the user's active participation in the process. This representation does not help the professionals to motivate their users to assume an active role. To be effective, the process needs the users' collaboration; they should take responsibility for managing their own conditions, and use the support and advice provided by the professionals to become independent. For instance, assigning a long cane to a disabled user and teaching him to walk with it does not imply that once the process is over, the disabled person will use the cane to leave home. There is a difference between obtaining or being trained in the use of a technical aid and using it in everyday life.

Because of the psychological difficulties people face in adapting to a disability, it is up to the professionals to promote a change in the users' attitudes (Godshalk, Brown, Brown, and Brown, 2008; Hayeems, Geller, Finkelstein, and Faden, 2005). To achieve this goal, it is important for the professionals to perceive the users as able to state their needs and solve their problems, representing them as independent, productive, and self-effective. This is why a passive user representation does not help professionals to be effective. Moreover, incoming users may not have active representations of themselves.

Users' passivity is not negative in all cases. Sometimes, it is important for users to rely upon the professionals' ability to take care of them (e.g., when it is not possible to act directly in relation to the problem, as when it is necessary to undergo surgery). In fact, passivity can solicit the professionals' care, and this is useful because the intervention relies upon their performance. Nevertheless, in the ATA process model, the users must rely upon the professionals' performance, but they must participate actively, because this helps them to collaborate effectively with the professionals.

Moreover, a team of professionals implies different representations that must be combined. As shown in cluster 1 (management) of the research, this does not facilitate the work, and extra effort is needed to manage it. The difficulty faced in combining types of professional expertise can lie within the professionals' different representations of the process and of the user.

Finally, the possibility to understand and reorganize the representations of all the participants in the ATA process (users, professionals, relatives) would allow for the improvement of the service provided by the professionals, thus making it more effective for the disabled user in the short and long term. Furthermore, the center could become a real reference for the disabled user if further problems should occur.

8.8 Conclusions

This chapter deals with the professional skills of psychologists and the manner in which they are applied in a center for technical aid. This chapter also provides an original contribution to the study of the representations that psychologists and other professionals endorse of disabled people and AT.

As Meloni et al. (2011) demonstrated, and as is reported and discussed in Sections 8.1 through 8.3, the international scientific literature pays very little attention to the role and skills of the psychologist in the field of rehabilitation, and in particular, in the process of matching people with AT. One of the likely causes of this neglect could be that the real novelty of the biopsychosocial model, constituted by the presence of the prefix "psycho"
between “bio” and “social,” has been largely disregarded through the noncoding of personal factors in the ICF. The psychologist in a center for technical aid is, first and foremost, an expert on personal factors, as the predispositions and reactions of people to using AT are highly personal and individual. Only the psychologist has the appropriate curriculum and expertise to investigate personal factors, to identify the ones that are critical in allowing or hindering the matching of a person and a technology, and to promote adaptive changes on the human side of the person–environment polarity. Particularly, the competencies of the psychologist are involved in some crucial phases of the ATA process model: (i) accepting and evaluating the user’s request, (ii) promoting the AT solution, and (iii) providing support and follow-up.

In Section 8.6, Mazzeschi highlighted the psychologist’s main professional goals in a center for technical aid, which we can summarize as follows: (i) to advocate for the user’s request in the user-driven process, through which the selection of one or more technological aids for an AT solution is made; (ii) to act as a mediator between the users seeking solutions and the multidisciplinary team of a center for technical aid; (iii) to facilitate team-building among the members of the multidisciplinary team; and finally (iv) to reframe the relationship between the clients and their families or caregivers within the framework of the new challenges, limitations, and restrictions they are facing. In order to achieve these goals, the psychologists should be experts both in handling the main diagnostic and assessment tools and in using their relationships with the users to promote personal awareness, growth, and the development of human potential, and to maximize empowerment.

In the last section, Cordella, Greco, and Grasso developed another important point in outlining the psychologist’s role in a center for technical aid, which concerns the representations that the psychologist and the other multidisciplinary team members endorse of disability and the functions of AT. The quality of life and well-being of a disabled person depend largely on the ability of professionals, relatives, and caregivers to imagine a range of existential alternatives, and not to nail the prevailing social stereotypes and cultural prejudices onto the disabled person. For this reason, the psychologist should be engaged in promoting (both in the multidisciplinary team and in the broader sociocultural context) the diffusion of a complex, multidimensional, universal, and holistic approach to disabled people, firmly founded on the biopsychosocial model of disability.

In conclusion, we have noted the need for a change in attitude and practice in relation to the role of the clinical psychologist in the ATA process, spurred on by the recent advance of the biopsychosocial model in the social and scientific communities, the integration of objective and subjective measures into the diagnostic process, the recognized relevance of contextual factors, and in particular, the personal factors affecting the long-term success of AT matching and the increasing interest in the “imbalance of power” in the relationship between professionals and users. We are convinced that a revision of the ICF is urgently needed in order to develop those personal factors that can make a substantial difference during the rehabilitation process, and in particular, during the ATA process.

8.9 Summary

This chapter deals with the role and the competencies of the psychologist in a center for technical aid. The lapse of the psychologist’s role in AT assessment is probably due to the noncoding of personal factors in the ICF. In viewing the psychologist as the “specialist”
on personal factors, the authors call for a revision of the ICF, so that in the biopsychosocial model, “psycho” does not continue as merely a prefix. The psychologist in a center for AT evaluation and provision has the goal of supporting the user’s request in the user-driven process, as well as acting as a mediator for users. The psychologist also acts to build a team spirit and enhance the relationship between the client and the home environment. Finally, an original study closes this chapter, focusing on the psychologists’ and professionals’ representations of disabled users and ATs.

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References


The Psychotechnologist: A New Profession in the Assistive Technology Assessment

Klaus Miesenberger, Fabrizio Corradi, and Maria Laura Mele

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9.1 Introduction

In 1991, the Canadian sociologist Derrick De Kerckhove coined the term “psychotechnology” in order to define “any technology that emulates, extends or amplifies sensory–motor, psychological or cognitive functions of the mind” (De Kerckhove, 1991b, p. 132). According to De Kerckhove, underlying this definition, there is a reflection about the
emerging aspects of person–technology interaction, which evolves into the constitution of electronic sensory extensions of our central nervous system and externalizes cognitive functions able to extend the human mind. In this manner, any technology is an object able to externalize a property of the body, and it represents the amplification and the extension of the human mind connecting to other people's cognitive processes (De Kerckhove, 1990, 1991a, 2001).

According to a biopsychosocial perspective, a psychotechnology could better be defined as a “technology that emulates, extends, amplifies and modifies sensory–motor, psychological or cognitive functions of the mind” (Federici, Corradi, Mele, and Miesenberger, 2011). By borrowing what Olivetti Belardinelli (1973) claims, the Federici's definition of psychotechnology affirms that intrasystemic relation is not to be considered simply like an addition of the objective component—the artifact—with the subjective components—the user—of the interaction: the object cannot be considered per se since it always falls out of the human experience. The introduction of the “modification” factor into the De Kerckhove’s definition of psychotechnology highlights the dynamic and mutual nature of the human–technology interaction and also allows overcoming the current cause/effect perspective by considering the human behavior as the result of the interaction between personal, environmental, and social features. As Bruner (1977) highlights, the human being specializes his abilities by means of technologies, which allow a consequent evolution of the specie. In fact, any kind of artifact can be conceived both as an amplifier transporting in itself systems of symbols organized by rules, restrictions, and knowledge possibilities, and a method to guide users to a cognitive and cultural readaptation. In this manner, psychotechnology has a double function: on one side, it permits the human being's adaptation to the environment system; on the other side, it forces users to a cognitive and cultural modification and adaptation (Federici, Borsci, Mele, and Stamerra, 2010).

Furthermore, the modification function of psychotechnology is permitted by increasing the information conveyed by the human–technology interaction process: in fact, the interaction with an artifact enhances and enriches the information flow and modifies the knowledge stored in the long-term memory. In this light, information systems—such as sensory and cognitive extensions—directly participate in the Working Memory processes. Following this perspective, the artifact is not to be considered only as an object of which affordances emerge during the user–technology interaction (Gibson, 1979), but it is also a psychotechnology that shares and modifies the features and the functions of the mind: during the interaction with psychotechnologies, the object becomes a part and an extension of the subject while he or she is interacting. In this manner, psychotechnologies allow a different synthesis of the information and provide the reorganization of the relations between the elements constituting the experience.

Following this perspective, the artifact becomes, at the same time, structure of knowledge and mental representation, and has the function of reconfiguring and restructuring the problem by enriching and recodifying information or decreasing constraints. In other words, psychotechnology is not only a cause of the insight process—as the concept of affordance can be interpreted—but it also takes an active part to the insight process becoming a “place” of an entire synchronous perception of a meaningful gestalt (Koffka, 1935).

Starting to this theoretical perspective, in this chapter, the role of the psychotechnologist with regard to the following will be illustrated and discussed:

1. The analysis and the evaluation of the user–assistive technology matching, conducted by considering the three dynamic components of the interaction system—the person system, the technology system, and the socio-environment system—in order
to analyze both barriers and facilitators occurring within the interaction system (WHO, 2001, 2007).

2. The field of assistive technologies (AT), eAccessibility or eInclusion, which allows to overcome limitations and disabilities by enabling interfacing and interacting mainstream Information and Communication Technology (ICT)-based systems and services by using Assistive (Psycho)Technology.

We will discuss the profession of the psychotechnologist by analyzing the following subjects: (1) the psychotechnologist and the AT assessment (ATA) process; (2) case example: application of the model and measurements; (3) AT assignation process in center for technical aid and the psychotechnologist; (4) psychotechnology education: an example.

9.2 The Psychotechnologist and the ATA Process

The psychotechnologist is an expert of ICT, in particular, in Human–Computer Interaction (HCI) and human factors and he or she analyzes the relations emerging from the person–technology interaction by considering the following:

1. All the psychological and cognitive components that, according to De Kerckhove (1990, 1991a,b), are directly involved in the technological system as a fundamental and dynamic part of it, and

2. The possibilities of adapting and designing eSystems and eServices in an adaptable and accessible manner (eAccessibility). eAccessibility defines the mechanisms and concepts how eSystems and eServices, in particular, at the level of HCI, have to be designed that people with disabilities and the aging population can interact with mainstream ICT seamlessly, using the embedded adaptability and flexibility features of the general ICT/HCI, or using AT. To “interface the interface” (Crombie, Lenoir, McKenzie, and Miesenberger, 2004), to access mainstream eSystems and eServices both in terms of AT and eAccessibility is a key component of the work of the psychotechnologist.

The following are the roles of the psychotechnologist:

1. Evaluate the pertinence of one or more technological aids selected for an AT solution in a user-driven assessment process during a “setting set-up” phase arranged by a multidisciplinary team (Figure 9.3). For the evaluation of the user and technology matching, the psychotechnologist makes use of direct and participant observation methods such as Cognitive Walkthrough (Wharton, Rieman, Lewis, and Polson, 1994) combined with Thinking Aloud (Lewis, 1982) or integrated models (Federici and Borsci, 2010; Federici et al., 2005; Federici, Scherer, Micangeli, Lombardo, and Olivetti Belardinelli, 2003) by using validated measures, such as the Matching Persons and Technology (MPT) assessment tools (Scherer, 1998; see Chapter 3) or the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST; Demers, Weiss-Lambrou, and Ska, 2000, 2002; see Chapter 2).
2. Evaluate the environment if and how eAccessibility is considered and how to impact on redesign for accessibility using related guidelines, methodologies, tools, and laws (e.g., W3C/WAI 2011). It is a key role of the psychotechnologist to influence mainstream to take up eAccessibility as a fundamental human right in the information society.

The multidisciplinary team—along with the user—assesses the AT proposed, seeking for an AT solution in a specific context of use (Federici et al., 2015; Federici, Scherer, and Borsci, 2014; Section I). During the observation, the psychotechnologist checks if the AT matches the user’s needs during the evaluation trial (AT efficacy) and in prospect of the AT introduction within the end-user’s environment (AT effectiveness). Moreover, the psychotechnologist supervises the reorganization of relations between user and assigned AT solution within the interaction environment by following a biopsychosocial perspective. In this manner, the psychotechnological approach allows to measure both postural and cognitive changes resulting from the user–AT matching: the psychotechnologist analyzes the components emerging from the person–technology matching the cognitive apparatus developing through the relationship between the space and time dimensions (De Kerckhove, 1990, 1995). He goes beyond the person–environment centered adaptation and reaches out to support a general implementation of eAccessibility as a sociopolitical and economic issue.

In order to better understand the focus of the measurement and assessment process in which the psychotechnologist is involved, it is important to clarify the distinction between the role of the ergonomist and the role of the psychotechnologist (Federici et al., 2011). The cognitive ergonomist analyzes the effects arising from the user–technology interaction and the resulting mental model of the system (Halasz and Moran, 1983), and he or she indicates the necessary strategies to evaluate all the responses related to an artifact or to a specific interaction contest. In particular, the ergonomist analyzes the following components of the human–technology interaction:

- The effects of technologies on health, performance and human behavior;
- The implementation of working settings by considering the related required activities and the potential skills of final users in order to improve the productivity and avoid both cognitive and physical load.

In this manner, the main purpose of ergonomics is to evaluate and focus each implementation and design phase on the cognitive processes (perception, attention, memory, etc.) involved in the user–technology interaction system. As Norman (1983) stated, ergonomics recognize three typologies of mental models participating in the user–technology interaction system:

1. The user’s mental model
2. The image of the system
3. The conceptual model of the system

Starting from these three typologies—which are related to the person system and the technology system—the psychotechnologist introduces a new feature—the socio-environment system—by following the biopsychosocial perspective (Figure 9.1). In this manner, the psychotechnologist aims to analyze both barriers and facilitators occurring within the
interaction system in order to obtain the best combination among all its components (WHO, 2001, 2007).

According to the International Classification of Functioning, Disability and Health (ICF) perspective, it is important to follow a systemic approach in which aid becomes a part of a complex system composed by the user and his or her caregivers in a specific environment in order to allow him or her better autonomy (Scherer, 2005). In this manner, the psychotechnologist overcomes the ergonomic approach—which analyze only the user system–technology system interaction—by considering also the user's needs in order to evaluate the related goals contextualized within the user's environment and his or her reached autonomy degree (Federici et al., 2014, 2015; see Chapter 4).

By following an integrated or intrasystemic model (Federici and Borsci, 2010; Federici et al., 2005), the psychotechnologist investigates the three person, technology, and environment dimensions as an entire and complex system in which the object (system) and subject (user) are a part of a composite and dynamic empirical observation process within a specific environment. For this reason, the evaluation process of the system is based on a combination of top-down and bottom-up evaluation methodologies (Federici et al., 2005). The top-down methodologies are used for verifying the accordance of the specific environment to standard rules and guidelines, for example, the specifications suggested by the International Standard Organization (ISO) and the World Wide Web Consortium (W3C, WAI): this kind of methodologies could mainly be applied to the evaluation process in order to identify the accessibility parameters of the related interface. On the other hand, the bottom-up methodologies are used for evaluating the method in which the final user interacts with the interface into the specific environment of use: the evaluations are conducted by observing the user's behavior and giving psychometric analytic trials. This kind of methodologies is mainly addressed to observe the user's behavior while interacting with the interface and measure satisfaction levels: in this manner, the bottom-up methodologies measure the usability levels of the user–technology–behavior system.

That being so, the psychotechnologist's role is to investigate and verify the dynamic and complex user–technology–behavior system by integrating top-down and bottom-up methods in order to highlight the empowerment offered to the user by the AT solution (Borsci, Kurosu, Federici, and Mele, 2013; Federici and Borsci, 2010; Federici et al., 2003, 2005, 2011).
9.3 Case Example: Application of Models and Measurements

This section describes the application of the assessment process to a case example. Taking as example the case of Arianna (Table 9.1), the psychotechnologist will investigate whether the environmental expectations (family, health, and educational

**TABLE 9.1**

Medical Case of Arianna

Name: Arianna
Age: 6.5 years
Beginning of disease: from birth
Diagnosis: ICD-10-CM: Congenital quadriplegia G80.0 // ICD-9-CM: Congenital quadriplegia G80.0

*ICF-CY: International Classification of Functioning, Disability and Health—Children and Youth Version (WHO, 2007)*

<table>
<thead>
<tr>
<th>Body Functions</th>
<th>Body Structures</th>
<th>Activities and Participation</th>
<th>Environmental Factors</th>
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<tr>
<td>b114.1 Orientation</td>
<td>s110.8 Structure of brain</td>
<td>d140.30 Learning to read</td>
<td>e310 + 4 Immediate family</td>
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<tr>
<td></td>
<td>s730.4 Structure of upper extremity</td>
<td>d145.30 Learning to write</td>
<td>e320 + 4 Friends</td>
</tr>
<tr>
<td>b144.0 Memory</td>
<td>s750.4 Structure of lower extremity</td>
<td>d310.30 Communicating with—receiving—spoken messages</td>
<td>e325 + 4 Acquaintances, Peers, colleagues, neighbors and community members</td>
</tr>
<tr>
<td></td>
<td>Mental functions of language</td>
<td>d330.44 Speaking</td>
<td>e330 + 4 People in positions of authority</td>
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</tbody>
</table>

**Vineland Adaptive Behavior Scales**

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<th>Age Equivalent</th>
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<td>Expressive</td>
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<td>&lt;1.6</td>
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<td>Written</td>
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<td>3.10</td>
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<tr>
<td>Daily living skills</td>
<td>Personal</td>
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<tr>
<td></td>
<td>Domestic</td>
<td>0</td>
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operators) satisfy the actual user’s possibilities to use the AT to communicate; moreover, the psychotechnologist will also analyze all the related clinician material and, once individualizes the real user’s needs, he or she will seek the appropriate assistive solution in cooperation with all the multidisciplinary team by using different tools (e.g., the Vineland Scale). During the checking trials of the matching process, the psychotechnologist will lead the team by monitoring critical issues, strengths, and possible problems.

9.3.1 Case Description

Arianna was 6.5 years old with a diagnosis of severe spastic quadriplegia with a dystonic component as outcomes of cerebral palsy from birth and no verbal speech. Arianna had excellent cognitive resources, appearing to be very communicative and participatory with the environment. She attends the first grade in primary school, following a curriculum for students with special needs. Her prognosis is favorable regarding reading and writing. At the time of the observations, Arianna had difficulty in separating from her mother, crying and calling for her repeatedly when her mother left her.

9.3.1.1 Communication Strategy

The patient uses adequate and appropriate augmentative and alternative communications, both by request and declarative, being able to communicate much complex moods like affection, with a motivated and contextual smile, responding to closed questions “yes” with anti-flexion of the head and “no” with slight lateral movements of the head side to side. She uses, when requested, a book with pictures to tell her experiences and a binder with figures, pictures, and icons for communicating. She adequately and clearly expresses “yes” and “no” with head and eye movements. She points grossly with her right fist, because of her low muscle and gaze control. For communicating, Arianna uses a code of facial mimicry and gaze shared by the caregivers but not understandable to unfamiliar people.

9.3.1.2 Evaluation of Visual, Perceptive, and Motor Functions

With regards to visual and perceptual functions, specific strategies and a specific interaction with her were used in order to evaluate her ability. In particular, the symbols of Hyvärinen (circle, square, sweetheart, and cottage) were used (Hyvärinen and Jacob, 2011). The child had good visual acuity and a normal color sense, sensitivity to contrast and field of vision. Moreover, the child managed to perceive and locate objects in both the proximal and distal distance, with good ability to fix and track. She moved voluntarily within the room using a motorized wheelchair. Arianna was very interested in objects that were presented to her and she attempted in all ways to reach and grasp, but was unable to implement the action due to the presence of significant dystonia.

9.3.1.3 Functioning and Environmental Factors

The milieu is careful to respect Arianna’s time and manners, facilitates activities appropriate in content and form, and is available to work for the inclusion of alternative strategies for communication and education. The mother plays the role of “interpreter” of the code...
of communication (gaze and facial mimicry) used by Arianna. The milieu shows high expectations with respect to the insertion and use of AT by Arianna.

9.3.1.4 Request
Technological strategies and assistance to enhance Arianna’s communication have been requested. The request concerning identification of ATs that allow Arianna to keep up with the school’s curriculum and Checking the use of Augmentative and Alternative Communication (AAC) strategies adopted by the family without an expert consult and, eventually, including a new AT for communication to facilitate daily communication with a variety of children and adults.

9.3.2 The ATA Process
The Psychotechnologist acts in six following steps.

9.3.2.1 Multidisciplinary Team Meeting
1. User data valuation
2. Setting design

In this step, the psychotechnologist analyzes all the related clinician material (user data) and through instruments such as the MPT he or she set the framework assessment agreement together with the multidisciplinary team, by highlighting any environmental, personal, and technological issue. In agreement with the multidisciplinary team, the psychotechnologist analyzes the medical case of Arianna by detecting the individual predisposition to the assistive solutions by considering his previous experiences with AT, the current motivation to use an AT, and all those environmental factors that may affect the matching process (SOTU and ATD-PA of the MPT tests by Scherer, 1998; see Chapter 3). Particularly, the psychotechnologist does the following:

- Checks if the social environment will support the solution particularly for supporting scholastic learning
- Checks the equipment that will be part of tests during the assessment to select some ATs, such as switch and adapter to connect the switch to the computer and communication software
- With the multidisciplinary team, he checks a postural system that could improve her posture, integrating and supporting the AT for learning and communication

9.3.2.2 Setting Set-Up
In this step, the psychotechnologist prepares the setting and check that all the selected technologies are correctly working; in the case of Arianna, the psychotechnologist tests an eye transfer system. The eye gaze communication board, E-Tran, allows rapid communication with a facilitator, a software to reorganize communication boards, an automatic scanning system with switch and adapter to connect the switch to the computer, and a postural system. The system allows active postures to perform all operations necessary to use AT assigned with minimal effort and maximum performance.
9.3.2.3 Matching Process

1. AT solution proposal
2. AT solution user-trial
3. AT solution outcome

Together with the occupational therapist and the childhood neuro- and psychomotric-ity, the psychotechnologist directly offers Arianna the previously tested technologies by explaining their functioning and features. Then, supported by the multidisciplinary team, Arianna tests the proposed AT solutions while the psychotechnologist supervises his interaction by collecting any critical situation to subsequently apply the better solutions to optimize the AT use. If it is possible, any customization and/or configuration of the tested instruments will be applied by following the results of any trial performed by her using direct and participant observation methods.

9.3.2.4 AT Solution Multidisciplinary Team Evaluation

In this phase, the psychotechnologist discusses the observations made during the interaction of Arianna with the ATs with the multidisciplinary team, highlighting the strengths and weaknesses. The team decides whether tests are altogether satisfactory or not and communicates the results of the entire session to Arianna and her mother, showing them the potential and the limits of the proposed solutions.

9.3.2.5 User Support

After the evaluation process, the psychotechnologist meets Arianna, her mother, and her teacher to inform them about the potential and limits of any proposed technology and to collect information about any issues raised during the use of the given AT solutions and to show of the relationship between Arianna and the ATs in the classroom environment.

9.3.2.6 Follow-Up

The psychotechnologist periodically meets Arianna’s parents to ask them information about his experience of use with the solution and his needs; to check the process, the team uses some tools such as QUEST (Demers et al., 2000, 2002; see Chapter 2). If necessary, the psychotechnologist asks her parents to return to the center for technical aids to perform a new evaluation process.

9.4 The Role of the Psychotechnologist in a Center for Technical Aid according to the ATA Process Model

The following two flow charts show the phases within the ATA process ideal model (see Section I) in which the psychotechnologist is involved. As is shown in Figure 9.2: see Chapter 1, Figure 1.1 for the color version, the psychotechnology specialist plays a role within the user-driven processes by working in concert with the occupational therapist, the architect, and the engineer.
In Figure 9.3, a brown button sign shows the phases of participation for the psychotechnologist intervention. The psychotechnologist, along with the multidisciplinary team, evaluates the data and user’s request.

- If the data provided by the user are not sufficient for a “matching process,” the user is requested to convey more information and the process returns to “user data collection.”
- If the data provided by the user are sufficient for a “matching process,” the psychotechnologist, in accordance with the multidisciplinary team, proceeds by setting and scheduling an appointment for a meeting with the user.

The psychotechnologist, because his or her principal skill is technological and psychological competency, receives from the multidisciplinary team the commitment to arrange a suitable setting for the matching assessment. Then, the multidisciplinary team, along with the user, assesses the assistive solution proposed, tries the solution, and gathers outcome data.

The psychotechnologist, according to the multidisciplinary team, evaluates the outcome of the matching assessment.

If successful, the team proposes an assistive solution to the user and schedules a new appointment. If not successful, the team restarts the “matching process.” When the AT solution proposed requires an environmental evaluation, the team initiates the environmental
The Psychotechnologist

9.5 Psychotechnology Education: An Example

Basically, the concept of disability in this is per-se integrated into the psychotechnological framework. Disabilities or functional limitations are a precondition that enters into the profile of adaptive systems or services with widened system boundaries. Nevertheless, it has to be underlined that psychotechnology for the user group of people with disabilities is of much higher importance to allow accessing and interaction with mainstream by overcoming functional limitations. Presenting efficient or fancy alternatives for the average, people with disabilities using ICT and AT often gain the first-time independent access and participation in systems and services and thereby to mainstream.

For people with disabilities, psychotechnology offers new possibilities to overcome sensory–motor limitations and pushes adaptation or “normalization” to a new level that is...
known today as (e)Inclusion. Most importantly, the general ICT forces societal contexts to change, by making them modifiable, adaptable, and more fluent. This ICT revolution leads to a process of ongoing adaptations of societal contexts to better satisfy the requirements of users. This fundamentally changes the understanding of disability as it cannot be defined any longer as pure individual phenomenon defined by sensor-motor-cognitive conditions against a fixed environmental context, but also much more as a social phenomenon defined by the environmental settings and designs allowing, supporting, or hindering interaction and participation. It is no longer only asking how to best match an individual with AT into an environment, it is more and more how to design and adapt the environment how to best match the needs of users with an widened diversity of skills and requirements (Miesenberger, 1998, 2004, 2009a). From an individual/medical model over an environmental model, we reach a social model of disability (Gustavsson and Zakrzewska-Manterys, 1997). The plasticity of ICT includes the demand toward mainstream to respect the needs and requirements of AT users—eAccessibility—into the assessment and matching process and complements the scope of tasks of the psychotechnologist.

9.5.1 The Context of the Profession Psychotechnologist

A psychotechnologist is a person/profession who fixes persons with technology to become social and interactive with mainstream. Usability and sometimes accessibility experts call themselves psychotechnologist (http://restrictioniseexpression.com/post/43184264/am-i-a-psychotechnologist-now). In the context of AT, this outlines the “intentional” character of the profession. The psychotechnologist supports inclusion and participation in established contexts by providing access to mainstream systems and services. eAccessibility and eInclusion are two-folded: AT should enable people with disabilities to interact with mainstream systems and services. As outlined above, AT permits human being’s adaptation to the environment and also asks users for a cognitive and cultural modification and adaptation. Further on, eAccessibility asks for a general societal adaptation, for respecting and implementing mentioned accessibility standards to allow AT powered interaction with mainstream systems and services as a prerequisite for participation (Darzentas and Miesenberger, 2005; Miesenberger, 2009a,b). This brings a wide and complex scope to the psychotechnologist as it is not only the user and its personal technological framework, which is at discussion, with eAccessibility addresses ICT in general. The technological infrastructure, developments, and changes impact on our communities and thereby also on the possibility as well as the quality of participation. Owing to the accepted need to overcome the traditional separation and exclusion of people with disabilities, a more intense interaction and communication with mainstream processes is a key objective.

This expands the number of potential context and, in particular, the complexity of changing external opinions, procedures, and processes to suit the needs of AT federated participation. AT users live and act in diverse context and most of the time they address inclusion in mainstream contexts; therefore, AT assessment and the psychotechnologists inherit an according complexity from both the “internal,” person-centered AT, and the “external” eAccessibility context. “Making AT social” in this wide contextual sense is the core challenge of AT psychotechnologists.

9.5.2 Psychotechnologist: The Need for Education

This multilevel complexity underlines the need for a broad set of skills and qualifications. Analyzing and watching the state of the art (Matausch, Hengstberger, and Miesenberger,
2006; Miesenberger, 2006; Miesenberger, Hengstberger, and Batusic, 2010), it was found that no such training and qualification programs are so far available. Traditional professions such as, for example, rehabilitation specialists or special/inclusive teachers are still very reluctant to take AT (in particular ICT related AT, which is a key enabler for inclusion today) and eAccessibility on board. Education is, more or less, still oriented toward an “internal” context of a medical, therapeutically, special educational, or technological approach. The traditional disciplines and their education only slowly take up the potential of ICT, AT, eAccessibility, and Design for All.

On the other hand, the last years are characterized by a constant growth of awareness toward aging and disability also leading to according legal and administrative frameworks demanding for eAccessibility and eParticipation (W3C-WAI, 2011). Demographic developments clearly show an increase of older adults and people with disabilities in general (Lifetool, 2004). Several economic sectors already reacted to these developments by starting to produce apparatuses particularly for the older adults respecting and following the concepts of eAccessibility and Design for All. Not only technical apparatuses for a convenient life are of interest for older adults, but also support systems to gain independence through life, as this group of population is more likely to be affected by a disability. Survey shows that older adults aim autonomy in their lives. People with disabilities and older adults are able to gain greater control over the own life by the use of ATs. They allow participation and more contribution to activities at home, school, work, leisure time, or other communities.

The current educational offer in the field is inconsistent. Expertise is developed through both learning-by-doing and single seminars. Different enterprises working in the field of ATs offer seminars, each lasting for maximum a couple of days. Another offering was SART (1999), a summer academy on rehabilitation technologies, which occurred in 1999. Beyond the local context at European and international level, there is still a lack of such possibilities. The TELEMATE (TeleMate, 2011) network, and CSUN’s AT Training programme (CSUN, 2011) are some of the few examples that consider AT, eAccessibility, and this complex matching process, at least in part. All this motivated to work on a more holistic and comprehensive course for experts (psychotechnologists) in this field (Matausch et al., 2006; Miesenberger, 2006; Miesenberger et al., 2010).

The need for education is rising, expressed first as a need for “training on the job” that experts can cope with eAccessibility. Step by step, this should lead to an increasing demand for more comprehensive and formal educational settings. To satisfy the growing demand, more and well-educated experts on AT and eAccessibility will be necessary. To make full use of the potential of AT and eAccessibility, it is again not only the technological background that matters. It is the entire context that the psychotechnologist has to consider and manage, which defines the frame of skills and competences required. This gap, between a growing need for professionals and the lack of education, motivated to start working toward a new academic course aiming at providing a holistic curriculum for the profession we call her psychotechnologists aiming at matching people with AT to make systems and service social and inclusive. Assistec as an educational program aims at developing the expertise in managing the multidimensional process of eAccessibility and eInclusion.

9.5.3 The Assistec Program

In the following, we will outline the setup of the university course (Matausch et al., 2006; Miesenberger, 2006; Miesenberger et al., 2010). The duration of the university course
encompasses four terms. The first course started in the winter term 2006 and the course language is German. The course Assistec is offered as an online eLearning application with a certain amount of mandatory attendance hours. The course can be referred as in-service training. Intentions for this kind of realization are a high temporal and regional flexibility for participants, particularly for employees. However, it supports lecturers too, for they save time and it was easier to involve experts from different regions. The course graduates will be awarded an academic degree called “Experts on Assistive Technologies.”

The university course aims to educate people from different vocational and academic backgrounds in respect to the outlined complexity of AT provision and eAccessibility. Graduates will be experts in the area of ATs particularly concerning assortment of appropriate AT, usability of AT, environmental and social contexts, funding, application, adaptation, management and service, and counseling. Practical experiences show that these professionals also have a strong need, besides technical and personal skills, for expertise in demand analysis, environmental and social analyses, finances, funding, and more. Moreover, the course stresses concentrated and goal-oriented transfer of knowledge according to the up-to-date state of the art in a multidisciplinary environment. One major key feature and goal as well is that the course substantially emphasizes practical training and application of the theoretically gained knowledge. Another major intention is to enhance quality in the practical treatment regarding the profession fields of health care and support and services of people with disabilities. In addition to that, the implementation of the university course also aims to improve and foster product development of ATs.

The course is intentionally appealing to people from different vocational and educational backgrounds. Therefore, the target groups addressed by the university course are multifaceted and could be summarized as follows:

- **Vocational field of rehabilitation, therapy and welfare**: Within this vocational field, the course is particularly addressing people employed in the field of “people with disabilities” and “integration of people with disabilities” dealing with counseling, care, support, service, and accompaniment of people with disabilities.
- **Vocational field of health care**: In particular, people who are working in the fields of rehabilitation, nursing, care, and support of people with disabilities and older adult people are approached.
- **Vocational field of education**: Within this target group, we are appealing to both teachers of standard schools and adult education as well as special school teachers and pedagogues dealing with children with disabilities.
- **Vocational field of Assistive Technologies**: Particularly addressed are the people who are engaged in the areas of production, distribution and trading, maintenance, training, research, and development of AT.
- **(Emerging) vocational field of eAccessibility and Design for All**: The course in particular addresses the still small but growing number of people focusing on eAccessibility and Design for All in their job, be it in mainstream (e.g., software/web developers) or in specialized fields such as AT industry of service provision for people with disabilities.

To be in accordance with the idea of equal access to education, Assistec encourages, in particular, people with disabilities to participate as “disability” and such experiences in this context should be viewed as beneficial. To enhance vocational chances of people with
disabilities at the open labor market owing to an upgraded qualification is therefore also a goal of the course.

9.5.4 The Curriculum

The university course’s curriculum consists of four modules. Each of the modules is composed of single seminars. Overall, the university course comprises 4 modules and a total of 17 seminars. The Figure 9.4 outlines the university course’s contents.

Module one is focusing on imparting fundamental knowledge concerning medicine, physiology, psychology and classification of disability, legal foundations regarding disability and funding facilities, ATs, and, finally, Design for All and eAccessibility. As the module’s name already implies, the contents constitute fundamentals for the course and especially for the following subject.

Teaching contents of module two are emphasizing on the special knowledge of ATs including practical training units regarding AT products and their application. Therefore, this module disposes of a central position in the entire curriculum. This also includes the reference of AT to eAccessibility, the requirements of mainstream systems, and services to allow AT-facilitated interaction and participation.

Module two allows students to specialize in AT for a specific target group including a first phase for working on concrete practical examples.

Module three is dealing with the management and realization of the process of assortment and provision of ATs, as a goal could be described as “to educate counsellors and process/case managers.” Hence, pivotal issues are the assessment of needs, analysis of

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**FIGURE 9.4**

Contents of the university course Assistec.
the environment of people with disabilities in respect of technical, sociological, and economical areas, and mediation. It is the module treating with the outlined complexity of the field of “psychotechnologists” in its technological, medical, and psychological aspects in diverse social, political, and other environmental contexts. A particular emphasis, as outlined, is given on the “intentional” nature of eAccessibility and how to mediate with or influence mainstream to respect the needs of AT users.

During fourth module, participants have to undergo practical experience by managing and documenting a process of assortment and provision of AT by means of composing a scientific thesis. This kind of work placement/secondment also can be completed among holding down a job as the entire university course is organized as an in-service training. Based on an understanding of AT provision, considering both the user and the environment, a special emphasis is given to the practical problems covering the entire complexity of AT provision.

This shows that the developed curriculum is a composition of different professional subjects and contents of teaching by considering the complex nature of AT provision, as outlined above in Section 9.4. The range of subjects highlighted covers medical, legal, technical, economical, and management aspects and sociological aspects as well as psychological aspects. In addition, the crucial elements of the course are the cooperation and networking with the enterprises in the field of AT, as well as dealing with eAccessibility as a mainstream requirement.

9.5.5 eLearning System

The design of the course is characterized by a blended learning system, which “combines face-to-face instruction with computer-mediated instruction” (Bonk and Graham, 2006). According to this definition, blended learning is used regarding the university course Assistec as a combination of online learning and presence learning elements.

As the university course should be open for all people equally regardless of a possible disability, the issue of accessibility has to be raised. As a fully accessible system is not to be found at the market, the idea occurred to adapt an already existing eLearning system. An open source course management system (CMS) called Moodle (2011) has been chosen owing to its good results according to a first accessibility evaluation following the Web Content Accessibility Guidelines published by the Web Accessibility Initiative (Chisholm, Vanderheiden, and Jacobs, 1999). The used eLearning System has been evaluated several times by people with specific needs. Nevertheless, the fact is that the evaluation and the gathered experiences using and testing this system still show deficits concerning full accessibility. Great attempts are being undertaken to achieve a fully accessible version until the start of the course. The eLearning system acts both as a communication platform and a platform where all study materials are available in accessible formats.

Even though the eLearning system Moodle plays a crucial role within the blended learning settlement, the phases of personal attendance also are of great significance. Mandatory presence is planned for averaged three times per term with duration of two days. The phases of presence are, on the one hand, used in order to initiate social contacts and formation of groups and, on the other hand, to demonstrate and present practical and theoretical contents.

Overall, the blended learning settlement is enabling a high level of regional and temporal flexibility for the participants—and this is particularly beneficial for people with disabilities in respect of access to the course itself and mobility issues.
9.5.6 Graduates: Psychotechnologists

The qualification profile of the graduates is characterized by the following features:

- Graduates gain comprehensive and scientific specialist knowledge in the area of AT and eAccessibility and their application in diverse and complex societal settings.
- Graduates have the ability to provide people with disabilities and older adults with adequate ATs and to support them through the process of assortment and provision of AT by considering the diverse environmental settings.
- Graduates gain skills and competences in implementing eAccessibility and mediating the process of changing design and development processes toward eAccessibility. They have profound knowledge in related guidelines, laws, evaluation and repair, design and development methods, and tools.
- Graduates are qualified to self-contained organization, coordination, management, and handling of the entire process of assortment and provision of AT.
- Graduates are opening up of a new field of profession owing to their interdisciplinary knowledge concerning the social, technical, medical, and rehabilitation areas.
- Graduates are highly aware of the societal context of disability, aging, and AT.
- Graduates own knowledge regarding the legislative framework and funding possibilities in respect of the issue of disability associated with AT.
- Graduates have an increased sensibility and social competence in interacting and dealing with people using ATs.
- Graduates acquire a verifiable degree.

Keeping this profile of qualifications in mind, the graduates of Assistec gain during their education the vocational field of psychotechnologist or “Experts on Assistive Technologies” can be specified by some criteria. First of all, they act as the central contact person for AT users and their environment. Having one main contact person arranging all aspects of the assortment and provision of AT is a crucial advantage for people provided with AT. The experts are independent counselors who are not sales oriented but do have a detailed overview on the entire range of AT products, and they choose the most adequate device for the clients. Furthermore, AT experts are process managers. That is, to say that they are empowered to organize and coordinate the provision process of AT considering juridical, medical, psychological, technical, economical, and sociological aspects. Obviously, not experts in all domains are able to make available the resources, and expertise is required for the individual provision. Owing to this, they have leadership and management skills. Moreover, they are a representative of the user group of AT as well as of economy referring to AT organizations producing and distributing AT. In addition to that, these experts act as multipliers in their vocational field in the respect as they fulfill the task of awareness raising and sensitization for eAccessibility and eInclusion. Finally, a significant aspect of the expert’s vocational field is the usage of mediation and conflict management skills, if conflicts and difficulties emerge during the process of assortment and provision of AT. Figure 9.5 summarizes the influence and impact of the developed university course Assistec and its graduates on wider society.
9.5.7 Impact

Assistec is viewed as an example of education for the emerging field of psychotechnologist in the AT and eAccessibility domain. The course is a contribution toward current efforts on eInclusion of people with disabilities by reducing the gap between the growing need and the lack of offers in education. Graduates have competencies to manage a process of assortment and provision in complex and diverse settings from the very beginning till required trainings and maintenance relating to all categories of Assistive Technologies. They orient toward eAccessibility and its application in mainstream eSystems and eServices. This should help to improve the quality of service provision for people with disabilities and eAccessibility implementation in mainstream. This should also allow incentives to product development owing to an intensive communication between clients and psychotechnologists.

9.6 Conclusion

In this chapter, we introduced the meaning and background of psychotechnology, and we explained the role of psychotechnologist within the matching people with disabilities and AT process. In particular, we described some applicative examples in different contexts, from the traditional context, focused on the interaction between person with disability and AT within their everyday life environments, to the ICT context in which eAccessibility is a fundamental requirement to allow participation, independence, and inclusion to people with disabilities. Starting from a theoretical background, we described the evolution of the meaning of psychotechnology, “a technology that emulates, extends, amplifies and modifies sensory–motor, psychological or cognitive functions of the mind” (Federici et al., 2011): the interaction between user and technology is a dynamic intrasystemic relation in which the artifact has the role of amplifier transporting rules and knowledge possibilities and permits both the adaptation to the system and a cognitive and cultural modification.
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(Federici and Borsci, 2010). In this light, we show the role of psychotechnologist by focusing on two different fields of application: the ATA process in the center for technical aid and the psychotechnologist education field, concerning ICT-based systems and services.

The role of psychotechnologist is to investigate the psychological and cognitive components involved in the interaction environment—be it either a physical environment or an ICT environment—by analyzing and evaluating the following issues: (1) the pertinence of one or more technological aids selected for an AT solution in a user-driven assessment process by using different tools such as, for example, the MPT model (Scherer, 1998); (2) if and how eAccessibility is considered into an ICT environment and how to impact on redesign for accessibility using related guidelines, methodologies, tools, and laws (e.g., W3C-WAI, 2011). In order to better explain the role of psychotechnologist, we have shown two case examples: first, we described the role of psychotechnologist within the assessment process by showing the case of Arianna as a case example; then, we focused on an example of educational project, the Assistec program, which aims at lowering the gap between the growing need for and lack of education by forming experts who are able to manage this complex, multidimensional process of eAccessibility and eInclusion.

9.7 Summary

This chapter is focused on explaining the concept behind the term “psychotechnology” and the role of “psychotechnologist” within the matching people and AT process. According to a biopsychosocial perspective, a psychotechnology is defined as any “technology that emulates, extends, amplifies and modifies sensory–motor, psychological or cognitive functions of the mind” (Federici et al., 2011), highlighting in this manner the intrasystemic relation between the artifact and the user. Starting from these suggestions, the primary role of psychotechnologist is to follow a systemic approach to allow users a better autonomy (TeleMate, 2011). This goal is possible only by considering the users’ needs, their reached autonomy degree, and the environment they live. In this chapter, we have explained in detail two fields of application of this new professional figure: the ATA process in center for technical aid and the ICT-based systems and services, that is, eSystems and eServices.

References


Miesenberger, K. 2006. BFWD and Assistec: Two university degrees relevant to design for all: Accessible web design and assistive technologies. Paper presented at the International Design for All Conference (pp. 1–5). Rovaniemi, FI.


10

The Occupational Therapist: Enabling Activities and Participation Using Assistive Technology

Desleigh de Jonge, Melanie Hoyle, Natasha Layton, and Michele Verdonck

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10.1 Occupational Therapist’s Perspective

The overarching goal of occupational therapy is to enable people to engage in health and well-being promoting occupations, that is, everyday tasks, activities, and participations that enrich their lives (Curtin, 2009). To this end, occupational therapists partner with people to select and use Assistive Technologies (ATs) that allow them to continue doing the things they want and need to do. Occupational therapists use a broad range of knowledge and skills to examine the transactions among the person, the activities they engage in, and the environments in which these activities are undertaken. Occupation, or activity engagement and participation, plays an essential role in human life, influencing people’s state of
health (Kielhofner, 2004; Polatajko et al., 2013). Occupation also helps to organize time, and brings structure and meaning to life (Polatajko et al., 2013).

Each person simultaneously fulfills various roles that require him or her to perform a diversity of activities in a range of environments. Activities range from activities of daily living (including personal care), household, or community tasks called instrumental activities of daily living (such as shopping and cooking), to activities for work, education, leisure, play, sleep and rest, and social participation (American Occupational Therapy Association [AOTA], 2014). People have personal preferences, interests, and expectations that influence their choice of activities and the manner in which they undertake these (Ripat and Woodgate, 2011). Activities are invariably performed in and across a range of settings including home, school, work, and various community and natural settings. Each environment, while offering opportunities for participation, has physical, social, cultural, temporal, and virtual contexts (AOTA, 2014).

This transactive view of the person, activities, and the environment is supported by a number of occupational therapy models including the Person–Environment–Occupation model (Law et al., 1996) and the Person–Environment–Occupational Performance (PEOP) model (Christiansen and Baum, 1997; Baum, Christiansen and Bass, 2015) and aligns well with AT models such as the Human Activities and Assistive Technology (HAAT) model (Cook and Polgar, 2015) and the Matching Person and Technology (MPT) model (Scherer, 2005; see here Chapter 3) as well as the International Classification of Functioning, Disability, and Health (ICF) (World Health Organization [WHO], 2001a). Although the terminology and emphasis varies, the primary focus of each of these models is on optimizing activity and participation. Each model also recognizes the dynamic and reciprocal interaction among the person, activity, and the environment. All models are founded on the notion of “goodness of fit,” or the match between the person’s skills and abilities and the occupational and environmental affordances and demands. These models also reflect the values of the disability movement, in which the environment is viewed as an agent in creating disability (Brown, 2009).

Given the complexity of each person’s situation, occupational therapists use a person-centered approach in which each person’s unique perspective is recognized and valued. Individuals are viewed as having distinctive personal attributes, capacities, and life experiences that influence their priorities and preferences (Curtin, 2009). Using a person-centered approach, the occupational therapist listens carefully to the person to understand their experiences and aspirations and works with them to develop occupational goals related to the use of AT. Informal and formal assessment strategies focus on identifying the specific challenges to individuals engaging in activities of choice and the environments where these are to be undertaken. Occupational therapists work collaboratively with each person, using a variety of interventions, considering varied levels of AT complexity, and negotiating four sequential stages of the AT process as described in this chapter.

10.2 Occupational Therapy Interventions

ATs have long been considered an essential intervention strategy by occupational therapists (Østensjø, Carlberg, and Vollestad, 2005). Traditionally, ATs were viewed as a replacement or accommodation for a loss of function (Roulstone, 1998, 2016; see here Chapter 2) and were frequently “prescribed” by occupational therapists based on the individual’s impairment. For example, a manual wheelchair would be recommended for someone with paraplegia because they could push the chair independently, whereas a powered
wheelchair would be recommended for someone with tetraplegia who was unable to use their arms to push. Little consideration would be given to the various activities the person wanted to engage in or the range of environments they sought to mobilize in.

When the enabling capacity of ATs is recognized, and the focus is on what the person needs/wants to be able to do and where they need to do these activities, ATs are designed and selected to meet the activity and environmental demands. For example, the person with paraplegia referred to previously may need to move quickly across a university campus between classes and would therefore manage these demands better in a powered wheelchair. Using this AT, the individual would not be so exhausted from pushing a wheelchair that they struggle to take notes on their laptop at lectures.

Occupational therapists utilize a diverse set of interventions to optimize activity engagement and enhance the person–environment–occupation fit. A key skill entails the establishment of a strong therapeutic relationship with an individual based on perspective sharing and understanding in order to work with the person to tailor an intervention best suited to their individual preferences and circumstances (AOTA, 2014). ATs are identified as one of the six interventions used by occupational therapists to promote occupational engagement that include reducing the impairment, compensating for the impairment, redesigning the activity, redesigning the environment, or introducing personal support (Smith and Benge, 2004). Generally, a number of these interventions are required in combination to achieve a successful outcome.

Occupational therapists often work with individuals to ensure that their capacities and skills have been optimized in combination with redesigning activities or environments, introducing AT, and recommending personal support as necessary to meet relevant goals. For example, remediation strategies, such as neurorehabilitative techniques, may be used to optimize functional capacity where appropriate. If an occupational therapist observes that the person is poorly positioned, he or she will examine the impact of repositioning on performance before exploring assistive devices. Furthermore, an individual with limited experience or skill performing a task may benefit from skills training prior to deciding on the most suitable AT. Occupational therapists are often involved in teaching people and their families how to use AT to ensure the person’s goals are achieved (Verdonck and Maye, 2016).

Occupational therapists work in a variety of service delivery contexts within the health, education, disability, community, and aged care sectors. Each of these contexts has defined foci and priorities as well as variable resources and demands that can impact on the nature of services occupational therapists are able to offer. Managing these “pragmatic constraints” is recognized as an essential aspect of professional reasoning (Creek, Ilott, Cook, and Munday, 2005). Occupational therapists consider these along with other considerations such as the person’s narrative, research evidence, and prior clinical experience to ensure that the best possible outcome is achieved for each individual. Consequently, occupational therapists may need to advocate for additional AT options and/or resources and articulate the related occupational benefit and social value to support individual funding applications or systemic change (AOTA, 2014).

10.3 The Definition and Role of Assistive Technology

AT is defined as “technologies, equipment, devices, apparatus, services, systems, processes and environmental modifications used by older people or people with a disability
to overcome the social, infrastructural and other barriers to independence, full participation in society and carrying out activities safely and easily” (Hersh and Johnson, 2008, p. 196; see Section I). This definition recognizes both the physical device (hard technology) and the systems (soft technologies) that enable a person to use that technology (Cook and Polgar, 2015; Waldron and Layton, 2008). In doing so, it acknowledges the importance of viewing devices and surrounding service elements as an integrated whole, which is critical to ensuring good AT outcomes (de Jonge, Scherer, and Rodger, 2007). Despite the extensive range of technologies available, these alone are rarely enough to ensure the success of an AT intervention. Support systems or soft technologies are generally required to ensure the effective use of AT. Soft technologies include collaborative assessment, trial, customizing the device to suit the individual’s specific requirements, training to enable the person to use the device, follow-up, and providing support for the repair and maintenance of the device. The need for soft technologies increases with the complexity of the technology, the task or activity, demands of the environment and the nature of the impairment.

The International Standard for Assistive Products (ISO9999) also defines the role of AT as being for use by and for “persons with disability for participation, to protect, support, train, measure or substitute for body functions, structures and activities, or to prevent impairments, activity limitations or participation restrictions” (2016, p. 1). Both definitions acknowledge the enabling aspects of AT, viewing them as tools for overcoming barriers to full participation. However, the ISO9999 also recognizes the number of purposes that AT might serve, thus highlighting the complexity involved in identifying the best option.

Particularly, the ISO9999 (2016) defines assistive products as “any product (including devices, equipment, instruments, technology and software) especially produced or generally available” (p. 1). Assistive products that have been particularly produced for people with disability include wheelchairs, seating and positioning systems, computer access technologies and specialized software, augmentative communication devices, and environmental control systems. Products that are “generally available” or mainstream can range from simple devices such as nonslip mats or electric can openers to sophisticated options such as smart and home automation technologies. The ever-growing range of mainstream technologies that affords many of us a great deal of convenience and new opportunities can have even greater value to older people and people with disability.

AT ranges from simple low-tech options to sophisticated, high-tech devices (Cook and Polgar, 2015). Cook and Polgar (2015) note that the complexity level of the AT selection process does not entirely map to the complexity of the device. In order to consider the complexity that may arise from the transaction among the device, the person, the task, and the environment, four levels of complexity are proposed, based on the literature (Hammel and Angelo, 1996; Summers and Walker, 2013) and policy work being undertaken in Australia (National Disability Insurance Agency [NDIA], n.d.). These levels, described by Australia’s National Disability Insurance Scheme (NDIS) (NDIA, n.d.), recognize the complexity of the interaction between the technology and the situation, that is, the nature of impairment, competencies required to operate the technology and level of challenge in the activity or environment(s) where the AT is likely to be used. As described in Figure 10.1, Level 1 and 2 ATs are considered to be lower risk in terms of human and financial costs than Levels 3 and 4.

Level 1 AT includes mass-produced consumer products that are perceived as low risk, being easy to acquire and simple to operate. However, while many of these devices are low cost and readily available, not everyone is aware of these devices or their capacity to make everyday tasks easier and safer. People with limited exposure to specific products of interest may find it difficult to locate information on the full range available in order
to make an informed choice. If someone has a recently acquired impairment, he or she may not yet be able to determine whether the various features and functions will meet their specific needs and requirements. While many people are capable of selecting a mass-produced product without the assistance of a health professional, in some situations there are risks associated with the use of these devices. For example, everyday technologies, such as propping stools or reachers, may be required by a person returning home from palliative care. In this more complex situation, the person’s health, the tasks as well as environmental and temporal considerations add complexity and risk when selecting and using the AT.

Occupational therapists are often well placed to inform people about Level 1 devices when discussing and observing the challenges they experience in day-to-day activities. The ever-expanding range and availability of devices can make it difficult for people to understand their options and identify the device best suited to their needs. Occupational therapists with a good understanding of AT information systems and mainstream technologies can assist people to navigate these systems and locate potentially suitable options. They also have a role in empowering people to seek and access further information on these products. In more complex situations, occupational therapists work with individuals to understand their situation and the risks associated with products of interest and identify specific functions and features best suited to the complexity of their situation.
Level 2 refers to off the shelf, adjustable AT. These purpose-specific devices include bathing, toileting, and domestic aids as well as transfer equipment and often have some degree of risk associated with appropriate selection and use. While locating information on these devices has become easier with the advent of the Internet, the volume and diversity of products can easily overwhelm the uninitiated. This level of AT can generally be safely selected and used by people who have experience in using the AT or only use the device infrequently or for specific activities. However, people who are likely to be reliant on the AT or have multiple or complex health conditions, such as problems with balance, cognition, bone density, or skin and joint integrity may benefit from the input of a health professional, such as an occupational therapist, to assist them in identifying the features and functions best suited to their specific requirements. Some Level 2 AT in themselves have risks associated with their use. For example, bathseats are off the shelf, adjustable devices, but may be contraindicated owing to issues with person (e.g., transfer and sitting balance) and environment (both dimensions and setup) fit. In these situations, a comprehensive screening process and impact evaluation are indicated. Level 2 devices may also require selection and adjustment to fit the individual and their specific situation as well as training in effective use and maintenance. Occupational therapists can provide instruction on device adjustment, use, and maintenance that ensures safe and effective use of the device and reduces the risk of device abandonment, a common problem with AT that is provided without such supports (Wessels, Djicks, Soede, Gelderblom, and De Witte, 2003).

Level 3 AT comprises of devices that are highly specialized and designed with a specific group of people or application in mind such as powered mobility, communication devices, environmental control units, prosthetics, and pressure care management systems. There are moderate risks associated with the selection and use of these devices, particularly for people who have altered muscle tone, skin integrity, or impaired cognition. The range of activities for which these devices are used and the variety and complexity of environmental considerations also add to the risks associated with Level 3 AT. People are generally less familiar with these devices, which require careful consideration in the selection and associated training for effective use. Considerations related to person, activity, and environment “fit” add to the complexity of identifying the most suitable option and ensuring its safe and effective use. Occupational therapists without dedicated experience or training with this level of AT may find that it is beyond their personal scope of practice to provide the level of expertise required when selecting these devices (Maywald and Stanley, 2015; Verdonck, McCormack, and Chard, 2011). Consequently, the assistance of an experienced AT user and professional is invaluable during selection to ensure that the person is well apprised of how the device operates and can be adjusted to his or her specific requirements. People also benefit from the expertise of a professional once they acquire the device to customize the AT to their specific requirements and develop tailored training and learning support to optimize the effective use of the AT in the application environment(s) (de Jonge and Rodger, 2006).

Level 4 AT includes customized devices that are appropriately tailored to the individual’s specific requirements (Summers and Walker, 2013). People with significant impairments are often faced with complex positioning, mobility, access, and communication issues, which require the AT to be configured uniquely and integrated with other technologies across a range of environments. Even small additions or changes to the person’s existing setup can result in adverse outcomes that have significant consequences. People requiring this level of AT often have multiple complex impairments, so the AT may also need to accommodate issues associated with posture, skin integrity and muscular changes, or prevent/remediate further impairment or concerns. Consequently, this level of
The Occupational Therapist

AT typically requires diverse expertise, extensive problem solving and multidisciplinary input to craft a solution. The multidisciplinary team generally comprises rehabilitation engineers, physiotherapists, occupational therapists, speech pathologists, educators, technicians, suppliers, and most importantly AT users and associated family members and/or care providers. The success of the AT is dependent on each team member bringing their specialist knowledge and understandings to the table and working collaboratively to identify the components required and integrating these into the final solution. The complexity of AT and the individual’s situation at Level 4 also indicates that careful attention needs to be given to integrating the AT into the application environment(s). This may require changes in the physical or social environment to ensure that the AT can be accommodated and adequately supported. Occupational therapists are often involved in providing training and support to the individual and significant others in each application environment on the effective use, maintenance, and repair of the AT as well as identifying how to monitor the ongoing effectiveness of the solution.

People are likely to use a range of AT to address their activity limitations or participation restrictions. At the lower levels of risk, a range of AT might be used across a number of activities in several environments. At Levels 3 and 4, a combination of AT, as well as other supports such as environmental modifications and personal assistance, is often used within activities and environments. The identification and integration of these personalized “assistive solutions” (Association for the Advancement of Assistive Technology in Europe [AAATE], 2012; see Section I) can be complex. Occupational therapists, with their focus on enabling occupation and understanding of the person–environment–occupation transaction are well placed to work with individuals to identify the best combination of AT for them in their individual situation. Their expertise in environmental modification also equips them to ensure that the environment is carefully considered and utilized when designing assistive solutions. The person’s environment has a critical role to play in mediating the effectiveness of any AT (Anaby et al., 2013). This includes the immediate environment (doorways, circulation spaces) as well the community environs (continuous path of travel, accessible buildings) and the concept of “inclusive” or welcoming environments (Layton and Steel, 2015). Occupational therapy practice extends to systemic advocacy and future roles in building accommodating communities and workplaces that will enhance participation opportunities for the AT user, beyond the home environment.

10.4 Occupational Therapists Involvement in the Assistive Technology Process

The quest for AT generally begins before the person contacts a professional, and the effective use of the device extends well beyond their encounter with a professional or team. Working in a person-centered manner requires a deep understanding of the person’s experience and perceptions of selecting and using AT. This understanding allows the occupational therapist to shift the focus from what the professional can do for the individual, to work collaboratively with them to successfully navigate the process and achieve a good AT outcome.

Effective selection and use of AT is a multistep process for the person seeking AT (see Section I). The four steps of the AT journey presented in Figure 10.2, build on literature, a substantive qualitative study (de Jonge et al., 2007), as well as ongoing validation of the four steps with AT users. First, the person has to be able to imagine the possibilities—what AT might
enable them to achieve. Second, he or she needs to seek information on the AT available. Third, the process of choosing (and acquiring) the best option occurs. Finally, the person learns how to live successfully with the technology. The occupational therapist works collaboratively with the person throughout this process, understanding the individual’s aspirations, expectations, preferences, and lived experience of disability and their use of AT. This enriched picture of the person, the activities they wish to participate in, and the environment(s) where the AT is to be used enables the occupational therapist to bring their specific experience and expertise to the AT process. This person-centered view of the journey that people undertake when selecting and using AT aligns well with the Assistive Technology Assessment (ATA) process model, which outlines user and center actions in the AT delivery system (Federici, Scherer, and Borsci, 2014; see Section I).

10.4.1 Imagining Possibilities

The process generally begins with someone envisioning doing something or anticipating the potential of technology (Alliance for Technology Access, 2005). Consistent with the ATA process model, this stage corresponds to the User actions’ phase 1 “The user seeks a solution” and to the actions of the AT service delivery phase 1 “welcoming a user’s request” (Federici et al., 2014; Section I). Some people come to the process with a vision of what they want to be able to do; however, this vision can also evolve slowly throughout the process of exploration as the person comes to understand the technology and what it has to offer them. When people come with their own vision, the occupational therapist works with them and provides information on technologies that can enable them to realize this vision. Sometimes people come with information on a specific product such as a particular motorized scooter or iPad. In such cases, it is important to understand what the person is
hoping to achieve with this product. By fully understanding the person’s aspirations and preferences as well as the intended purposes and environment(s) where this technology is to be used, the occupational therapist can work with the person to develop a full vision of possibilities and a clear understanding of the outcome to be achieved (de Jonge et al., 2007; Wechter, McDonell, and Verdonck, 2016).

For those who have not yet developed a vision, the occupational therapist works with them to imagine what might be possible by exploring the technology and where possible introducing them to peers who are achieving goals using AT. A vision of possibilities can also be achieved by reviewing activities and participations of interest through informal conversation or using assessment tools such as the ICF Checklist (WHO, 2001b) or Activity Card Sort (ACS) (Baum and Edwards, 2001). Imagining possibilities is a very important step in the process, particularly for people who have had reduced opportunities owing to the impact of condition or circumstance or those who have abandoned activities which became too problematic.

Once a vision has been created, and the person’s need and desire for technology have been identified, the potential of technology can be explored (Scherer and Galvin, 1996). At this stage, the occupational therapist gathers information about the person’s preferences, past experiences, and expectations of technology and examines if they are open to the use of technology and able to manage it (de Jonge et al., 2007; Krantz, 2012). Furthermore, the capacity of the application environment(s) to accept and support the technology is considered (Scherer and Galvin, 1996). Using this in-depth understanding of the person’s aspirations, technology possibilities and the opportunities and constraints of the application environment(s), a goal is crafted collaboratively. Effective development of goals engages people in the process and facilitates good outcomes (Law and McColl, 2010). Although some people can have very clear and specific goals (Sprigle and Abdelhamied, 1998), others benefit from working with an occupational therapist to develop their goals (de Jonge et al., 2007; Scherer, 2000). AT goals need to describe the “who, what, where” (person, activities and environments) to ensure the AT achieves what it needs to achieve. That is, each goal should capture the person’s aspirations or expectations of the technology, for example, independence, efficiency, and aesthetics. The goal should also specify what activities or participations the person wishes to engage in and where (as well as when and with whom) these activities are to be undertaken. Occupational therapists often collaborate with other stakeholders (e.g., family, teachers, therapists, or employers) to explore goals and expectations, if the AT user is uncertain or unable to articulate their goals (Cook and Polgar, 2015).

Occupational therapists commonly use informal interviews to develop an understanding of a person’s goals; however, structured processes offered by tools such as the Canadian Occupational Performance Measure (COPM) (Law et al., 1994) can assist in developing an understanding of the person’s current performance and priorities. This and similar tools such as Goal Attainment Scale (GAS) (Malec, 1999) and the Individualised Prioritised Problem Assessment (IPPA) (Wessels et al., 2002) also provide a mechanism for evaluating the effectiveness of the technology in addressing the person’s goals. The MPT assessment process, particularly designed to examine a person’s technology needs, has dedicated forms that provide a structure for exploring goals, preferences, and the person’s view of technology (Scherer, 2000). Once the person’s overall goals have been identified, the specific requirements can be determined.

10.4.2 Seeking Information

The next stage of the process focuses on identifying the person’s specific requirements, establishing device criteria and then exploring potential technologies using a range of
local resources and supports. According to the ATA process, this stage corresponds to the actions of the AT service delivery phase 2 “arranging a suitable setting for the matching assessment” (Federici et al., 2014; see Section I). A clear understanding of requirements is essential to identify the most appropriate technology. For example, occupational therapists have traditionally focused on demographic and anthropometric data such as the person’s age, size, and weight to determine the appropriate specifications of the device. Furthermore, the person’s specific skills and abilities are evaluated. It is also useful to examine the person’s ability to access and use the proposed technology to develop a clear understanding of the person’s actual abilities, because it is often not possible to predict how well someone will manage a piece of technology. The person’s experience, preferences, and expectations of technology are similarly important considerations when developing a list of requirements, as these ensure a good person–technology “fit.”

When establishing user requirements, it is also necessary to closely examine the activities to be undertaken. Valued activities identified by the individual are discussed and observed to understand how he or she wishes to engage in these and related activities that enable full participation. Discrete tasks and the barriers to participation and performance are carefully examined for all aspects of the activity. For example, wheelchairs were traditionally designed to allow people with injuries and health conditions to mobilize on surfaces from one location to another. Today, our understanding of where and how people move within a community and the value of being at eye level with others has resulted in the development of features, such as all-terrain tires and standing functions being incorporated into the design of wheelchairs that have substantially contributed to the wheelchair user’s ability to actively participate in society.

Similarly, a thorough understanding of the environments in which the person wishes to participate now and in the near future influences the technological requirements of the AT (Anaby et al., 2013; de Jonge et al., 2007). Physical environment aspects likely to affect technology, include topography, temperature, climate, sound, and lighting conditions (Layton and Steel, 2015). Furthermore, the social and cultural context of the environment, including the capacities and perceptions of others, are well recognized as impacting on the acceptance and uptake of AT (Cook and Polgar, 2015; Ripat and Woodgate, 2011; Scherer, 2000). The aesthetic appeal of the technology and its impact on others’ perceptions of the user is increasingly being recognized as a critical consideration (Parette and Scherer, 2004; Ravneberg, 2012). Because circumstances rarely remain constant, the temporal context of the environment, including the person’s past experience with technology and their expectations for the future can also influence their technology preferences and requirements (Krantz, 2012). Finally, the virtual context enabled through the Internet and cloud computing is an increasingly important consideration. People now have virtual lives and engaging in these holds many opportunities for people with disabilities. However, despite the opportunities offered by the virtual environment, many technologies remain inaccessible to people with physical, cognitive, and sensory limitations (Verdonck and Maye, 2016).

Many people who rely on AT, use several devices together. Consequently, existing and future technologies need to be carefully considered when seeking novel AT. Devices may not be compatible with each other owing to differences in operating systems (e.g., Windows Microsoft and Apple macOS) or communication protocols, such as Wi-Fi or Infrared. Furthermore, many devices now offer wider and overlapping functions. For example, a powered wheelchair may include an Infrared environmental control function. Similarly, an assistive and augmentative communication (AAC) device may too have an infrared environmental control capability. These overlapping features may be redundant
or alternatively may offer creative opportunities to do activities in multiple ways with different ATs. The added features may also incur greater unnecessary costs or become redundant in the future.

Some consideration must also be given to devices that may require the same communication resources. For example, a smartphone may link to a headset via Bluetooth. That same smartphone may be used for accessing an environmental control system application (App), which is activated using a Bluetooth switch adapter. In this case, the person may then not be able to use the headset and environmental control system at the same time as the phone may only allow one single blue tooth connection.

Once the requirements are clearly articulated, the device criteria/characteristics can be established. The person’s goals determine the nature of technology, whereas their preferences influence the style of device. A user’s experience with technology often dictates the level of sophistication, whereas their skills and abilities would determine the interfaces and programming requirements. The range of activities and tasks dictates the specific features and functions of the technology system(s), whereas the range of application environments determines the characteristics required by the technology to ensure that it can manage and operate effectively in the application environments. Attending to expectations and possible future changes ensures that the selected technology can accommodate developments in the person’s life and extends its usefulness. Existing technologies will also likely influence the platform, operating system and connectivity requirements.

People often use a range of resources and information systems when exploring AT options including other AT users, suppliers, service providers, such as therapists, specialist AT information services, and the Internet (de Jonge et al., 2007). This is not dissimilar to the range of resources used by anyone looking for a new car, computer, smartphone, or other types of technology. With the advent of the Internet, people have access to large volumes of information; however, people can quickly become overwhelmed and find it difficult to discern the validity of claims made on various websites. Furthermore, with an ever-expanding range of mainstream and specialized technologies available, it is increasingly difficult to distinguish between them (Alliance for Technology Access, 2005). Occupational therapists work with the AT user and other team members to develop a good understanding of the range of devices available and the features and characteristics that are best suited to the user, the activities he or she wishes to engage in, and the environment(s) where the technology is to be used. Exploring the available technologies provides the person with a sound foundation for selecting potentially suitable devices to examine more closely.

### 10.4.3 Choosing the Best Option

Once a number of suitable devices are identified, the occupational therapist then works with the person to evaluate how each device meets the identified requirements, develop a funding strategy, and determine a preferred device to purchase (Cook and Polgar, 2015; de Jonge et al., 2007). According to the ATA process, this stage corresponds to the User actions’ phase 2 “The user checks the solution” and to the actions of the AT service delivery phase 3 “assessing/matching the assistive solution.” In this phase, when needed, the team initiates the Environmental Assessment Process (Federici et al., 2014; see Section 1).

The device criteria developed in the seek stage are further refined to closely examine whether each device meets the requirements of the person, activities, and application environment(s). During this stage, it is imperative to trial the device and to allow the user to review its aesthetics, comfort, and usability (de Jonge et al., 2007; Verdonck, Steggles,
Nolan, and Chard, 2014). The user needs to trial each option long enough to examine the relative merits of each option and determine whether any of it cause discomfort or pain. The trial also provides the user with an opportunity to determine if each can be adjusted to allow efficient and effective use now and into the future, as activity and environmental demands change. The capacity of each device to perform all required operations related to each activity also need to be compared. Finally, compatibility with other technologies; the support requirements in each environment and the immediate and ongoing costs of each option should be examined closely (de Jonge et al., 2007).

Occupational therapists also assist the user to explore funding sources and navigate the administrative processes to secure the appropriate technology. This often involves a detailed description of need and relative suitability of various options. Once the best device is selected, the device is then purchased (Cook and Polgar, 2015). Good practice in AT service provision does not regard the purchase of the device to be the end of the process. Further important stages for the AT user include maintenance, review, and replacement cycles. With mastery, comes the potential for new goals; AT users describe lifelong relationships with their AT solutions. Occupational therapists play an important role in ensuring that the person has the skills, supports, and strategies for living successfully with their AT across the lifespan (Layton, Wilson, Colgan, Moodie, and Carter, 2010).

10.4.4 Living Successfully with Assistive Technology

After the device is purchased, it may need to be fitted to the specific requirements of the user and set up by someone with appropriate expertise (Cook and Polgar, 2015; Scherer and Galvin, 1996) to ensure that it is operating as intended and is integrated with other technologies (Nochajski and Oddo, 1995). According to the ATA process, this stage corresponds to the User actions’ phase 3 “The user adopts the solution” and to the actions of the AT service delivery phase 4 “follow-up and on-going user support: the assistive solution is evaluated in the daily life context of the user” (Federici et al., 2014; see Section I).

Many devices require further customization after purchase to ensure that the device is adjusted to the specific requirements of the user when undertaking various tasks across the day in a range of environments (de Jonge and Rodger, 2006). The ongoing effectiveness of technology is dependent on the comfort and ease of use for the user when using the device for extended periods of time. Research has raised concerns about pain and discomfort experienced by AT users (Patterson, Jensen, and Engel-Knowles, 2002). Technology interventions need to be adjusted to ensure that use does not result in discomfort and strain (Scherer and Vitaliti, 1997). Becoming familiar with technology can also be a “hassle” (Verdonck et al., 2014). The interaction between hassle and engagement, when getting used to technology, relates to technological challenges and frustrations, as well as the need to alter routines and habits. Successful use in turn leads to less hassle and enjoyable engagement with the technology (Verdonck et al., 2014).

Training and acclimatization to the use of the device is therefore fundamental to the ongoing effectiveness of technology interventions (Cook and Polgar, 2015; Myburg, Allan, Nalder, Schuurs, and Amsters, 2015). Without adequate training, the technology is at risk of being abandoned (Wessels et al., 2003; Scherer, 2002). Technological challenges and frustrations, as well as the need to alter routines and habits can become overwhelming for the AT user. Acknowledging these challenges and the effort required for integrating AT into life throughout the AT process will support the person in overcoming these
“hassles” (Verdonck et al., 2014). Effective training ensures that the user is well equipped to operate the technology to successfully complete activities across all relevant environments, thereby enabling participation and minimizing possible abandonment. However, it is important for the occupational therapist to be aware that nonuse is still a feasible and acceptable outcome when based on adequate experience of use (Verdonck et al., 2014). Users consider their AT in a transactional manner and weigh up the benefits and cost. They consider what it is like to use AT and its ease of use as well as the value of the end task or activity when considering long-term AT use (Krantz, 2012). Over a lifetime, people may re-enter an AT selection and acquisition process multiple times; for many, establishing what the options are and being supported to make an informed choice is a key outcome.

Occupational therapists, who are often responsible for training, ensure that the effectiveness of this stage by establishing well-defined objectives (Cook and Polgar, 2015). AT users need to develop both “operational and strategies competence” (Cook and Polgar, 2015) for successful use. Operational competence ensures that the user is able to turn the device on and off, adjust the various features, understand the maintenance requirements, and can troubleshoot problems. Strategies competence (Cook and Polgar, 2015) enables the user to use the device to perform specific tasks. Although operational training can be provided soon after delivery, training for strategy competence is most effective in situ (Nochajski and Oddo, 1995) when the user can develop skills in using the device to complete activities in the application environment(s). AT users also need to know how to maintain the device and who to contact when it is in need of repair (Kelker and Holt, 2000).

Periodic reevaluation is required because there are likely to be ongoing changes in terms of the user's skills and abilities, the activities they wish to engage in, and the application environment(s) that will affect the effectiveness of the acquired technology. Scherer (2005) identified possible factors that were associated with nonuse of AT in adults with disabilities, which included unrealistic expectations, inappropriate need assessment, poor device selection, lack of support from caregivers, changes in person's abilities, or any combination of the aforementioned. These findings indicate the importance of reassessment and need for follow-up of AT to ensure that the AT solutions are effective and decrease the potential for AT abandonment. In line with the transactional nature of experience, goals are dynamic and changing, and frequently not reflective of one set end goal. Therefore, an ongoing process of regular evaluation is necessary to assess whether goals remain the same and if attainment has been achieved. Furthermore, as technologies continue to improve, the user may benefit from technological developments (de Jonge et al., 2007). Ongoing monitoring of the effectiveness of the technology and developments in the design of devices ensures that technology interventions are replaced and upgraded as required.

The occupational therapist's role throughout this process is not only to work with the person to identify the best possible option but also to actively engage the person in the process (see Section I). Previous research on abandonment has highlighted the importance of involving the client in the process (Federici and Borsci, 2016; Federici, Meloni, and Borsci, 2016; Martin, Martin, Stumbo, and Morrill, 2011; Scherer and Federici, 2015; Wessels et al., 2003). This active engagement ensures that the process is well informed by the person's aspirations, expectations, preferences, lived experience of disability, and use of AT. Throughout the process, the occupational therapist is also equipping the person to understand the process of AT selection and use and to become an “expert assistive technology user” (Andrich and Besio, 2002), preparing them for future explorations of AT.
10.5 Overview of the Process Involved in Selecting and Using Assistive Technology Case Studies

The case studies will illustrate how the four steps—imagining possibilities, seeking information, choosing the best option, and living successfully with assistive technology—are achieved when the person partners with an occupational therapist using a transactive approach and a broad range of knowledge and skills.

10.5.1 Case Study: Partnering with Ben on His Assistive Technology Journey

Eleven-year-old Ben is a keen sports fan, pet owner, sibling, gamer, and primary school student. Ben lives with cerebral palsy and has recently acquired a new power wheelchair. In addition to his limitations in mobility, he also has some restrictions in range and movement of both his upper limbs. Ben and his parents consult an occupational therapist on the recommendation of his school as he will be moving to high school in the near future, to establish how best to manage this transition, his new environment, and the required activities.

10.5.1.1 Imagining Possibilities

When exploring his current engagement in activities, Ben informs the occupational therapist that he wishes that he could play computer games with his friends and younger brother. Ben’s parents anticipate the potential for a gap to emerge between Ben’s capabilities and the difference in performance expectations between primary and high school. Particularly, they are concerned with how Ben will manage the computer-based schoolwork in high school as at primary school he was frequently assisted by a teacher’s aide. The occupational therapist shows Ben and his parents some ways that he can access a computer using a joystick similar to a wheelchair joystick, and explains that Ben might be able to get an add-on component installed onto his wheelchair so he could control the mouse directly from his wheelchair. In addition, the occupational therapist shows Ben and his parents how to use the mouse with an on-screen keyboard to type, and how predictive text could make this process faster. The occupational therapist explains that this setup would work for schoolwork and some simple games, but more complicated games would require more components and possibly a completely different setup. Ben becomes very excited as he had never imagined he could participate in gaming in this way and his parents were heartened by the possibilities for schoolwork and increased opportunities for social interactions with his friends/family. Collaborative goals are then set, giving due consideration to Ben’s personal preferences, his past experiences of computers technology, the range of gaming and school activities he would like to engage in and the nature of the environments in which these activities were likely to occur.

Ben, his family and the occupational therapist develop two goals:

1. Ben will be able to independently complete schoolwork such as note taking, accessing Internet sites, and completing assignments using a computer at school and home.
2. Ben will have a method to participate effectively in some age-appropriate computer games by himself and with his peers.
10.5.1.2 Seeking Information

Once goals are established, the occupational therapist works with Ben and his family to complete objective assessments to obtain information on Ben’s range of motion, strength, endurance, and fine motor abilities. An interview is conducted with both Ben and his parents to ascertain details about Ben’s productive, social, and leisure activities. These activities and their associated environments are then examined in detail and Ben’s ability to use and access possible technology options relevant to the activities are reviewed. Ben is unable to use many of the technology options currently available to him. For example, Ben does not have sufficient speech clarity for successful use of speech-to-text software. This information is then used to establish the criteria for the technology to assist Ben to utilize a computer from his wheelchair, including its features and functions, characteristics, style, level of sophistication, interfaces, and programming.

For school work production, the criteria includes the following:

- Able to be used from Ben’s wheelchair
- Simple and quick to set up—easy for teacher aids to complete in a busy class environment
- Able to perform mouse movements and mouse clicks
- Able to type out words (through a physical or on-screen keyboard)
- Use gross movement such as with a larger joystick, trackball, or large switches

For gaming, the criteria included the following:

- Able to be used from Ben’s wheelchair
- If possible, able to be used with an Xbox One console (which his brother plays at home) as well as Windows PC
- Ideally, left in situ on a tray or desk for easy access after school (but ability to move to a different location if needed, for example, if going to a friend’s house)
- Use gross movements (as per school work access options)—but more buttons were required—at least four buttons (or a joystick) for directions and 3–4 buttons for actions such as jumping and shooting

Potential technologies are then investigated through a range of resources including the Internet, suppliers, service providers, an AT specialist service, and other AT users’ reviews.

10.5.1.3 Choosing the Best Option

As the gaming goal is based on the technologies already sourced for school work, the occupational therapist investigates computer access for school work first. This investigation results in the identification of three potential technologies:

1. A separate USB joystick with inset buttons on its platform for different mouse clicks, plus an on-screen keyboard.
2. Integrated into wheelchair joystick, with external jelly bean switches for mouse clicks and an on-screen keyboard.
3. Integrated into wheelchair joystick, with Dwell software to assist with mouse clicks. On-screen keyboard for text entry.
Each technology is then sourced, trialed, and evaluated by Ben and his parents in collaboration with the occupational therapist. The evaluation conducted reviews how well the three potential options meet the established device criteria and also considers Ben's ability to use the device, his preferences for the way it looks and feels when in use, and how well each performs in gaming and educational activities.

For use at school, the third option is considered by Ben, the occupational therapist and his parents to be the best fit given that it was simple to set up and relatively easy for Ben to use. The second option is deemed most appropriate to address Ben's gaming goal as, during the trial, Ben demonstrates good ability to use two buttons on his tray and two buttons behind his head, on his headrest. It is agreed that integrating option two with option three is feasible, given that the technology required for gaming is similar to that required for school with the addition of the external jelly bean switches and an add-on component for the Xbox, so that Ben could play some arcade-style video games. Once the final combination of devices is chosen, the occupational therapist, Ben and his family discuss options for funding the device, including personal- and scheme-based funding solutions.

10.5.1.4 Living Successfully with Assistive Technology

Post purchase and delivery, the supplier and occupational therapist work with Ben and his family to set up the new technology, integrate it with Ben's wheelchair and computer system, and ensure that it is positioned to allow Ben's independent use while maintaining his ergonomic positioning and comfort. Furthermore, the occupational therapist and supplier provide Ben and his parents with training on utilization of the technology for both gaming- and school-based activities within the relevant environments. The occupational therapist also recommends Ben and his parents insure the new technology and provides a suggested maintenance program and details for qualified repairers. Once Ben uses the technology for a few weeks, the occupational therapist completes an outcome interview to identify whether the technology satisfies the expectations related to his personal requirements, the activities he engages in, and the environments where the technology is being used. The occupational therapist also explores whether the technology creates any unexpected difficulties such as not allowing access under desks or not integrating with popular and desired games or programs provided at school. Ben and his family are also alerted to be aware of the issues that might arise, such as changes in posture, pain or discomfort, and decreased ease of use, as well as general wear and tear of the technology, and encouraged to seek a review if Ben's situation should change.

10.5.2 Case Study: Partnering with Edith on Her Assistive Technology Journey

Edith, a woman in her early seventies, lives independently in her own home in a large regional community, where she and her husband have lived for most of their married life and raised their family. She is a social person and up until her husband became unwell, she was an active volunteer and participant in the community and travelled frequently to visit family. Edith's husband has now passed away, her daughters reside in other towns in state, and her son lives interstate. Edith's older sister, Fay lives locally, and Edith assists Fay with shopping, paying her bills and going to the bank.

Edith recently experienced a mild stroke, secondary to a history of high blood pressure and Type II Diabetes. She has “recovered well” from her stroke but still has some persisting difficulties with her short-term memory, her mobility, and has a slight loss of visual field on her right side. Additionally, while Edith's language comprehension has returned,
she has some continued word-finding difficulties, which become more pronounced with fatigued. Edith says, “I am very lucky to have recovered as well as I did, as many don’t, but sometimes I get so frustrated with myself as I am not quite the same as before. I want to get-up and get on with my life, I have things I want to do.” She is aware that she will be unable to return to driving and will likely need assistance with activities such as heavy cleaning and laundry when she returns home. Edith has not received in home support previously; however, she reports that modifications were made to her home when her husband was unwell. Edith’s daughters are concerned about their mother returning to live independently in the community as they are fearful that she could fall, may have difficulty managing her blood pressure and diabetes medications, or may have another stroke.

Edith values “keeping busy and active” and longs to be more connected to her family and local community again. Edith identifies that she had to make choices while caring for her husband but is keen to pursue valued activities again, “I had to put everything on hold for while, I don’t regret it, I would do it again, but now I want to do things again that are important to me. I will not let a stroke or the few difficulties that I have stop me from doing what I want.” She also identifies that she wants to do this as independently as possible so she can do what she needs/wants to do at her leisure. She states “I want to do things my own way in my own time, I don’t want to burden anyone and I certainly don’t want to wait for anyone to tell me when and where I can do things.”

10.5.2.1 Imagining Possibilities

Edith admits that she is currently feeling isolated; although she wants to live independently, she feels vulnerable. Despite this, Edith is determined to return home and reinstate her participation in her valued activities. Edith is looking for ways in which technology can support her to safely maintain her independence in her home and local community. Some of her friends have smart devices, and she is keen to explore whether it may be useful and worth the time and “hassle” to upgrade her existing technology (phone and desktop computer) to “make life easier” and enable her to stay in contact with friends and family.

The occupational therapist shows her some smart technologies that may contribute to her life in a useful manner, particularly regarding increasing her confidence accessing her local community, allowing her to manage her health and medical conditions independently, and enabling her to stay connected with important friends and family members without relying on assistance of others. During this discussion, Edith reports that she had not been aware of the potential of the discussed technologies, and she is particularly interested in the reassurance offered by the possibility of allowing her daughters to know her location and enabling “quick contact” with them should her health deteriorate or she feels at risk.

The occupational therapist speaks to her about what she would like to achieve and the specific device functions she is interested in exploring further. Based on this, Edith and the occupational therapist develop the following goals:

1. Edith will be able to confidently and safely access her home and community, to complete her necessary activities and participate in community volunteer work in her home region, and to travel to see her family, both within and interstate.
2. Edith will be able to attend to the daily management of both her blood pressure and diabetes by herself within her home environment.
3. Edith will be able to contact and spend time with her chosen friends and family members, both from her home environment and out in the local community.
10.5.2.2 Seeking Information

To help meet Edith’s goals, the occupational therapist completes an interview to find out more about her experiences of AT, her perceptions of AT use, and the environments in which potential technology will be used in the future. The interview identifies the following:

**Experiences and Perception of Assistive Technology:** Edith is aware that her abilities are not quite the same as above and may change further as she ages. She accepts that, in the future, she may need more support; however, for now, she wants to do whatever she can for/by herself. Prior to her stroke, she was not using any AT, and while she has a computer, which she describes as “dated,” she says that her husband managed it and she only used to “make the odd birthday card and write the yearly Christmas letter.” She has a standard cell phone, which she reports that she only keeps on hand to call people if she needs to when out or travelling. She is currently using a single-point stick to mobilize indoors however, requires a four-wheeled walker when outside or for longer distances. Edith indicates that it is important to her that she is not perceived “as someone who needs help” so she is happy to use AT so that she does not require the assistance of others, but would prefer where possible to use more mainstream technology or AT that allows for discrete use.

**Home and Local Community Environment:** Edith describes her home as comfortable, and it is clear from her narrative that it holds significant value for her, holding many memories and items of personal significance. She states that it conveniently located to “everything I need” including a local shopping center, with shops, bank, post office, local doctor’s surgery, and pharmacy. Edith reports that an occupational therapist has previously made recommendations for modifications to support activities of daily living, particularly showering and using the toilet, for her husband. Upon review of these, it is determined that the existing modifications in these areas are also suitable for Edith to utilize with the addition of a threshold ramp at the front and back doors to allow for the use of the four-wheeled walker.

The home and local environments are easily managed by Edith; however, she is concerned about how she will manage in the wider community and travelling to see family. She is particularly concerned about falling and getting lost as she says “my brain and legs are just not what they used to be, sometimes they let me down.” Uneven terrain and unfamiliar environments that are particularly busy or poorly signed are challenges for Edith. She also reports that negotiating traffic is difficult as “I am so much more cautious and just not as quick as I once was.”

It is very clear from the interview that Edith’s life perspective is influenced by a long history of being a competent and independent woman. She has worked hard to keep herself busy and to actively contribute to her family and local community. To enable her to do this, Edith likes to plan the structure of days and weeks in advance. She states “I had a routine I liked to keep to, it kept me efficient, I feel like I lost it when my husband died and I haven’t been able to get it back while I have been in here (hospital). It means that I have not been able to do what I want to do. If I could get my routine back I think I will be more like me again.”

Based on the goals and the information collected from the interview, the occupational therapist works with Edith to explore the device types associated with GPS tracking, health management, and social connection via an online database. During this, the occupational therapist also takes the opportunity to identify Edith’s preferences in
regards to the product’s features, functions, and relative pros and cons. Additionally, the occupational therapist seeks feedback from Edith about her level of familiarity and comfort with technologies being explored. This investigation identifies three potential options that might suit Edith and meet her requirements.

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
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<tbody>
<tr>
<td>Community Safety</td>
<td>Smart Phone</td>
<td>GPS watch</td>
</tr>
<tr>
<td>Health Management</td>
<td>Portable glucose monitoring device</td>
<td>In-home glucose monitoring device</td>
</tr>
<tr>
<td>Social Connection</td>
<td>Smart Phone + video chat application</td>
<td>Dedicated video phone device</td>
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<tr>
<td></td>
<td></td>
<td>Smart Phone + Bluetooth Watch</td>
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<tr>
<td></td>
<td></td>
<td>Smart phone linked portable glucose monitoring device</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tablet with video chat application</td>
</tr>
</tbody>
</table>

Once the potential options are identified, the occupational therapist talks with Edith about the experiences of other clients of the various devices. Edith is also encouraged to speak to friends and family who currently use some of the devices, particularly the Smart Phone, about the benefits and challenges of these. The occupational therapist also suggests that she could visit local information and communication technology suppliers to talk with staff and look at various products.

10.5.2.3 Choosing the Best Option

After Edith has had a chance to investigate the options independently, she and the occupational therapist reconvene to examine and evaluate the options in detail. The evaluation focuses on how well the devices meet Edith’s requirements, enable her to reach her goals, and the way in which the device looks and feels to Edith. The occupational therapist also explores with Edith potential integration and full impact of the options. Rather than identifying one primary outcome, outcomes are mapped to WHO ICF Activity and Participation domains both to prompt a full consideration of all life areas that may be enhanced, and to maximize solution effectiveness. Given the potential for occupational imbalance to occur as Edith returns to her life (i.e., where a focus on activities of daily living and instrumental activities of daily living limit opportunities for social participation and leisure), the occupational therapist encourages Edith to consider the potential impact of using available community support worker hours to meet some of her “need to do” activities and allow more time for her “want to do” activities.

Edith decides on option 1, although she is very interested in moving to option 3 once she becomes more comfortable with the use of her new smart phone. Furthermore, she declines to use available community support worker hours at this time, as she would prefer to evaluate what she is able to achieve through the use of the AT alone in the first instance. Edith reports that she is in a position to and would prefer to purchase the technology privately from her own funds. The occupational therapist puts Edith in contact with a local supplier where she can purchase the glucose monitor and smart phone and seek follow-up support. The occupational therapist also provides an information sheet on smart phone applications suited to seniors that might be of value to Edith in the near future.

10.5.2.4 Living Successfully with Assistive Technology

Once the AT is purchased, the occupational therapist talks with Edith about charging requirements and updates of the smart phone and supports her to identify people in her
immediate circle and local resources to assist her in setting up the device for her specific requirements; learning how to use the device, and troubleshooting issues that might arise.

The occupational therapist contacts Edith a few weeks after the initial setup appointment to check whether the devices have been addressing her safety, health management, and social connection needs.

Edith is having some difficulty with the accuracy of her typing using her finger on the screen, locating icons, and reading the text in messages. The occupational therapist talks to her about using a stylus and sends her information on where they could be purchased. The occupational therapist suggests Edith talks with her daughter about rearranging icons and making folders for the apps she is not yet using and encourages Edith to visit the center so that they can customize the text size and contrast settings for her specific visual requirements.

10.6 Conclusions

Occupational therapists use a person-centered approach to enable people to engage in health and well-being promoting occupations, that is, everyday tasks, activities, and participations that enrich their lives (Curtin, 2009). Using a transactive approach, the occupational therapist develops an understanding of the person, the activities they engage in, and the environment(s) in which these activities are undertaken to determine the potential requirements and suitability of AT. Occupational therapists partner with people on their AT journey working with them to imagine the possibilities, seek information on suitable AT, choose the best option, and live successfully with their AT.

10.7 Summary

This chapter explains enabling activities and participation using AT from an occupational therapy perspective. This perspective is based on facilitating people to do the things they want and need to do. Occupational therapy is complex owing to the need to consider a wide range of roles, activities, environments, and contexts for each person and their AT.

AT is one of the several possible occupational therapy interventions. Occupational therapy aims to achieve a person–environment–occupation fit, which may be achieved through skill acquisition, education, environment adaptation, and/or activity redesign in conjunction with AT.

AT differs in terms of complexity and risk ranging from level 1 AT, which is mass produced and enables activities without needing the involvement of an occupational therapist, to level 4 AT which is highly complex and requires expert multidisciplinary input including specialist occupational therapists. Occupational therapists are extensively involved in level 2 AT but may require dedicated experience or training to be involved with level 3 complex AT solutions.

The AT process involves four stages imagining possibilities, seeking information, choosing the best option and living successfully with AT. The occupational therapist’s
role is to actively involve the person in all stages of this process. Imagining possibilities requires provision of information, exploring technology, understanding personal preferences, past experiences, and expectations. Seeking information involves identifying a range of suitable AT as well as evaluating the person’s skills and abilities, their environments, contexts and anticipated activities and goals to be completed using the AT. A wide range of information resources are available including expert users, suppliers, service providers, AT information services, and online resources. Choosing the best option requires a trial of devices, exploring funding sources and administrative processes culminating in the purchase of an AT solution. The final stage, living successfully with AT, is an ongoing stage requiring initial customization, fitting, training and subsequent adjustment, reassessment, and follow-up. This process has been illustrated using two case studies. The occupational therapist using a person–environment–occupation lens and breadth of knowledge across AT devices is well placed to partner with people to attain optimal AT solutions.

References


11

Pediatric Specialists in Assistive Solutions

Lucia W. Braga, Ingrid Lapa de Camillis Gil, Katia Soares
Pinto, and Paulo Sérgio Siebra Beraldo

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11.1 Pediatric Specialists in the Process of Development and Rehabilitation

The development or neurorehabilitation process of the child with impairment requires an approach involving different areas of specialization, because these children may present difficulties or challenges in various developmental domains (sensorial, motor, neuropsychological, communication, and socialization, among others). This generates the need for assessments and interventions by interprofessional teams of physicians (pediatricians, orthopedic surgeons, neurologists, geneticists, psychiatrists, and other specialists); nurses;
physical, occupational, and speech therapists; psychologists; special educators; technologists such as engineers, and prosthetics/orthotics technicians.

A child’s development is a process mediated by both family and sociocultural setting. It is the family’s natural role to help stimulate and encourage children's development, teach them how to play, walk, talk, and think; to help them become an adult part of a community. This role, however, is often transferred to health-care professionals when a child is born with, or acquires, a brain injury and presents the attendant impairments this may bring (Braga, Campos da Paz Jr., and Ylvisaker, 2005). Once a diagnosis is made, the daily life of these children and their families is often transformed into a series of visits to medical facilities of various specialized professionals. This fact may often result in depriving the child and family of experiences specific to childhood, such as parks and places in which actions become significant to the child’s development (Braga and Campos da Paz Jr., 2006).

However, an approach to the child’s rehabilitation goes beyond interventions from different areas of specialization. Human beings should integrate different abilities in order to engage in their activities. It is known that interprofessional teamwork is both a fundamental factor in rehabilitation and an essential element in rendering quality health assistance (Bakeit, 1996; Halper, 1993; King, Nelson, Heye, Turturro, and Titus, 1998; Körner, 2010).

The fact that a child is observed by many different professionals does not guarantee an integrated approach. Families often complain of a fragmentation in the health services they receive, which may often be due to a multidisciplinary (albeit nonintegrated) manner of treating the individual. The professionals work in a parallel or serial manner, with well-defined roles and tasks, focused on conducting their specific evaluations and interventions, assuming responsibility only for their particular aspect of development. Although the child is observed by an entire team, the professionals establish their own goals and treatment proposals for the child (Körner, 2010). Commonly, poor communication and differing treatment courses lead to this type of fragmented assistance, generating conflict and extra stress for the families insofar as it increases the risk of discrepancies or redundancies in treatment.

Teamwork is not defined by the isolated interventions of various specialties. The professionals’ effective communication and cooperative action are among the most important characteristics of an interdisciplinary team approach (Bakeit, 1996; Körner, 2010). Consequently, this model requires that practitioners meet frequently to discuss and assess, define coherent, consistent rehabilitation goals and plans; and conduct the child’s treatment in a cooperative manner. Joint teamwork integrates knowledge and experience from practitioners in diverse areas of specialization (Braga, 2006; King et al., 1998). To be effective, teamwork has to be established so that the child is at the center of rehabilitation efforts. This unified approach is developed in conjunction with the family, who in turn is empowered to exercise their natural role of educators and co-collaborators in the child’s stimulation (Braga, 2009). This signifies that the joint assessments and discussions be done in partnership with those who care for the child, focusing on existing developmental and contextual needs (Braga, 2000; Braga, 2006; Davis and Gavidia-Payne, 2009; Hinojosa, Sproat, Mankhetwit, and Anderson, 2002; King, Teplicky, King, and Rosenbaum, 2004).

In this manner, it is possible to construct a unique, individualized program based on functional, contextualized child-centered activities that require the child to concomitantly use various skills. The program should be based on and guided by realistic, viable long- and short-term goals, depending on the child’s potential and sociocultural setting. This effort by a team of pediatric specialists constitutes a context-sensitive, family-based approach to promote the child’s development (Braga and Campos da Paz Jr., 2006).
Pediatric Specialists in Assistive Solutions

Integrated teamwork incorporates the knowledge and experience that each professional from distinct fields brings to the rehabilitation program. It also fosters professional development and growth for the practitioner, since intra-team communication promotes a continued acquisition of knowledge across different areas. Furthermore, it enables more coherent communication between the team of practitioners and the family, thereby improving compliance with the treatment program.

In a child’s infancy, families often consult a pediatrician before any other doctor. In a rehabilitation team, the pediatrician plays a broader role, such as establishing the diagnosis and prognosis, discussing and defining the treatment program with the rest of the team, and accompanying the child’s development over time. In this first contact with the family, it is essential that the pediatrician be attentive to the various aspects of childhood development and aim toward an integrated approach with other pediatric specialists to guarantee a treatment plan targeting not only the child’s clinical needs, but also his/her developmental necessities.

To this end, it is essential that the pediatrician’s approach encompass, in addition to general pediatric knowledge and experience, broad knowledge including childhood development, psychology, neurology, orthopedics, genetics, and psychiatry. The aim is to trace, and, if possible, diagnose, any existent disorder in these areas. It is often necessary, in the process of defining a diagnosis, to integrate the various members of the neurorehabilitation team, which also includes other medical fields, to discuss the varied and complex developmental disorders in a manner that fosters cooperation, mutual understanding, and consensus.

A comprehensive approach that addresses both the definition of the diagnosis and the treatment plans requires that the pediatrician and the rest of the team work in cooperation to develop increasingly effective rehabilitation programs. Pediatricians should acknowledge and understand that their role in the process of development and rehabilitation goes far beyond that of the clinical alone.

Another reason that the process of rehabilitating children with disabilities often involves a large number of practitioners is that many areas of development may be impacted (Campos da Paz Jr., Burnett, and Nomura, 1996; Ylvisaker, 1998). This can generate obstacles to an integrated approach between the family and the team in planning adequate, contextualized interventions. Effective teamwork does not mean that all the practitioners must be present at every step of the treatment process. This process is dynamic. Some children may have predominantly motor disorders while others have more language or neuropsychological impairments. Depending on the significance of the main problems, the child may need closer follow-up from one or more practitioners, who end up becoming case managers; that is, the team members closest to the family throughout treatment.

Case managers play the role of organizing and directing the rehabilitation process, integrating information and decisions between the team, child, and family (Braga, 2006). Over the course of development, the case managers can be substituted by other practitioners working with the child, depending on the treatment needs at that particular moment. For example, a child with cerebral palsy (CP) and acute involuntary movements, such as dystonia, who has significant pain and difficulties sitting, will benefit from a joint collaboration between the pediatrician and the physical or occupational therapist: together, they can determine the best method to position the child by employing assistive technology (AT) resources, such as adaptations to sit, as well as the need for pharmacological intervention. With adequate, comfortable positioning, alternative communication systems can be better implemented, with closer support and follow-up from other members of the team, such as speech therapists or special-need educators.
On the other hand, in the case of children with predominantly neuropsychological or behavioral disorders, for example, caused by Traumatic Brain Injury, the pediatrician would work more closely with the psychologist and educator, who would be the case managers, to establish a diagnosis and also determine the best treatment plan for these conditions. This incorporated teamwork then facilitates more effective communication, guidance, and support for the family, teachers, and school community, facilitating instructions about the best educational strategies and methods of handling the child’s special needs and behavioral challenges.

Development is procedural; thus, the team’s longitudinal follow-up of the child assures that progress is being assessed and goals are being adjusted to his/her potential, interests, and the needs that change over time.

Every approach to rehabilitation should aim at promoting independence and expanding the child’s ability to interact with the world. It is important to acknowledge: (1) the child as an individual person in a process of development, with unique interests and potential; (2) the fundamental partnership and role of the family; and (3) the value of sociocultural contexts for the child’s development and inclusion.

11.2 Pediatric Specialists in Assistive Solutions

Studies have shown that the interdisciplinary team approaches are more effective in the rehabilitation process (Bakeit, 1996; Körner, 2010), particularly with regards to the implementation of assistive solutions (Stoner, Maureen, and Angell, 2010). AT services and tools are important for fostering and maximizing the development and/or rehabilitation of children with impairments. For an effective assistive solution, this technology should be applied in a functional manner aimed at improving the child’s abilities and expanding his/her potential for social interaction with surroundings and community (Scherer and Craddock, 2010; Zapf, Scherer, Baxter and Rintala, 2016).

Children with disabilities in early childhood may have impairments that linger throughout life and change as the child grows and develops (Cattelani, 1998; Warzak, 1995). These changes can be characterized by the learning of novel skills as well as an early loss of performance, when the child reaches adolescence or adulthood (Bottos, Feliciangeli, Sciuto, Gericke, and Vianello, 2001; Strauss, Ojdana, Shavelle, and Rosenbloom, 2004). Over time, the use of AT resources can also be valuable for helping people with disabilities acquire or maintain independence (Wilson, Mitchell, Kemp, Adkins, and Mann, 2009).

Three aspects that should be highlighted when studying the application of assistive solutions are as follows: the participation of the interdisciplinary team, the solutions proposed in the context of the binomial child-family and, particularly, these approaches in the child’s learning process. Because of the importance of these aspects, their main characteristics will be described next.

11.2.1 Assistive Solutions and the Interdisciplinary Team Approach

Given the great variation of motor, cognitive, communicative, and sensorial disorders that a child with disabilities may have, and the diverse social and cultural circumstances involved, it is evident that individualized goals should be adopted, avoiding fragmented and one-size-fits-all approaches. Therefore, a thorough assessment by the team of pediatric
specialists should precede the introduction of any AT tools. It is important to investigate the child’s potentials and/or limitations in various domains (motor, cognitive, language, etc.), in addition to developmental needs, special interests, social setting, and context of daily life (e.g., family, school).

The main focus of interdisciplinary intervention is to foster the child’s development and social participation through activities geared toward acquiring as much autonomy as possible, often with the aid of AT resources.

The functional use of AT tools conjoins the interaction of motor, cognitive, emotional, and somatosensitive aspects. Thus, assistance in development and rehabilitation can be qualified by the joint action of rehabilitation, which favors the establishment of developmental priorities and permits a focus on contextualized activities that involve more than one area of development (Braga and Campos da Paz Jr., 2006). In many instances, this joint action can be optimized through integrated sessions, in which more than one professional participates, contributing to the observation of the child’s potential through the simultaneous perspective of different areas of specialization and the discussion of what they observed, thereby informing the decision-making process.

At times, difficulty performing a task, such as using an adaptation for drawing a design or using a walker to get around, can initially appear to stem from a motor disorder but may actually be caused by an attention deficit. In other words, a poorly designed drawing or problems getting around obstacles with a walker could be caused by attention or visuo-constructive disorders rather than actual coordination or balance impairments. In these cases, a team working in an integrated manner can program activities that ally motor and neuropsychological components based on joint evaluations and discussions. In these cases, the rehabilitation professionals, working in an integrated manner, can design activities that associate motor and neuropsychological components, chosen after the team has jointly assessed and discussed the case. The team can, for example, unite gait training with the demarcation of obstacles that need to be circumnavigated, establishing signs and techniques for the child to use and orienting the parents about verbal strategies that can be applied when the child’s focus wanders from the task at hand.

The teamwork in the sphere of AT improves not only the approach to the child, but also enhances the team’s effectiveness as a joint force and as individual practitioners: interdisciplinary knowledge is constructed throughout the group discussions and course of treatment. Shared knowledge transforms and broadens the experience of each team member, making the evaluation and intervention processes more efficient. The team-based process has benefits for the teams, including the development of more specific and achievable technology goals; confidence of team members; and more effective teamwork to assist decision making (Copley and Ziviani, 2007).

As a result, the family also becomes part of the team. They bring knowledge about the child and daily life at home, routines, interests, likes, and dislikes, which enrich the clinically obtained information, and constitute the essential elements for the decision-making process (Braga, 2000; King, Teplicky, King, and Rosenbaum, 2004). A joint approach optimizes and enhances rehabilitation, and how to proceed with the selection and implementation of AT tools. It also enables better coordination of technology use between home and school.

Some researchers in the field focus on studies about refining the assessment process and how to best select and implement resources; the goal is to help match technologies to the child, based on his/her needs, interests, characteristics, and the manner each tool works (Scherer, 2004; Scherer and Craddock, 2002; Scherer, Sax, Vanbiervliet, Cushman and Scherer, 2005; Zapf et al., 2016). It is important to evaluate how well the child is able to
understand the manner in which these tools function and what their purpose is, and to assess the efficacy of the AT tools in day-to-day life. In other words, during the evaluation, the team should focus not only on observing the skills of the child and factors intervening in development, but also formulate hypotheses about possible strategies or resources that can help foster their interaction and social participation.

Depending on the type of adaptation, more complex skills may be required. Children with cognitive disorders, for example, may have difficulties using resources that demand more complex movement sequences, and more elaborate working memory and planning (Pueyo-Benito and Vendrell-Gomez, 2002; Scherer, 2005), such as handling a lever to control a self-propelling car with only one hand. Strategies such as dividing the task into several stages and encouraging trial and error can help in the implementation of more complex AT resources. In addition, getting to know the child’s previous experiences with AT can be helpful when adding and adjusting AT resources (Murchland and Parkyn, 2010; Scherer, 2005).

In general, the team’s interdisciplinary work, together with the participation of the child’s family, is fundamental to the planning, implementation, assessment, and follow-up of any assistive solutions for improving the child’s performance and quality of life.

11.2.2 Assistive Technology Resources Applied to the Daily Life of the Child and Family

The effective use of an AT tool is achieved through its functional application in daily life; in other words, when it is incorporated into the child’s day-to-day routine, altering the possibilities and manner in which the child can interact in and with the environment (Lindsay and Tsybina, 2011). Two aspects are essential to this process: (1) the active involvement of the family, which provides ongoing opportunities for practice; and (2) the effectiveness of the tool for helping the child improve performance in a given task.

Many of the activities in the child’s daily life are centered on tasks that are culturally significant to the family. The more a family values a given resource, the more opportunities the child will have for practicing and using it (Kellegrew, 2000). Some families, for example, will encourage their child to evolve in self-care activities, such as going to the bathroom alone and eating independently without needing the help of others. The tasks emphasized by the family reflect their beliefs and values about childhood and impairments, socioeconomic and educational views that influence their daily routines, and, consequently, the child’s participation (or lack of participation) in certain activities. Depending on cultural values, the use of adaptations in performing daily life tasks can be either reinforced or ignored by the family (Ripat and Woodgate, 2011).

Families, in their interactions with the rehabilitation team, often signal the tasks their child shows most interest, or those they are trying to perform (Hinojosa et al., 2002). The pediatric specialist, based on the team’s assessment, works at adjusting the rehabilitation goals to the child’s potential. By helping the families understand the child’s potential, as well as identify the needs and limitations caused by the impairment, the specialist can help them direct their expectations and make changes in the family setting that can maximize the child’s development and progress.

The demands brought about by the child’s need for assistance effect a number of changes in the family’s daily routine. In addition to the importance of a joint assessment of the child by the interdisciplinary team, the amount of time that will be spent on the activity is relevant in the discussion about the team’s involvement in training the child and family to use AT resources. One change includes giving the child as much time as needed
Pediatric Specialists in Assistive Solutions

The time variable tends to yield a more profound impact in children whose functional abilities are more compromised or who are slower than independent children (Kelleghrew, 2000). The time spent on each activity should be evaluated to avoid excessive efforts by the child (Østensjø, 2003). The team should also be aware of the impact that time may have on the family’s perception of the child’s performance. They may feel anxious or concerned watching the child take too long to perform a task or use a given AT tool. It is important to help the family understand the challenges that the child is facing, as well as the resources that can help facilitate the child’s performance; this may help the family members feel more at ease. They can see that the child is using time more efficiently, even if it takes longer. Furthermore, the child will play a more active role when the activities are planned around the family’s daily routines at home (Ketelaar, Vermeer, Hart, van Petegem-van Beek, and Helders, 2001). The situations that the child faces can also change depending on the setting. At home, for example, the child may have more time to perform a task than at school. In this sense, strategies should change to ensure greater participation in activities, such as taking bite-size foods to school that do not require cutting, thereby reducing the amount of time needed for lunch and snack time.

Often, an AT tool may end up in disuse by the child and family because it lacks significance for their particular routine and setting. For example, when the team fails to work in conjunction with the family in the implementation of an AT tool, there is the risk that it will not be effective. It can occur because it is not directed toward the family’s needs and environment, even if the device itself would have brought important benefits to the child. It is important to investigate how the AT tools are seen by the child, how the family perceives them and how they can become part of the child’s and the family’s social context (Skår, 2002).

The pediatric specialist should be attentive to the child’s real potential and capacity for executing a given task so that the most effective assistance can be offered to the entire family (e.g., guiding the participation of others in the activity or introducing adaptations, when necessary). This type of intervention can most positively impact the quality of life of the child and family.

11.2.3 Assistive Technology and Learning

The application of AT resources involves a learning process that grows as the child’s skill at using the tools evolves. The use of a device implies in the development of a functional ability that encompasses planning and executing organized movements through which the child achieves an objective or function. The capacity for developing a skill is, in part, determined by biological potential. Nevertheless, the development or reorganization of functional brain systems is promoted by social demands, and depends on the lifestyle, beliefs, and values of each culture, in accordance with the possibilities of the child’s morphological substrate and chances for practice (Leontiev, 1978; Vygostsky, 1991, 1984). In other words, certain functional skills that evolve through the use of AT tools are achieved or honed according to the child’s capacity and opportunity to develop them (McNaughton et al., 2008).

The ability to use an alternative communication interface, for example, is achieved through the ability to control certain bodily movements or after attaining a level of cognitive development. However, it also depends on the child’s chances to learn and improve the manner in which the tool is used. What at first may appear to be a difficult or uncoordinated movement that demands a lot of time and effort can, with practice and incentive, become easier and more effective.
The strategies used by the family, for example, for communicating or managing meal-times (e.g., how they initiate and conduct conversations or how they encourage the child to eat) can significantly contribute to the development and improvement of skills that will gradually lead to greater functional independence. Allowing a child to experiment using a device for handling a spoon will contribute to the development of that functional skill. Even with children and adolescents who have severe motor impairments and minimally intelligible speech communication can be improved by AT devices (Pennington, Goldbart, and Marshall, 2004; Puyuelo, 2001).

Augmentative and alternative communication (AAC) systems should be adjusted periodically throughout development and adapted to the child’s communication needs and settings (McNaughton et al., 2008). Initially, the system may appear ineffective because the child will likely need time to express a communicative intention, and the interlocutor may have to adapt his/her conversational style to the child’s new forms of self-expression. It is important to remember the benefits that communication will bring to the child’s socialization and academic processes (Branson and Demchak, 2009). Although AAC systems facilitate more autonomy and independence in social interactions, they do not substitute speech nor do they guarantee real time in dialogue, thus demanding that interlocutors adapt to and respect the child’s temporal dynamic. It is important that everyone involved be skillful at handling the devices so that they can be properly used and can come to effectively improve the child’s competence (Murphy, Markova, Collins and Moodie, 1996; Scherer, 1996).

Furthermore, any AT resource that is indicated for and used by the child is much more than a simple mechanical aid. AT resources are important tools in the development and rehabilitation of children with impairments. Improved functional outcomes, quality of life, accessibility, and participation in school and community are benefits gained by the use of specially designed devices and equipment. The team of pediatric specialists indicates and incorporates these resources, within a context-sensitive, family-based approach, considering the child’s needs, developmental stage, individual interests, level of recovery, family setting, and community context. AT tools are integral to the child’s body and impact self-perception of functionality and appearance. Generally, the simpler and more functional the tool, the greater are the chances that the child and family will use it regularly. When AT tools are truly incorporated into the child’s daily life and activities, they can eventually be viewed as extensions of the child’s own body (Huang, Sugden and Beveridge, 2009).

When dealing with a child who has the potential for attaining a greater level of independence, it is important to ensure that the family understands what their child is capable of achieving. It is also essential that they be aware of what can be done to promote the child’s development through the application of AT resources and the planning of domestic routines.

In a longitudinal follow-up, the use of AT resources varies from very simple to more complex, depending on each child’s abilities, potential, and developmental stage. In addition, changes in the child’s interests and the consolidation of novel functional skills can alter performance and possibilities, which in turn demand modifications of the tools being used over time (Jahiel and Scherer, 2010).

Going back to the example of using an AAC system, throughout his/her life, a child can develop motor or cognitive skills and better emotional self-control, which may permit updating the AT tools to more complex ones. For example, using an interface with only one key requires a single motor action. As the child’s motor skills develop and the coordination of movements increases, along with improved cognitive functions that allow
for more elaborate mental planning involving sequential procedures, it is possible to use an interface with five keys and a semi-directed search engine. A change such as this one implies in greater communicative effectiveness by promoting speed in dialogues or written communication.

Furthermore, an alternative communication interface of a single key can have several uses throughout the child’s development: initially, it can be a resource used for playing with toys. As the child grows, it can be used for signaling “yes” or “no” and, later, it can be used for computer programs. Consequently, this tool can have more than one function at any given time in the child’s development. If it is adjusted to the needs and potential of the child’s specific stage, the same tool can be applied to achieve the main goal of expanding communication.

The strategy chosen for introducing an AT aid in the child’s daily life should be adjusted to his/her current motor and cognitive potentials. The construction and use of communication symbol boards, for example, enhances the vocabulary of children with unintelligible speech and improves their chances for self-expression. The child’s level of mental representation will determine his choice of symbols; these can be photographs, drawings, graphic symbols, letters, words, and/or sentences. The rehabilitation team and family should explore the child’s communicative needs and context, purposes of interactions, and choice of symbols (Fallon, Light and Achenbach, 2003; Fallon, Light and Paige, 2001); the boards should be created according to the child’s abilities, mode of selection, and scanning (Blackstone, Williams and Wilkins, 2007). Similarly, it is essential that everyone involved in the use of these tools be adequately instructed in their application, thereby facilitating, through a context-sensitive and family-based approach, their true integration in the child’s daily life and improvement of everyone’s quality of life (Jans and Scherer, 2006).

Rehabilitation intervention is formative in nature. The aim is to understand a routine that already exists and, gradually, include novel aspects in the most natural way possible, which changes and enriches the functioning of the real-world activities. An intervention program that focuses on function and on a context-sensitive approach facilitates carry-over and transference of learning to other contexts (Ylvisaker, 1998). In addition to the contextualization of proposed activities, it is important to anticipate the gradual decrease of proffered support as the child’s self-sufficiency increases.

In sum, adequately selected AT resources are those that expand the child’s ability to act, that promote new learning and foster development. By expanding the manner in which the child can act and communicate with the world, these tools enrich his/her experiences and interactions, leading to changes in development and social participation.

11.3 Technological Development from Interdisciplinary Knowledge

Teamwork generates interdisciplinary knowledge that leads to new technologies and resources. The interdisciplinary knowledge and solutions that evolve over the course of treatment serve as the springboard for forging new assistive tools capable of helping a greater number of children.

In clinical practice, a team commonly encounters problematic situations that cannot easily be resolved with existing assistive options. In these cases, the first step is to identify the similarities among the demands of the various patients treated in the rehabilitation
program and check whether customizing the existent resources will resolve these needs. If not, the next step is to develop a new resource.

The quality of what is developed is greater if it includes the involvement of, and communication among, an interdisciplinary team, the longitudinal follow-up of children for the testing, training, evaluation, and adjustments to the prototype, generating intermediary models until the final resource is achieved.

Once the problematic situation is identified, a chain of activities is created that integrates the dynamic of the patient’s longitudinal follow-up, including rehabilitation design and engineering professionals. New prototypes are produced and tested in a contextualized manner, within the treatment environment, and given to patients to use at home or in social settings, thereby complementing the tool’s assessment. Part of the development chain is the patient’s return visits and feedback about the device’s use in real life situations. It is this circular delivery of feedback and the testing of the devices by various children that guarantee an informed development process. This continuous flux contributes to the creation of assistive solutions that are increasingly well suited to the variety of needs observed throughout the numerous interactions between children and the AT resources.

An example of this development chain is the adapted flyer designed by the SARAH Network—an assisted locomotion tool for children in wheelchairs who require help in maneuvering them.

Different models were created and tested (Figure 11.1). After the successful use of two specific models, a definitive version was created for kids between 4 and 11 years old (Figures 11.2 and 11.3). The final result (Figure 11.4) is an AT resource of defined prescription, three sizes, and positioning adjustments that are highly functional (Macário, 2015).

FIGURE 11.1
Adapted flyer: prototypes (A).
FIGURE 11.2
Adapted flyer: prototype (B).

FIGURE 11.3
Adapted flyer: prototype (C).
11.4 Case Evaluation in an Interprofessional Team

Two case studies of children, one with CP and another with traumatic brain injury, who benefited from technological tools, are presented to illustrate how the team of pediatric specialists select and promote the appropriate use of these tools, considering the child's setting and developmental needs. These cases are in longitudinal follow-up and are described according to the ICF model and framework (McDougall, Wright, and Rosenbaum, 2010; McDougall, Wright, Schmidt, Miller, and Lowry, 2011; OPS/OMS, 2008; Raghavendra, Bornman, Grandlund, and Björck-Akesson, 2007).

11.4.1 Case 1: Michael (Cerebral Palsy)

11.4.1.1 Case History

Michael* presented tetraplegic choreoathetoid CP caused by perinatal hypoxia. Today, he is 16 years old and has been observed by an interprofessional team at the SARAH Network of Neurehabilitation Hospitals since he was ten months old. He was born with respiratory insufficiency owing to prolonged labor and was intubated for 40 minutes immediately after birth, remaining in the ICU for two days, on mechanical ventilation. He is the first child of the couple (a geographer and an economist) and has a sister who is 9 years younger. He has no associated cognitive or sensorial deficits or seizure disorders.

11.4.1.2 Motor Evaluation

Michael evolved with neurodevelopmental delays. At admission to SARAH Hospital, he presented with involuntary movements of the four limbs and perioral muscles, which

* Not the patient’s real name.
continue to this day and interfere with his coordination, handling of objects, postural control, and facial mimicry.

At 10 months, Michael had not yet attained any motor acquisitions and had no head control. There was persistence of some archaic movements, such as asymmetrical tonic neck reflex; placing and parachute were absent. He tried to reach and grasp objects but was unable to do so because of movement difficulties.

Currently, he exhibits regular trunk balance and uses customized manual and power wheelchairs that facilitate positioning and locomotion.

11.4.1.3 Neuropsychological Evaluation

Michael's cognitive development has always been compatible with his chronological age. At admission, he showed interest in social interaction and exploring objects. His attention was at the expected level for his age, but his concentration was impaired because of his involuntary movements. He could recognize familiar faces, persisted in reaching for objects and tried to imitate ways of exploring them.

When he was five years and three months old, he underwent a cognitive evaluation with the Columbia Mental Maturity Scale. He scored a total of 42 points, compatible with the 77% percentile and a maturity level of a six year old.

Currently, he attends regular high school and his scores and performance are compatible with his age and grade.

11.4.1.4 Communication Strategy

Upon admission, Michael's means of communication were precarious. He had difficulties controlling the movements involved in gesturing and vocalizing. He communicated his basic needs through cries, social smiles, and by responding to visual contact. He had good contextual comprehension, but no conventional forms of expressing communication with his interlocutors, such as head nods, pointing, or “yes/no” signals.

Today, Michael is capable of independently communicating through alternative communication systems, although he still requires interlocutors familiar with his communicative signals.

11.4.1.5 Evaluation of Visual, Auditive, and Perceptive Functions

Michael does not present any associated sensorial deficits or convulsive disorders.

11.4.1.6 Neurorehabilitation Team Approach

The program for stimulating Michael's neurodevelopment at a young age comprised of integrated activities to improve his neck and trunk balance, manual skills, joint attention, exploration of objects, vocabulary expansion, and conventionalization of nonverbal communication signals. At that time, the AT resource used was primarily a special chair that more adequately positioned Michael in a seated position, making it easier for him to choose and play with toys and sustain visual attention so that he could observe his surroundings and interact socially. Figure 11.5 shows a special chair that permits positioning the child in a manner that increases stabilization of the trunk, better visual contact, and allows him to use the upper limbs to handle toys.
As expected, his cognitive and linguistic development progressed more quickly than his motor development. Over time, the impact of his involuntary movements made it impossible for him to walk, speak intelligibly, or write manually.

Currently, Michael exhibits regular trunk balance and can remain seated by using his hands. He gets around by dragging himself in a seated position. He can kneel without support, but only for a short time. Michael uses his left hand to grasp objects, albeit with significant lack of coordination. He is not capable of manual writing and is dependent in activities of daily living (eating, dressing, hygiene). He continues to use customized manual and power wheelchairs for positioning and locomotion.

Michael’s cognitive development has always been compatible with his age, but the use of AT became necessary to support his learning and to help him make new acquisitions. The main goals for employing AT resources included expanding expressive communication and fostering social interaction.

Initially, the concern was to create a consistent pattern of affirmative and negative responses by means of conventionalizing Michael’s specific gestures, as well as providing him with dialogical actions with his interlocutors so he could more actively participate in conversations. To this end, the interlocutors had to say question-like phrases, which also require training. The themes chosen on this occasion were situations based on his routine, but in a make-believe manner, using AT aimed at fostering greater control of his environment, such as custom-made switches on electronic toys that allowed Michael to control them as if he were using a remote control. Figure 11.6 is an example of a custom-made switch on electronic toys that require a single movement of a hand, foot, or the head.

Another goal of the neurorehabilitation team was to help Michael attain more functional means of getting around, since he was only able to drag himself about in a seated position, with substantial balance deficits; he was typically transported in a conventional baby carriage. To this end, an alternative device for locomotion was introduced, such as the adapted flyer in Figure 11.4. This tool allowed Michael to get around more independently in controlled environments (e.g., home, school, and stores).
Because of Michael’s dependence on others for his activities of daily life, (eating, dressing, and hygiene), his toilet seat was customized to allow him to remain sitting while using it (Figure 11.7). Similarly, the use of a customized bathing chair, such as the one in Figure 11.8, allowed better positioning during bath time. Presently, the placement of a support bar is sufficient to help him remain seated on the toilet seat (Figure 11.9).

The introduction of AT resources for better communication and learning gave Michael greater autonomy in his communication processes and daily school life. As Michael’s symbolic development evolved, other devices were incorporated, such as communication boards to enhance learning and foster the construction of scholastic concepts. Digital accessibility was also enhanced by new AT resources. As he was not able to use a conventional mouse and keyboards, switches to run software and attention and memory games (which were developed by the SARAH Network) were added, to help stimulate voluntary attention and planning, that are neuropsychological skills needed to use more complex systems in the future.

At that point, Michael began using a pediatric wheelchair. This aid was customized with anatomical seat and backrest, as well as a seatbelt, to provide better positioning, contributing to his head and trunk balance, manual function, and improved ability to grasp and explore objects. Figure 11.10 is an example of an adapted wheelchair. A table-board that was adjusted across the armrests as a support for communication boards, which contained vocabulary words associated with daily life activities (eating, leisure, places, people) to expand his means of expression during conversations at home and in school.

The boards were enhanced with letters and numbers to aid in activities of learning to read. Learning to read is an important acquisition for these children because mastering
FIGURE 11.7
Customized toilet seat

FIGURE 11.8
Bathing chair.
FIGURE 11.9
Support bar for toilet seat.

FIGURE 11.10
Pediatric wheelchair with anatomical seat and backrest.
written language permits use of unlimited vocabulary, which in turn expands the child’s means of expression and allows for the use of more complex AT, such as editing words and using talkers.

Michael’s alphabetization was supported by boards with symbols and letters, which he selected by pointing with his thumb: a motion that he started to associate with this function. As he learned to read, more sophisticated AT resources were introduced, such as Software Keyboard Mouse (SKM) and activation switches for his left hand. Better control of the movements of his left hand made it possible for Michael to use a keyboard enhanced with a template, joystick, and switch for the mouse functions. Nevertheless, it is hard to safely transport a computer to parks, clubs, or children’s parties. Therefore, a talker was also incorporated to help Michael communicate in these settings, allowing him to more fully partake in the social situations they entail.

Michael continues to study in regular school, without any difficulties mastering the curriculum. He has a customized laptop and printer in the classroom to help him complete his school activities, a board attached to his chair-top desk with symbols and letters, as well as a switch, joystick, and talker. This permits Michael to communicate using agreed-upon gestures, boards, computer writing, and talker, according to the setting and how much his interlocutors know about the technological resources he uses. Figure 11.11 shows a talker developed by the SARAH Network that Michael uses with simple switches to scan letters for forming words.

With the development of new commercial resources, Michael is able to access devices with touchscreen technology, such as tablets and smartphones, using a simple switch developed by the SARAH Network connected to the Tecla Shield (Figure 11.12). This

![Figure 11.11](image)

**FIGURE 11.11**
Talker that uses simple switches to scan letters for forming words.
equipment connects wirelessly to iOS or Android systems via Bluetooth and can be used with external keyboards or joysticks.

As Michael grew, his needs changed, among them, the desire for greater independence and ability to move about in his community. He began training the use of a motorized wheelchair system developed at the SARAH Hospital (Figure 11.13), that allows him to maneuver it with various types of devices. This system consists of a projected electronic plaque that substitutes the original joystick and can be programmed to receive commands from different devices by generating signals previously activated by a joystick. The system can be controlled by a single button, a joystick that is not attached to the wheelchair or a USB device such as the mouse used on a computer. To ensure the equipment's safety, it includes six ultrasonic distance measure, magnetic sensors on the wheels, and an

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**FIGURE 11.12**
Assistive solution for iPAD access: single switch and Tecla Shield.

**FIGURE 11.13**
Motorized wheelchair system.
emergency stop button. Figure 11.13 details the mounted system. Training on this special wheelchair promoted enhanced functional performance, which enabled Michael to eventually control a motorized wheelchair by means of a conventional joystick, which he still uses today (Figure 11.14).

Currently, Michael also uses several AT resources whose purpose is to afford him greater independence. These devices allow the individual control of electronic equipment and even parts of infrastructures in their environment. Some of these resources permit children or teenagers with motor dysfunction to turn on, turn off, and adjust electronics such as lights, heat and air conditioning, television, audio systems, doors and windows, curtains, telephones, and alarms. An example of such devices is the accessible remote control developed by the SARAH Network (Figure 11.15), which can be turned on or off directly or indirectly, using mono- or multicommand activators. They can be used by pressing a button, by touching, physical proximity, optics, breath, blinking, voice commands, and other methods. Michael uses a monocommand activator that only requires slight pressure to turn on and adjust a television.

Michael was longitudinally followed-up by the pediatric specialist team. In addition to using AT, Michael’s process of school inclusion was facilitated by favorable Brazilian educational policies, although there exist some moderate barriers in the educational services. Within this context, the aid and participation of the family, integration among the
TABLE 11.1
Case 1: Bodily Functions in Initial Evaluation; Activities and Participation at Admission and Currently; Environmental Factors; Application of AT Resources, according to the Needs of Each Developmental Stage

<table>
<thead>
<tr>
<th>Bodily Functions</th>
<th>Activities and Participation</th>
<th>Environmental Factors</th>
<th>Assistive Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>b117.0</td>
<td>d4103.4 (admission)</td>
<td>e1151 + 3</td>
<td>• Special chair</td>
</tr>
<tr>
<td>b167.0</td>
<td>d4103.2 (current)</td>
<td></td>
<td>• Customized toilet seat</td>
</tr>
<tr>
<td>b210.0</td>
<td></td>
<td></td>
<td>• Customized bathing chair</td>
</tr>
<tr>
<td>b230.0</td>
<td></td>
<td></td>
<td>• Support bar for toilet seat</td>
</tr>
<tr>
<td>b320.4</td>
<td>d4102.4 (admission)</td>
<td>e1201 + 3</td>
<td>• Adapted wheelchairs</td>
</tr>
<tr>
<td>b7354.4</td>
<td>d4102.2 (current)</td>
<td></td>
<td>• Alternative device for locomotion (adapted “flyer”)</td>
</tr>
<tr>
<td>b7650.4</td>
<td>d450.4 (admission and current)</td>
<td></td>
<td>• Motorized wheelchair</td>
</tr>
<tr>
<td></td>
<td>d335.4 (admission)</td>
<td>e1251 + 3</td>
<td>• “Yes/no” signs</td>
</tr>
<tr>
<td></td>
<td>d335.2 (current)</td>
<td></td>
<td>• Communication boards</td>
</tr>
<tr>
<td></td>
<td>d330.4 (admission)</td>
<td>e1301 + 3</td>
<td>• Letter boards</td>
</tr>
<tr>
<td></td>
<td>d330.3 (current)</td>
<td></td>
<td>• Game software</td>
</tr>
<tr>
<td></td>
<td>d360.4 (admission)</td>
<td></td>
<td>• Switches for running software</td>
</tr>
<tr>
<td></td>
<td>d360.2 (current)</td>
<td></td>
<td>• Software keyboard mouse-SKM</td>
</tr>
<tr>
<td></td>
<td>d440.4 (admission)</td>
<td>e1401 + 3</td>
<td>• Talker</td>
</tr>
<tr>
<td></td>
<td>d440.3 (current)</td>
<td></td>
<td>• iPad</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cellphone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Toys with switch</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Customized remote control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Digital books</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Virtual games</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e355 + 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e415 + 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e340 + 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e5852 + 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e5850 + 2</td>
<td></td>
</tr>
</tbody>
</table>

educational and health-care professionals, as well as support in the classroom by a personal assistant hired by Michael’s parents were indispensable to his development and success in school. He is currently preparing to enter college. This process is detailed in Table 11.1, in accordance with ICF.

11.4.2 Case 2—John (Traumatic Brain Injury)

11.4.2.1 Case History

John* sustained a TBI (Glasgow 8) in a serious car accident when he was 12 years old. He was treated at a trauma center and remained in the ICU for 58 days. When he was admitted to the ICU, he underwent a CT scan of the brain, which revealed various cranial fractures and mild to moderate brain swelling. He was tracheostomized for 19 days and experienced seizures, which did not re-occur after discharge from the hospital.

* Not the patient’s real name.
At the time of the accident, he was attending sixth grade at a regular school, played soccer, took swimming and karate lessons, and was independent in activities of daily living. He is an only child, lives with his mother, who is a high school graduate; his father attended college for two years.

John was admitted to the SARAH Network by an interprofessional team, six months after the accident. He presented with spastic tetraplegia and left-sided facial paralysis; he kept his mouth open most of the time. He was not attending school and was being seen at a public clinical rehabilitation facility, where treatment included daily sessions of physical therapy, occupational therapy, speech therapy, and water therapy in the pool. His family complained of fragmented assistance, lack of guidance, and failure to adequately attend to John’s rehabilitation needs and social reinsertion.

An MRI showed an anterior lesion to the temporal lobe bilaterally, with impairment of the amygdala and hippocampus on the left; thalamic, parietal, and frontal lesions on the right, and parietal and frontal on the left; supratentorial ventricular dilation, ex-vacuum without the need of ventriculo-peritoneal derivation valve.

11.4.2.2 Motor Evaluation

Upon admission to the rehabilitation program at SARAH Hospital, John presented with increased tonus in the four limbs, more pronounced on the right side. Babinski plantar reflex was present on left. There was an extensor pattern of the lower limbs (feet in equinus and in right inversion) and flexor pattern on the upper limbs (elbow and wrists). When asked, John could flex and extend his right elbow, flex and extend his right knee, with no active movement of lower left limb.

He had regular neck balance, no trunk control, gait, or voluntary grasping. He was totally dependent for activities of daily living, and did not have a wheelchair. At home, John typically lay in bed or on a recliner-type seat, on which he was also fed and bathed. For longer distances, he was taken in the family car, while at home he was carried around.

11.4.2.3 Neuropsychological Evaluation

During the period of admission, John underwent a qualitative assessment of his cognitive state. He responded to simple, contextual requests by smiling and directing his gaze.

After a consistent pattern of responses was established through conventionalization of signs, he was also submitted to Raven’s Special Scale of the Colored Progressive Matrices (1988). The data revealed a cognitive performance “definitively below average,” with errors compatible with moderate intellectual deficits. John’s answers were perseverant, albeit contextualized, also revealing difficulties with mental flexibility, planning, and abstraction.

11.4.2.4 Communication Strategy

Initially, John exhibited contextualized smiling and crying, sought visual contact and joint attention, and gave consistent responses to some of the questions he was asked by directing his gaze. He was able to vocalize some sounds but did not yet use them to effectively communicate. He had verbal comprehension of contextual events, but his capacity for verbal expression was compromised to the point of being unintelligible owing to facial paralysis and severe dysarthria.
11.4.2.5 Evaluation of Visual, Auditive and Perceptive Functions

John had visual deficits, characterized by limited field of vision and mild loss of visual acuity, with better performance on the left side. He was able to adjust the position of his head in order to improve his visual focus. He did not present any other sensorial impairment.

11.4.2.6 Neurorehabilitation Team Approach

AT tools were gradually introduced into John’s neurorehabilitation process, during periods of inpatient treatment, according to his neurological progress and communication and social needs.

During his first inpatient stay at SARAH Hospital, the family was given a wheelchair, as per the rehabilitation team’s indication, to attend to John’s needs and functional level. The chair was customized with anatomical seat and backrest, enabling better inclination for his degree of neck and trunk control; the chair also had headrest, seatbelts, and support for a table-board. This resource fostered better positioning and permitted greater stability during transport, playtime, learning, and eating activities; it also made it easier for the family to participate in these tasks. With better positioning in the wheelchair and the ability to actively move his upper limbs, John was able to get around more independently at home, as he could manage the wheelchair back and forth for short distances over flat terrain using verbal commands.

With regards to communication, the team’s initial goal was to re-establish a consistent pattern of affirmative and negative responses. As he was able to say “e” for “yes” answers and a subtle movement of his head for “no,” these were the conventionalized signs. His communication and cognitive progress were aided by the introduction of other AT devices: sound switches and boards with illustrations and, later, with letters, which were selected by using his communication signs or by having others do an oral sweep through the letters. The use of a sound switch was aimed primarily at greater control of his environment: John used it to call family members and became accustomed to it, and later he used it in computerized communication systems. The figure boards added to the possibilities of John’s expression and speed in conversations. They were enlarged because of his vision impairment, and allowed him to make an unlimited number of words. To write, he would point at the letters with his right index finger. A special support was designed for adding the boards and reading materials onto the wheelchair, making it easier for John to engage in these activities. When he was discharged from this first inpatient stay, the family was guided through his return to school, since he now possessed ways of communicating and getting around.

By the time he was admitted the second time for inpatient rehabilitation, John had already been reinserted back into sixth grade at the school he had been attending. The teachers asked for information and instruction about how to assess his learning process. At that time, the rehabilitation focus was primarily on strategies for cognitive and writing re-education. The SKM AT tool was added, with the switch John was already using, but without the sound device. He was able to write by scanning, turning on the switch with his right hand. A meeting was held with his teachers, at which modifications to the curriculum were suggested to help his learning process and facilitate his interaction with classmates, expand his communication, and master new content. Adaptations were
also made to John’s way of communicating; in other words, using the SKM and alphabet boards to write his answers or by pointing to the correct answer in multiple choice questions.

On John’s third inpatient rehabilitation period, he was attending the same school and had passed to the seventh grade. He was using the communication board with the alphabets and months of the year on one side, and days of the week and numbers on the reverse side. He had better neck and trunk balance, and improved manual function. During this time, new boards were added, with ready words and phrases about the foods he ate, leisure activities and places, activities of daily life, names of friends, and feelings. These new boards aimed at speeding up and expanding his communication with other children. Improved manual function allowed John to use a conventional keyboard with larger letters, placed on the same support as the boards, on the left side, within his field of vision. Figure 11.16 shows a rod affixed to his wheelchair to hold and better position the keyboard within his field of vision. Since using a mouse was not functional, a table-board with joystick and switch were made. Furthermore, the computer was reconfigured with new accessibility options: repeatedly pressed keyboard keys that froze up, short cuts, and extra-large letters on the screen. As his balance and manual function improved, John started training how to feed himself, with customization of eating paraphernalia, such as dishes that affixed to a table-board with raised edges to keep utensils from sliding off. A tubular bathing chair was also added, ensuring greater safety during bath time and allowing John to more actively participate (he was able to soap up some parts of his body with his right hand).

A fourth inpatient rehabilitation period included the introduction of a talker with keyboard (Figure 11.17). A support was made for mounting the monitor to the table-board, which already had a rack for the keyboard. Recording the ready phrases expanded John’s means of communication in different settings and situations. This tool did not exclude the
use of the word/letter boards. A transparent board, in acrylic, was made for John to use in the pool at school, during swim time with his classmates, such as the one in Figure 11.18. This transparent alphabet board also made his communication more similar to common exchanges, in which individuals speak face to face. Communication became more fluent
and effective, since the interlocutor was already able to read the words as John wrote them, rendering the exchanges more functional.

Currently, John has used the talker in school on a daily basis and the communication board with family members. He also uses a tablet to access social networks and play online games. He types mainly with his right thumb. His left hand was adapted with a touch capacitive pointer clip that helps him type (Figure 11.19). John uses a power wheelchair maneuvered with a conventional joystick. Table 11.2 details this process.

### TABLE 11.2

<table>
<thead>
<tr>
<th>Bodily Functions</th>
<th>Activities and Participation</th>
<th>Environmental Factors</th>
<th>Assistive Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>b117.2</td>
<td>d4103.4 (admission)</td>
<td>e1150 + 1 (admission)</td>
<td>• Customized bathing chair</td>
</tr>
<tr>
<td>b164.2</td>
<td>d4103.3 (currently)</td>
<td>e1151 + 3 (currently)</td>
<td>• Customized wheelchairs</td>
</tr>
<tr>
<td>b16700.1</td>
<td>d450.4 (admission and currently)</td>
<td>e1201 + 0 e1201 + 3</td>
<td></td>
</tr>
<tr>
<td>b2100.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b2101.2</td>
<td>d335.3 (admission)</td>
<td>e1251 + 0 (admission)</td>
<td>• Sound switch</td>
</tr>
<tr>
<td>b230.0</td>
<td>d335.2 (currently)</td>
<td>e1251 + 3 (currently)</td>
<td>• Verbalizations and “yes/no” signs</td>
</tr>
<tr>
<td>b320.4</td>
<td>d330.4 (admission and currently)</td>
<td>e1301 + 1 (admission)</td>
<td>• Communication boards</td>
</tr>
<tr>
<td>b7354.4</td>
<td></td>
<td>e1301 + 3 (currently)</td>
<td>• Letter boards</td>
</tr>
<tr>
<td>b7300.2</td>
<td></td>
<td></td>
<td>• Keyboard with template and large adhesive letters</td>
</tr>
<tr>
<td></td>
<td>d440.4 (admission)</td>
<td>e1401 + 0 (admission)</td>
<td>• Talker</td>
</tr>
<tr>
<td></td>
<td>d440.3 (currently)</td>
<td>e1401 + 3 (currently)</td>
<td>• Acrylic letter boards to use in water</td>
</tr>
<tr>
<td></td>
<td>d710.0</td>
<td>e355 + 2 (admission)</td>
<td>• Touch-enabled pointer clip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e355 + 4 (currently)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e410 + 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e5852 + 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e5850 + 2</td>
<td></td>
</tr>
</tbody>
</table>
11.5 Conclusions

These case studies show the importance of the functional application of AT tools in neurorehabilitation programs.

Michael’s case illustrates how assistive solutions enhance and foster the development of the child with brain injury. Notably, the use of technological resources should be customized to the child’s cognitive and motor abilities, follow-up on his learning process, and attend to his setting and needs for social interaction. It is important to stress that the combined use of more and less technologically sophisticated devices can help expand the child’s means of communicating, socializing, and acting more independently, with the freedom for self-expression and choice making.

The case of John highlights how AT can contribute to helping the child return to activities of daily life, school, leisure, and community, based on his motor and neuropsychological potential. AT resources can be used in the neurorehabilitation of the child with TBI according to their recovery process and can be used temporarily or permanently, depending on the child’s state. It is important to use AT tools adjusted to the child’s different communication settings and needs, expanding their social interaction, as shown in Figure 11.20.

11.6 Summary

This chapter describes the role of the pediatric specialist in the neurorehabilitation process of the child that incorporates AT—its uses, applications, and indications. Two case studies, a child with CP and one with TBI illustrate how AT impacted the children’s development, recovery, and progress, and how the pediatric specialist played an essential role in this process.
References


Macário, H. M. 2015 *Design e tecnologia assistiva: uma abordagem inserida no contexto de reabilitação*. 120 f., Dissertação (Mestrado em Design) Universidade de Brasília, Brasil.


12
The Geriatrician

Martina Pigliautile, Lorenza Tiberio, Patrizia Mecocci, and Stefano Federici

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12.1 Introduction

The word “geriatrics” was coined by Ignatz Leo Nascher (1863–1944), a Viennese man who worked as a physician in New York and who claimed that aging is not a disease but a period of life with its own physiology, requiring the need to treat geriatric medicine as a separate entity, as is done for pediatrics (Achenbaum, 1995; Morley, 2004). In the 1930s, Marjory Warren developed the principles of modern geriatric medicine in the United Kingdom, by enhancing the environment, introducing active rehabilitation programs and emphasizing the importance of the older person’s motivation (Morley, 2004).

Over time, geriatric medicine developed core values, a knowledge base, and clinical skills in order to improve the health, functioning, and well-being of older people and to afford appropriate palliative care, for which a marked expansion over the past three decades occurred to satisfy the growing needs for care of the aging population (American Geriatrics Society Core Writing Group of the Task Force on the Future of Geriatric Medicine, 2005). In fact, the U.S. Census Bureau data (Kinsella and He, 2009) reports an extraordinary demographic and epidemiological change that can be viewed as a success story for
public health policies and for socioeconomic development, consisting in an increase in the world’s population aged 65 and over (from 7% in 2008 to 14% by 2040, with Japan in first position in the ranking countries with the oldest population followed by Italy and Germany), an increase in life expectancy and a rise in the number of the oldest old (population aged 80 and above).

A geriatrician is consulted when an older person is frail and/or disabled (Fried, 1994; Fried, Ferrucci, Darer, Williamson, and Anderson, 2004; Fried and Guralnik, 1997; Fried et al., 2001; Fried, Walston, and Ferrucci, 2009), as written by Hazzard:

> How often have I been asked over the past 30 years, “What is a geriatrician?” I cannot count the times and the ways that I have tried to answer this question. But clearly, even as the field has grown and matured, the public continues to have at best a vague idea of what a geriatrician is and does and why. […] I am a geriatrician. I specialize in the medical, psychological, and social care of old people. […] Perhaps my most typical patient is the old-fashioned picture of frailty, a man – or more often a woman – who lives on the razor’s edge between independence and triggering a tragic cascade of diseases, disabilities, and complications that all too often prove irreversible. […] I am by definition an expert in subtlety and complexity (2004, p. 161).

Unfortunately, the geriatrician is still now defined as an unknown professional (Campbell, Durso, Brandt, Finucane, and Abadir, 2013), a fact that highlights the importance of defining its role in technology assessment.

### 12.2 Analysis of the Older Patient: Diseases, Disability, and Frailty

Hazzard’s words become clearer when considering the aging process. Aging is defined as an “accumulation of diverse deleterious changes in the cells and tissues with advancing age that increase the risk of disease and death” (Harman, 2001, p. 2). Disease, disability, and frailty play an important role in the aging process. Recursively, it could be said that frailty is defined as a deficit accumulation and that geriatric medicine is defined by frailty (Rockwood and Mitnitski, 2011).

#### 12.2.1 Disease

Fried (2000) identified the 15 most prevalent conditions among people aged 65 years old or above in the United States: arthritis, hypertension, heart disease, hearing loss, influenza, injuries, orthopaedic impairment, cataracts, chronic sinusitis, depression, malignant neoplasms, diabetes mellitus, visual impairment, urinary incontinence, and varicose veins.

Heron and colleagues (2009) found that heart disease, cancer, strokes, chronic lower respiratory tract disease, accidents (unintentional injuries), diabetes mellitus, and Alzheimer’s disease were the seven leading causes of death in the United States in 2006.

Studies on comorbidity—the combination of additional diseases beyond an index disorder (Feinstein, 1970)—and multimorbidity—the co-occurrence of diseases in the same person (Batstra, Bos, and Neeleman, 2002)—have been conducted using different methods with the aim of identifying the relationship between disease clusters, health outcomes and possible prevention programs (de Groot, Beckerman, Lankhorst, and Bouter, 2003; Guralnik, 1996; Marengoni, Rizzuto, Wang, Winblad, and Fratiglioni, 2009). A recent study
evaluated patterns of comorbidity and multimorbidity in an elderly population and found that chronic diseases were more likely to occur with comorbid conditions than alone (Marengoni et al., 2009). Hypertension and dementia were the most frequent diseases occurring with and without a comorbid disorder, whereas a few cases of heart failure and hip fracture occurred without any comorbidity. Heart failure and visual impairment were associated with the highest number of comorbid diseases and dementia with the lowest. Circulatory diseases were the most commonly co-occurring pairs of conditions. Co-occurring diseases clustered together beyond that which would be expected by chance, and five major clusters were identified: two of them were linked to vascular diseases, the others to dementia, diabetes mellitus, and malignancy.

Older age, female gender, and low socioeconomic status were found to be the main causes of multimorbidity, whereas disability and functional state decline, poor quality of life, and high health-care costs were the major consequences of multimorbidity (Marengoni et al., 2011). Considering epidemiological data on mental disorders in the older population, it is important to know that comorbid mental disorders are associated with functional status and quality of life, and that mental disorders increase the risk of death (Gijsen et al., 2001). In particular, dementia and depression are very common mental disorders in the elderly population. Around 47 million people live with dementia worldwide, with the number being projected to double every 20 years. Approximately 60% of dementia patients live in developing countries, and this number is projected to increase to more than 131 million by 2050 (Alzheimer’s Disease International, 2016). The main cause of dementia is Alzheimer’s disease (50%–80% of dementia cases), followed by Lewy body dementia (20%) and vascular dementia (5%; Corey-Bloom, 2004). Considering the epidemiology of depression in the general elderly population, Alexopoulos (2005) reported 1%–4% for major depression and 4%–13% for minor depression. The incidence and prevalence of depression is double this in the oldest old, and the prevalence in medical settings is higher than in the community. Late life depression is common in individuals with medical and psychosocial problems such as cognitive impairment, diseases, and social isolation. The care of depressed older people is complicated by a reciprocal interaction of depression with disability, medical illness, treatment adherence, and psychosocial factors (Alexopoulos et al., 2002). Depression is a predictor of disability in both sexes; in fact, it causes physical and social inactivity and the psychological aspects of depression even provoke a sense of disability (Taş et al., 2007).

### 12.2.2 Disability

Considering the interaction between disease and the environment, the concept of disability, in a biopsychosocial perspective, is an important aspect to consider in a society with an increasing number of old people.

In a recent study (Landi et al., 2010), physical disability in aging was described as an effect of diseases plus physiological alterations connected to aging. In this view, social, economic and behavioral factors and access to medical care modify the impact of the underlying causes. At the same time, disability is considered as an adverse health outcome and a risk factor for other adverse health outcomes. Based on several studies, the authors wrote that “disability, independent of its causes, may predict subsequent difficulty in instrumental and basic activities of daily living, and it has been associated with an increased risk of death, hospitalization, need for long term care, and higher health care expenditures” (Landi et al., 2010, p. 752).

During the last few decades, different scenarios have been proposed concerning the patterns of health trends in older people resumed by Jagger (2000):
1. The compression of morbidity theory suggests that disease and disability will become compressed into a short period before death if changes in lifestyle delay the age at onset and the progression of nonfatal disabling diseases (Fries, 1980).

2. The opposite view, namely the expansion of morbidity theory, proposes that living longer implies living with a disabling disease such as Parkinson’s disease, dementia, vision and hearing loss, and arthritis (Kramer, 1980).

3. The third theory supports a dynamic equilibrium between an increase in the number of years lived with a disability and the number of years lived with a less severe disability (Manton, 1982).

Many different studies have been dedicated to exploring the trends in mortality, morbidity, and disability. The U.S. Census Bureau (Kinsella and He, 2009) data report that the prevalence of chronic conditions is increasing while disability is decreasing in developed countries, whereas the prevalence of disability is likely to increase in developing countries.

In the Rotterdam Study, an analysis of the incidence of disability and its risk factors in multiple dimensions in community-dwelling women and men of older age found that age, self-rated health, being overweight, depression, joint complaints, and medication use were predictors of disability for both men and women. Stroke, falling, and the presence of comorbidities predicted disability in men only, whereas having a partner, poor cognitive functioning, osteoarthritis, and morning stiffness predicted disability in women (Taş et al., 2007).

According to the compression morbidity theory, a recent study identified clinically distinct trajectories of disability in the last year of life and attempted to determine whether and how the distribution of these trajectories differed according to the condition leading to death (Gill, Gahbauer, Han, and Allore, 2010). The results demonstrated that, for most of the decedents, the course of disability at the end of life did not follow a predictable pattern based on the most common conditions leading to death: cancer, advanced dementia, organ failure, frailty, sudden death, and other conditions. Dementia was the condition with the least variation and was characterized by high levels of disability throughout the last year of life. For the other conditions, catastrophic disability was found a few months before death. The authors commented on evidence supporting the need to provide services at the end of life, particularly for patients with dementia. In line with this, it was shown that dementia is the most important risk factor for the development of geriatric syndromes during hospitalization (Mecocci et al., 2005), suggesting that the hospital environment should be adapted to the needs of patients with cognitive problems.

Although it has been documented that disabilities and limitations have shown improvements over the last decade (Freedman, Martin, and Schoeni, 2002), and that people are living longer than they did previously, with less disability and fewer functional limitations (Christensen, Dobhlammer, Rau, and Vaupel, 2009), older people (particularly of the oldest age) are often described as a “frail” group who are particularly vulnerable to diseases and functional disability and who are at a greater risk of losing the ability to manage their daily activities independently (Fried et al., 2001; Song, Mitnitski, and Rockwood, 2010).

12.2.3 Frailty

Frailty is defined as “a clinical state of increased vulnerability and decreased ability to maintain homeostasis that is age-related and centrally characterized by declines in functional reserve across multiple physiologic systems” (Fried et al., 2009, p. 634).
A recent review identified different models of frailty coexisting in the literature where the “physical phenotype” and the “multidomain phenotype” that can be considered as extreme points on a continuum ranging from physical aspects to multiple aspects, respectively, including cognitive, functional, and social domains (Abellan van Kan et al., 2010). The main differences between the proposed models are due to the differences in considering physical, functional, cognitive, and social domains as components of the frailty model or as frailty outcomes. For example, disability is considered by many as a component of frailty and by others as an outcome; in fact, a survey of 62 geriatricians, focusing on the significance of the terms “frailty” and “disability,” showed that 98% of the respondents considered frailty and disability to be two distinct entities with different prognoses and health-care implications (Fried et al., 2004). A different predictive capacity for clinical outcomes is associated with various models. The “physical phenotype” defines frailty as a biological syndrome of decreased physiological reserves resulting in a cumulative decline in all physiological systems and vulnerability to adverse outcomes and provides an operational definition by means of measurable items (exhaustion, weight loss, low energy expenditure, weak grip strength, and slow walking speed) that allow the classification of older people into “no frailty,” “intermediate” and “frail” groups (Fried et al., 2001). This model supports the distinction between frailty, comorbidity and disability. The physiological changes associated with aging can be considered as being the factors that contribute to frailty. Frailty can cause a risk of disability, but the fundamental concept is that although frailty, disability and comorbidity are often associated, one is not synonymous with the other: comorbidity represents an etiological factor of frailty and disability is an outcome of frailty (Fried et al., 2001, 2004). Disability can arise from a dysfunction in a single system or in many systems, but frailty always implies a multisystem dysfunction. Disability does not need to be associated with instability, whereas frailty always is (Rockwood, Hogan, and MacKnight, 2000). Frailty is a predictor of falls, hospitalization, disability, and death (Fried et al., 2001). The “multidomain phenotype” includes multidomain models resulting from regression models that consider cognitive, functional, and social aspects (Abellan van Kan et al., 2010). Frailty measures depending on the deficit identify frailty by means of comprehensive geriatric assessment (CGA). Rockwood and colleagues (1999) compiled a Frailty Index considering cognitive status, mood, motivation, communication, mobility balance, bowel and bladder functions, activities of daily living (ADL), nutrition, and social resources, as well as several comorbidities. This index was highly predictive of death or institutionalization. More recently, a standard procedure for constructing a Frailty Index was proposed (Searle, Mitnitski, Gahbauer, Gill, and Rockwood, 2008). Based on the idea that having more health deficits corresponds to a major probability of becoming fragile, the Frailty Index counts deficits in health (symptoms, signs, diseases, disabilities, or laboratory, radiographic or electrocardiographic abnormalities). At the same time, in this theoretical framework, disability and dementia are components of the Frailty Index and are evaluated as poor clinical outcomes in the theoretical framework. The social domain receives particular attention because social isolation could have a strong impact on the development of dementia or disability (Abellan van Kan et al., 2010). Recently, four major consensus points on physical frailty and recommendations were proposed by a consensus group, consisting of delegates from six major international, European, and the U.S. societies (Morley et al., 2013).

Now, it appears clearer why Hazzard defines the geriatrician as an expert in subtlety and complexity. The explanation of these three main concepts highlights how complex this particular population is and how great the need is for an expert physician. In fact, the care of older people differs from that of younger people for different reasons related to life
expectancy, disease prevalence and comorbidity, social resources, goals of treatment, and preferences for care (Reuben, Shekelle, and Wenger, 2003).

12.3 Geriatric Assessment

The Geriatric Medicine Section of U.E.M.S. defines geriatric medicine as “a specialty of medicine concerned with physical, mental, functional and social conditions in acute, chronic, rehabilitative, preventive, and end of life care in older patients” with the aim to “optimise the functional status of the older person and improve the quality of life and autonomy” (2008, p. 1). Older patients are described as a group that requires a holistic approach and difficulties in the diagnostic process, response to treatment, and the need for social support are emphasized.

Straus and Tinetti (2009) identified five factors that distinguish clinical approaches toward elderly people from the traditional medicine proposed for young adult patients:

1. The difficulty in differentiating age-related physiological changes in organ systems from disease and the coexistence of chronic diseases.
2. The fact that distressing symptoms or impairments frequently depend on several factors (physical, psychological, social, environmental, etc.).
3. The difficulty for the physician in selecting and interpreting diagnostic tests that may be affected by age and comorbidity.
4. The variability observed in the importance that older patients assign to potential health outcomes.
5. The involvement of caregivers who support the patients provide information and facilitate in terms of treatment, but could also be a source of conflict when their goals do not coincide with those of the patient.

Unlike the traditional disease-oriented form of medical evaluation, the geriatric approach to the patient includes the assessment of cognitive, affective, functional, social, economic, environmental, and spiritual factors, as well as a discussion about the patient’s preferences regarding advance directives (Reuben and Rosen, 2009), as illustrated in Figure 12.1.

In addition to medical history, a physical examination and laboratory and ancillary tests, the geriatrician considers visual and hearing impairments, malnutrition/weight loss, urinary incontinence, balance and gait impairments, falling and poly-pharmacy.

The assessment could be implemented by a single geriatrician or by a team of health professionals; in the latter case, the term “comprehensive geriatric assessment” is used. This term was defined by the National Institute of Health (NIH) Consensus Development Conference in 1987 as a

multidisciplinary evaluation in which the multiple problems of older persons are uncovered, described, and explained, if possible, and in which the resources and strengths of the person are catalogued, need for services assessed, and a coordinate care plan developed to focus interventions on the person’s problems. (NIH Consensus Development Program, 1987)
and by Rubenstein as a “a multidimensional interdisciplinary diagnostic process intended to determine a frail elderly person’s medical, psychosocial, and functional capabilities and problems in order to develop an overall plan for treatment and long-term follow-up” (Rubenstein, 1995, p. 3). The goals of CGA have been summarized by Rubenstein (1995) as follows: enhancing diagnostic accuracy, optimizing medical treatment, and living location, improving medical outcomes, improving function and quality of life, reducing unnecessary service usage, and arranging long-term care management.

A CGA can be performed in different health contexts, ranging from the hospital to the patient’s home, which require different programs, assessment instruments, and goals, depending on the setting (Reuben and Rosen, 2009).

Having identified impairments and disabilities through a CGA, there are alternative approaches of delivering care. One of these approaches is rehabilitation, which represents a core element in the practice of medicine for older people.

In the following section, a definition and an overview of geriatric rehabilitation that highlight the key relevant clinical diagnoses and rehabilitation interventions focusing on the role of assistive technology in the care process and everyday support of the frail and/or disabled elderly are presented.

### 12.4 Geriatric Rehabilitation

Rehabilitation is one of the basic elements of comprehensive geriatric care and it has been defined as “an active problem-solving and educational process, focused on disability and aiming to maximize the patient’s participation in society and his or her well-being while
reducing stress on the family” (Wade, 1999, p. 176) (please see also Wade, 1992). As described in previous sections, the elderly population is characterized by the presence of comorbidity, disability, and frailty, which require appropriate geriatric rehabilitation services.

Geriatric rehabilitation has two main objectives: on the one hand, it limits the impact of disability and, on the other hand, it stimulates and strengthens residual abilities, encouraging and supporting motivation and needs through therapeutic interventions focused on the person and his or her living environment. The burden of a comorbid disease influences a patient’s ability to tolerate a rehabilitative intervention. Therefore, an interdisciplinary approach should be adopted in order to achieve the best functional outcomes (Wells, Seabrook, Stolee, Borrie, and Knoefel, 2003a).

Geriatric rehabilitation can be provided in a rehabilitation clinic, subacute rehabilitation unit, skilled nursing facility, or via home health assistance. The basic team consists of different subspecialty professionals, such as a physical therapist, who will assess a wide array of abilities, including strength, balance, transfer (rising from a chair), and walking. An occupational therapist evaluates the following: self-care skills, ADL, and the home environment. The occupational therapist can also provide training on how to use assistive technologies, incorporating meaningful activities to promote participation in everyday life. The occupational therapist assesses the patient’s ability to perform his or her daily activities, whereas the physical therapist focuses on improving mobility. In addition, other professional members of the rehabilitation team are the speech therapist, nurse, social worker, dietician, psychologist, physiatrist, and pharmacist (Brown and Peel, 2009; Tsukuda, 1990). Rehabilitation treatment requires collaboration between team members, the patient, and his/her family. On the one hand, the patient should play an active part in the care and decision-making process, and, on the other, the family should ideally receive training in how to assist the older patient at home. This involvement influences not only rehabilitation outcomes but also the quality of life of the patient in all aspects: functional, physical, social, and emotional. A patient’s satisfaction with care tends to be greater when there is such involvement (Toseland et al., 1996). This approach is in line with the biopsychosocial model, where the functioning of an older patient is not only observed in association with health condition but is also linked to personal and environmental factors. In order to prescribe an appropriate rehabilitation treatment, the health-care team should have a common understanding of health and functioning in a disability context. The International Classification of Functioning, Disability, and Health (ICF) model provides a helpful framework that illustrates why geriatric rehabilitation must be an interdisciplinary activity (WHO, 2001).

Some common clinical problems in geriatric rehabilitation include hip fracture, stroke, and cognitive impairments, which have been discussed earlier (Wells, Seabrook, Stolee, Borrie, and Knoefel, 2003b). The most serious risk factor for fracture is falling and frailty and, as a consequence, disability. Frequently, fractures occur at home, but they also occur just as frequently in hospitals and in residential contexts. Appropriate preventive measures should be taken to protect the elderly who are at risk. Hip fractures require the most intense use of hospital resources and an intensive period of post-operative medical care and inpatient rehabilitation. The risk of stroke doubles every 10 years from the age of 55: 72% of all strokes occur after the age of 65 (Feigin, Lawes, Bennett, and Anderson, 2003). Elderly patients suffering from a cerebrovascular accident have a clinical onset more severe than in younger patients, with a higher mortality rate by 30 days, and a greater number of long-term admittances (Asplund, Carlberg, and Sundström, 1992).
Among the clinical factors that contribute toward the worst outcomes, two are very significant: the presence of a more severe initial clinical symptoms frame and reduced recovery capabilities (Nakayama, Jorgensen, Raaschou, and Olsen, 1994).

The literature underlines the need for screening to identify patients who are most likely to benefit from geriatric rehabilitation. In this respect, CGA and the role of the geriatrician are very essential for two main reasons. First, they offer a clear picture of the patient, the disease, and the possible health and social disadvantages that might result from the disability. Second, they decide upon the type of rehabilitation treatment to be used and the most appropriate intervention in terms of a technological aid.

An important goal of screening patients is in fact to identify comorbidities that may affect rehabilitation outcomes by evaluating functional impairment, medical complications, psychological functioning, and social support (Mosqueda, 1993). Cognitive screening is also crucial in selecting patients for geriatric rehabilitation: cognitive disorders are commonly and potentially critical regarding rehabilitation outcomes because they affect different aspects of treatment (e.g., difficulties related to understanding instructions or remembering information) (Ruchinskas and Curyto, 2003). Cognitive impairments hinder the outcome of rehabilitation treatment (Patrick, Knoefel, Gaskowski, and Rexroth, 2001). Evidence from the literature shows that cognitive disorders are correlated with limited and poor results in functional and rehabilitation outcomes in elderly patients, particularly with regard to hip fractures (Colombo, 2004). Cognitive disorders are considered as selection criteria for admission to a rehabilitation process. When a patient is suffering from a mild form of reduced cognition, there is good reason to be optimistic about rehabilitation outcomes. In addition, depression is a frequent complication after hip fracture or stroke that can negatively affect rehabilitation treatments. In general, depression is a very common disorder in the elderly and its effects on rehabilitation should be considered because persistent symptoms of depression are associated with a decline in cognitive and physical functioning (Wells et al., 2003b). In this respect, detailed neuropsychological screening is required to detect cognitive impairment and depression and, consequently, to determine the course of further treatment (Ruchinskas and Curyto, 2003).

Aside from medical conditions, several factors may influence the success of rehabilitation treatment (Brown and Peel, 2009). When disability has been present for many years, the goals of treatment may be directed toward compensatory strategies or the treatment of deconditioning. Patients with low motivation require goals that are attainable and which can be reached in measurable steps in order to benefit from rehabilitation therapy. For patients nearing the end of rehabilitation, interventions should be focused on reducing the workload of the caregiver and the patient's discomfort. Critical circumstances, such as states of severe disability, malnutrition, the absence of a caregiver, financial limitations, and cultural beliefs, may limit the benefits from rehabilitation treatments, precluding the use of certain techniques and assistive solutions.

One of the most commonly used interventions in geriatric rehabilitation, as well as in physical and cognitive exercise programs, is the implementation of assistive solutions, often including the use of specific technological devices suitable for an individual's disability. The use of assistive technology enables the older person to interact more favorably with their life environment.

In the next section, a definition of "assistive solution" and an overview of today's technologies for promoting independence and quality of life for elderly people with a disability will be given.
12.5 Assistive Solutions: A Challenge in Geriatric Rehabilitation

Interest in the contribution of technology in gerontology can be traced back to late 1980s, and to date it represents a remarkable research field that promises innovative approaches in eldercare (Piau, Campo, Rumeau, Vellas, and Nourhashemi, 2014; Schulz et al., 2015). The International Standards Organization (ISO) 9999 (2007) defines technical aids as “any product, instrument, equipment or technical system used by a disabled person, especially produced or generally available, preventing, compensating, monitoring, relieving or neutralizing impairments, activity limitations and participation restrictions.” The ICF adopts a more concise definition: “any product, tool, equipment or technology adapted or designed specifically to improve the functioning of a disabled person” (WHO, 2001, p. 164).

Technological development is one of the factors that pushed the WHO to reconsider the International Classification of Impairments, Disabilities, and Handicaps model based on a linear causal relationship impairment → disability → handicap (WHO, 1980, p. 11). According to the ICF, disability should not be seen as an attribute, but as a situation in which every individual could happen to find him/herself whenever there is a gap between individual capacity and environmental factors. In order to compensate for a disability, a technological device may not be sufficient. A merger is required between mainstream and assistive technologies with an assembly that is different from one person to another as the situation changes from one context to another. This merger can be designated as an personalized assistive solution (AAATE, 2003, p. 3), indicating the entire set of human and technology supports required by an individual to compensate for disablement and participate in society on equal footing (Andrich, Mathiassen, Hoogerwerf, and Gelderblom, 2013; Section I).

It is a part of the ICF model of functioning and disability that environmental factors such as assistive technologies have the potential to reduce the impact of disability on a person's performance in all areas of daily living, and so increase the individual's autonomy and independence. Kanade (2012) and Schulz (2013) coined the term Quality of Life Technologies to describe intelligent technologies specifically designed to support the physical, cognitive, social, or emotional functioning of humans. Their definition considers not only systems that are compensatory or assistive, as well as assistive technology, but also technologies that are preventive and those that stimulate or improve psychological well-being as well as those that facilitate information seeking and sharing, social connectedness, and the performance of tasks including everyday activities.

Within geriatric rehabilitation, assistive solutions may have the potential to enhance the outcomes of interventions through the systematic application of technological devices that meet the functional needs of people with cognitive and physical disabilities.

In this section, we will try to provide an overview of the areas where technological systems may offer support to the everyday life of the elderly and their caregivers.

Over the last few years, field research studies have focused on the needs that the elderly and their caregivers expressed regarding the contribution of assistive technology to their everyday life, and outlined four main areas of support: a need for the management of dementia symptoms, a need for social contacts to be maintained, a need for daily life activities, and a need for health monitoring and safety support (Lauriks et al., 2007; Piau et al., 2014).

More recently, Schulz et al. (2015) have identified five core life domains in which technology development can be helpful having a considerable potential impact on older adults’ quality of life. Particularly, they classified technologies for physical and mental health,
mobility, social connectedness, safety and everyday activities, and leisure. In each of these life domains, the use of technology can be useful for monitoring or measuring the environment of the individual, for diagnosing or screening aimed to identify problems or needs and for treating of them.

In the last decade, various sponsored research projects have been conducted on the concept of Ambient Assisted Living solutions (AAL). AAL “refers to intelligent systems of assistance for a better, healthier and safer life in the preferred living environment and covers concepts, products and services that interlink and improve new technologies and the social environment” (van den Broek, Cavallo, and Wehrmann, 2010, p. 6). In most AAL research projects, it is assumed that the developed assistive solutions and services will improve the quality of life and well-being of elderly people. Unfortunately, the impact on health and quality of life is not yet firmly documented in the scientific literature (Federici, Tiberio, and Scherer, 2014; Siegel, Hochgatterer, and Dorner, 2014).

It is important to note that an ethical debate on assistive technologies is in progress, and three areas emerge as important. The first is in regard to personal living environment and concerns privacy, autonomy, and obtrusiveness. The second refers to stigma and human contact. The third area relates individual approach, affordability, and safety. The terms “obtrusiveness” and “visibility,” which are often not clearly explained, are used to indicate the degree to which a device is noticeable by the user and other individuals, both at home and in public (McLean, 2011; Mittelstadt, Fairweather, Shaw, and McBride, 2011; Zwijsen, Niemeijer, and Hertogh, 2011).

The following section provides examples of commercially available and emerging assistive technologies for elderly people aimed at compensating for deficiencies such as memory and motor problems. A brief survey of socially assistive robotic systems is also given. Their main function is aimed at rehabilitation and at enhancing elderly health and psychological well-being.

12.5.1 Technological Devices for Elderly People with Cognitive Impairments

Assistive technologies to compensate for cognitive and neuropsychological disabilities consider “cognitive prosthesis” or “cognitive orthosis” devices. Cognitive prostheses are computer-based systems that reduce the negative impact of disability on daily functional activities (Cole, 1999). When these systems are used for rehabilitation purposes, it is necessary to design them with features that are highly customizable and easy to use. In general, cognitive aids include wearable devices, computer systems, personal digital assistants, and integrated sensory systems. They may improve the performance of elderly people with cognitive impairments and dementia through reminders or assistance in the execution of tasks (DeVaul, 2004; Gorman, Dayle, Hood, and Rumrell, 2003; Mihailidis, Boger, Craig, and Hoey, 2008; Philipose et al., 2004; Pollack et al., 2003). Cognitive impairments are one of the reasons for medication nonadherence and treatment failure (Muir, Sanders, Wilkinson, and Schmader, 2001).

Cognitive prospective memory aids, for example, are context-aware technological aids that can help older people with cognitive disabilities to perform a programmed task (reminder systems) or they may provide a set of instructions related to procedural guidance in activity execution (prompting systems). Reminder systems, such as electronic organizers, voice recorders, software for computers, communication devices, and personal digital assistants, are also very useful in case of difficulty in the management of medication therapy by older people. These devices can provide an alarm system, daily schedule planning, and the temporary or permanent storage of information in order to monitor medication use (McGarry Logue, 2002).
A systematic review carried out by Gillespie, Best, and O’Neill (2012) provides a framework for evaluation and prescription of assistive technology for cognition (ATC) using the ICF as the basis for the profile of cognitive deficits. A new classification of technology for cognitive impairments based on cognitive function is introduced, and the results show that assistive technology has been used to effectively support cognitive functions relating to attention, calculation, emotion, experience of self, higher level cognitive functions (planning and time management), and memory.

The Planning and Execution Assistant and Training (PEAT) system is an example of automatic planning software that operates on a personal digital assistant or mobile phone. It provides personalized prompts to guide a person during the execution of a task (Levinson, 1997). The ISAAC Cognitive Prosthetic Assistive Technology system is a handheld cognitive prosthetic aid specifically designed for individuals who have a wide range of cognitive disabilities. It delivers individualized prompts and procedural information in a speech, audio, text, checklist, or graphic format. A case study involving two individuals with brain injury showed improved independence in ADL and better communication with caregivers as a consequence of ISAAC (Gorman et al., 2003). Cognitive Orthosis for Assisting Activities in the Home (COACH) is a prototype system designed to support people with dementia in completing a hand-washing task autonomously. The COACH system provides prerecorded verbal prompts and uses a single video camera, artificial neural networks, and plan recognition in order to automatically monitor the execution of the task. The results from a clinical trial with 10 elders with moderate to severe dementia showed significant improvements in the completion of hand-washing tasks without caregiver assistance following the use of the COACH system (Mihailidis, Barbenel, and Fernie, 2004).

Another problem associated with cognitive disability that accompanies the early stages of dementia, particularly in the case of Alzheimer’s dementia, is disorientation at not only the temporal level but also at the spatial level. Spatial–temporal disorientation is a threat to the safety of these patients and increases the apprehension and burden of caregivers. Global Position System (GPS) technology provides some aids that include wrist watches with a GPS locator (GPS Locator Watch by Verify, and Digital Angel for Senior Wanderers). An integrated system using a wireless transceiver can detect the exact position of the older adult and allows caregivers to communicate and monitor the person from a distance (Parnes, 2010). However, these technologies have not yet been widely validated and require further investigation, including long-term usage tests focused on identifying the key needs of both elderly people suffering from dementia and their caregivers, and on seeking ethical approval.

More recently, O’Neill and Gillespie (2014) have proposed framework for ATC based on the mental functions. They consider physical high-tech devices that have been explicitly developed to augment cognitive disability.

12.5.2 Technological Devices for Elderly People with Motor Disability

Daily activities also require the ability to move and interact with the environment as independently as possible. Osteoporosis, one of the most common bone diseases in the elderly population, and changes in visual and auditory perception can easily lead to reduced personal mobility in old age. In this regard, there are several devices that claim to make life easier for seniors. Assistive technologies for older people with mobility limitations cover different products and intelligent systems, from bath lifts and rails, powered and autonomous wheelchairs, and smart walkers to upper/lower limb prosthetics.

The smart walker “Guido,” the latest evolution of Personal Adaptive Mobility Aid (PAM-AID), was designed to facilitate the mobility of blind elderly people and focuses on power-assisted
The Personal Aid for Mobility and Monitoring (PAMM): the device is aimed at supporting the navigation of elderly people who live independently or in senior-assisted living facilities. It provides both guidance to destinations through preprogrammed maps, schedules, user commands and sensed obstacles, and continuous health monitoring (Yu, Spenko, and Dubowsky, 2003). Wheelchair Mounted Robotic Arms (WMRAs) are devices with a manipulator arm on the wheelchair to provide assistance throughout the day (Alqasemi, McCaffrey, Edwards, and Dubey, 2005). Typical tasks of WMRAs include manipulating and moving objects, assistance with eating and drinking, and controlling communication devices and environment control units. Older adults can typically control the WMRA using a joystick, keypad, voice command, or other input devices.

The Assistive Robotic Manipulator, known as MANUS, is a commercially available, wheelchair-mounted robotic arm that is able to assist older people with an upper limb disability. Through a keypad and a joystick, the older person can drive MANUS manually, deciding the location and orientation to be achieved (Driessen, Evers, and van Woerden, 2001; Hok Kwee, 1998). Several studies have tested the effectiveness of an upper limb robotic therapy based on the use of MANUS for improving motor outcomes among chronic stroke patients. The results showed positive benefits in trials with people who had moderate impairments, but also among severely impaired chronic stroke patients as well (Krebs et al., 2004).

12.5.3 Socially Assistive Robotics Systems

This section describes robotic devices for assisting elderly people. Assistive technologies, based on robotic platforms, may play an important role both in the rehabilitation domain and social assistance area. In the first case, the systems described in the previous section offer support based on physical interaction (intelligent wheelchairs, artificial limbs, etc.). Socially assistive robots are being considered as enablers to support the process of care giving or keep elderly at home longer and they may be perceived as social entities that communicate with the user through social interaction (Kachouie, Sedighadeli, Khosla, and Chu, 2014). Social robots are divided into service robots (telepresence systems, reminding, and monitoring) and companion robots. The use of socially assistive robots in the context of eldercare has received increasing attention over the last decade as illustrated by a growing body of research in this area (Mordoch, Osterreicher, Guse, Roger, and Thompson, 2013; Moyle et al., 2014; Robinson, MacDonald, Kerse, and Broadbent, 2013). Studies on socially assistive robots describe several devices for the maintenance of personal autonomy in terms of support for basic ADL (eating, bathing, toileting, and dressing), the mobility of people (including shipping), and environmental and personal monitoring. Examples of these robots are “nursebot Pearl,” which includes a system of reminders (e.g., medication, appointments in the program), telepresence (to allow medical personnel and operators to interact remotely with a senior person who lives alone), and monitoring (for systematic supervising of the activity/health status of the person). Pearl is also a personal assistant and a social interaction system that facilitates contact with others (Pollack et al., 2003). The I-Cat robot is a robot cat that shows different facial expressions as an index of emotions. The studies on I-Cat focused on aspects of social interaction between older people and robots and on the effects of I-Cat behavior on its acceptance by elderly people (van Breemen, Yan, and Meerbeek, 2005). Through Care-O-bot, older users can control lighting, heating, and air conditioning in their own homes, and they can also get in touch with a doctor or relatives. The Care-O-bot robot is a mobile robotic home assistant designed to perform household tasks, media management, daytime management (e.g., time for medicine), the supervision of vital signs, and make emergency calls. It has the ability to guide a person around the house whilst avoiding obstacles, and operates safely and reliably.
in different environments. The latest prototype, Care-Obot II, also has manipulator abilities that make it a more efficient assistant in the tasks of daily living (Graf, Hans, and Schraft, 2004). The Italian project RoboCare has developed an intelligent prototype system integrating robotic, sensory and software agents to create innovative services for an elderly person at home. Its key feature is the ability to maintain continuity of behavior, such as ensuring the continuous monitoring of the state of an assisted elder and of his/her domestic context, creating a context at the knowledge level around the actions that the assisted person performs and providing contextualized interaction services aimed at proactive assistance for the assisted older adult (Cesta et al., 2003). Part of the research in RoboCare focused on an evaluation of elderly people’s perception of assistive robots. The results showed how the acceptability of robotic devices in the home setting does not only depend on the practical benefits they can provide, but also on the complex relationships between cognitive, affective, and emotional components of people’s images of a robot. The RP-7 In-Touch Health platform is a tele-presence device that allows patients to be monitored remotely. Patients can view and hear their doctor in real time through a video screen and speaker system. Patients prefer to see their doctor, through a robot. Health-care professionals can make decisions based on vital signs transmitted in real time by visiting the patient remotely. The first results of a study conducted at the University of Maryland Hospital showed that most patients are comforted by the use of this robot because the platform enables them to maintain more constant contact with health-care professionals (InTouch Health, 2004).

Kompai is a robot developed to remotely monitor older adults’ physical activity and health indicators through stereoscopic cameras, two-way audio communications, and a touchscreen interface (Zsiga et al., 2013). The Kompai robot provides nutrition assistance by means of eating and drinking reminders, as well as telemedicine and cognitive stimulation services, remote controls for the home environment, fall alarms and detection, and the possibility to connect to a care center. Older adults who tested the robot in their home environment were extremely positive about the experience, finding it a useful assistive device. Recent advances in socially assistive robotics have improved telepresence platforms in a wide variety of services related to health care and aging in place contexts (Kristoffersson, Coradeschi, and Loutfi, 2013). The Giraff robot is a remote controlled mobile human-height physical avatar integrated with a videoconferencing system (Cesta, Cortellessa, Orlandini, and Tiberio, 2013). Recently, the feasibility of a Giraff robot as an assistive technology for enhancing communication between residents with dementia who were living in a long-term care facility and their family was explored (Moyle et al., 2014).

The Giraff robot is being tested by the ExCITE project team (Orlandini et al., (in press); Tiberio, Cesta, and Olivetti Belardinelli, 2013). More recently, Cesta, Cortellessa, Orlandini, and Tiberio (2016) analyzed the impact of a telepresence robot through an ecological long-term case study. Particularly, the objective of the study was to understand the user’s experience, attitude, interaction behaviors, acceptance, and beliefs toward a technological solution and how they impact on the adoption and effective daily use of a telepresence robot in a real context of daily life.

### 12.6 Acceptance, Rejection, or Abandonment of an Assistive Technology

The acceptability and willingness by elderly people to use assistive solutions seem to be complex issues. A technological aid is a helpful support when used properly and designed...
appropriately on the basis of a user's characteristics and needs. Aging effects certainly have an influence on how willing older adults are to use existing technologies as well as how they learn to use new technologies. The development of predictive models that are able to determine a person's potential to adopt a particular technology continues to be desirable and to foster research interest. Most of the assistive solutions described above were developed and evaluated using a UCD approach and user-experience (UX) evaluation (Borsci, Kurosu, Federici, and Mele, 2013). Over the past decade, the AAL approach strongly promoted the UCD and process in order to meet end users' needs and expectations by adapting products to the characteristics of the physical environment and social milieu in which they are supposed to be used in order to prevent technology nonuse or abandonment (Federici et al., 2014; Scherer, 2014).

Personal factors such as age-related changes in perception, cognitive and motor systems, anxiety, self-efficacy, and familiarity with technology represent strong predictors of technology adoption and its effective use (Czaja et al., 2006). McCreadie and Tinker (2005) suggested a complex model of acceptability, in which the interaction between individual “felt need” for assistance and “product quality” plays an important role. According to the authors, the synergy between individual needs and the personal life environment create the perception that a person needs help. In addition, if a technological device works properly, reliably, and safely, older people are more willing to accept and use it in everyday life. When a person accepts the technological aid only in terms of necessity and as a means of carrying out activities of daily life, acceptability is defined as reluctant. When the assistive solution is perceived as being part of one’s own life, the acceptability is defined as grateful, and when a person considers the technological device as being a part of themselves, the acceptability is described as internal (Karmarkar, Chavez, and Cooper, 2008). Another factor that influences the acceptability of assistive solutions is the perception of advantages or disadvantages of a device: if the perceived advantages outweigh the disadvantages, acceptability of the assistive solution increases. Cesta et al. (2011), in their study on the interaction of elderly people with an assistive technology domestic system, identified relevant issues about the acceptability of a robotic by elderly users in the domestic environment. They found that the elderly people recognize the practical advantages provided by an intelligent assistant, which can help the users in the management of everyday activities and age-related difficulties and makes them feel sure.

The Technology Acceptance Model (TAM; Davis, 1993) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Morris, Davis, and Davis, 2003) are the models often employed in technology acceptance studies and aimed at explaining technology (non)use by individuals in organizations. The predictor variables in the TAM are perceived usefulness and perceived ease of use, while the UTAUT includes social influence and facilitating conditions. UTAUT also includes four moderating variables (gender, age, experience, and voluntariness of use). Reviews of studies involving older adults have indicated that the TAM and the UTAUT are missing important predictors of technology use that are specific to community-dwelling older adults, including biophysical, psychological, and contextual factors (Lee and Coughlin, 2015; Peek et al., 2014). A recent qualitative explorative field study shows that older adults’ perceptions and use of technology are embedded in their personal, social, and physical context (Peek et al., 2016).

The acceptability of a specific support is probably influenced by the coping strategies elderly people commonly utilize to manage the weakening of their competencies (Brandtstädter and Renner, 1990; Slangen-de Kort, Midden, and van Wagenberg, 1998). Assimilative strategies involve an active modification of the environment in order to reach personal goals; conversely, accommodative strategies imply a personal adaptation to the
environment. In this respect, it is clear that the acceptability of a technological support may depend on the extent to which it modifies the characteristics of the older adult’s home. In addition, another issue to be considered is the features of daily life for which the assistive solution is expected to be used. Environmental barriers (such as a two-story house) could limit the acceptability of an assistive solution, so it is important to assess physical environmental barriers in the home and in the outdoor environment (Iwarsson and Slaug, 2001). Another factor affecting the acceptability of an assistive solution is the potential risk that using such a device will stigmatize the disabled person. Furthermore, the use of an assistive solution can indicate a change in personal competencies, and this is associated with negative social judgments, affecting personal motivation and the adoption of a technological aid (Gitlin, 1995).

Training in the use of a device is an important component for improving acceptability (Elliot, 1991). One of the initial difficulties in the use of a device may be its installation, which might require skills and learning steps that are not always easy for an elderly person to learn, particularly when there cognitive deficits are present. Electronic systems, such as reminder systems, may be difficult to manipulate and their interfaces could be too small and unclear to learn. Chiu and Man (2004) indicated that older adults who received training after discharge from the hospital showed a higher rate of satisfaction and usage of a device than older adults who did not receive training. A training program for the use of an assistive solution should allow for client and family involvement in the selection of a device and provide follow-up care and training in its use (Karmarkar et al., 2008).

Overall, the abandonment of an assistive device is often the result of an unsuccessful process of “matching person and technology” (Scherer, 1998, 2002; Scherer and Craddock, 2002). When providing an assistive solution, it is essential to conduct a careful evaluation of the potential user and to consider several steps before providing a technological aid. In this respect, the biopsychosocial model of the ICF can improve the selection of assistive solutions and help determine the best match of a technological aid for an elderly user (Arthanat and Lenker, 2004; Scherer, 2005).

12.7 Role of the Geriatrician in the Assistive Technology Assessment Process

When the user of a Center for Technical Aid is an older person, the geriatrician should be involved in the Assistive Technology Assessment (ATA) process as a professional consultant. Generally, an elderly person is admitted to a Centre for Technical Aid following a geriatric assessment. In an initial interview, focused on gathering background information of the potential user, the geriatrician helps in reading and interpreting the data from the geriatric assessment.

In the multidisciplinary team, the geriatrician cooperates in deciding whether the data are sufficient for a “matching process” and, if necessary, he/she can assess the user or suggest instruments of assessment. In order to describe the user from an ICF perspective, the geriatrician relates the geriatric assessment dimensions to the ICF code, as illustrated in Table 12.1, because by adopting the ICF language the geriatrician is able to facilitate a dialogue with the other professional consultants of the multidisciplinary team. In the last few years, assessment tools of geriatric domain have been adapted and/or validated.
TABLE 12.1
Geriatric Assessment and ICF Codes

<table>
<thead>
<tr>
<th>GA Components</th>
<th>Examples of Tests and Assessment Techniques</th>
<th>ICF Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medical</strong></td>
<td>Interview center on clinical history + Laboratory, imaging, and other ancillary test + Direct observation and functional testing + Hachinski Scale (Hachinski et al., 1975) Cumulative Illness Rating Scale (CIRS) (Parmelee, Thuras, Katz, and Lawton, 1995)</td>
<td>BS and BF</td>
</tr>
<tr>
<td><strong>Visual impairment</strong></td>
<td>Interview • Standard method: Snellen eye chart •; Interviewers and self-report: Activities of Daily Vision Scale •; VF-14 •; VFQ-25 •; Cataract Symptom Scale •</td>
<td>BF: from b210 to b229</td>
</tr>
<tr>
<td><strong>Hearing impairment</strong></td>
<td>Interview • Method AudioScope 3 • Whispered voice test • Hearing Handicap Inventory for the Elderly-Screening Version (HHIE-S) •</td>
<td>BF: from b230 to b249</td>
</tr>
<tr>
<td><strong>Malnutrition/weight loss</strong></td>
<td>Initial visit: question about weight loss within the previous 6 months • Weighing patients at every office visit • Calculating body mass index • Nutritional Screening Initiative’s 10-item checklist • Mini-Nutritional Assessment (MNA) •</td>
<td>BF: b530</td>
</tr>
<tr>
<td><strong>Urinary incontinence</strong></td>
<td>Interview • Three incontinence Questions (3IQ) •</td>
<td>BF: b620-b630-b639</td>
</tr>
<tr>
<td><strong>Balance and gait impairment and falling</strong></td>
<td>Asking about falling in the last year • Asking about fear of falling • Timed up and go test • Gait speed over 10 m • Performance-Oriented Assessment of Mobility • Functional reach test •</td>
<td>BF: from b710 to b789</td>
</tr>
<tr>
<td><strong>Poly-pharmacy</strong></td>
<td>Instructing the patient to bring in all current medications—both prescription and nonprescription medications—to each visit •</td>
<td>EF: e110</td>
</tr>
<tr>
<td><strong>Cognitive</strong></td>
<td>Mini Mental Status Examination (MMSE)a</td>
<td>BF: b114-b117-b140-b144-b167-b172-b176</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 12.1 (Continued)
Geriatric Assessment and ICF Codes

<table>
<thead>
<tr>
<th>GA Components</th>
<th>Examples of Tests and Assessment Techniques</th>
<th>ICF Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attention</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digit Span&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d135-d160</td>
<td></td>
</tr>
<tr>
<td>Trial making test A and B (TMT)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d160</td>
<td></td>
</tr>
<tr>
<td>Stroop tests&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d160-d220</td>
<td></td>
</tr>
<tr>
<td>Corsi’s Block-tapping test&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d135-d160</td>
<td></td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>Benton Visual Retention Test (BVRT)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b144</td>
</tr>
<tr>
<td>Auditory Verbal Learning Test (AVLT)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b144</td>
<td></td>
</tr>
<tr>
<td>Babcock Story Recall Test (BSRT)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b144</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d325-d330</td>
<td></td>
</tr>
<tr>
<td>Complex Figure Test (CFT): Recall administration&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b144</td>
<td></td>
</tr>
<tr>
<td><strong>Concept formation and reasoning</strong></td>
<td>Raven’s Coloured Progressive Matrices (RCPM)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b164</td>
</tr>
<tr>
<td></td>
<td>AP: d163</td>
<td></td>
</tr>
<tr>
<td>Proverbs and Similarities&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d163/d310</td>
<td></td>
</tr>
<tr>
<td>Wisconsin Card Sorting Test (WCST)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d220</td>
<td></td>
</tr>
<tr>
<td><strong>Construction</strong></td>
<td>Coping Drawings&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Complex Figure Test (CFT): copy Administration&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b176</td>
<td></td>
</tr>
<tr>
<td>Clock face&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b167</td>
<td></td>
</tr>
<tr>
<td><strong>Language</strong></td>
<td>Controlled Oral Word Association (COWA—sometimes labeled FAS)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b167</td>
</tr>
<tr>
<td></td>
<td>AP: d210</td>
<td></td>
</tr>
<tr>
<td>Boston Naming Test (BNT)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: 167</td>
<td></td>
</tr>
<tr>
<td>Category fluency&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b167</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d210</td>
<td></td>
</tr>
<tr>
<td>Token Test&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b167</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d310</td>
<td></td>
</tr>
<tr>
<td><strong>Executive functions and motor performance</strong></td>
<td>Tower of London&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b164</td>
</tr>
<tr>
<td></td>
<td>AP: d163-d175-d220-d440</td>
<td></td>
</tr>
<tr>
<td>Frontal Assessment Battery (FAB)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b164</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d163-d220</td>
<td></td>
</tr>
<tr>
<td>Examining for Apraxia&lt;sup&gt;a&lt;/sup&gt;</td>
<td>BF: b176</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AP: d130-d440</td>
<td></td>
</tr>
<tr>
<td><strong>Affective</strong></td>
<td>Interview •</td>
<td>BF: b152</td>
</tr>
<tr>
<td>Geriatric Depression Scale (GDS) (Yesavage, 1982)</td>
<td>BF: b176-b525-b620</td>
<td></td>
</tr>
<tr>
<td>Patient Health Questionnaire-9 (PHQ-9) •</td>
<td>BF: b176-b525-b620</td>
<td></td>
</tr>
<tr>
<td><strong>Functional</strong></td>
<td>Activity Daily Living (ADL)—</td>
<td>BF: b176-b525-b620</td>
</tr>
<tr>
<td></td>
<td>(Katz, Ford, Moskowitz, Jackson, and Jaffe, 1963)</td>
<td>AP: d410-d440-d450-d460-d510-d520-d530-d540-d550-d560</td>
</tr>
</tbody>
</table>

(Continued)
in order to facilitate the ICF adoption (De Vriendt, Gorus, Bautmans, and Mets, 2012; Luttenberger, Reppermund, Schmiedeberg-Sohn, Book, and Graessel, 2016).

When a description of the individual’s level of functioning is obtained, the user’s request is evaluated and the geriatrician informs the team about the hypothetical scenarios regarding the progression of a particular health condition with the aim to identify factors that may influence the matching process in terms of acceptance and the risk of rejection or abandonment. When assessing the assistive solution proposed, the geriatrician intervenes in monitoring the health condition and in evaluating the efficacy of the device. If an environmental evaluation is necessary, the geriatrician should also be involved.

Considering the state of the art, it seems important to reflect on two problems: on the one hand the scarce implementation of the ICF in geriatric medicine, and on the other the importance of training in assistive solutions by geriatricians.

With respect to the first problem, it should be noted that the ICF offers a unique opportunity to describe and classify functioning, disability, and health in a common framework and in a common language, which would be very useful in a multidisciplinary

### TABLE 12.1 (Continued)
Geriatric Assessment and ICF Codes

<table>
<thead>
<tr>
<th>GA Components</th>
<th>Examples of Tests and Assessment Techniques</th>
<th>ICF Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrumental Activity Daily (IADL)—(Lawton and Brody, 1969)</td>
<td>Interview about safety of the home environment •;</td>
<td>BF: b176</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AP: d177-d230-d360-d440-d450-d460-d475-d620-d630-d640</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EF: e110-e115-e120-e125-e165</td>
</tr>
<tr>
<td>Environmental</td>
<td>Interview about access to personal and medical services •; Interview about drive function checklist for patient and their families •.</td>
<td>EF: from e110 to e125-e240-from e310 to e340-e355-e360-e398-e465</td>
</tr>
<tr>
<td>Social support</td>
<td>Interview about social history and quality of relationship •; Interview about availability of assistance •; Caregiver Burden Inventory—(Novak and Guest, 1989); Brief Symptom Inventorya</td>
<td>EF: e310-e320, e340-e355-e360-e410-e440</td>
</tr>
<tr>
<td>Economic</td>
<td>Interview about economic status and insurance •</td>
<td>AP: d870</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EF: e165</td>
</tr>
<tr>
<td>Spirituality</td>
<td>Interview about religion or spirituality •</td>
<td>AP: d930</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EF: e440-e465</td>
</tr>
<tr>
<td>Advance directives</td>
<td>Discussion about patients’ goal and preferences •</td>
<td>All codes depending from the goals</td>
</tr>
</tbody>
</table>

Note: The geriatric assessment procedure is a multidimensional assessment that explores nine domains: medical, cognitive, affective, functional, environmental, social support, economic, spirituality, and advance directives (first column). The domains comprise several components reported in the second column. In the third column, an example of geriatric assessment techniques and tests are presented. For a specific description of the assessment techniques and tests referring to the references if given, refer to Straus and Tinetti (2009) for items with “+”, to Reuben and Rosen (2009) for items with “•” and to Lezak, Howieson, Loring, Hannay, and Fischer (2004) for items with.

a The last column lists the ICF codes belonging to Body Structures (BS), Body Functions (BF), Activities, and Participation (AP), Environmental Factors (EF) related to geriatric assessment.
team assessment. Moreover, despite the fact that all member states of the WHO were invited to implement the ICF in the health sector (Stucki, Üstün, and Melvin, 2005), different conceptualizations of disability coexist and several studies consider the transition from health to disability from the “The Disablement Process” perspective, proposed by Verbrugge and Jette (1994) and based on the model by Nagi (1964, 1965, 1991). In recent years, among gerontology researchers, the concept of disability has begun undergoing a profound transformation owing to the adoption of the ICF language for the study of late life disability, although there has been much resistance (Freedman, 2009; Guralnik and Ferrucci, 2009; Jette, 2006, 2009). There were two reasons for the reluctance of the gerontological community to embrace the ICF language (Freedman, 2009). The first is the lack of accuracy in the crosswalk between the existing measures of functional limitation ADLs and instrumental activities of daily living (IADLs) and the ICF language. The second is that the ICF is not intended to be a dynamic model because it does not present a model of disability as a dynamic process. Jette (2006, 2009) invited the United States scientific community to adopt the ICF framework, highlighting the similarities and differences between the Nagi and ICF concepts and definitions, in order to use a common, international language in the rehabilitation field with the possibility of improving communication across national boundaries and disciplines, to facilitate interdisciplinary research, to improve clinical care, and to dialogue with health policy and management. The National Health and Aging Trends Study (NHATS), a new resource for the scientific study of functioning in later life, appears promising in this regard because it was developed with both the ICF language and a consideration of the Nagi roots in mind. The NHATS is being conducted by the Johns Hopkins University Bloomberg School of Public Health with support from the National Institute on Aging, and its scope is to foster research that will guide efforts to reduce disability, maximize health and independent functioning, and enhance quality of life at older ages. The NHATS supports studies of disability trends and trajectories in later life. One important objective is to work on developing, testing, and fielding a state-of-the-art disability instrument. Being part of the NHATS, Freedman (2009) puts into evidence the benefits that can be derived from the ICF language: the addition of the term “participation” to geriatrician vocabulary, the explicit and defined role for the environment, the availability of positive analogues for concepts that have traditionally been expressed in terms of loss in an advancement and the distinction between capacity to perform and the actual performance of a range of activities. Recently, new assessment instrument tools for disability based on the ICF perspective were proposed as an alternative to the classic ADL and IADL (Rejeski, Ip, Marsh, Miller, and Farmer, 2008).

Another important step in order to enhance the applicability of the ICF in clinical practice and research is the ICF Core Set project created with the aim of selecting ICF domains that include “the least number of domains possible to be practical, but as many as required to be sufficiently comprehensive to cover the prototypical spectrum of limitations in functioning and health encountered in a specific condition” (Stucki, Ewert, and Cieza, 2002, p. 936). The goal of the ICF Core Sets Project is to “serve as minimal standards for the assessment and reporting of functioning and health for clinical studies, clinical encounters and multi-professional comprehensive assessment” (Stucki et al., 2005, p. 350). A Core Set is developed by means of a consensus process that can be used as an assessment schema of individual problems and needs, prognoses, rehabilitation, and functioning in the acute and post-acute condition, for communication at a rehabilitation team conference (Grill and Stucki, 2011).

Concerning the second problem of giving geriatricians a role in directing a patient to a Centre for Technical Aid, it is necessary to introduce training in assistive solutions for health professionals.
At the same time, it is important to update and promote research on assistive solutions in order to diffuse the available knowledge about assistive solutions and to understand the factors that determine the best match between an older user and technological aids.

In recent years, several studies have been dedicated to highlighting the ICF as a framework for the clinical assessment of people for assistive technology (Arthanat and Lenker, 2004; Scherer, 2005).

Referring to matching older users with technology, Scherer and colleagues (2011) developed an ICF core set for matching older adults with dementia and technology (MOADT) in order to provide a systematic coding scheme for health information systems and to establish a common language for describing the assistive technology assessment. The MOADT represents a useful tool for better communication between the different Centers for Technical Aid, Institutes for Geriatric Rehabilitation, Geriatric Medical Centers and Institutes, and people with dementia, their families and caregivers. In the process of “matching older people and technology,” it becomes essential that the geriatrician works with providers in order to identify appropriate technology for an older client.

In order to provide an example of the geriatrician as a professional consultant in a Centre for Technical Aid, a clinical case is described linking a geriatric assessment and the ICF perspective with an explanation of the factors that influence the matching process while considering a hypothetical scenario of the progression of a health condition.

12.8 Case Study and the Assistive Technology Assessment Process

Name: S.V.
Age: 89
Age at the beginning of disease: 86

Diagnosis ICD-9-CM: 331 Mild Cognitive Impairment (multiple domain), 401.9 hypertension, 250.02 Diabetes mellitus without mention of complication, type II or unspecified type, uncontrolled, 272.4 other and unspecified hyperlipidemia, 389.00 hearing loss, 296.21 mild depression in association with apathy.

Since the age of about 84, Mr. S.V. began to notice executive function and memory problems (difficulties in planning and into finding personal effects, episodic and prospective memory deficits). As the years passed, there was a slow worsening of his medical and functional conditions. Recently, his family members decided that he can no longer safely drive a car because he shows difficulty in managing the ADL without assistance. Frequently, he appears to be apathetic and depressed.

The anamnestic data show hearing loss, hypertension (at the age of 67), and diabetes (at the age of 62). At the age of 87, Mr S.V. presented depressive symptoms and he refused pharmacological treatment. He attended middle school and he was a government employee. The family history shows a sister who died from dementia (probably vascular dementia).

He is assessed every six months by a geriatric center in order to monitor the evolution of the disease and to maintain pharmacological treatment. Mr. S.V. lives alone and suffers as a result of the distance from his sons who live far away from him. A family assistant (caregiver) carries out housework, plans and prepares food, and supports S.V. in doing laundry and taking medication. A son support S.V. in managing the finances. He can carry
out the ADL by himself (dressing, toileting, transferring, continence, feeding, and bathing). He can dial a few well-known numbers, and he is able to heat food. He performs light daily tasks such as dishwashing and bed making. He is not capable of dispensing his own medication because he has difficulty in recalling. If necessary, Mr. S.V. can manage day-to-day purchases but needs help with major purchases and bank transactions. The presence of sons seems to have a remissive effect on his depressive and apathetic symptoms. Mr S.V. agrees to receive home help, but he refuses group activities and he wants to preserve his independence. He spends time watching TV. He is able to use computer and sometimes he sends e-mails to his sons.

- **Motor evaluation:** He is able to maintain a sitting position without support and to shift positions autonomously. Mr S.V. is able to maintain an erect position autonomously, and he can walk without support. Pendular movements are present. The upper limbs present mobility and can be used for functional activities. Poor physical activity. Low muscular tone.

- **Neuropsychological test:** Mr. S.V. is poorly motivated. He has difficulties in shifting attention between different situations and difficulties in planning actions, organizing his time, and executing actions. His episodic, semantic, and prospective memory are compromised. He can read and understand words, sentences, simple and complex orders, and short texts. He can produce short speeches. He can copy simple figures but he has difficulties with complex models. His performance in concept formation and reasoning is normal.

- **Communication strategy:** He has the ability to communicate. He can use a computer (e-mail).

- **Evaluation of visual, perceptive, and motory functions:** He has hearing impairment but no visual impairment. He can move independently inside the home.

- **Aids and assistance:** At the moment, Mr S.V. has neither aids nor assistance.

- **Request:** Aids and assistance in monitoring health status, medication adherence, and social stimulation.

### 12.8.1 The Role of the Geriatrician in the Assistive Technology Assessment Process for the User S.V.

Mr S.V. is monitored by a geriatric center for the evolution of the cognitive impairment, general health status, and pharmacological treatment. The geriatric centre carries out Mr S.V.'s CGA. The information about S.V. (medical, cognitive, affective, functional, environmental, social support, economic, spiritual, and advance directives) represent the input data for the Centre for Technical Aids.

Table 12.2 show the correspondence between the dimensions of the geriatrician assessment and the ICF codes; Figure 12.2 illustrates the patient’s profile from the point of view of the biopsychosocial model.

If the multidisciplinary team decides there are sufficient data for a matching process, then the selection of the proper technological aid is pursued.

Based on the literature and experience, the geriatrician could envisage hypothetical future scenario. S.V. presents a combinations of chronic conditions, functional limitations, and geriatric syndromes that predict health outcomes (Clegg, Young, Iliffe, Rikkert, and Rockwood, 2013; Koroukian et al., 2016; Noguchi et al., 2016).
**TABLE 12.2**

Geriatric Assessment of Clinical Case

<table>
<thead>
<tr>
<th>GA Components</th>
<th>ICF Codes</th>
<th>S.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>b280, b410.0, b415.0, b420.2, b430.0, b440.0, b510.0, b515.0, b525.0, b535.0, b540.0, b545.0, b555.1, b620, b730, b710, s110.0, s710.0, s720.0, s730.0, s740.0, s750.0, s760.0</td>
<td>Hypertension, Diabetes, Mild cognitive impairment</td>
</tr>
<tr>
<td>Visual impairment</td>
<td>b210.0, b215.0</td>
<td>No visual impairment</td>
</tr>
<tr>
<td>Hearing impairment</td>
<td>b230.2</td>
<td>Hearing impairment</td>
</tr>
<tr>
<td>Malnutrition/weight loss</td>
<td>b530.0</td>
<td>No weight loss in the last five months</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>b620.0</td>
<td>No urinary incontinence</td>
</tr>
<tr>
<td>Medical Balance and gait impairment and falling</td>
<td>b235.0, b710.0, b715.0, b730.0, b735.1, b740.0, b750.0, b755.0, b760.0, b765.0, b789.2</td>
<td>No balance and gait impairment, No falls in low muscular tone</td>
</tr>
<tr>
<td>Poly-pharmacy</td>
<td>EF: e110</td>
<td>Current medications are ramipril (for hypertension), insulin (for diabetes), refuses antidepressant medication</td>
</tr>
<tr>
<td>Global status</td>
<td>BF: b114.0, b117.2, b140.2, b144.2, b156.2, b167.0, b172.0, b176.0 AP: d130.0, d135.0, d160.2, d166.0, d170.0, d172.0, d310.0, d345.0, d440.0</td>
<td>Cognitive deficit compatible with mild cognitive impairment</td>
</tr>
<tr>
<td>Cognitive Attention</td>
<td>BF: b140.2 AP: d135.0, d160.2, d220.2</td>
<td>Deficit in alternate attention</td>
</tr>
<tr>
<td>Memory</td>
<td>BF: b144.2 AP: d325.0-d330.0</td>
<td>Deficit episodic, semantic, and perspective memory</td>
</tr>
<tr>
<td>Concept formation and reasoning</td>
<td>BF: b164.0 AP: d163.0, d310.0</td>
<td>Normal performance</td>
</tr>
<tr>
<td>Construction</td>
<td>BF: b175.2, d130.0, d440.0, d163.2</td>
<td>Difficulties in writing numbers in a clock face and in copying complex figures</td>
</tr>
<tr>
<td>Language</td>
<td>BF: b167.0 AP: d210.1, d310.0</td>
<td>Normal performance in category fluency and anomies</td>
</tr>
<tr>
<td>Executive functions and motor performance</td>
<td>BF: b164.2 AP: d163.2/b176.0/d175.2/d220.2/d440.0/d130.0</td>
<td>Difficulties in planning and set shifting</td>
</tr>
</tbody>
</table>

(Continued)
<table>
<thead>
<tr>
<th>GA</th>
<th>Components</th>
<th>ICF codes</th>
<th>S.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affective</td>
<td>BF: b152.2</td>
<td></td>
<td>Depressive and apathetic symptoms</td>
</tr>
<tr>
<td>Functional</td>
<td>BF: b176.0, b525.0, b620.0</td>
<td>d410.0, d440.0, d450.0-d460.0, d510.1, d520.0, d530.0, d540.0, d550.0, d560.0, d177.1, d230.3, d360.0, d475.4, d620.2, d630.2, d640.2</td>
<td>Bathing, gets clothes and dresses without any assistance. Goes to toilet room, uses toilet, arranges clothes, and returns without any assistance; controls bowel and bladder completely by self; feeds self without assistance; dials a few well-known numbers and sends e-mail; shops independently for small purchases; prepares adequate meals if supplied with ingredients; performs light daily tasks such as dishwashing, bed making; no launders small items; no rinses stockings, etc.; fear to drive; is not capable of dispensing own medication; manages day-to-day purchases, but needs help with banking, major purchases, etc.</td>
</tr>
<tr>
<td></td>
<td>EF: e110.2, e115.0, e120.0, e125.2, e165.0</td>
<td>e110.2, e115.0, e120.0, e125.2, e310 + 3, e340 + 3, e355 + 1</td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>EF: e110.0, e115.1, e120.1, e125.1 e310 + 3, e340 + 3, e355 + 1, e360 + 0, e410 + 3, e440 + 0</td>
<td>d475.4</td>
<td>Services within walking distance; geriatric assessment every six months; no auto</td>
</tr>
<tr>
<td>Social support</td>
<td>EF: e310 + 1, e320 + 0, e340 + 3, e355 + 1, e360 + 0, e410 + 3, e440 + 0</td>
<td>d870, e165</td>
<td>Family is a valid support but they live away; family presence reduces depressive and apathetic symptoms. No friends</td>
</tr>
<tr>
<td>Economic</td>
<td>AP: d870</td>
<td>e165</td>
<td></td>
</tr>
<tr>
<td>Spirituality</td>
<td>AP: d930.8</td>
<td>e465 + 8</td>
<td></td>
</tr>
<tr>
<td>Advance directives</td>
<td>EF: e360 + 3</td>
<td></td>
<td>The patient accept familiar caregiver</td>
</tr>
</tbody>
</table>

**Note:** The geriatric assessment procedure, conducted with instruments indicated in Table 1 explores nine domains: medical, cognitive, affective, functional, environmental, social support, economic, spirituality, and advance directives (first column). The domains encompass several components reported in the second column. In the third column, S.V. condition is described.
Frailty, recurrent falls, delirium, progressive worsening of cognitive deficit (conversion from mild cognitive impairment to dementia), functional decline, sarcopenia hearing impairment, and adverse drug reactions are important aspects to prevent and manage. The geriatrician illustrates to the team the strengths and weaknesses of S.V.’s condition considering his desires. From S.V.’s multidimensional geriatric assessment, four aspects are important: (1) he wants to stay at home; (2) he accepts help but he refuses antidepressant treatment; (3) he is able to use a PC to send e-mails; (4) the presence of sons attenuates depressive and apathetic symptoms. In order to prevent adverse outcomes, it is important to monitor medication, hydration, nutrition, and vital signs. Moreover, it is urgent to introduce mental, social, and physical stimulation.

Considering all of these factors, assistive technological devices that are recommended for Mr S.V. include the following:

A health monitoring system which can check activities and physiological parameters in the home using a network of sensors distributed throughout the home. Also included are physiological sensors as well as environmental sensors that measure the physical status of the patient (e.g., heart rate, blood pressure, temperature, blood glucose, oxygen saturation, and weight) and detect the environmental condition of the home living environment (e.g., whether somebody occupies a chair, falls down or moves inside a room). The monitoring assistive solutions can be complemented with a social interaction component where geriatrician and older patient can discuss the collected data and monitor adherence to medical treatment during visits made via a telepresence robotic platform.

In addition, the telepresence robotic platform can allow the patient to stay in touch with family and friends.
By using a health monitoring system, the patient can be monitored in a holistic way. Supervision includes both remote contact between the patient and geriatrician or other health professionals in the form of videoconferencing, as well as monitoring of vital signs, falls, syncope, and other potentially dangerous situations. The aim is for S.V. to remain safely in the home environment under constant medical supervision.

12.9 Conclusions

This chapter illustrates the role of the geriatrician in relation to the main issues that characterize the ageing of populations: disease disability and frailty. Although the idea of frailty is a clear concept, there are different definitions in the medical literature that emphasize different aspects. However, they are unanimous in considering frailty as a condition of multifactorial global functional decline that can easily lead to disability. This chapter follows the ICF definition of disability from the perspective the biopsychosocial model outlines. This emphasizes that personal factors, environmental conditions and the health of the individual merge to define disability status.

The management of an elderly patient requires an approach that considers all the factors that can affect health (illness, functional status, psychosocial situation, and environmental conditions). This procedure is called the CGA and is characterized by a multiprofessional team working with the objective of establishing priorities for the individualized plan of care. This chapter provides a detailed description of the procedure underlining the validity of this approach in the management of an elderly patient. A care plan also provides rehabilitative treatments: in this chapter, the clinical course of geriatric rehabilitation is described, emphasizing the importance of first performing a screening assessment of the patient, multidisciplinary interventions and continuity of care. Assistive solutions can offer an important contribution to the practice of geriatric rehabilitation and continuity of care.

A description of state-of-the-art applications based on intelligent technologies is provided. Particularly, this chapter describes ICT-based assistive living solutions for the elderly with cognitive and/or motor disabilities. Particular emphasis is given to the role that some individual factors have on technology acceptance by older users.

The role of the geriatrician is analyzed via a case study illustrating the Matching Person and Technology (MPT) Assessment Process. In a Centre for Technical Aid, the geriatrician could collaborate as a professional consultant in order to support a collaborative partnership between the service providers and the older user. A CGA approach combined with an ICF model offers a unique opportunity to describe and classify functioning, disability, and health in a common framework with a universal language (Scherer et al., 2011; Stier-Jarmer et al., 2011). Furthermore, the MPT process contributes to guide the service provider in assistive technology decision making, and in the use of evidence-based outcome measures. Adoption of the ICF in geriatric medicine and geriatrician training in assistive solution is debated.

In conclusion, this chapter underlines the need to introduce training in assistive solutions for health professionals and to update and promote research in this area. Moreover, health workers need to be trained in order to spread the available knowledge about assistive solutions and to understand the factors that best determine the match between an older user and technological aids. All of these factors are to be considered for the ICF biopsychosocial framework (Arthanat and Lenker, 2004; Scherer, 2005; Scherer et al., 2011).
12.10 Summary

Heterogeneity in the health status of elderly patients requires a particular care approach, and geriatric medicine is the answer. In order to cope with frailty, disability, and diseases, the geriatric assessment approach guides the geriatrician into considering the interaction between functional status and cognitive, medical, affective, environmental, social support, economic, and spirituality dimensions. Rehabilitation is the goal of the geriatric assessment, and the introduction of assistive solutions in geriatric rehabilitation makes possible a scenario in which the functioning of elderly people with physical or cognitive limitations is improved. This chapter provides an overview of the areas where technological systems may offer support to the everyday life of the elderly and their caregivers. The contribution of a geriatrician in a Centre for Technical Aid is described, linking the CGA with the ICF model. The lack of implementation of the ICF and the requirement of training in assistive solutions for geriatricians and caregivers are discussed.

References


Colombo, M. 2004. Assistive technology: Mind the user! Gerontechnology, 3(1), 1–4. doi: 10.4017/ gt.2004.03.01.001.00


13

Role of Speech–Language Pathologists in Assistive Technology Assessments

Katya Hill

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13.1 Description of the Professional Profile

A speech–language pathologist (SLP) is a professional trained to evaluate and treat people who have communication and swallowing disorders. A person should have the required academic training and clinical experience to be certified or licensed as a SLP. The SLP is then able to diagnose and treat disorders across the lifespan, pertaining to speech production, language, cognition, voice, resonance, and fluency as impacting communication competence and performing daily living activities. In addition, evaluation and treatment of swallowing involves all aspects of swallowing and feeding behaviors. The specific course requirements and extent of clinical training vary across curricula and awarded degrees internationally. In some countries, professionals may practice as speech therapists with a two or four year degree. However, the more accepted standard for delivering clinical SLP services requires completion of a Master’s degree. In North America, SLPs become independent practitioners after earning a Master’s degree in communication science and disorders, completing a clinical fellowship year, and receiving a Certificate of Clinical Competence from the American Speech–Language–Hearing Association (ASHA). An advanced degree may be earned through a clinical doctorate program with an emphasis on medical speech–language and swallowing disorders. Specialty certificates focusing on professional development of specific communication disorders or techniques may be used for supporting advanced training related to augmentative and alternative communication.
(AAC) and assistive technology (AT). In addition, Board Certification may be another avenue to support the specialization of AAC and AT expertise. The Ph.D. is the terminal degree for the profession.

ASHA standards have typically been applied with some modification worldwide. The standards vetted by ASHA will be used in this chapter for describing the professional role and responsibilities of the SLP in practicing on the AT assessment team. The standards reflect an optimal model to strive for internationally in developing curricula, clinical/educational certificate and credentialing programs, Board Certification requirements, and clinical services that hold the interest of the individual with a disability paramount. ASHA members are committed to ensure that all people with communication disorders receive services to optimize communication (ASHA, 2006). Many individuals being treated by SLPs for communication disorders have disabilities that require the use of AAC and AT.

The Scope of Practice in Speech–Language Pathology (ASHA, 2016) includes a framework based on the World Health Organization’s (WHO, 2014) International Classification of Functions and Disability (ICF; see Figure 13.1). SLPs provide clinical services consistent with the ICF. ASHA documents support the expectation and provision of the highest-quality, evidence-based services. The profession has identified and described the role of SLPs in providing AAC and AT services in various preferred practice patterns, position statements, guidelines, and knowledge and skill documents. Regardless of the extent of training, a certified SLP may perform clinical, educational, and advocacy services across the eight domains of SLP service including collaboration, counseling, prevention and wellness,

![Body functions and structures](https://example.com/body-functions.png)

**FIGURE 13.1**
Interaction of various components of the ICF model from ASHA’s Scope of Practice. This model applies to individuals or groups. (From American Speech–Language–Hearing Association. 2016. Scope of Practice in Speech–Language Pathology [Scope of Practice]. Available from www.asha.org/policy.)
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screening, assessment, treatment, modalities, technology, and instrumentation with the expectation of adherence to the Code of Ethics (ASHA, 2016) and specific principles therein.

Referrals for an AT assessment may be for individuals across the lifespan with a variety of congenital or acquired disabilities with a range of severity. AT may be considered to meet temporary needs, for example, required by patients hospitalized and in intensive care or acute care units (Costello, 2000). However, for many individuals with disabilities, AT is a lifelong need requiring upgrades or completely new recommendations at critical life transition periods or with technology innovations. Regardless, the Scope of Practice in Speech–Language Pathology indicates that SLPs is responsible for providing services across any of the eight domains of services for individuals with communication and swallowing disorders that also require AT. Table 13.1 identifies examples of lifelong and acquired disabilities that frequently are accompanied with speech, language, cognition, communication, and/or swallowing disorders. An SLP should be included in the interdisciplinary team conducting the AT assessment in order to provide evidence to support the AT recommendation or to help design a treatment protocol that recognizes the individual’s disability holistically.

The principle that SLPs shall provide all services competently may seem obvious. In addition, apparent may be principles that address client confidentially and nondiscriminatory conduct. Additionally, clinicians are expected to engage in only those aspects of service consistent with their level of education, training, and experience (Principle of Ethics Rule II-b). Therefore, as professionals, SLPs are expected to refer when appropriate to ensure that clients are being provided with high-quality service. Another rule indicates that lifelong learning is required to maintain and enhance professional competence. Gaining knowledge and skills related to the highest quality of professional care in AAC and AT training and experience may become challenging; perhaps more so related to AT content areas such as computer access, vision technology, seating and mobility, prosthetics and orthotics. Continuing education, specialty certification, and Board Certification are methods to document lifelong learning. When in doubt about the ability to maximize an individual’s potential, to err on the side of holding paramount the welfare of the persons served professionally is advised (Principle of Ethics I).

### 13.1.1 AT Teams and the SLP

Collaborative teaming has been a widely acknowledged and accepted approach to conduct AAC and AT assessments particularly within an ICF framework (Cook and Hussey, 2002;
The professional teams recognize that “disability is complex, dynamic and multidimensional” (WHO, 2002) requiring interdisciplinary teams. AT team members, besides the SLP, may include families, therapists, educators, counselors, psychologists, rehabilitation specialists and engineers, vendors, and manufacturers, as well as the individual central to the team (Binger et al., 2012; Dietz, Quach, Lund, and McKelvey, 2012; Hill, Lytton, and Glennen, 1998). AT teams have many overlapping and shared roles and responsibilities, making coordination and responsibility of services challenging (Lieber et al., 1997). Establishing a collaborative team culture is essential to develop effective AT teams (Bodine and Melonis, 2005). A principle to establish effective team management and collaboration is that the knowledge and skills of various team members are honored, yet the responsibility in assessing and implementing the AT plan is shared (Haines and Robertson, 2005). While focusing on the adult AAC assessment process, Binger et al. (2012) have identified key assessment personnel and their roles including: finder, general practice SLP, clinical specialist, communication partner, collaborating professional, research/policy specialist, manufacturer/vendor, funding agency/funding personnel, and technology training agency personnel. However, the make-up of key team members likely would be different depending on the primary AT need of the individual. For example, a wheelchair evaluation would require professionals specializing in seating and mobility to have a primary role. While an occupational therapist or AT specialist may be considering speech recognition software as a computer access method, the SLP on the team would be providing clinical evidence on speech production intelligibility. Evidence on speech production would be contributed by the SLP on the team to support or rule out speech recognition software as a computer access method being considered by an occupational therapist or AT specialist. Table 13.2 offers examples of the role SLPs may play in teams assessing individuals for various categories of AT.

SLPs bring specific knowledge and skills about the oral and written communication and listening and reading skills of the individual under consideration. In addition, SLPs can assess and provide evidence on various cognitive-linguistic and executive functioning skills. Although these domains overlap with the knowledge and skills of other AT team members, the competence or expertise of addressing these domains and functional communication abilities of an individual is critical to the matching persons with technology (MPT) process (Hill and Scherer, 2008). Consequently, successful collaborative teaming is dependent on team members having regular opportunities to share their expertise, identify common goals, build plans of support, and determine responsibilities (Hunt, Soto, Maier, Liboiron, and Bae, 2004).

The expected roles of SLPs working with individuals who rely on AAC apply or generalize to the responsibilities of SLPs on AT teams (ASHA, 2005):

- Conduct a comprehensive assessment of the individual who requires AT
- Provide assessment and documentation of AT methods, components and strategies evaluated and selected
- Evaluate the effectiveness and usefulness of the chosen AT
- Develop and implement intervention plans
- Advocate for increased responsiveness and funding needs
- Coordinate and collaborate AT services that optimize performance and outcomes

The SLP may be asked to assume the role of case manager or team leader because the domains of communication are frequently areas of concern for many AT cases (ASHA,
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The life experience of individuals who are AAC speakers and/or writers is affected by their achieved communication competence. Consequently, the SLP is in the position of discussing how communication influences all other aspects of daily living and life skills. The SLP is the professional who frequently works with the variety of other professionals, delivers services to the individual and/or family, and expresses the expectation to optimize communication in order to promote or maintain the highest quality of life.

In summary, to be realistic, team members may need to play multiple roles based on personnel availability and resources. In addition, access to experienced AAC or AT specialists may be a barrier to individuals and families receiving quality and prompt services. Over reliance on involvement of an AAC or AT manufacturer/vendor in the assessment process may result in limitations to the MPT process and bias in recommendations (Hill et al., 1998; Hill and Hayes-Diges, 2008). A savvy and experienced SLP can guide team members in consumer protection practices that ensure individuals and families are fully informed of all their technology and intervention options.

13.1.2 Evidence-Based Practice and SLPs

Authority-based approaches to making AT decisions historically placed teams in the position of relying on “expert opinions” and hierarchical approaches to MPT (Hill and
Romich, 2007). Historically, teams subscribed to an established “authority” rather than feel bombarded by the full range of options and endless list of features and components in selecting an AT intervention. Today, however, SLPs are applying the principles of evidence-based practice (EBP) to their decision making with the incorporation of data collection and outcome measurement in guiding the provision of services (ASHA, 2002, 2016, 2017).

Dollaghan (2007) states that the goal of EBP is to reduce uncertainty about clinical decisions. Uncertainty is reduced by having a fully informed patient, identifying his or her preferences, and using the best evidence. Best evidence has been identified and described by several authors (Dollaghan, 2007; Law and MacDermid, 2008; Sackett, Strauss, Richardson, Rosenberg, and Haynes, 2000) to include the following: (1) external or research evidence, (2) internal or clinical evidence, and (3) personal evidence. The ability and experience to fully inform individuals and families, and appraise and integrate these three critical types of evidence requires competence in the following domains (ASHA, 2005):

- Knowledge and skill in using systematic observation
- Knowledge and skill in identifying and measuring outcomes
- Skill in preparing, monitoring, documenting, and analyzing goals, objectives, procedures, and progress
- Knowledge of performance ratings for technology interventions

The experienced SLP supports the AT team in applying EBP to the assessment and intervention processes. Figure 13.2 (Hill and Romich, 2003) serves as a system model for AT service delivery that starts and ends with the interests of the individual with a disability and their family. The process starts with characterizing the individual. Characterizing the individual is a crucial process that identifies, classifies, and prioritizes the areas and problems associated with a disability and an individual’s level of functioning. Given the compiled profile, the team may need to gather additional assessment data. The SLP may realize that additional evaluation of the individual’s receptive and expressive language, written language skills, and literacy abilities will be needed to proceed through the EBP steps. If individuals are using any AT currently for oral and written communication than baseline, performance data will need to be collected by the SLP as well.

All too frequently, adding procedures to collect diagnostic clinical and educational data is overlooked or considered too time consuming by AT teams. However, without a complete picture of the individual’s capabilities, the entire EBP process is threatened. In reality, the feature match process is extended by avoiding full characterization of the individual, for example, complete clinical and personal evidence. AT teams starting at the level of matching the person with technology often find themselves in a “trial and error” process repeating trials and/or needing more time for additional AT trials. The wide range of speech, language, and communication abilities and behavioral characteristics common among children and adults diagnosed with Autism Spectrum Disorder (ASD) demands that SLPs collect and interrupt quantitative clinical data regarding these domains at the start of considering AT interventions. No two adults referred for an AT evaluation with a diagnosis of aphasia present with the same residual abilities related to an oral-motor speech or oral and written language disorder. AT teams cannot assume that the individual’s current rehabilitation and educational records contain the diagnostic data required to proceed through the EBP and MPT processes. The SLP is a team member whose role may be to review the records and suggest what additional testing, interviewing, and observations are required for improving the assessment outcome.
The data gathered from all team members that characterize the individual support the team in formulating well-built, value-based questions. These meaningful questions lead to locating the best external evidence or to identifying strategies to gather more authentic clinical/educational and personal evidence (Hill, 2006). The SLP may suggest posing two types of questions: background and foreground (Sackett et al., 2000). The team may start by asking background questions if their experience is limited and/or information is missing related to a particular disorder or condition. For example, the AT team may ask background questions seeking additional evidence on the characteristics of fragile X syndrome or the side effects of baclofen. However, a foreground question is formulated to search for research evidence to guide decisions.

The acronym PICO used by Sackett et al. (2000) provides a structure that includes identifying the type of patient or problem, a broadly defined intervention, a comparison intervention, and an outcome. Experience with EBP is required to distinguish the elements of a PICO question and determine the level of detail regarding the intervention, comparison, and outcome components of the question. Consider the following PICO questions supporting the goal to reduce the uncertainty of a decision about an AT solution:

- For a college student with cerebral palsy (P) will word prediction (I) or orthographic word selection (C) result in the greatest increase in the selection rate (bits per second) and average communication rate (words per minute) (O) for generating writing assignments for college classes and personal correspondence?
• For an adult with severe nonfluent aphasia \((P)\) would computer-based AT using a visual scene user interface for word retrieval \((I)\) or a grid-type interface with core and activity rows \((C)\) lead to the greater increases in accurate word order and utterance length \((O)\) for conversations with family?

• For a child with autism \((P)\) what approach would result in greater gains in accurate word recognition and word fluency \((O)\) during oral reading tasks: computer-based AT software based on a four-block model \((I)\) or traditional instruction with no technology support \((C)\)?

In each of the above examples, the knowledge and skills of the SLP can be tapped to pinpoint the elements and extent of detail of the question. If the client is a child with ASD (as above), is that enough detail for the question? Detailed client information regarding emergent or elementary literacy skills may be added. Perhaps the \((P)\) could indicate that the child was at the “phonology-metaphonology” transition of language acquisition? The SLP may have knowledge and skills about specific interventions and recommendations about comparison strategies that include posing the alternative as “no treatment.” Finally, the SLP can recommend outcome elements that match the intervention are measurable, and are considered critical to optimize communication.

Once the best or most meaningful question is formulated, the search continues to locate and appraise the external evidence. McKibbon, Wilczynski, Hayward, Walker-Dilks, and Haynes (1995) emphasize that the best research-derived evidence is valid, important, and applicable. Research evidence is appraised based on the levels of evidence. SLPs are trained to identify not only the strength of the evidence, but also to use the acronym POEM to evaluate if the evidence is Patient-Oriented Evidence that Matters (Dollaghan, 2007). However, SLPs realize that POEM on treatment effectiveness for individuals with significant disabilities frequently is limited. Therefore, at times, perhaps a single case study may be the best evidence to support an AT decision.

EBP does not rely on external evidence alone. The clinical and personal evidence gathered by the SLP are the two other EBP components required to guide decision making. Additional clinical and personal evidence, for example, quantitative and qualitative data, may be needed as the AT team evaluates all the evidence. At this point, functional analysis and psychosocio-environmental evaluations that address the specific context of use are conducted. Note how the EBP model (Figure 13.2) depicts a continuous loop in collecting and evaluating the evidence. In the end, teams place the individual’s benefits first when applying EBP, pose specific questions of direct practical importance, evaluate the current best evidence objectively and efficiently, and take appropriate action guided by evidence (Gibbs, 2003).

13.1.3 AT Assessments and the SLP

Applying the systematic steps of the EBP model becomes even more critical when no standardized battery of tests comprise the AT evaluation. Minimal research exits to support a specific AT evaluation model (Hill and Scherer, 2008). In addition, no current, standardized, evidence-based AT procedures exist to determine if an individual would benefit from AT. Yet, evidence is available to identify procedures for conducting reliable, valid, and dynamic or authentic assessments that can be recommended to collect data to identify an individual’s abilities, needs, and expectations. For example, the Student, Environment, Task, Tools, or SETT framework (Zabala, 2005) provide questions for school teams to answer to help make AT decisions. However, inventory and impression AT benefits data
should be supported with quantitative performance data to use during the feature match process.

Quantitative data for the feature match process may be collected using formal and information procedures, and standardized or nonstandardized tools. Two types of evidence-based assessment processes that are valuable for the AT assessment and integrate with the ICF framework are as follows: (1) authentic assessment; (2) dynamic assessment. Authentic assessment refers to providing opportunities for a child or an adult to demonstrate abilities or accomplishments during presented activities that are meaningful and important for his/her environments, that is, school, home, and community (Palm, 2008; Wiliam, Lee, Harrison, and Black, 2004). One could also consider that the tasks are meaningful to improve the types of participation or increase the levels of participation. The use of ecological inventories and daily journals could be considered authentic assessment tools and may help to identify variables or barriers for successful implementation of AT interventions (Beukelman and Mirenda, 2013). Various contexts or tasks associated with collecting an oral or written language sample could be considered an authentic assessment. Dynamic assessment refers to Vygotsky’s theory of education that proposed individuals to learn most effectively when information is presented at a level that the person understands with assistance and prompting from the teacher (Vygotsky, 1978). The level is called the Zone of Proximal development (ZPD). Although Vygotsky theorized on child development, the AT assessment process might want to consider at what level an adult is functioning in order to provide the most appropriate level for training and to scaffold someone to higher levels of performance.

A primary role for the SLP as a team member assessing an individual for AT is to collect, analyze, and interpret evidence (data) related to oral and written communication (speech production, language, cognition, voice, resonances, fluency) and swallowing (feeding) abilities, needs, and expectations. The unique knowledge that SLPs bring to the AT evaluation is their ability to assess the subsystems of language—phonology, morphology, syntax, semantics, and pragmatics—as they relate to spoken and written language (ASHA, 2002). Consequently, the SLP answers the questions the team has about an individual’s basic language knowledge at the level of sounds, words, sentences, and interactive conversation regardless of whether the communication disorder is developmental or congenital in nature or acquired. In addition, the SLP provides evidence on literacy skills and cognition and executive functioning (ASHA, 2017).

For the pediatric population with disabilities and associated cognitive-communication disorders, the SLP contributes evidence related to how the child is progressing through the transitions of speech, language, and literacy acquisition along with identifying milestones related to cognition and play. Once a child has achieved pre-linguistic skills, being able to observe how a child moves through the three major language transitions is important for the success of the MPT process. These three transitions take place during the first five years of life (Paul, 1997): (1) pragmatics to semantics; (2) semantics to syntax; and (3) phonology to metaphonology. Following a developmental model provides evidence to guide SLPs and the AT team in determining the capabilities of the child and the cognitive-linguistic requirements of an AT intervention (Hill, 2009). In addition, these transitions along with literacy skills provide benchmarks for when, what, and how to collect data to monitor the effectiveness of AT interventions, and when to modify or revise AT decisions.

For the adult population with disabilities and associated communication disorders, the SLP contributes evidence related to the type, severity, and prognosis of the disorder. SLPs support the transition of pediatric clients into adulthood and changes that may occur with aging. Adults with acquired communication disorders who may benefit from AT must be
evaluated to determine a course of AT treatment to support regaining or improving skills, for example, aphasia or traumatic brain injury. In other cases, the individual may be evaluated to determine an AT solution to maintain function or meet the changes to function across the course of the underlying disease complex, for example, Amyotrophic Lateral Sclerosis, Parkinson’s disease or Huntington’s disease. In either case, the SLP contributes evidence by administering clinically, linguistically, and culturally appropriate approaches to assess the current cognitive-linguistic abilities. This information then serves as baseline data.

A clear distinction exists among the type of assessments conducted to identify speech production, language, cognition, and overall oral and written communication capacities. A thorough and comprehensive evaluation of cognitive-linguistic skills is paramount to begin the feature match process. For both the pediatric and adult populations who may benefit from AT, identifying the shared and distinctive targets assessed by the SLP and other educational or rehabilitation professionals highlights the importance in collecting thorough evidence. Table 13.3 illustrates the overlapping domains of language and literacy assessed by SLPs and teachers (Ukrainetz and Fresquez, 2003). Such detailed reporting of specific parameters of language and literacy provide clear targets/markers for matching the operational requirements for various AT intervention. Similar language and literacy abilities and/or executive functioning skills can be identified to show the distinctive and shared targets that are evaluated by SLPs and rehabilitation professionals working with adult populations. These results are used for matching the AT requirements and features.

The SLP is responsible for assessing the relationship the domains of communication competence, that is, linguistic, social, strategic, and operational (Kovah, 2009; Light, 1989) may have on the individual’s ability to benefit from various AAC and AT interventions. These domains have been identified as important to the feature match process and for monitoring outcomes. The linguistic and social domains require evaluating data on the various subsystems of language identified earlier in this section. The strategic and operational domains involve an individual’s use of AT features and require evaluating data on executive functions and the cognition, sensory, and perceptual domains. Such approach provides an overlap of AAC and AT intervention. For example, linguistic skills may be built by using the AAC system to emulate with a computer for increasing the opportunities for

<table>
<thead>
<tr>
<th>TABLE 13.3</th>
<th>Illustration of Overlapping Domains of Language and Literacy Assessed by SLPs and Educational AT Team Members</th>
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<tr>
<td>Language</td>
<td>Overlapping</td>
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<td>Speaking and Listening</td>
<td>Literate Language</td>
</tr>
<tr>
<td>• Form and content for social and personal uses</td>
<td>• Academic and metalinguistic uses</td>
</tr>
<tr>
<td>• Phonemic awareness</td>
<td>• Abstract and figurative content</td>
</tr>
<tr>
<td>• Lexical retrieval</td>
<td>• Decontextualized and formal forms</td>
</tr>
<tr>
<td>• Auditory memory</td>
<td>• Print concepts</td>
</tr>
<tr>
<td>• Articulation</td>
<td>• Formal oral contexts</td>
</tr>
<tr>
<td>• Fluency</td>
<td>• Print contexts</td>
</tr>
<tr>
<td>• Voice</td>
<td>• Letter knowledge</td>
</tr>
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writing and emailing. Operational skills using a high performance AAC system may be observed and improved by using the AAC system features to control electronic appliances (controlling the television or operating a robotic toy).

In summary, as part of the AT assessment battery, SLPs will include procedures that are applicable to everyday life using authentic tasks and dynamic observations. Critical components of AT assessments, and certainly AAC assessments, include formal and informal evaluation of speech, language, cognition, vision/hearing, and physical/motor skills. Conducting a task analysis to identify the operational requirements of AT under consideration or a discrepancy analysis to identify the performance of peers on similar tasks may provide additional insight for feature matching. Interviewing is conducted to identify the client’s or family’s values, expectations, believes, and goals. However, AT assessments limited to ecological inventories, interview, and observations in activities of daily living will fail to gather the performance evidence required to be most effective in the feature match process.

**13.1.4 Matching Persons with Technology and SLPs**

The MPT model is best applied at the point of selection and trial of the AT interventions and then used to determine the outcomes of the process of matching the person and the AT device/system (Scherer, 2002; Scherer and Craddock, 2002; Scherer, 2004). As noted above, external, clinical, and personal evidence is collected and vetted to arrive at the process of identifying or matching the features and components of an AT device/system for demonstration and trial. The features of AAC systems have been identified as primary, secondary, and tertiary components (Cooper et al., 2009; Romich, Vanderheiden, and Hill, 2005). This approach places more value on features that enhance communication performance and productivity than typical feature listings or coding categories used for funding (Hill, Baker, and Romich, 2007). A similar performance-based approach may be taken for AT pertaining to oral and written communication, because features that enhance the speakers’ or writers’ performance and ultimately well-being have higher value (Hill and Scherer, 2008).

The primary, secondary, and tertiary AT components used for oral and written communication are identified in Table 13.4. Primary components focus on the language parameters of the AT system. These language-based components are compared to the assessment data contributed by the SLP and related to how the speaker or writer generates spoken or written messages. As many AAC–AT systems include stored vocabulary and messages, how the speaker or writer accesses the two vocabulary categories of core (high frequency) words and extended (specific to a topic or activity) words affects performance. In addition, features for spontaneous, novel utterance generation (SNUG) or access to preprogrammed utterances/messages influence spoken and written productions and should be identified as available or not.

Secondary components relate to the user and control interfaces and output options. The primary components influence the user interface and software, or what the speaker or writer sees, and how the individual accesses AT. If the speaker/writer requires letter-by-letter spelling, then the user interface may be a standard onscreen keyboard. However, if the speaker/writer requires word prediction as a feature then the user interface will need to include a word prediction window that may be placed on different locations on the screen and allow for varying the size of the window. Sensory, perceptual, and motor skills will influence the interfaces and selection methods. Therefore, the evidence from the SLP regarding cognitive-linguistic abilities and executive functioning skills will influence
the use and arrangement of symbols/lexemes, navigational features of the user interface, and other related human factor principles. These capacities assessed by the SLP may also provide insight into the selection of AT system outputs.

Tertiary components relate to additional supports that influence short- and long-term effectiveness of the selected AT. Again, the SLP can provide insights into the use of peripherals and integration of an AT system with other devices. For example, individuals using wheelchair who require AAC will need to select a wheelchair mounting system to meet their needs. Many AAC speakers want mobile access to phones and are interested in integrating an AAC system with phone access. Individuals using computers to support written communication desire integrating environmental controls with the computer for more independent control of other electronic devices in the home. Individuals with hearing impairments may benefit from frequency modulation (FM) systems also. The SLP may recommend specific trainings and supports for the individual, family, and team. Several manufacturers provide initial in-home installation and training on AT and offer internet-based trainings that do not require travel to another location. Finally, more SLPs

### TABLE 13.4

Diagram Represents the Primary, Secondary, and Tertiary Components to Consider during an AT Assessment

<table>
<thead>
<tr>
<th>Matching Persons and AAC Technology</th>
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<tr>
<td><strong>AAC Primary (Language Software) Components</strong></td>
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<tr>
<td>Language representation methods</td>
</tr>
<tr>
<td>Single meaning pictures</td>
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<tr>
<td>Alphabet-based methods</td>
</tr>
<tr>
<td>Multi-meaning icons (semantic compaction)</td>
</tr>
<tr>
<td><strong>Secondary (Hardware) Components</strong></td>
</tr>
<tr>
<td>User interface</td>
</tr>
<tr>
<td>Symbols (types/set)</td>
</tr>
<tr>
<td>Display size</td>
</tr>
<tr>
<td>#location on display</td>
</tr>
<tr>
<td>Color coding</td>
</tr>
<tr>
<td>Navigation/#pages/displays</td>
</tr>
<tr>
<td>Automaticity</td>
</tr>
<tr>
<td>Human factors</td>
</tr>
<tr>
<td><strong>Tertiary Components</strong></td>
</tr>
<tr>
<td>Peripheral and integrated features</td>
</tr>
<tr>
<td>Computer access/internet</td>
</tr>
<tr>
<td>Phone access</td>
</tr>
<tr>
<td>Switches and mounting systems (multiple; wheelchair)</td>
</tr>
<tr>
<td>Electrode peripherals</td>
</tr>
</tbody>
</table>

*SNUG (spontaneous novel utterance generation)

are offering tele-rehabilitation services to support training and intervention for clients using AT.

The MPT process is client-centered and requires that the individual, including family or significant others, participate in the selection of AT options. Depending on the type of AT and client’s abilities and needs, the SLP may have the role of explaining the full range of AT solutions along the continuum of no technology to high performance technology. In addition, the SLP may explain and demonstrate the various AT components related to speech and oral and written language and communication and cognitive skills. This instructional and demonstration time ensures that the client and family are fully informed of all the options and are actively involved in the selection of the AT interventions considered for trial. Certainly, the SLP’s role would change for clients being evaluated for mobility technology, a prosthesis or hearing aid for example. However, secondary and tertiary features that identify other AT devices, peripherals, and functions still can be identified using this framework. For example, a young woman with an upper spinal cord injury may be evaluated for eye gaze as an alternative computer access method (a secondary control interface feature) and eye gaze practice software (tertiary peripheral) for training selection accuracy. Data logging (a secondary output feature) may be identified for an adult with a traumatic brain injury to monitor use and performance for a wheelchair. The SLP may provide insights into the collected data for measuring the effectiveness of the AT interventions.

Individuals and/or family members may enter the MPT process with preconceived notions about the type of AT they want. By providing an overview of the range of AT options and descriptions of AT in terms of primary, secondary, and tertiary components, the person and family gain an appreciation of the complex nature of the MPT process and can prioritize features they value (Hill and Scherer, 2008). Although off-the-shelf products may be a final solution, more frequently the selected AT includes features that provide more flexibility and customization for the person’s unique capabilities despite universally designed commercial products. With limited knowledge, an individual may have high satisfaction with an AT solution, but once they are fully informed about the performance differences that exist among the available solutions their initial satisfaction vanishes. Consequently, the external, internal, and personal evidence gathered by the SLP is used to support the details for the feature match.

13.1.5 Evaluation of the Effectiveness and Usefulness of the AT

The trial portion of the MPT process requires collecting quantitative and qualitative data to evaluate the effectiveness and usefulness of the AT intervention. Typical in the United States third-party payers require that the AT team provide documentation for at least three trials on similar solutions before making a selection. Although three trials may be documented, the AT team must have reviewed the range of solutions and a detailed comparison among the possible AT options. Since no research evidence exists regarding the length required for an AT trial, the professional opinion of the AT team along with the choice of the individual and family makes the decision about the trial lengths.

Baseline data on any current AT that was collected at the start of the assessment can be compared with data being collected during the AT trials. Automated performance monitoring or data logging provides quantitative data to use at the trial stage (Hill and Romich, 2001). The built-in data logging feature of several AT systems, integrated software, or external tools offer effective and efficient methods for monitoring gains in performance or for comparing AT solutions under consideration. The SLP’s role includes identifying the most
reliable and valid measures to monitor performance and recommending the methods to collect oral and written language samples.

The collection and analysis of language samples is the most authentic procedure for identifying communication competence (Hill, 2009; Light and Binger, 1998; Paul, 2007). The parameters used to measure communication competence are the same across cohorts and the lifespan. The parameters used to determine the severity of a communication disorder are also valid for AT speakers and writers. The SLP selects those measurements that will provide the most reliable and valid data for decision-making and monitoring progress. Typical data related to the subsystems of language (semantics, morphology, syntax) include the measures of vocabulary, syntactic diversity, and the length and complexity of utterances.

A variety of language sampling contexts may be recommended to collect the most representative example of an individual’s language functioning (Dollaghan, Campbell, and Tomlin, 1990). Various factors have been found to affect the quality of the language, such as the visual and auditory prompts of the tasks (Shadden, B. B., Burnette, R. B., Eikenberry, B. R., and DiBrezzo, R. 1991) or asking for a description rather than a narrative (Duchan, 1991). McNeil, Doyle, Park, Fossett, and Brodsky (2002) has validated a Story Retell Procedure for adults. Hill and Romich (2001) compared an interview and a picture description task for AAC speakers and found both contexts to be reliable and valid to report communication performance. Obviously, the most representative sampling would come from the AT speakers’ or writers’ communication during the activities of daily living. Without using automated data logging, capturing these data would be impossible.

Language activity monitoring (LAM) refers to a principle and set of tools that places primary value on the use of language samples in making decisions about AT solutions for spoken and written communication. LAM principles focus on the importance of collecting and analyzing the parameters of communication used across contexts, environments, and the lifespan. LAM tools record a log file to document the use of an AAC/AT system. The LAM logfile starts with a header and includes a privacy statement, the device sending the information, the current software version, and date (Hill, 2004). The data format has been standardized for analysis programs to accept the data from different sources. In addition, the standard format ensures that the logfile can be (1) readily uploaded or saved on a computer, (2) readily interpretable by AT teams, (3) easily visually inspected to identify possible treatment targets, and (4) suitable for standard language analysis. Figure 13.3

![Diagram representing the language activity monitoring (LAM) process uploading a logfile to generate a performance report. (From Hill, K. 2004. Topics in Language Disorders: Language and Augmented Communication, 24, 18–30)](image-url)
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represents the process when LAM is a built-in feature of an AAC system. KeyLAM (AAC Institute, 2009) software allows the computer to record a logfile when other AAC systems are used or the AT writer is using a computer.

The time stamp element of LAM and other performance measurement tools provide quantitative data that other observational and video or audio recording tools and software cannot provide. The Performance Report Tool (PeRT; AAC Institute, 2001; Romich et al., 2003) allows SLPs to create a transcript from LAM data. It also automatically generates a two-page report that contains seventeen summary measures, some with graphic representation and a variety of appendices related to vocabulary and utterance use. Compass software (Koester Performance Research, 2007; Koester et al., 2003) measures AT writer’s skills in various kinds of computer interactions to help AT teams evaluate computer access. The various skills assessed include keyboard and mouse use, navigation through menus and switch use. The SLP can provide insights into determining the sampling tasks that would be most representative for reporting data for AT decision making.

13.1.6 Development and Implementation of AT Intervention Plans

The AT assessment and MPT processes are not concluded without the development of an intervention plan or detailed treatment protocol. Now, the International Classification of Functioning, Disability, and Health (ICF; WHO, 2014) has elevated therapy and technology to more strongly match the desired activity and participation of the AT user (Cooper, 2007). When surveyed, individuals with disabilities and family members expressed a clear sense of maximizing potential and independence as an important outcome (Pain, Dunn, Anderson, Darrah, and Kratochvil, 1998). Therefore, the focus of intervention is not on the recommended AT, but is client-centered and aimed at optimizing the client’s performance and outcomes using the chosen AT.

For individuals with communication disorders, therapy or treatment will include goals and objectives to support gains in speech, the subsystems of language and literacy that are tied to an authentic and dynamic assessment. These would be the evidence-based treatments if AT had not been recommended. Evidence-based intervention methods are used with children for language acquisition goals. Evidence-based strategies are used in therapy to support regaining language for adults with aphasia. Evidence-based strategies are used in treatment for individuals with degenerative neurological disorders. In addition, AT may frequently support targeting deficits in speech–language comprehension and/or expression and cognitive functioning by the use of voice output, written modes of communications, and other educational and clinical software features.

13.1.7 The SLP’s Role in Advocacy

The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD, 2007) was the first human rights treaty to establish the right of disabled people to be treated as full and equal citizen. The National Joint Committee (NJC; Brady et al., 2016) for the Communication Needs of Persons with Severe Disabilities has proposed that all people, regardless of the severity of their disabilities, have a basic right to use communication as a means of affecting how they live. Professionals have an obligation to monitor international and national trends in the implementation and access to disability related services and AT (Borg, Lindström, and Larsson, 2009; Madans, Loeb, and Altman, 2011). Indeed, consideration of AT should not be based on exclusionary criteria in determining eligibility for AT supports and services (Kangas and Lloyd, 1988; NJC, 2016). Rather, the ICF acknowledges
the rights and dignity of individuals with disabilities and encourages AT teams to look at how an individual falls on a continuum of participation in daily activities and environments (Huer, Hill, and Loncke, 2006; Huer and Hill, 2007). Therefore, SLPs advocate for a zero exclusion policy when institutional or administrative policies may be in place that determines the individuals’ eligibility first.

13.2 Case Evaluation in a Multidisciplinary Team or as a Professional Consultant

The following case study exemplifies following the EBP principles and uses performance and outcome measurement to monitor gains toward achieving short- and long-term goals of intervention (Hill, 2006). An interdisciplinary team approach was involved in the assessment process. As a client-centered principle, the client managed the team that consisted of the SLP clinical supervisor, graduate students in SLP training, physical therapist, AT consultant, rehabilitation engineer, rehabilitation counselor, university advisor, and parent. The goals and objectives of intervention reflect the ICF model. The client self-identified the need to re-evaluate his use of AT, because he was failing his first semester at the university. His goal was to receive a four-year degree, become gainfully employed, and live independently.

13.2.1 Characterizing the Client

The case involves a 22-year-old college student with cerebral palsy. He was referred to the AT center of a university by the university’s office for students with disabilities. The referral indicated the need to identify strategies to improve communication and academic performance. The student had a high school diploma and an associate degree in accounting from another college. He transferred at the start of the semester into a four-year degree program. High school and college transcripts, medical records, and other educational testing records were reviewed. Standardized screening indicated no hearing or visual acuity problems. Spoken and written language samples confirmed linguistic and communication competence. Other standardized instruments indicated that auditory comprehension and vocabulary skills were within normal adult ranges. Performance data on current use of an AAC system and computer were collected and reviewed. Interviewing was used to collect personal evidence about the client’s values and needs for spoken and written communication and participation in other daily living activities. The ICF was used to support the activities and level of participation expected by the client. His expressed values were consistent with the desire to be a “faster, more efficient” communicator with comments that he did not appreciate having his messages “guessed” by other people. He valued being able to use his own words rather than having prestored messages. In addition, he valued that all his AT could be integrated and upgraded to work as efficiently and effectively as possible.

*Step 1—Asking meaningful EBP questions:* The team discussed the PICO format of asking questions to seek the evidence that mattered for this client. The patient was an adult with cerebral palsy enrolled in college; his current AT was used as the intervention; the comparison was an alternative language representation method; and the outcome was increased
communication rate and communication fluency. However, the following three questions summarize the value-based questions that were asked by all team members:

1. Is the client’s communication rate as fast as others of similar profile?
2. Is the client’s use of alphabet-based approaches the most effective language representation method possible?
3. Is the client’s use of direct selection the most effective access method to an AAC system?
4. Are the client’s various AT devices integrated to maximize his potential in college?

Step 2—Collecting clinical and personal evidence: Traditional methods of observation and language activity monitoring (LAM) tools were used for this process (Hill, 2004). The Performance Report Tool (PeRT) software was used to analyze language samples and generate a performance report. Although traditional methods of observation allowed for the collection of the multimodal aspects of communication, only LAM tools provided the accuracy required to monitor change or make comparisons among interventions. In addition, the measurement of communication and selection rate requires a time stamp for calculating standardized units of measure (Romich and Hill, 1999).

Based on the formulated EBP questions, the following performance measures were critical to obtain: (1) average and peak communication rate; (2) communication rate of language representation methods; (3) selection rate; (4) mean length of utterance; and (5) frequency of complete utterances.

Step 3—Locating and reviewing research evidence: The electronic search for evidence resulted in eight (8) studies, which were used to provide external evidence to guide decisions. These studies were summarized by the SLPs and shared with the team. An electronic database managed by the author was mined to find performance data of individuals with similar profiles (Hill, Dollaghan, and Nyberg, 2000). The results provided information on the performance achieved by others using AT systems under consideration. In addition, the client joined an online discussion group to seek user input on satisfaction with various AAC/AT options. He shared responses to his queries from the discussion group with the team as well as content on related topics he felt pertained to his situation.

Step 4—Using the evidence: This step involved using the external, clinical, and personal evidence for the MPT process. The primary, secondary, and tertiary features were discussed and demonstrated to the client with trials. The client requested the following three trial periods before making a decision about AAC and/or AT: (1) His current AAC device with modifications and current computer arrangement, (2) an upgraded touch screen AAC system that included eye gaze technology, and (3) two additional AAC systems with eye gaze technology. All three AAC systems trialed could emulate with the computer.

The primary components became the major features for the client to select. Identifying the various language representation methods (LRMs) used to generate communication for spoken or written language would influence performance. Becoming aware of how core and extended vocabulary could be stored and retrieved was a feature he had not considered previously. Since the client preferred not to use prestored messages, but wanted SNUG to be his primary means of communicating, customizing a bank of preprogrammed sentences was not considered.

The secondary components offered a wide range of options to consider and manipulate. The SLPs on the team and AT consultant were more involved in discussing, demonstrating,
and comparing the various language software with pre-stored vocabulary configurations, different numbers of display locations, symbol types, color display options, sizes of touch screens, etc. In addition, given the client’s significantly reduced selection rate on his current systems, the team suggested evaluating eye gaze as an alternative access method as a means to increase communication rate. The client indicated that he wanted the option to switch between direct keyboard selection and eye gaze, depending on his physical status during the day. Other features that were considered desirable by the client included blue tooth control for computer access and environmental control, and data logging. In comparing the various AAC systems under consideration, the client found value in the following secondary user interface features: core and activity row configuration to access vocabulary, icon prediction, and icon tutor, and easy access to display status and tool box customization. However, an eye gaze technology comparison was essential for the MPT process.

The central tertiary component important to the client was being able to have access to his AAC system with eye gaze when not in his wheelchair and to use the AAC system with a computer. The client chose an adjustable mount for his chair and a wheeled mount to use when in a reclining chair and in bed. Setting up the peripherals in the dorm was required for this to happen. In addition, mounting solutions and fabrication of other peripherals were required and performed by the rehabilitation engineer. The client also took into consideration the services offered by the manufacturer.

Step 4 involved a clinical summary at the end of three months. The summary was written to describe the result of the assessment and trial process and culminated in submitting a funding request for a new AAC system and updates to computer access. Training and intervention on the new communication technology included a one-hour therapy session a week that was reduced to every other week after a month and by the second month sessions were schedule as requested. The built-in LAM feature provided an efficient method for monitoring progress by both the client and the SLPs and prompted discussion about treatment outcomes. Within three months of treatment, the client had learned his new language application program and was selecting words using semantic compaction 90% of the time. While his average communication rate started at under 10 words per minute with 25% errors in selection, at the end of the first month, his communication rate of 25 words per minute was with 10% errors in selection. In this case, the use of semantic compaction was 16 times faster than spelling. By the end of the academic year, performance and outcomes data indicated significant gains and that overall spoken and written communication were more effective and efficient and user satisfaction was high.

The utilization of PeRT allowed for precise and accurate reporting of performance measures during the assessment and intervention processes. The performance reports provided an ongoing, reliable record of progress for treatment outcomes. In addition to improvements in his communication performance in various social environments, his communication in classes was also considered to be improving. With an improvement in his grades, withdrawal was no longer considered necessary. Two years later, the client graduated from the university with a four-year degree. He has met his long-term goals by being self-employed and living independently.

### 13.3 Conclusion

Our case adheres to the precepts of a client-driven process to reach an AT solution that allows individuals to reach their highest potential within the ICF framework. The client’s
request, based on his concern over his school performance, triggered the referral and assessment processes. The client invited specific members to the team considering how the components of the ICF model related to him: his body functions and structure, personal, and environmental factors. The SLP became the team coordinator and manager because the primary area of concern was related to the significant discrepancy in his spoken and written communication with his college peers.

The final AT solution was identified by applying the principles of evidence-based practice. This included becoming familiar with resources and services to support the long-term effectiveness of the AT solutions. In our client’s case, after he was shown video clips of individuals speaking with high performance voice-output systems, he shared that he had never met another AAC speaker. The team conducting his previous evaluation had never performed an assessment for an AAC system and computer access, and he had not been made aware of environmental controls. His original team had made decisions based on “ease of use at first encounter, rather than long-term effectiveness.” His first AT team found an immediate solution, but not the most effective, efficient, or satisfying AT solution. During separate conversations, with the client and his family, we came to realize that they had no idea that individuals with severe communication and physical disabilities were communicating so effectively and fast using an AAC system.

At the first assessment session, the client was introduced to various Internet resources through the AAC Institute web site at http://www.aacinstitute.org. He was encouraged to post questions about the AT assessment process to members of a discussion group to be a better advocate for himself. Internet resources can provide access to information that is current and useful, when sources are evaluated carefully and prudently.

Today, the SLP on the AT teams is expected to conscientiously and judiciously use the best evidence or data to support decisions that fit onto the ICF framework. SLPs practice the principles in this chapter “place the client’s benefits first when applying evidence of direct practical importance to planning” (Gibbs, 2003). Our case is an example that individuals who are AAC speakers believe that the fundamental, desired outcome of independent spoken and written communication can be achieved with appropriate technology and appropriate long-term, intensive intervention strategies (Creech, 1995). Our client’s quality of life was dramatically enhanced by striving for a solution that resulted in the most, effective, and independent communication as well as integrating other AT solutions together. AT teams that are client-driven and include the family and significant others can feel secure that the client’s benefits are placed first when evidence is used judiciously and conscientiously within an organized framework.

13.4 Summary
The chapter highlights the knowledge and skills the SLP contributes to the AT team. The SLP is one member of a collaborative, dedicated group of people who work together to reach the best solution for a client. The SLP provides unique clinical measures related to an individual’s speech, language, oral and written communication, listening, reading, and swallowing capabilities. In addition, the SLP contributes performance measures and functional analysis of speaking and writing skills to support AT solutions. The use of LAM resources and tools provide evidence to quantify client achievement of specified goals with respect to effectiveness, efficiency, and satisfaction in desired activities and
environments. Personal well-being and life experience is directly related to an individual’s ability to communicate as effectively as possible.

References


Role of Speech–Language Pathologists in Assistive Technology Assessments


Section III

Assistive Technology Devices

Stefano Federici and Marcia J. Scherer

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III.1 Introduction

Assistive Technology (AT) can be a specialized product, a mainstream or everyday technology (e.g., smartphone), software and apps, and more. If it supports the functioning of a person with a disability, then it is AT (see Section I). Today a lot of information about ATs can be obtained from many databases and websites on the World Wide Web (WWW). However, we can make a clear distinction between databases and websites: AT websites mostly aim to present a catalogue of technologies for a specific kind of disability, such as the American Printing House for the Blind (https://www.aph.org/), or for other specific groups of disabilities, such as the Cambium Learning Technology Company website (http://www.cambiumlearningtechnologies.com/). Databases are more focused on the diffusion of technical information about equipment by collecting a very extensive list of ATs.

The two largest and most complete databases of devices are the following:*

- AbleData.com (http://www.abledata.com): Created by the National Institute on Disability and Rehabilitation Research in 1996, this database currently provides information on about 46,000 products classified into 20 areas. It also offers information on noncommercial prototypes, customized and one-of-a-kind products, and do-it-yourself designs.

* The number of products on http://www.abledata.com and http://www.eastin.eu was retrieved in March 2017.
• The European Assistive Technology Information Network (EASTIN, http://www.eastin.eu): In 2003, some of the best known expert information providers in Europe joined together to create a comprehensive information service on AT, which currently offers information on about 56,000 products. All products and associated information in the EASTIN databases are classified according to the ISO 9999 (2016) international standard. The website works in all European Union official languages.

The impressive number of products offered by those databases is evidence of the growth in AT devices that has occurred. This rapid increase in the amount of online information about AT products underscores the need and desire for technologies that meet the diverse needs of people with disabilities in all facets of their lives: from products for medical treatment to supports for school, work, and self-care to equipment for housekeeping, recreation, and sexual activity.

Company investments in the improvement of AT have led to the development of novel products as well as product upgrading and updating. Simultaneously, literature appears on product usability, use versus discard, and on the optimal matching of user and technology.

Despite the huge increase in the availability of AT products, only 1 in 10 people in need have access to AT. The assistive products industry is currently limited and specialized, primarily serving high-income markets (Borg, Lindström, and Larsson, 2009; Borg and Östergren, 2015). In order to increase access to AT, the Global Cooperation on Assistive Technology (GATE), coordinated by the World Health Organization, promoted a world initiative so that everyone from everywhere can access “high-quality, affordable assistive products to lead a healthy, productive and dignified life” (http://www.who.int/phi/implementation/assistive_technology/phi_gate/en/).

Section III, by aiming to analyze both the interaction between the user and the technology in the Assistive Technology Assessment (ATA) process model and the development of new ATs, is focused on the idea that it is impossible to represent the most recent ATs without losing the race with the advancement of technology, in which something that is new today becomes outdated in a week. In order to avoid the possibility of discussing outdated technology, the seven chapters (Chapters 14 through 20) comprising Section III are focused on new landscapes in AT development and research by presenting technologies that are not now available on websites and databases (such as brain–computer interface technologies) while emphasizing new concepts and methods for improving the next generation of ATs.

### III.2 Presentation of the Chapters of Section III

The chapters in Section III are organized in conceptual order from the most theoretical—the role of user experience evaluation in the ATA process and the assessment of gestural input and tracking technologies—to the most concrete—the use of technology in music therapy.

**Chapter 14**, titled *The Systemic User Experience Assessment*, presents a theoretical framework of the role of user experience (UX) in the ATA process using an integrated approach of evaluation in the rehabilitation system. The UX holistic perspective and definition are presented along with the concepts of usability and accessibility, as well
as product useworthiness and personal realization of benefit from use (Scherer and Federici, 2015). The authors introduce a new conceptual perspective based on the UX framework and an integrated model of interaction evaluation. The authors endorse the assumption that UX evaluation concerns not only the user’s experience with an assigned technology but also the user’s experience of the action of the center for technical aids (i.e., ATA process functioning), proposing an ATA process under the lens of UX evaluation in order to assess both the relation between the AT and the users and that between the users and the center for technical aids. Finally, the authors present different examples concerning the application of the UX framework to the design process of systems for rehabilitation.

In Chapter 15, titled Gesture, Signing, and Tracking, Michael Craven discusses a holistic approach to assessment of gestural input and tracking technology for AT, augmentative and alternative communication, and rehabilitation applications. He suggests three methods to assess new technology: a lab-based functional assessment and ISO standards for physical input devices, a user-centered approach for assessing and evolving technology solutions in the real world, and clinical evaluations that include outcome scales in current use for assessing a patient’s function and daily living abilities, and highlighting the need to address psychosocial factors.

Chapter 16, titled Using Brain–Computer Interfaces for Motor Rehabilitation, discusses brain–computer interfaces (BCIs) for restoring communication and movement in patients with severe and multiple disabilities. It presents the history of BCIs and brain activity measures. The authors endorse the idea that BCIs are information and communication technologies that support the daily life activities of people with disabilities. In this sense BCI technologies are ATs that aim not to compensate for a deficit but to promote the user’s social participation.

Then, four new chapters, with respect to the first edition, complete this section, enriching it with new technological horizons and applications. Chapter 17, titled Graphic User Interfaces for Communication, explores a new gaze text-entry technology, a predictive graphic user interface for writing and communicating by means of the eyes. The new interface, developed by Cogisen, can be used by people with residual eye motor abilities, residual language comprehension, decoding and production ability, and symbolic communication ability.

Chapter 18, titled Exoskeleton: The New Horizon of Robotic Assistance for Human Gait, provides a glimpse on a new horizon of technological development: robotic assistance. The exoskeleton, an active mechanical device, anthropomorphic in nature, “worn” by an operator and working in concert with the wearer’s movements, allows patients with gait motor disorders not only to stand bolt upright, but also to move autonomously in their surroundings. The use of the exoskeleton is revolutionizing neurorehabilitation therapy, promoting new rehabilitative techniques based on neurorobotic or neuroprosthetic training.

In Chapter 19, titled Assistive Technologies for Children with Autism Spectrum Disorder, the authors reflect on gaps and limitations in the use of AT with children with autism. They also propose a new technology, Painteraction, developed by Donnari, that facilitates therapists in the interaction with nonverbal low functioning children with autism.

Finally, Chapter 20, titled Technology Developments in Music Therapy, tackles the need to incorporate music technology activated by AT into an intervention of music therapy with people with disability. As traditional tools could not meet the special needs of people with disability, an AT can provide access to being an active agent in the therapeutic process and the music making.
References


The Systemic User Experience Assessment

Simone Borsci, Masaaki Kurosu, Maria Laura Mele, and Stefano Federici

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14.1 Introduction

The term “user experience” (UX), which was coined by Norman and colleagues (1995) refers to the pleasure and value that the user gets from a human–system interaction and the performance of the system during such interactions. Good system usability is necessary but not a sufficient condition for a good UX; while usability is one dimension of the interaction, UX is a holistic perspective on how a user feels about using a system. There are various definitions of UX (for a review on UX, see also Borsci, Kurosu, Federici, and Mele, 2013; Bussolon, 2016) including the one provided by Norman, “all aspects of the user’s interactions with the product: how it is perceived, learned and used. It includes ease of use and, most important of all, the needs that the product fulfils” (1998, p. 47), and the definition provided by Garrett, “how the product behaves and is used in the real world” (2003, p. 17). Recently, the International Organization for Standardization (ISO) 9241-210 (1999) defined it as “a person’s perceptions and responses that result from the use or anticipated use of a product, system or service.” The ISO also states that

User experience is a consequence of the presentation, functionality, system performance, interactive behavior, and assistive capabilities of an interactive system, both hardware and software [...]. It is also a consequence of the user’s prior experiences, attitudes, skills, habits and personality. (ISO, 1999)
A total of 30 usability professionals and others took part in a workshop on UX in Dagstuhl, Germany in 2010. The discussion was summarized by Roto and other editors in the “User Experience White Paper” (Roto, Law, Vermeeren, and Hoonhout, 2011).

UX is a complex concept that includes and extends the usability dimensions, without completely replacing them. Many authors have pointed out the areas in which UX amounts to more than usability (Hassenzahl and Tractinsky, 2006; Law, Vermeeren, Hassenzahl, and Blythe, 2007). These areas were well summarized by Petrie and Bevan (2009):

- **UX is more holistic than usability**: As previously discussed, usability focuses on performance of and satisfaction with users’ tasks and their achievement in defined contexts of use; UX takes a more holistic view, aiming for a balance between task-oriented aspects and other nontask-oriented aspects (often called hedonic aspects) of eSystem use and possession, such as beauty, challenge, stimulation, and self-expression.

- **UX is more focused on subjective perception of the system than usability**: Usability has emphasized objective measures of its components, such as percentage of tasks achieved for effectiveness and task completion times and error rates for efficiency; UX is more concerned with users’ subjective reactions to eSystems, their perceptions of the eSystems themselves, and their interaction with them.

- **UX is more focused on positive aspects of the system than usability**: Usability has often focused on the removal of barriers or problems in eSystems as the methodology for improving them; UX is more concerned with the positive aspects of eSystem use and how to maximize them, whether those positive aspects be joy, happiness, or engagement.

Although accessibility and usability are dimensions of the device and system and thus can be described objectively, the UX concept encompasses subjective factors such as the user’s expectations, perception, and memory. In other words, system or device traits such as usability and reliability can be regarded as independent variables whereas UX is a dependent variable that is influenced by devices and system traits. This indicates that consideration of system and hardware traits alone will not necessarily lead to a design offering a good UX. Emphasizing the importance of the UX makes for better design than just focusing on system and device traits.

Kurosu (2015, 2017) presented a model of quality characteristics as shown in Figure 14.1. It is similar to ISO/IEC 25010 (2011), in which the product quality and the quality in use are distinguished. However, differently from the standard one, Kurosu’s model compares the design process and the usage process so that are categorized as the quality in design and the quality in use. Furthermore, the model in Figure 14.1 distinguishes objective and subjective qualities of a product. Objective qualities such as the usability, functionality, performance, and reliability and the effectiveness, efficiency, and productivity can be measured externally by physical measures. Subjective qualities such as attractiveness and satisfaction can be measured internally or by the use of rating scale. In Figure 14.1, the UX is represented as a concept that includes the entire quality in use including the objective quality in use and the subjective quality in use, the user characteristics, and the context of use.

Experience is the key concept in marketing, particularly as it relates to the formation of expectations. Establishing good consumer expectations is one of the goals of marketing activity, but marketing is less concerned about how people use the device or system, which is the focus of user engineering.
Kurosu and Ando (2008) and Kurosu (2010) combined these two perspectives on experience and proposed a four-phase model of UX based on the idea that people will change their perspective from that of a consumer to a user when they purchase a system (Figure 14.2). In the first phase, people act as consumers and their expectations of a device or system are influenced by subjective factors (e.g., simple desire) and objective factors (e.g., foreseeable usage) on the basis of various pieces of information obtained through printed advertisements, TV commercials, and other media (e.g., web sites, journal articles, and information from friends). Marketing focuses on this phase of the UX. Potential purchasers may go onto

**FIGURE 14.1**

**FIGURE 14.2**
Four phases of user experience.
to obtain an impression of the device and to trial the system. Summative usability evaluation corresponds to this phase. Usability testing is one way of capturing the interactive experience, but it does not capture the full UX because tests typically are short interactive events that rarely can affect or capture all the variables to properly map the real UX.

After purchasing a device or system, the individual becomes a user and starts interacting with the system in real-world contexts. The user will accumulate memories of his or repetitive interactions with the device in real-world contexts, thus forming an evaluation of the system. Because this evaluation of UX is based on the memories of cumulative experience with the system, it varies over time according to the quality of the user’s ongoing interactions with the system. For instance, ISO 9241-210 (2010) claims that 6–12 months experience of a system is necessary for evaluation.

The experience with the device is typically transformed in attitudes, beliefs, and the learnt interactive shortcuts, thus becoming part of the end-users knowledge. This knowledge will serve as a basis for searching—as a consumer—for a new device or system in the next cyclical stage. Thus, the four phases form a spiral structure.

Kurosu and Hashizume (2016) combined the UX process and the business process as shown in Figure 14.3. The four phases of UX is similar to the one in the UX white paper (Figure 14.2). The business process starts from the planning, then designing that includes four stages of design proposed in ISO9241-210. After designing, manufacturing, advertisement, sales, and user support follow. During the phase of advertisement, the information of the product or service will be given to the consumer, thus forming the expectation. During the phase of sales, the information and the product or service itself will be given to the consumer, and some user will purchase the product or service. Important point is that the usability evaluation is conducted during the design phase and the UX evaluation should be conducted as the user survey after the sales and user support, so that the information on UX will be fed back to the planning and designing.

**FIGURE 14.3**
If one considers the UX, it is clear that it is not possible to obtain a realistic evaluation of a system simply by analyzing its functionality particularly if the analysis is conducted in an experimental setting, using specific tools or techniques that provide an evaluation that is at least somewhat objective (i.e., automatic evaluation and expert evaluation). Focusing on UX embodies User Centered Design (UCD) or Human Centered Design (HCD) philosophy, by shifting away from an old perspective in which design and evaluation processes consider only the engineering aspects of the system to a new perspective based on consideration of users’ experiences with the system in real use environments.

It is not sufficient to consider the object (device and system) and the subject (user) as two extreme points of the interaction continuum. The weakness of this dichotomous model is that it does not properly consider the dynamic relationship between the system and user, which is an emergent phenomenon that is not reducible to components (system and user) (Borsci et al., 2013; Federici and Borsci, 2010; Federici et al., 2005). A member of the design team who tries to evaluate user–system interactions should evaluate the relationship between the system and user, considering the perspectives of both the object and subject (Figure 14.4).

**FIGURE 14.4**
Intrasystemic relationship between users and eSystems. UX is represented as the user’s perspective on the relationship between user action and eSystem feedback. The universal design properties of the eSystem correspond to the intersection of the eSystem’s usability and accessibility. According to Petrie and Kheir (2007) universal usability problems represent interaction problems of usability and accessibility that all kinds of users find when the intrasystemic relationship is bad because the UX is bad (universal design problems). When problems mainly affect disabled people’s interactions with the system they may be termed “pure accessibility problems” and when the problems are not related to disability the term “pure usability problems” can be used. Between these two extremes, there are many interaction problems that affect the UX of disabled and non-disabled users to varying degrees. (From Borsci, S. et al. 2013. Computer Systems Experiences of Users with and Without Disabilities: An Evaluation Guide for Professionals. Boca Raton, FL: CRC Press; Federici, S., and Borsci, S. 2010. Usability evaluation: Models, methods, and applications. In J. Stone and M. Blouin (Eds.), International Encyclopedia of Rehabilitation (pp. 1–17). Buffalo, NY: Center for International Rehabilitation Research Information and Exchange (CIRRIE); Retrieved from http://cirrie.buffalo.edu/encyclopedia/article.php?id=277&language=en; Federici, S. et al. 2005. Checking an integrated model of web accessibility and usability evaluation for disabled people. Disability and Rehabilitation, 27(13), 781–790. doi:10.1080/09638280400014766.)
14.2 From System Accessibility and Usability to the User’s Experience

14.2.1 The Relationship between Accessibility and Usability

Various definitions of usability have been used in the field of human-computer interaction (HCI); the definition in use today is set out in ISO 9241-11 (1998). This standard defines usability as “the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.” There is no comprehensive, agreed definition of accessibility. ISO 9241-20 (2009) defines accessibility as “the usability of a product, service, environment or facility by people with the widest range of capabilities.” In this definition, the relationship between usability and accessibility is not in parallel but is inclusive.

The concept of accessibility is linked to that of rights of “access” to a wide “range of services, information, cultural exchanges, identity reaffirmations and social transactions [...] seen as a basic right of citizens in many advanced society contexts” (Roulstone, 2010, p. 9). In this sense “Web accessibility” means that “people with disabilities can use the Web [...] more specifically [they] can perceive, understand, navigate, and interact with the Web” (Web Accessibility Initiative (WAI), 2006). Di Blas and colleagues stated that “W3C [World Wide Web Consortium] guidelines only guarantee ‘technical readability,’ that is, the very fact that screen readers can work; they do not ensure at all the fact that the Website is ‘accessible’ by blind users, in the sense that blind users can effectively access it.” (2004, p. 1). These authors underline that the most important aim of the World Wide Web Consortium (W3C) is to ensure an effective user experience, or “usable accessibility” (Di Blas et al., 2004). It is interesting that although definitions of accessibility are less comprehensive, there is more agreement and better definition of methods of assessment than in the case of usability. Assessment of accessibility takes the form of objective analysis of the system through assessment of compliance with international guidelines, whereas there are no unique methods of evaluating usability. Usability evaluations focus on whether users achieve their goals, how easily they do so, and how satisfied they are, which makes usability a mixed qualitative and quantitative approach to assessment. Usability evaluation is driven by the personal (subjective) interaction experience immediately after the use. In tune with that usability is a subjective-oriented assessment to gather, with several methods, insights people performance and perception of an interactive system.

While the accessibility assessment is objective oriented and quite stable in terms of methods, usability is more subjective, and how people performance and perception of the interaction are observed and measured in the usability field can vary substantially.

Despite their different evaluation objectives, the concepts of accessibility and usability are related because they offer two perspectives on interaction problems. As Petrie and Kheir (2007) noted, accessibility and usability problems can be seen as overlapping sets of problems, which can be split into three categories as follows (Figure 14.4):

[i] Problems that only affect disabled people; these can be termed “pure accessibility” problems; [ii] Problems that only affect non-disabled people; these can be termed “pure usability” problems; [iii] Problems that affect both disabled and non-disabled people; these can be termed “universal usability” problems. Accessibility problems were not a complete sub-set of usability problems. (p. 398) (please see also Horton, 2005; Lazar, 2007; Shneiderman, 2003).
According to this framework, accessibility problems are not a subset of usability problems, nor are usability problems a subset of accessibility problems.

14.2.2 An Overview of Usability Standards

Organizations in charge of international standardization include the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the Comité Européen de Normalisation (CEN). In addition to these, there are local organizations such as Japanese Industrial Standards (JIS), the Deutsches Institut für Normung (DIN), the British Standards Institute (BSI), and the American National Standards Institute (ANSI). They have issued many standards and documents relating to usability and accessibility, sometimes in conjunction with each other. Typically, international standards are established first and some are subsequently incorporated into local standards, but sometimes local standards become international standards, as in the case of JIS X8341-1 (2006) and ISO 9241-20 (2009).

The Technical Committee (TC) on the ergonomics of ISO (see http://www.iso.org) has published many standards and documents relating to usability. The ISO/TC159 has four Subcommittees (SCs), SC1, SC2, SC3, and SC4. SC4, which is in charge of the “Ergonomics of Human-System Interaction,” has 11 Working Groups (WGs) and WG6 is in charge of “Human-Centered Design Processes for Interactive Systems.”

WG6 of TC159 has published some of the most usability important standards:

- ISO 9241-210 (2010), formerly ISO13407 (1999): Important for its definitions of HCD and UX. The description of how HCD can be achieved is also an important part of this standard. Its four-stage model of HCD based on (1) understanding and specifying the context of use, (2) specifying user requirements, (3) producing design solutions, and (4) evaluating designs against requirements is now a world-famous scheme.
- ISO/TR 18529 (2000): This document is a first attempt to expand the scope of HCD to cover not just the design process (as in ISO 9241-171) but the entire life cycle. It specifies a set of methods that should be adopted in each activity.
- ISO/TR 16982 (2002): This document presents the sets of methods that should be adopted at each stage of the HCD process as per ISO 9241-210; however, the appropriateness of the methods described is still a matter of debate.
- ISO/PAS 18152 (2003): This document is an extension of the HCD concept and of the approach to the product life cycle. This standard specifies a human-systems (HS) model for assessing the maturity of an organization’s approach to the processes that make a system usable, healthy, and safe. This HS process of assessment is composed of four human-systems components: HS.1—life-cycle involvement, HS.2—human factors integration, HS.3—usability engineering (as in ISO 9241-210), and HS.4—human resources.

relate to the usability of everyday products and “ease of operation” is defined in terms of the functionality of the product and the operation of the user interface and is strictly linked to usability. There is, however, still international debate on the adequacy of these standards.

Another set of usability standards was produced by committee JTC 1 on information technology, and in particular SC7, which deals with software and systems engineering.

- **ISO/IEC 25010 (2011):** This standard was a revised version of ISO/IEC 9216-1 (2001a). This is a part of SQuaRE (Systems and software Quality Requirements and Evaluation) and presents the system and software quality models. Importance of this standard lies in that it distinguishes the product quality and the quality in use.


This brief overview underlines the relevance of the broad concept of usability to many dimensions of HCI. In particular, the analysis of the usability-related standards shows clearly that the concept of usability is related to that of accessibility; this is reflected in some national and international definitions of accessibility, such as Section 508 of the U.S. Rehabilitation Act of 1973 (e.g., see the web site for understanding and implementing the requirements of Section 508, [http://www.section508.gov](http://www.section508.gov)), the JIS X8341 series in Japan, and the definitions of the WAI, which have been applied in the usability standards. The relationship between accessibility and usability is clearly expressed in ISO/IEC Guide 71 (2001b), which specifies how the needs of older persons and persons with disabilities should be considered in the interaction assessment and design, in ISO 9241-20 (2009), which sets out accessibility guidelines for information/communication technology equipment and services, and, in ISO 9241-171 (2008), which sets out guidance on software accessibility.

The relationship between usability and accessibility is particularly evident in ISO/IEC Guide 71 (2001b), in which it is recognized that accessibility and usability are important for both products and services because “some people with very extensive and complex disabilities may have requirements for access to the product.” This guide describes a process by which the needs of older persons and persons with disabilities may be considered in the development of standards; provides tables to enable standards developers to relate the relevant clauses of a standard to the factors which should be considered to ensure that all abilities are addressed; offers descriptions of body functions or human abilities and the practical implications of impairment; offers a list of sources that standards developers can use to investigate more detailed and specific guidance materials. (ISO and IEC, 2001b)

As we have seen in this section, the relationship between accessibility and usability is clearly indicated in both the standards and the UX theoretical approach. Although this relationship is evident, practitioners are accustomed to splitting the evaluation of products
into two uncorrelated processes: an evaluation of accessibility and an evaluation of usability. The accessibility evaluation covers the evaluation of objective access to the interaction, and is a measure of the way the architecture accomplishes the standards (i.e., objectivity), whereas the usability evaluation covers the subjective use of the interaction (i.e., subjectivity). The separation of objective and subjective aspects of interaction is a limitation of UX studies that can be overcome only by an integrated interaction evaluation model (Borsci et al., 2013; Federici and Borsci, 2010).

### 14.3 Evaluation of Systems

#### 14.3.1 A Conceptual Framework: An Integrated Interaction Evaluation Model

The relationship between accessibility and usability is often reduced to one of objectivity and subjectivity (Borsci, Federici, Bacci, Gnaldi, and Bartolucci, 2015; Borsci et al., 2013; Federici and Borsci, 2010; Federici et al., 2005), but this simplification does not capture all the aspects of the interaction between technology and user (Annett, 2002; Kirakowski, 2002). As Federici and Borsci (2010) argued:

> Accessibility refers to the interface code that allows a user to access and achieve the information (e.g., a user can read a text alternative description of a figure by a screen reader), usability pertains to the subjective perception (satisfaction) of the interface structure's efficiency and effectiveness (e.g., a user is satisfied because they can immediately achieve the information they are looking for). However, when the relationship between accessibility and usability is defined in this bi-polar way, accessibility might be established as the objective end of the user interaction, while usability could be correlated to the subjective aspects, as determined by users' inherent individual differences. From this perspective, a technological product is reduced to a neutral entity that functions independently from its user in a neutral environment. As a result, a machine could be perfectly accessible but not usable. Consequently, usability does not pertain at all to the technological aspects of a machine functioning, but to the cognitive and functional aspects of the individual differences. (p. 2)

Therefore, as Federici and colleagues (2005) state, objective and subjective in the context of accessibility and usability evaluation of interaction cannot be considered as separate entities. Subjective and objective are two different moments both included in the continuum of empirical observation. An entity cannot be considered separately from its observer during the interpretation or reconstruction process, because the entity is only known by the subject as an observed and perceived object (Figure 14.5).

From this perspective, accessibility and usability are not characteristics of two separated interacting entities, but of one intrasystemic relationship in which both object and subject are just moments in a multiphase process of empirical observation. Resonating with that an interactive system is in constant relation either to its designer or to its user, and accessibility of a system always refers only to the possible entrance and exit of a signal needed to fulfill the task for which it was designed. In this sense, a machine should not be accessible and yet unusable at the same time.

Federici and Borsci (2010) argued that accessibility and usability cannot be considered as two separated approaches to look at the objective (accessibility) and subjective (usability)
aspects of the user–technology relationship. In fact, interaction should be viewed as bidirectional, and usability and accessibility are two outlooks of a continuum from which an evaluator can observe the reality of the user/technology system. The accessibility of an interactive environment is therefore defined in terms of the ease with which the user can initiate and terminate the operation that completes the system’s task (functioning construct), whereas its usability is defined in terms of the user’s perception of the user–technology interaction (user performance). The functioning construct of a system is based on the standard rules (e.g., Web Content Accessibility Guidelines) against which accessibility is assessed. Once that a system fulfills the functioning construct (i.e., it is accessible), the user performance allows us to properly deduce scales (e.g., efficiency, satisfaction, cognitive load, and helpfulness) of usability scores.

The object of the evaluation cannot be merely reduced to the artifact or to the user: what is being evaluated is the functionality of the intrasystemic dialogue between the user (i.e., the subjective party in the interaction) and the interface (i.e., the objective party in the interaction). Assessments of accessibility and usability should, therefore, be viewed as estimates of the extent to which it is possible, or likely, that the user will achieve his or her goals through navigating the given interface. Evaluation of the intrasystemic relationship between user and technology should be based on both object- and subject-oriented methods, but even so the overall evaluation should not be based on the sum of the results of evaluations carried out using these two approaches; it should represent the integration of evaluations of accessibility and usability. An integrated usability evaluation model is compatible with a universal model of disability according to which ability–disability is viewed as a continuum. A dichotomous characterization of real-world

**FIGURE 14.5**
Possible perspectives on evaluation of the intrasystemic dialogue between user and system: objective-oriented and subjective-oriented. Evaluation of the interaction should consider not only its properties with respect to single dimensions (accessibility or usability), but also the bidirectional relationship linking the objective part of the interaction to the subjective part. In this context, accessibility and usability are considered as necessary steps for the evaluation of the intrasystemic relationship between interface and user.
functioning in terms of “ability” or “disability” is of only theoretical interest; in practice nobody is completely without disability and similarly nobody is completely without ability (Bickenbach, Chatterji, Badley, and Üstün, 1999; Meloni, Federici, and Dennis, 2015; Zola, 1989). Therefore, ability/disability are referred to (and by) the activities performed by an individual, originating from the environment and valued by a predetermined functioning construct. These activities can change both the topology of an environment, and the evaluation criteria that an evaluator has to use to assess the interaction.

The model proposed by Federici and Borsci (2010) and subsequently extended by Borsci et al. (2013) is based on the UX framework and on the idea that UX problems have their origin in the distance between the models used by the designer and user of a given technological product to reason about it, to anticipate its behavior, and to explain why it reacts as it does (Craik, 1943). Mental models, according to Norman’s (1983) definition of “system causality conveyance,” are collections of knowledge and skills that guide the holder’s interaction with an interface (in the case of the user) or guide the creation of the interface (in the case of the designer). As far as the evaluation process is concerned, we need to consider that

• The cognitive processes of the developer(s) involved in the design of the system are mostly connected to problem-solving strategies, to decision making about the product functioning, to the representation of knowledge, and to expertise in complex task environments. Although these processes have been analyzed deeply, the difficulties owing to the effort of “simulating the user mental model” have never been studied properly. When designing an interface, the developers simulate how a user would go about achieving his or her goals and hence they develop the system’s functions based on their ideas about the potential user and his or her hypothetical interactions with the system. There are many stakeholders involved in the development process, including the planner, the designer, the advertising people, and the retailer and they may not all have the same picture of the system. The design process thus represents the integration of the designers’ design skills and their ability to simulate user behavior. Although standard models set out in several sets of international guidelines on accessibility and usability offer some sort of representation of the typical user’s behavior this is not sufficient to guarantee the success of a product. To deliver a satisfactory product, the designers should have some ability to simulate potential users’ behavior, but the ability to “simulate” someone else’s behavior is one of the hardest and most complex cognitive processes that a human being can perform (Decety and Jackson, 2004; Meltzoff and Decety, 2003).

• The user’s cognitive processes when interacting with the system are quite different from those of the designer(s). First of all, it is a fact that, in interacting with the system, the user uses the same cognitive processes as the designer used when creating the interface (i.e., problem solving, representation of knowledge, and expertise). Thanks to the shared nature of these processes the user is able to “operate” the interface (i.e., the interface is understandable and usable). However, while the designer applies these shared cognitive processes to simulate the hypothetical user’s behavior (i.e., in the design of the information architecture), the user does not need to simulate the designer’s intention. The user’s cognitive processes are used only to operate the interface in tune with his or her mental model, expectations, beliefs, and attitudes. The user’s interaction with the system is not based on an “imagined” or “simulated” developer; he or she simply operates the interface in pursuit of his or her personal goal.
The distance separating the designer and the user in the interaction mostly depends on the different methods of applying their mental model. The designer uses the simulation of the interaction to bring the designed functions of the system closer to the user expectations, by aiming to match the user’s mental model. The user’s interaction with the system is driven by his or her mental model. The distance between designer and user can be reduced if both can adapt their personal mental models to enable them to act appropriately (i.e., to simulate the user’s interaction with the system and to interact with the system, respectively). The better the designer is at simulating the hypothetical user, the shorter the distance separating their mental model from that of the user; the better the user is at operating the system, the shorter the distance separating his or her mental model of the interface from the conceptual model of the interface (and therefore from the designer’s model).

Both the user and the designer are part of the construct we need to measure (the interaction), so neither the designer’s perspective (expectations about how the system should work) nor the user’s perspective (experience of and satisfaction with the system) can be used as a reference point for the evaluation. In fact, both of these perspectives are only a part of what we need to measure. In this sense, we need to find an external unit of measurement able to generalize the relation between the designer and user mental models. This standard unit we want to introduce can be observed only by introducing an external model (i.e., evaluator’s model), which can be used for estimating the distance between the two actors involved in the intrasystemic interaction. This model should be based on the available guidelines, for example, Web Content Accessibility Guidelines 2.0, heuristic list, design principles, etc., and usability evaluation methods (UEMs) for subjective- and objective-oriented observation. An evaluator’s model based on methods of interaction assessment will be able to introduce a new conventional unit of measurement, the reliability of which will be granted by the agreement of the international scientific community. Moreover, this new unit of measurement should also conform to the principle of economy (i.e., efficiency and efficacy), meaning that it should reduce the cost of identifying interaction problems.

Interaction problems are the unit in which the distance between user’s and designer’s mental models is measured (Figure 14.6). The evaluator’s mental model, just like the other two, is composed of the evaluator’s expertise and knowledge, but two other components also influence the evaluation process:

1. Standards the evaluator should consider when evaluating the interface properties (accessibility and usability) are determined by the relevant international guidelines.

2. The techniques actually applied by the evaluator for evaluating accessibility, usability, and satisfaction (see for a review Borsci et al., 2013, 2015). Using a particular technique forces the evaluator to adapt his or her mental model to the perspective endorsed by the technique. In other words, because the evaluator’s model is influenced by the techniques used to do the evaluation, the outcome of the evaluation is strongly dependent on the choice of techniques.

At the end of the evaluation process, the evaluator should arrive at estimates of accessibility, usability, user satisfaction and, indirectly, the distance between the designer’s and user’s mental model; this corresponds to the distance between the technology functions—the conceptual model created by the designer’s mental model—and the users’ perception of the functions of the technology. The evaluators obtain the measure of the interaction distance matching the errors of the system, analyzed by expert analysis (objective-oriented approaches) with the problems observed by the users testing the system (subjective-oriented approaches).
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14.4 Applying the UX Concept to the Design of Rehabilitation Systems

14.4.1 UX in the Assistive Technology Assessment Process

By using the integrated approach in the rehabilitation system, we might consider that the UX evaluation is not solely concerned with users’ experience with an assigned technology,
but also users’ experience of the entire assistive technology assessment (ATA) process functioning (i.e., action of the center for technical aid), that can be considered as the degree of accessibility and usability of the service.

In fact, the assignation process of a center for technical aids may be considered as a system interface itself by which a user can reach a goal. In this sense, we can evaluate the UX of the ATA process on two levels (Figure 14.7: see Section I, Figure I.3 for the color version):

1. The first level concerns the UX evaluation of the ATA process (i.e., degree of accessibility and usability in the relationship between the users, and the center for technical aids). This level of evaluation is linked to managerial solutions that are able to grant access to and use of the service. While this is a long way from the classic use of UX evaluations, concerning the economical and managerial dimensions, it is necessary for guaranteeing the correct evaluation of the assistive technology (AT) (second level). Indeed, a good ATA process is the best guarantee of a satisfactory match between user and technology.

To do that, the ATA process should be evaluated by those dimensions, described by Scherer and DiCowden (2008), of well-being that involve person, milieu, and technology.

Accessibility at this level corresponds to the possibility and the satisfaction of the contacts, which are measured in terms of the users’ perceptions of the costs perceived of accessing the service and using it to achieve their goals, the availability of the service (availability), the ease with which users can contact

![Figure 14.7](image-url)

**FIGURE 14.7**
Matching Person and Technology model, as shown in this diagram, with AT as the example, occurs within and requires assessment of the context of environmental and personal factors. (See Figure I.3, page 8, for color version.)
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the service (comfort), the users’ expectation (appearance), and the users’ perceptions of the quality of the service (or an objective measure of service quality). The efficiency of the ATA process is guaranteed by the collection of data and by the center for technical aid’s staff (multidisciplinary team). Efficiency, defined as the “Resources expended in relation to the accuracy and completeness with which users achieve goals” (ISO, 1998), is measured in terms of the costs to the users, in time and effort, of obtaining the AT. In this step, the efficiency of the process, defined as “Accuracy and completeness with which users achieve specified goals” (ISO, 1998), implies efficiency under ideal conditions. In fact, before the users’ UX evaluation of the AT and the use of the AT in a daily life condition, it is impossible to measure the actual effectiveness of the process or to measure user satisfaction.

2. The second level is the UX evaluation of the assistive solutions (i.e., the matching of users with technical solutions). This step is the core of the matching process, when the user is involved in testing the AT and evaluating the UX. After the user has been matched with an AT device, it is possible to measure the real-world effectiveness of the device and the user’s satisfaction with the AT and with the ATA process using questionnaires (Figure 14.8).

**FIGURE 14.8**
Dimensions and Measures of the UX evaluation of the model’s functioning of the ATA process of a center for technical aid. In this schema, the evaluation of the UX of the AT is part of the evaluation of the efficiency and efficacy of the relationship between the user and the center for technical aid.
Evaluation of the UX of AT is one of the most important steps toward achieving the rehabilitation priority indicated by the World Health Organization, that is, “to ensure access to appropriate, timely, affordable, and high-quality rehabilitation interventions” (WHO 2001, p. 121) and to provide ATs that are “suited to the environment” and “suitable for the user” alongside “adequate follow-up to ensure safe and efficient use” (WHO and the World Bank 2011, p. 118). In fact, evaluation of the UX is relevant to both users’ interactions with AT and their assessment of the entire ATA process.

Another application of the UX framework is in product design. In the following sections, we describe the use of the sonification concept to create a particular kind of technology for blind users in order to illustrate how the concept of UX can be used to innovate and create opportunities for disabled people.

14.4.2 Sonification of the System

The way humans represent space has long been a subject of scientific discussion. Many authors have investigated whether spatial representation is directly guided by visual experience or is based on other sensory pathways that allow equivalent spatial representations. Although some authors have argued that visual experience is of the utmost importance for the processing of spatial cues (Thinus-Blanc and Gaunet, 1997), there is a broad consensus that spatial representations of information are independent of the way in which the sensory inputs are displayed. Some studies have shown that blind subjects are better at processing spatial auditory inputs than sighted people (Avraamides, Loomis, Klatzky, and Golledge, 2004; Mast et al., 2007; Zimmer, 2001). Moreover, as Bryant (1992, 1997) pointed out, blind people show a motion ability that is functionally equivalent to the visually guided method used by sighted people to perform spatial exploration tasks, but relies on natural acoustic cues. Starting from these suggestions, an amodal system of spatial representation has been proposed by explaining the involvement of the auditory, haptic, and kinesthetic information in the spatial mapping processing of people with visual disabilities (Millar, 1994). These findings conflict with other studies, which suggest that spatial understanding is directly related to visual experience and that spatial impairments are owing to a lack of visual experience (Ungar, Blades, and Spencer, 1997).

Starting from these findings, over the last 30 years there have been many research studies in various fields investigating ways to transmit spatial information through nonvisual sensory channels and particular attention has been paid to sonification methods as an alternative to traditional visual and haptic methods. One would expect this alternative approach to convey spatial information to be particularly useful in complex scenarios, for example, where there is visual overload, several distractors or incomplete signals owing to visual noise. Because sound conveys information about the spatial location of its source (Brunetti et al., 2005, 2008) it seems to be able to communicate the complexity of either static or dynamic data representations by preserving the relationships involved. Kramer and colleagues (1997, p. 3) defined sonification as “the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation.” Since the 1980s, an increasing amount of research—particularly in computer science and related fields—has focused on various methods of conveying spatial information through nonvisual sensory channels to improve nonvisual access to spatial information. For example, in the late 1980s, some researchers designed and tested several systems that used sounds to represent spatial cues and showed that human–computer interaction could be improved by means of nonverbal acoustic signals delivered through a graphic interface (Blattner, Sumikawa, and Greenberg, 1989; Gaver, 1986; Sumikawa,
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Blattner, Joy, and Greenberg, 1985). In the 1990s, Barfield Rosenberg, Levasseur and colleagues (1991) and Brewster (1997, 1998) designed nonspeech interfaces based on earcons, that is to say musical patterns providing navigational cues to hierarchical menus. These authors analyzed blind users’ recognition performance after a session of interacting with the interface to demonstrate efficacy of the nonverbal acoustic items. Blind subjects’ performance on several recognition tasks was highly accurate, indicating that the system was useful for spatial orientation tasks (Barfield et al., 1991; Brewster, 1997). Many researchers proposed loudspeaker-based systems in order to maintain the correspondence between the visual and acoustic spatial positions of items. For example, Lakatos (1993) proposed a system based on speakers transmitting complex auditory-spatial signals to analyze the pattern recognition performance of sighted users and both Golledge, Loomis, Klatzky, Flury, and Yang (1991) and Shinn-Cunningham and colleagues (1996) designed systems that simulated realistic sound sources in several locations using loudspeakers.

Using sonification techniques in the design process seems to be helpful in the case of mobility aids, for example, electronic travel aids (ETAs) that are able to “detect the environment within a certain range or distance, process reflected information, and furnish the user with certain information in an intelligible and useful manner” (Farmer and Smith, 1998, p. 238). Sonar techniques are the basis of the most commonly used mobility aids for blind people; they allow users to perceive spatial information about the environment by means of a technology that transduces an ultra-sound signal into an auditory or haptic feedback (Kay, 1964). Farmer and Smith (1998) suggest that ETAs could be split into four categories:

1. Devices with a single output that are used to warn the user about the presence of objects, for example, devices emitting audiotactile feedback indicating the obstacles encountered in the user’s path—for example, the Mowat Sensor (Morrissette, Goodrich, and Hennessey, 1981) or the Sonicguide (Kay, 1974).

2. Devices with multiple output that warn the user about the presence of objects, for example, the Laser Cane proposed (1973, 1974), a walking cane that receives and transmits spatial signals to help blind people to explore and move in an urban environment.

3. Devices providing both object preview and environmental information, for example, Kay (2000, 2001) Advanced Spatial Perception Aid Technology—KASPA, an ultrasonic device that takes about a month to learn to use and is designed to allow users to avoid obstacles when moving about in the environment.

4. Devices using artificial intelligence, for example, the Sonic Pathfinder, a sonification tool (Heyes, 1984) designed to help blind people to avoid obstacles by transducing the objects in front of the user into musical notes that are conveyed by five input/output loudspeaker devices.

All technologies and models described in the above-mentioned studies aim at providing sensory substitution systems for blind people, but none of them seems to have followed an effective user-centered approach in the design process. Most of the above-mentioned studies were based on an objective design process; users were only involved once the prototype had been produced, which meant that the subjective perspective, which is fundamental to an analysis of the components of the interaction between user and the sonification interface, was neglected.

One of the first attempts to take a user-centered approach to building a sonification system was that of Meijer (1992). Meijer carried out experimental analysis of the vOICe
system in an everyday life context. The vOICe system was software designed to “allow blind people literally to see through sounds” by providing a continuous horizontal scan of the real-life environment, which was recorded by a head-mounted camera that analyzed and translated the surrounding scene into a sine wave-based acoustic signal system. Functional magnetic resonance imaging (fMRI) has been used to analyze neural activation in sighted subjects and blind subjects using the vOICe system during object recognition tasks (Amedi et al., 2007). The authors found when subjects were using the vOICe system for object recognition the auditory stimuli it produced activated lateral-occipital tactile visual areas that are generally used to encode visual spatial information (Merabet et al., 2008). More recently, Zhao’s group at the Human Computer Interaction Laboratory, University of Maryland described a new sonification technique for transmission of georeferenced data through haptic and auditory signals (Zhao, Plaisant, and Shneiderman, 2005; Zhao, Plaisant, Shneiderman, and Duraiswami, 2004) that formed the basis of a new system called iSonic that allows people with visual disabilities to explore georeferenced maps using a combination of haptic and auditory information. The usability of the iSonic device was assessed in people who had been totally blind for a long time (Zhao, Plaisant, Shneiderman, and Lazar, 2008), blindfolded sighted people, and people with congenital or acquired blindness (Olivetti Belardinelli et al., 2007). Based on these usability studies, the authors suggested that during spatial orientation, totally or partially blind subjects tended to use a body-centered navigation strategy rather than an allocentric strategy, as is typical in mental rotation and scanning tasks (Delogu et al., 2010; Olivetti Belardinelli, Federici, Delogu, and Palmiero, 2009).

14.4.2.1 Application of a UX Framework for Designing a Sonified Visual Web Search Engine

In 2009 the Department of Computer Engineering (DIEI) of the University of Perugia and the Interuniversity Centre for Research on Cognitive Processing in Natural and Artificial Systems (ECONA) implemented a sonificated system on WhatsOnWeb (Di Giacomo, Didimo, Grilli, and Liotta, 2007), an accessible visual web search clustering engine that transmits indexed information related to a query in one single page by using graph-drawing methods to represent semantically clustered data. In this way, WhatsOnWeb is able to overcome the efficiency limitation of the top-down representation (the Search Engine Report Pages—SERPs) adopted by the commonly used search engines (Federici, Borsci, Mele, and Stamerra, 2008, 2010). The sonificated version of WhatsOnWeb has been tested on blind and sighted users using the Partial Concurrent Thinking Aloud technique (Federici, Borsci, and Mele, 2010; Federici, Borsci, and Stamerra, 2010), an evaluation protocol that overcomes the limitations of concurrent and the retrospective verbal protocols for evaluations involving blind users. In this usability study, blind subjects performed better at identifying errors of interaction than sighted people at a task involving spatial exploration guided only by auditory cues (Mele et al., 2009; Rugo et al., 2009). By making it easier for users with disabilities to map the elements in the interface, sonification significantly improves the accessibility and usability of web interfaces (Mele, Federici, Borsci, and Liotta, 2010).

Taken together, these studies suggest that sonification is an effective method of transmitting spatial information (e.g., graphic or environmental data). Many studies have shown that people with visual disabilities can demonstrate spatial capabilities equivalent to those of sighted users on both spatial orientation and spatial recall tasks. Based on this evidence many authors support the “amodal hypothesis,” namely that blind people use an amodal system for spatial processing of auditory, haptic and kinesthetic information. However,
almost none of the systems mentioned in the previous section were developed using a user-centered approach based on the needs of end-users. Lengthy training is required to use most of the proposed sonification tools effectively and they may induce cognitive overload.

The role of both user-centered design and the integrated model of interaction evaluation is today a main point for developing ATs that are mediators that are able to allow users to overcome their (virtual or physical) environment barriers. In this section, we have discussed the use of a UX framework to develop a sonification-based communication technology—WhatsOnWeb—that users can interact with via several alternative input devices (e.g., brain computer interaction). In Chapter 16 of the first edition of this handbook, Liotta and colleagues (2012) analyzed the design and evaluation of WhatsOnWeb and telemedicine tools (NuRhea Desk) that were described not just as methods of helping users achieve their goals (i.e., as AT) but also as eAssistive Solutions (eAS) that could, in the contexts in which they are used, increase users’ well-being.

14.5 Conclusions

This comprehensive review of usability standards, combined with an in-depth analysis of the difference between usability and the UX concept, has provided the basis for a discussion of applications of the UX framework in the field of rehabilitation. The chapter is divided into four parts:

1. The first section illustrates the different approaches to the UX concept and the fields in which it is applied. The UX perspective is a holistic perspective based on how a user feels about using a system or, according to the ISO (1999) definition, “a consequence of the presentation, functionality, system performance, interactive behavior, and assistive capabilities of an interactive system, both hardware and software.”

2. In the second section, we describe the usability and accessibility theoretical constructs and how they are related to the UX perspective. We introduce the concept of accessibility and usability under the UX theoretical approach. We also provide a brief overview of international usability standards.

3. The third section introduces an integrated model of interaction evaluation, a new conceptual perspective that is based on the UX framework and focuses on the intrasystemic dialogue between user and system within the interaction environment. In this approach, evaluating accessibility and usability becomes a bidirectional way of observing the person–technology interaction rather than merely objective or subjective factors.

4. Finally, in the fourth section, we present various examples of the application of the UX framework to the design of systems for rehabilitation. First, we present an analysis of the application of the UX framework to the ATA process and then we provide an overview of the state of the art in sonification methods. Finally, we introduce a visual sonificated web search clustering engine called WhatsOnWeb, a new communication technology developed using a user-centered design process.
An integrated model of interaction is used for evaluating the interaction between user and eSystem. The evaluator's mental model is used for evaluating the relationship between the designers’ and the users’ mental models from objective and the subjective points of view. The new perspective endorsed by the chapter is that the UX concept can be used not only to set up an evaluation of users’ interactions with AT, but also to organize and evaluate the ATA process and to design (or redesign) technologies to overcome the barriers to use that disabled users typically experience. The redesign of a sonificated web search engine is presented as an example of the growing need to use a UX-based approach to AT design.

14.6 Summary

This chapter discusses the relationship between the accessibility and usability constructs and how they relate to the UX theoretical approach. We present an integrated model of interaction evaluation, a new evaluation perspective based on UX that is intended to be used as a framework for evaluating users’ interactions with AT and to organize and evaluate the ATA process.

References


Meloni, F., Federici, S., and Dennis, J. L. 2015. Parents’ education shapes, but does not originate, the disability representations of their children. *PLoS ONE*, 10(6), e0128876. doi:10.1371/journal.pone.0128876


15

Gesture, Signing, and Tracking

Michael P. Craven

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15.1 Introduction

There is a wide and growing range of physical input devices for (or integrated into) PCs, mobile phones, games consoles, or other devices that depend on tracking bodily gestures, which promise to make computing, environmental control, and mobility more accessible, facilitating alternative and augmentative communication or supporting rehabilitation.

This is a particularly exciting time for innovators of assistive technologies since gestural input is fast becoming mainstream, with consumer level eye tracking and virtual reality being marketed for games and leisure, taking it out of the research and development setting and into the homes of the general population, which is reducing the price barrier and encouraging application developers. A variety of motion-tracking systems are
already present in well-known games consoles, and their capabilities continue to improve. Furthermore, contemporary mobile devices are packed with features that can detect motion and touch.

This chapter takes a holistic approach to gesture-based systems, focusing on evaluation techniques and, where these exist, identification of relevant standards, and a summary of some best practices offered in the literature for their application in assistive technology assessment (ATA). Examples that illustrate these techniques are presented as summaries of case studies from the literature.

### 15.2 Physical Input Devices and Gestural Interfaces

When considering the body as an input device, areas of anatomy commonly viewed in assistive technologies that use gestural interaction include one or more of the following: upper limb (shoulder, arm, hand), head (eye, mouth/tongue, forehead), and to a lesser extent lower limb (leg, foot) and trunk.

Devices that afford gestural input detection include mice and trackballs, stylis, joysticks, eye trackers (including glasses), light sensors (visible or infrared, from a video display or other light source), feature or object trackers (with images from a single visible, infrared or thermal camera, stereo cameras or depth sensor), three or six degrees-of-freedom in-air trackers (as typically found in virtual reality systems), which may include a glove or vest, touchscreen interfaces of smartphones etc., pressure or force sensors, and devices that use near-distance hover detection, ranging, or intersection techniques. Accelerometers, rotation sensors, and gyroscopes embedded in smartphones and wearables (smartwatches, wristbands, clothes, shoes) also readily detect motion. Recent innovations being developed for mobile devices and wearables include miniaturized ultrasound or radar transducers. Some input devices include detection of single clicks/taps or multiple touch events in addition to motion.

A full taxonomy of gestural interfaces is therefore quite complex, but it can readily be viewed that the most common interactions can be roughly divided into (a) 2D point-and-click or in-air gestural inputs that result in a stream of \((x,y)\) screen coordinates, alone or together with 1D clicks, taps, or touches (b) fully 3D gesture tracking that results in a sequence of location, acceleration, or rotation coordinates and (c) systems that capture 1D information such as finger flexion from a glove. To this can be added interactions that employ enhanced features of single contacts such as pressure sensing, and those that employ multiple contacts, for example, from two or more touch, hover or intersection events. Some camera-based techniques may use image/object recognition algorithms to extract 2D or 3D shape and optical properties such as color, for example, extraction of skin color as an image segmentation technique in sign-language recognition algorithms. Similarly, signal processing techniques are used for extracting gesture information from ultrasound and radar sensors.

A basic illustration of a range of devices is shown in \textbf{Table 15.1}. The products listed are mainly chosen as either examples of consumer products or innovative assistive technologies that have been subject to evaluation in the academic literature. It is not intended to be exhaustive and new devices and products are continually emerging. Some newer technologies being investigated for use in gestural interaction are cited at the end of this chapter.
15.2.1 Standards for Principles and Requirements

As introduced earlier in this volume (Chapter 14), ISO 9241 is a multipart standard from the International Organization for Standardization (ISO) covering the ergonomics of human–computer interaction. One part of the standard ISO 9241-400:2007 “Principles and requirements for physical input devices” covers the more common devices mentioned above and also includes the ergonomics of keyboards and legacy devices such as lightpens. The standard differentiates the following specific aspects of physical input device ergonomics in more or less the same manner as in the above introduction: bodily action (hand and finger, foot, mouth, speech, eye, motion); basic types of task, called task primitives (code entry, pointing, dragging, selecting, tracing); degrees of freedom (single, double, three); property sensed (pressure, motion, position, sound, optical properties).

ISO 9241-400:2007 also lists a set of design requirements in terms of appropriateness of the device for its intended user and the tasks to be performed in the intended environment, operability (obviousness, predictability, consistency, user compatibility, and feedback), controllability (responsiveness, noninterference, reliability and adequacy of device access, control access), and biomechanical load (posture, effort).

A related standard ISO 9241-410:2008 considers design criteria for the different types of physical input devices.

Depending on the device, to ensure good usability, some criteria address design of the externals and internals of the hardware and software, whereas others are about the

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**TABLE 15.1**
Examples of Physical Input Devices and AT for Gestural Interaction

<table>
<thead>
<tr>
<th>Device</th>
<th>Interaction(s)</th>
<th>Coordinate System</th>
<th>Events</th>
<th>Enhancements</th>
<th>Example Products and Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse</td>
<td>Point and click</td>
<td>2D</td>
<td>Mouse up/down buttons</td>
<td>Scroll wheel</td>
<td>Generic mouse, trackball etc.</td>
</tr>
<tr>
<td>Touch pad or screen</td>
<td>Point and sense</td>
<td>2D</td>
<td>Touch, Double touch</td>
<td>Hover, pressure</td>
<td>Generic mobile touchscreen, Gest Rest (Carrington et al., 2016)</td>
</tr>
<tr>
<td>Camera(s)</td>
<td>Image/object detection</td>
<td>2D/3D</td>
<td>Video frame capture</td>
<td>Depth, recognition, thermal imaging</td>
<td>Kinect (Standen et al., 2015), Leap motion (Smeragliuolo, Hill, Disla, and Putrino, 2016), Camera Mouse (Betke, Gips, and Fleming, 2002),</td>
</tr>
<tr>
<td>Eye tracker</td>
<td>Gaze detection</td>
<td>2D/3D</td>
<td>Eye presence, stream of gaze fixation points</td>
<td>Head facing direction, glasses</td>
<td>Tobii products, for example, Dynavox, Pro Glasses</td>
</tr>
<tr>
<td>In-air tracker</td>
<td>Anatomical point or feature location</td>
<td>3D + rotation on each axis</td>
<td>Continuous data stream from multiple locations</td>
<td>Glove</td>
<td>Polhemus products, GesRec3D (Craven and Curtis, 2003)</td>
</tr>
<tr>
<td>Glove</td>
<td>Hand pose and finger motion</td>
<td>1D/3D</td>
<td>Data from multiple digits</td>
<td>3D in-air tracker, for example, for hand location</td>
<td>Various products and systems</td>
</tr>
<tr>
<td>Vest/jacket</td>
<td>Trunk and shoulder motion</td>
<td>1D/3D</td>
<td>Data from accelerometer</td>
<td>Biosensing</td>
<td>Various products and systems</td>
</tr>
</tbody>
</table>
device’s relationship to the environment. An example of the former is the requirement to provide a hardware or software “lock” for a mouse or other 2D input device to facilitate dragging, tracing, or freehand input so that the user does not need to hold down a button. An example of the latter is the requirement to make it possible for the user to anchor their limb, that is, to create a stable relationship between a hand and the point of action, for example, rest a palm on a table. We can note that in assistive technologies an input device may itself be anchored, for example, joystick on a motorized wheelchair. In addition, for gestural input, it will be necessary to consider the potential for impairment of usability owing to poor arrangement of equipment with respect to the user’s body, for example, occlusion of a sensor such as blocking a camera’s field of view.

Evaluation of performance based on these criteria must then be developed for the particular devices, users, and environments in question.

15.2.2 Holistic Approach to Gestural Interaction

For the purpose of evaluating assistive, augmentative, or rehabilitation technologies, a holistic approach to ATA for gestural input devices and tracking technologies will be explored. This approach is hopefully justified by highlighting some generally similar features of the technologies while describing some key differences.

One similarity across gestural input devices is the acquisition of 2D or 3D coordinates to describe the motion or to record contact points. A motion data stream may be a more or less smooth continuous transition or one that is more discrete, such as with eye tracking where the eye’s direction of gaze moves rapidly from one point to the next, known as saccades. Specific motor impairments also affect an individual’s smoothness of motion. Tapping events may have 2D coordinates (such as mouse clicks or touches) or else the act of clicking is simply recorded (a 1D gesture). Magnitude of force/pressure and angles of flexion/extension are other examples of 1D data collection of general relevance in gesture interaction. If information about ordering of input or speed is required by the software, timing data or sample number will also be recorded.

Then, the individual’s continuous motion must be segmented, that is, split up to determine the end of each gesture. Segmentation of a gesture coordinate stream will be made explicitly or implicitly by the user’s action or else must be determined by an algorithm. For example, if a click event is used to make a selection after motion (such as point-and-click input), then segmentation of the preceding motion is being made implicitly by the user’s clicking action. Alternatively, a “reserved action” can be built into the system such as the use of “pigtail” gesture to end a stroke, as used in Scriboli, an early Microsoft pen interface (see Wigdor and Wixon 2011, p. 99).

For interfaces that do not use explicit selection at the end of a physical movement, the “Midas Touch problem” (Jacob, 1991) must always be addressed, that is, was the user’s action intentional or not with respect to the interaction task in question? To avoid this problem, isolation of intended action can be achieved through the use of a period of “dwell time,” where the user must remain still at the end of the gesture. For example, when using an eye tracker with dwell time, the user fixes his gaze on an object for a second or so in order to select it, whereas shorter glances are ignored as selection events. Setting the dwell duration is critical as it must be sufficiently long to avoid false positives but not so long as to slow down the interaction. The user must also understand and get used to the technique.

Segmentation may instead be dwell-free and integrated into a recognizer, such as in continuous online recognition systems, for example, eye typing or sign-language recognition.
where there is sufficient information in the gesture set to enable the system to ignore unintended gestures and distinguish all intended ones. Dwell-free methods may also involve predicting the trajectory and classifying the gesture before it is finished, to increase production speed. Some gesture recognition systems use a combination of methods for segmentation, for example, dwell/low velocity thresholds together with pattern recognition techniques (Craven and Curtis, 2003).

Alternatively, a “reserved clutch” can be employed whereby a gesture is considered to be intentional only when the clutch is engaged, for example, use of a “pinch” hand pose where a gesture is only recorded when finger and thumb are together (Wigdor and Wixon 2011, p.100). Another example of this is the two-step gaze interaction in Tobii products, for example, Dynavox PCEye Go. One further solution to the Midas Touch problem is to use a multimodal interface, for example, gesture combined with speech where the action from gesturing is gated by a speech command or vice versa (Wigdor and Wixon 2011, p.101).

Visual acuity is of particular relevance for accessibility of touchscreens. In a recent research paper, Luthra et al. (2015) considered the accessibility of gestural touch interaction in smartphone screen readers such as Voiceover in iOS and Talkback in Android by blind and visually impaired users. The authors offered insights into the forms of gestures that cause problems such as closed shapes and those with strictly defined angles.

15.3 Functional Evaluation of Physical Input Devices

15.3.1 Standard for Functional Evaluation

The technical specification ISO/TS 9241-411:2014 “Evaluation methods for the design of physical input devices” provides a good basis for functional assessment of gestural input for assistive technologies (and we can note that it also covers evaluation of keyboards, although this is not considered here).

Measurement of task precision in this specification is similar for mice, trackballs, and other 2D input devices and relates to defined interaction tasks. Task primitives in the specification include the following: movement along one or two perpendicular axes or at any angle; feedback and prompting such as showing the mouse cursor or providing visual, auditory, or tactile feedback when a target is hit; and target acquisition, either manual, for example, mouse clicking, or automatic, for example, eye tracker using dwell time.

To evaluate an input device on different tasks, effective index of difficulty $I_{DE}$ (in units of bits) is first defined as $\log_2 \left[ \frac{(d + w_c)}{w_e} \right]$ for selection, pointing or dragging tasks or $d/w_e$ for tracing tasks, where $d$ is the distance to the target and $w_e$ is the effective target width (which is a derivation of the actual feature width). Task precision is divided into four levels of difficulty C1–C4 where the highest is $I_{DE} > 6$ and the lowest $I_{DE} < 3$ such that any test should ideally include a range of difficulties.

Figure 15.1 shows three input evaluation tasks: single directional tapping, multiple directional tapping, and the tracing task. For the single directional tapping task, the user moves along one axis and selects targets of width $w$ separated by a distance $d$, repeated 25 times. The difficulty index is as defined above. For the multidirectional tapping task, the clicks are made across a circle, as close to the diagonal as possible, selecting the numbered targets in turn. The tracing task involves moving an object 360° between concentric circles without touching either edge. The dragging task according to the specification (not
shown), could involve selecting from a pull down menu or moving an object between windows. Other tests may be devised to assess free-hand or “grasp and park” actions.

Throughput in bits per second, a measure of input speed, is then defined for all tasks as $I_{de}/t_m$, where $t_m$ is the movement time.

### 15.3.2 Text Production via Gesture

In addition to the functional assessment of 2D interaction, a number of metrics for text entry throughput are suitable for assessing general PC input and Augmentative and Alternative Communication (AAC) applications such as Voice Output Communication Aids (VOCA) or eye typing.

Metrics for text entry are usefully summarized by Hansen and Aoki (2012). The metrics are based on text production speed and errors or corrections made, as follows: Words per minute (WPM); Rate of backspace activation (RBA), Keystrokes per character (KSPC); Minimum string distance (MSD)—the number of substitutions required to correct a word; Overproduction rate (OR)—ratio of actual to minimum number of keystrokes. These metrics are suitable for different means of physical input other than gaze. The authors also consider two gaze specific metrics suitable for onscreen eye typing: Read text events per character (RTE)—the ratio of the number of gazes to the onscreen text field and the number of characters actually typed; Attended but not selected rate (ANSR), which is the ratio of the number of keys gazed at but not typed (for example, gazed at less than the threshold dwell time) and the number of characters actually typed.

### 15.3.3 Comfort and Training

ISO/TS 9241-411:2014 includes metrics for user comfort. There are two sets of rating scales: one for independent evaluation of a single device and the other for pairwise comparison.

The Independent Rating Scale for single devices is a seven-point scale comprising of the following indices of comfort and fatigue:

- Force required for actuation (Very uncomfortable → Very comfortable)
- Smoothness during operation (Very rough → Very smooth)
• Effort required for operation (Very high → Very Low)
• Accuracy (Very inaccurate → Very accurate)
• Operation speed (Unacceptable → Acceptable)
• General comfort (Very uncomfortable → Very comfortable)
• Overall operation of input device (Very difficult to use → Very easy to use)
• Finger/Wrist/Arm/Shoulder/Neck fatigue (Very high → None, each part of body rated separately)

The Dependent Rating Scale for comparing two devices A and B uses a five-point scale (Most negative → Most Positive for the general indices and Extreme → None for the fatigue indices) for input device A, and −1 (Worse), 0 (Same) or +1 (Better) rating for device B.

In addition to these rating scales, the Borg CR10 scale (Borg, 1982) is suggested for determining perceived exertion effort for arm, shoulder, and neck. The standard also stresses the need for training of participants on unfamiliar devices and checking that learning effects have stabilized before testing. The training process should present a standard set of instructions whereby the user is asked not to correct errors during stabilization and a statistical technique such as Duncan’s Multiple Range Test (Duncan, 1955) is used to check that stabilization has been achieved.

15.3.4 Caveats for Real-World Deployment

There are a number of issues to be considered for enabling good translation from the laboratory to the real world, usefully described by Hill et al. in the context of Brain Computer Interfaces for AAC (Hill, Kovacs, and Shin, 2015). Four critical issues for assessment were identified: matching system features to individual requirements at multiple levels (language support, user interface, and hardware), aligning to a standard functional and disability assessment framework, focusing on language as the primary level of system assessment, and direct measuring of end-user benefit during and after intervention. Heikkilä and Ovaska (2012) list some particular caveats about transferring evaluation results from lab testing, which are summarized as follows:

• Lab tests with preset text do not require the thinking time that is involved in real-world composition; therefore, production throughputs are likely to be lower outside of the lab.
• Users may act differently in the lab when reading text if they are not required to understand the content.
• A/B comparisons between different input devices may not be “fair” if the user is much more familiar with the baseline system (such as mouse or keyboard input).
• Lab-based methods may use calibration methods, for example, chin rests, that would be unacceptable to users outside of the lab, so it will be important to test calibration in the real-world environment.

15.3.5 Case Studies 1: Camera Mouse

To illustrate the above functional evaluation techniques, the first case study for this chapter will now be introduced. Camera Mouse (Betke, 2002), which was developed some 15 years ago, is a PC application that uses video to track body features for controlling computer
mouse motion and employs dwell time to generate mouse clicks. The interface was designed for persons with limited voluntary motion or dexterity and limited ability to vocalize (so unable to reliably use speech input as an alternative), but are able to control their head or move a finger. Owing to low cost of high resolution webcams and free download of the software, Camera Mouse is a readily available camera-based system for gestural input.

To select a bodily feature, the user is helped to click a preferred point on a video of themselves shown on the screen and the software then extracts a small square template image around that point, which is tracked in subsequent video frames. The position of the moving template becomes the cursor position. In the original paper, the camera was tested with eye, lips, and thumb. The authors gave insights about the quality of the tracking (such as benefits of image contrast within the template; effect of the relative size of the feature in the video field; limits to speed of movement before tracking is lost, and lighting levels) and also discussed a number of set-up criteria, including choice of body feature for the tracking, dwell time, and boundary radius for generating mouse clicks (defaults 0.5 seconds and 30 pixels). Horizontal and vertical gain can also be set separately.

Other researchers have developed the Camera Mouse concept further and have carried out more systematic user testing. Magee et al. (2015) recently reported a comparison of Camera Mouse (CM1000, with a dwell time of 1.0 seconds) and Camera Mouse plus ClickerAID (CM_CA), which supports selection by means of single muscle contraction chosen to suit the user (e.g., eyebrow, jaw, cheek, chin), and Touchpad input for baseline comparison with both CM systems. Initial trials with 29 persons (presumed to have no motor disability) were performed on a standard multiple directional tapping task, FittsTaskTwo. Mean movement time, throughput in bits per second, dependent variable error rate and “target re-entry” rate were reported. It was seen that the touchpad outperformed both CM alternatives in speed and throughput but CM_CA was better than CM1000. Target re-entry rate was similar for all devices but error rate was highest for CM_CA. The authors investigated the reason for errors and observed differences between individuals in that some CM_CA users were clicking before the mouse was at rest (which is not possible with dwell-based CM) and some Touchpad users had made errors due to dragging the cursor after touching while other users made zero errors.

The CM_CA system was then tested by a single individual (coauthor with neuromuscular disease Friedreich’s Ataxia) in his work office environment, with Camera Mouse tracking his nose and ClickerAID (via a headband sensor) controlled by raising his brow muscle. CM_CA was tested against Camera Mouse alone with two different dwell times CM1500 (1.5 seconds) and CM2000 (2.0 seconds) and using a Trackball input device (instead of the Touchpad from before) as a baseline comparator. The results revealed that CM1500 provided best speed and throughput followed by CM_CA, and the trackball had the lowest error rate and re-entry rate followed by CM_CA. The user expressed a preference for ClickerAID for clicking, since it required less effort than the trackerball, which required lifting the hand several times between targets in the multidirectional test, but still allowing him to “stay in control” versus CM alone since he was unable to keep the mouse pointer completely still.

It can be observed that the above summary description of a Camera Mouse comparative study is fairly representative of the ISO 9241-411 standard approach to physical input device evaluation with its use of a multidirectional test and reporting of throughput and error metrics. Such an approach enables an evaluator to form a more in-depth assessment of the pros and cons of a new device. Clearly, there were some advantages to the combined CM_CA system for a motor-impaired user even if it was not optimal in any one test. So, whilst the evaluation did not report a systematic evaluation of effort or degree of control,
it is illustrative to see that the “best” solution was not based on test performance alone, but included nonfunctional aspects that were important to the user, and so the innovation was therefore judged superior on a multi-criteria basis. Final points to take away from this case study are that, although the CM_CA system was new to the user, the experiment can still be considered an expert-user study owing to their prior experience with similar systems, and also that the environment of use (workplace office) and seating position was familiar. The next case study will consider in more detail the process of evaluation from a user-centered perspective.

15.4 User-Centered Approach to Evaluation and Customization

15.4.1 The KEE Concept

The success of an assistive technology (AT) requires a user-centered approach. Donegan et al. (2012, 2009, 2006) as part of the COGAIN European programme on Communication by Gaze Interaction developed an action research methodology termed the “KEE” concept—Knowledge-based, End user-focused, and Evolutionary—that was aimed at introducing users with complex disabilities to gaze interaction technology. Although KEE was developed for eye tracking, the reader is encouraged to generalize this useful approach to other input devices.

The authors are keen to indicate that the gaze interaction will be a new skill to learn for most users whether they have a disability or not. Therefore, engaging them in a trial of eye-tracking technology requires careful preparation and planning. The overall philosophy of KEE is to customize each trial with the particular user in mind, with the aim of producing a relaxed but focused environment to try the technology out in, creating a positive experience overall. The objective is to maximize potential for success and to determine the changes that should be made to progress the user to an acceptable real-world outcome.

In KEE, “Knowledge-based” refers to gaining an in-depth understanding of the user, “End-user focused” is about designing a solution to meet an individual’s needs and interests, and “Evolutionary” indicates readiness to change the system in response to the user’s trying out of the technology. To realize the philosophy, KEE considers a trial with the technology in four parts: Pre-assessment process; Calibration process; Assessment Activities; and After the Assessment.

“Pre-assessment” involves fully understanding the individual’s background information: physical, communication, and cognitive abilities. For eye tracking, visual ability is of particular importance. Personal interests are also explored. Then, in the knowledge that the experience may be stressful and put pressure on the participant to do well, it is important for researchers to manage expectations so that any failure is ascribed to limitations of the technology or the experimental conditions, not the user. Other aspects of pre-assessment include adjusting the physical environment such as lighting and deciding if third parties may be present, as too many onlookers could be detrimental for some users.

“Calibration” is about using the information about abilities and preferences to customize the system as far as possible. Examples given for eye tracking are as follows: choice of one or two eye calibration; choice of feedback, for example, should the system speak out letters or symbols; customizing targets so they are visible and comprehensible. Further details include the following: finding the best mounting position for the eye tracker and determining the user’s most comfortable position with respect to it, for example, they may
be more comfortable lying down; organization of targets on the screen to fit the individual’s visual scanning ability, range, and direction of eye movement (which may be more or less impaired in different directions). The degree of customization possible during calibration will of course depend on how flexible the technology platform and software was designed to be.

“Assessment” is divided into three subsections. Before starting, the user is reassured about the expectations of the trial. Introductory “warm-up” activities are then used for presenting less cognitively demanding exercises to begin with to allow the individual to get used to the interface, and then make changes if required. As with calibration, personalizing targets and feedback with familiar and enjoyable themes is recommended at this stage. During warm-up activity, it is possible to try out a range of selection techniques such as dwell time, blinks/winks, or use of switches. Then, the assessment itself can proceed.

“After the Assessment” is also termed the “implementation period” where the potential of the system is realized in the real world and need for further customization is explored, including the potential for the involvement of system developers/manufacturers to make this happen.

15.4.2 Case Studies 2: Use of KEE to Optimize Gaze Interaction with End Users

Donegan et al. describe a number of examples of the use of their KEE approach with end users. In Donegan et al. (2006), it was reported that by using KEE to personalize the gaze interface with her needs and interests, one young end user was able to progress from non-use to writing emails independently, by starting off with a pictorial grid and progressing over time to a text-entry system. For another end user with nystagmus (involuntary eye movement) and involuntary head movement, KEE was used for improving the calibration process and adapting existing software to enable him to write on a $3 \times 2$ grid consisting of a hierarchical sets of words (people, places, alphabet, numeric and punctuation functions, extra functions). In Donegan et al. (2012), a third example of the use of KEE was presented for a user with nystagmus and blurred vision, using the Sensory Software Grid 2 software package. Musical feedback was first used for determining the user’s optimal grid size for gaze interaction. Color contrast of grid squares was initially chosen by trialing a range of foreground and background colors and positioning the writing cells according to preference. Colors, layout, and grid content were adjusted over several iterations, which resulted in a highly customized and personal solution allowing the user to write successfully. Donegan et al. (2009) gives further detail on the first two cases above and several other cases, and adds a more clinical approach to the evaluation methodology with the use of quality of life, depression, and burden scales. It also presents the COGAIN eye-tracking questionnaire that is used for measuring the four aspects of satisfaction and another more general questionnaire to capture frequency of use, ease of learning, learning after 7 days, and overall satisfaction.

The idea of KEE to maximize the results of user-centered evaluation speaks for itself. The authors conclude that there is no such thing as “the best gaze control system.” Instead, interfaces should be customized and evolved to fit with users’ needs and preferences.

15.4.3 Gaze Interaction for Environmental Control and Mobility

The previous section and case study has focused on computer access. Gaze interaction for environmental control and mobility is an area of research, which is ripe for further development. In addition to typical usability assessment, the evaluation of technologies
for control of domestic products and navigation must consider safety, that is, ensure that
the system behaves in a safe manner and enables the user or carer to respond to safety
critical events, for example, “A carer or assistant must be able to stop the wheelchair in an
emergency” (Bates et al., 2012). Technological solutions include adding proximity detec-
tion and alarms as feedback. Evaluation of response time is required to ensure that the
user remains in control.

15.5 Gesture-Based Systems for Motor Rehabilitation

15.5.1 Stroke Rehabilitation Systems

In addition to its use in AT and AAC, gestural interaction technology is finding use in
post-stroke and other muscular skeletal rehabilitation. This can be considered to be an AT
in terms of therapy being taken out of the clinic and into people’s everyday environment.
Research in this field is very active and is continually developing to make use of newer
devices. Much of the research in developing technological solutions for rehabilitation is
focused on stroke survivors with the aim of better fulfilling national guidelines on inten-
sity and frequency of therapy.

If rehabilitation is remote and unsupervised by a health-care professional (one modality
of telerehabilitation), there is a challenge in patient adherence to the therapeutic regimen
and ensuring correct performance of task-specific exercises without compensatory actions
that could limit motor recovery. Gamification is one strategy that is of particular interest
with the aim of motivating patients to perform the recommended exercises on low-cost
platforms (Putrino, 2014). A systematic review of 24 virtual reality and video game ther-
apy studies by Lohse et al. (2014) showed superiority of such games for post-stroke adults
compared to conventional care. Saposnik et al. (2016) recently showed in a randomized
controlled trial that using commercially available games on a Nintendo Wii console was
as safe and similarly efficacious as other leisure activities such as playing cards. Wittman
et al. (2016) showed that self-directed home therapy was safe and could provide a high
dose of rehabilitative therapy.

Standen et al. (2015) explain that while the UK’s National Clinical Guidelines for Stroke
recommend 45 minutes of therapy 5 days a week, patients in clinic are receiving between
half and a quarter of this, and also that time spent on upper limb activities during reha-
bilitation sessions is less than 8 minutes. Furthermore, half of the discharged patients who
are having some symptoms or disability are not referred for additional rehabilitation, and
of those that are sent home adherence is 50%–55%. To address this, the authors designed
home-based and gamified rehabilitation systems based on various technologies includ-
ing a glove tracked by a Nintendo Wii remote and the Microsoft Kinect depth sensing
camera system that is conventionally used with the Xbox games console. Use of mass mar-
ket games console platforms provides low-barrier access to gestural interaction and good
graphics, and places rehabilitation technology in people’s living rooms.

Other researchers have investigated the use of alternative camera-based systems such
as Leap Motion (Smeragliuolo et al., 2016), and there are numerous examples of the use
of commercially available bespoke input devices using, for example, gloves and vests to
capture hand, shoulder, and trunk information more directly (Adamovich et al., 2005;
Delbressine et al., 2012; Steffen, Schafer, and Amirabdollahian, 2013).
15.5.2 Usability of Computer and Wearable Technology in Stroke Rehabilitation

Mountain et al. (2010) investigated usability of home-based telerehabilitation and testing, and highlighted issues concerned with the sensors and methods of attachment, interpretation of on-screen presentation and appropriateness, and acceptability of equipment in domestic settings, and also found the need for users’ education and support throughout the testing period. Parker et al. (2014) examined extrinsic feedback requirement for telerehabilitation and uncovered key elements such as accuracy, measurability, rewarding feedback, adaptability, knowledge of results, and a number of personal and environmental contexts including the previous experience of service delivery, personal goals, trust in the technology, and social circumstances.

Bergmann and McGregor (2011) reviewed user preferences for body-worn sensor systems, which included applications in post-stroke rehabilitation and a number of other clinical domains, looking at both patient and clinician preferences. For stroke survivors, the findings from the literature were that systems should have the following characteristics: minimize incorrect use; have a simple interface; be compact (light and small), be simple to operate and maintain; be usable independently; be available alongside the work of health professionals; provide positive feedback to patients; and motivate users. For clinicians, the preferences were that sensors should be integrated in clothing; have a real-time function; assist the patient in their training; have a library of reference movements; be able to monitor progress; and have training and education embedded to explain how the system works.

15.5.3 Case Studies 3: Evaluation of Stroke Rehabilitation

As they are implementing therapies within clinical practice, it is unsurprising that evaluation of technological solutions is couched more in terms of clinical outcomes compared to AT and AAC. For post-stroke motor rehabilitation, there are a large number of scales (Baker, Cano, and Playford, 2011), which cover function, independence in daily living, and quality of life.

In the virtual reality trial introduced above (Saposnik et al., 2016), the primary outcome in the trial before and after the two weeks of intervention period was upper extremity motor performance measured by total time to complete an abbreviated form of the Wolf Motor Function Test (WMFT) (Wolf et al., 2001; Wolf, Lecraw, Barton, and Jann, 1989) where patients were asked to perform a series of tasks as quickly as possible. Six tasks were chosen from the WMFT (hand to table, hand to box, reach and retrieve, lift can, lift pencil, and fold towel) and the authors added two further tasks: grip strength and flip a card. A number of other tests were used for measuring the secondary outcomes of manual dexterity, quality of life, functional independence, independence in activities of daily living, disability severity, and grip strength. All tests were repeated at four weeks post-intervention. In addition, the kinematics of limb movement was measured before and after the intervention to assess motor learning and assess compensatory motion. Perceived exertion and fatigue were measured after each exercise using the Borg Scale and the adverse events were recorded.

In their trial with the glove and Wifi-based system, Standen et al. (2015) also used a set of clinical measures: WMFT (as above), Nine-hole peg test (Kellor, Frost, Silberberg, Iversen, and Cummings, 1971), Motor Activity Log (Taub et al., 1993), and the Nottingham Extended Activities of Daily Living Scale (Nouri and Lincoln, 1987). In addition, the software logged frequency of use to see how close therapy duration and frequency were compared to the recommended. For each participant, the study recorded the percentage of
recommended use, daily duration of use, and the number of sessions (either no use or 1, 2, 3, or 4+ sessions per day). Interviews were used for exploring barriers and facilitators to use the intervention as recommended. Barriers to use were found to include the technical problems experienced, confidence with technology, dependence on others to use the technology, health problems, competing commitments, and the desire to get back to pre-stroke activities. Facilitators included being able to carry out rehabilitation exercises at any time, motivational aspects of the games, using the system to alleviate boredom, belief in the health benefit and family support.

Psychometric instruments used by Delbressine et al. (2012) to evaluate table-top video games employing an wearable (accelerometer-based) input device included Intrinsic Motivation Inventory (IMI) (McAuley, Duncan, and Tammen, 1989) and an Credibility/Expectancy questionnaire (Devilly and Borkovec, 2000).

From these three examples and the above findings in the literature about usability, feedback requirements, and personal/social contexts, it is seen that evaluation is best conducted using the biopsychosocial principle. The choice of scales will depend on clinical practice and preferences of health-care professionals in the geographical area where the technology is being evaluated. The capturing of users’ individual needs, motivations, domestic arrangements, and social relationships all contribute to a successful evaluation outcome.

15.6 Sign Language Recognition

Sign-language recognition (SLR) is a technology related to gestural interaction that is still in the research or early prototype domain, but it will now be briefly introduced. Cooper, Holt and Bowden (2011) provide a comprehensive review of the state of the art from a few years ago.

SLR is the interpretation of bodily gestures, expressions, or poses for the purpose of communication, as used daily by many deaf or hearing impaired persons. The goal of automatic recognition is real-time translation of sign language into speech or text for understanding by nonsigners or as a means of human–computer interaction. Conversely, although not considered further here, systems that translate text or speech into sign or could support interpreting between different national sign languages are also in this area of interest.

Evaluation of SLR can be considered at different levels. At the lowest level, recognition of hand poses, body posture, lip shape and facial expressions are all very challenging pattern recognition problems, which are being approached with a variety of different artificial intelligence methods. As Cooper et al. explain, SLR has some of the characteristics that also make speech recognition a difficult problem, such as coarticulation. Added to this, however, is dealing with the nonsequential aspects of sign production and obscuration between hands or from clothing. The construct of sign languages also provides many challenges. Nonmanual features (facial expression), sign placement, body shift and positional signs (relationships of hand poses to other parts of the body, other people, and objects in the environment), and adverbs that involve the relative speed of gesture are just some of the constructs that a recognizer must be able to deal with. Also, inter-signer differences are large. At the production level, similar to gestures, throughput of sign production and recognition can be computed, and errors are measured by observation or with respect to standard corpuses of different sign languages.
15.7 Further Reading and Newer Technologies

For reasons of space and maintaining a holistic approach, with the exception of the case studies, this chapter has not gone into any great detail of specific technologies. Some suggestions for further reading are therefore offered, and some interesting newer technologies and applications are highlighted in order to complete the picture.

Applications of eye tracking, including computer access and AAC, mobility, and environmental control, are considered in more detail in the excellent volume from the COGAIN programme *Gaze interaction and applications of eye tracking: advances in assistive technologies* (Majaranta et al., 2012), content from which has been drawn on earlier in this chapter.

For the specifics of touch interaction, although it does not consider accessibility, the edition *Brave NUI world* (Wigdor and Wixon, 2011) is a good introduction to the design challenges for touch and considers the Midas Touch problem in some detail, which helped inform the earlier section on this. *Designing Gestural Interfaces* (Saffer, 2009) is another edition that is mainly about touch interaction. As touchscreens are now ubiquitous and cheap, touch interaction is an area where greater focus on usability is to be expected. One specific AT that is worthy of note with respect to touchpad interfaces is Gest-Rest (Carrington et al., 2016), a prototype set of “chairable” (c.f. wearable) technologies, which integrated switches, touchpad, and force/pressure sensing into wheelchair armrests. The authors evaluated and compared four variants of Gest-Rest using a defined set of gestures to test tapping, holding, directional, and pressure-based input with both manual and motorized wheelchair users, and also collected opinion from physiotherapists and occupational therapists.

Wearables, referred to earlier with respect to usability of telerehabilitation technology, are receiving active attention by researchers. Fitness trackers and smartwatches containing motion-tracking technology are becoming ubiquitous with a low-price barrier. Some products have open application programming interfaces which is encouraging researchers to experiment with their use as gestural input devices, for example, WristRotate (Kerber, Schardt, and Löchtefeld, 2015). Other ideas in the prototyping phase include using smart textiles as input devices, for example, GestureSleeve (Schneegass and Voit, 2016), which uses stroking or tapping gestures on a sleeve to control a smartwatch. With application in wearables, mobile devices and internet of things, Google’s Advanced Technology and Projects (ATAP) division is developing Soli, a gestural interface based on miniaturized radar, which is aimed at processing near-distance finger interactions with virtual buttons, dials, and sliders (Google, 2016), while Chirp Microsystems is a recent university spinout focusing on interaction via on-chip ultrasound (Przybyla, 2015). Analysis of “bio-acoustic” or “vibrotactile” signals from higher rate sampling of accelerometer signals is also under investigation with application in fine gesture classification (Khan, Hammerla, Mellor, and Plotz, 2016; Laput, Xiao, and Harrison, 2016; Shao, Hayward, and Visell, 2016). A clinical application of wearables is falls detection for elderly people using motion sensors embedded into pendants, watches, clothing, or shoes. User evaluation research in this area highlights the importance of both intrinsic and extrinsic factors (Hawley-Hague, Boulton, Hall, Pfeiffer, and Todd, 2014). It can be observed that much of the reporting on developments in the wearables field is to be found in technology-orientated sources. Some adaptation of existing methodologies and standards will no doubt be needed for their functional evaluation and testing with users with impairments.
15.8 Summary

A holistic approach to assessment of gestural input and tracking technology for AT, AAC, and rehabilitation applications has been presented. Case studies have been taken from the literature to cover typical evaluation approaches. These have been selected to introduce lab-based functional assessment and ISO standards for physical input devices (including consideration of user comfort/effort), user-centered approaches for assessing and evolving technology solutions in the real world, and clinical evaluations that include outcomes scales in current use for assessing a patient’s function and daily living abilities, and highlighting the need to address psychosocial factors.

The choice of method will depend on the stage of design of an input device and its application as an AT, in AAC or for rehabilitation. Functional evaluation is most appropriate during technology development, and it is seen that standard tests are available for this purpose. Although these tests are for physical input devices in general and are not specific to users with physical impairment, the Camera Mouse case study shows that they are useful in assessing independent and comparative performance of applications of assistive technologies. Comparison of a single technology against a standard database (such as a sign language corpus) is another approach. It was seen that when users involved with testing are faced with a new interaction technology it is necessary to provide opportunity for training and to ensure stabilization of learning as part of the assessment process, in order to ensure optimal results and perform fair comparisons.

A user-centered method such as KEE is important for summative evaluation of assistive solutions, to explore user preferences with existing technologies and to guide their customization. Although user-centered design philosophy may suggest it is never too soon to bring end users into the design process, it is seen that there are risks in presenting technologies that are suboptimal. Related to this, expectations need to be carefully managed. Making tasks less challenging to begin with and tuning them to a user’s interests are some of the suggested methods to ease the introduction of novel interaction technologies.

Clinical assessment has its own rules, requiring alignment to existing practice and an outcome-based research approach. It is seen that health-care professionals have needs and opinions in addition to caring patients. Therefore, they are ideally considered as a part of assessment in the clinical domain. This is equally important when the AT use is being supported by a caregiver.

References


16

Using Brain–Computer Interfaces for Motor Rehabilitation

Giulia Liberati, Stefano Federici, and Emanuele Pasqualotto

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16.1 What Is a Brain–Computer Interface?

A brain–computer interface (BCI) is a communication system that provides a direct connection between the brain and an external device, such as a computer or any other system capable of receiving a signal, without relying on the brain's normal output pathways or peripheral nerves and muscles (Figure 16.1) (Birbaumer, 2006; Birbaumer and Cohen, 2007; Wolpaw, Birbaumer, McFarland, Pfurtscheller, and Vaughan, 2002). BCIs can be used by persons with neurodegenerative and motor diseases who have lost motor function, such as those affected by spinal cord injury (Burns, Adeli, and Buford, 2014; Rupp, 2014), cerebral palsy (Cheron et al., 2012; Scherer et al., 2015; Taherian, Selitskiy, Pau, and Claire Davies, 2015), stroke (Curado et al., 2015; Ramos-Murgualday et al., 2013; Silvoni et al., 2011), or amyotrophic lateral sclerosis (ALS) (Halder et al., 2013; Kübler et al., 2005; Nijboer et al.,
2008; Riccio, Mattia, Simione, Olivetti, and Cincotti, 2012; Schettini et al., 2015; Silvoni et al., 2016; Simon et al., 2014), to continue communicating and interacting with their environment (Bamdad, Zarshenas, and Auais, 2015).

Because they can support activities of daily living by receiving, sending, producing, and processing information in different forms, and because they can promote neuroplasticity and rehabilitation, BCIs are considered assistive technology (AT) (Powers, Bieliaieva, Wu, and Nam, 2015). Moreover, BCIs are regarded as “cognitive prosthetics” or cognitive support technologies (CST) (Chu, Brown, Harniss, Kautz, and Johnson, 2014), as they can promote the sense of agency and goal-directed thinking in persons with severely impaired mobility, therefore supporting cognitive function that would otherwise be lost due to the lack of action (Liberati et al. 2015a).

The initial attempts to use brain activity for communication date back to the works of Vidal (Vidal, 1973) and Elbert and collaborators (Elbert, Rockstroh, Lutzenberger, and Birbaumer, 1980), who showed that brain signals recorded using the electroencephalogram (EEG) could be used to control the direction of an object moving on a screen. In the following decades, research on BCIs and their applications has grown remarkably, with hundreds of peer-reviewed studies published every year (Powers et al., 2015; Shih, Krusienski, and Wolpaw, 2012), and the appointment of the International Annual BCI Award, created to recognize outstanding research in the field (www.bci-award.com). Different researchers use a variety of terminology to refer to BCIs and their different applications (Powers et al., 2015; Rupp, 2014), including brain–machine interfaces (BMIs) (Schroeder and Chestek, 2016; Vidal, Rynes, Kelliher, and Goodwin, 2016), neural prosthetics (Li, 2014; Sahin and Pikov, 2011; Tsu, Burish, GodLove, and Ganguly, 2015), neural interfaces (Hatsopoulos and
Using Brain–Computer Interfaces for Motor Rehabilitation

Donoghue, 2009; Jackson and Zimmermann, 2012; Wang et al., 2010), and exoskeletons (del-Ama et al., 2012; Jarrassé et al., 2014; Louie and Eng, 2016).

16.1.1 How Does a BCI Work?

A typical BCI system consists of two separate functional blocks, namely a transducer, which translates the person's brain activity into usable control signals, and a peripheral device (Mason, Jackson, and Birch, 2005). The use of a BCI system implies five stages: (i) brain signal acquisition, (ii) preprocessing, (iii) feature extraction and selection, (iv) classification, and (v) application interface (Naseer and Hong, 2015) (Figure 16.2).

BCIs can be invasive or noninvasive (Burns et al., 2014; Chaudhary et al., 2016; Pasqualotto, Federici, and Belardinelli, 2012). Invasive BCIs require surgical implantation of electrodes or multielectrode grids (electrocorticography, or ECoG) (Donoghue, 2002; Donoghue, Nurmikko, Black, and Hochber, 2007; Hochberg et al., 2006). Although these systems have the advantage of providing a high signal-to-noise ratio, they are considered less desirable for clinical applications, as they require a craniotomy, that is, penetrating the skin and removing a piece of the skull for electrode placement (Burns et al., 2014). On the contrary, noninvasive BCIs do not require surgery and can rely on different types of brain signal acquisition such as EEG, magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), and functional near-infrared spectroscopy (fNIRS). In the following paragraphs, we will describe each of these different techniques. Their main characteristics are summarized in Table 16.1.

<table>
<thead>
<tr>
<th>Transducer</th>
<th>Preprocessing</th>
<th>Feature extraction</th>
<th>Classification</th>
<th>Application interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal acquisition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**FIGURE 16.2**

Mode of operation of a brain–computer interface (BCI) system. A BCI system consists of a transducer, which translates the user's brain activity into usable control signals, and a peripheral device. The use of a BCI system implies five stages: (i) brain signal acquisition, (ii) preprocessing, (iii) feature extraction and selection, (iv) classification, and (v) application interface.
16.2 Measuring Brain Activity

16.2.1 Electrocorticography

In ECoG, electrodes can be placed either subdurally or epidurally to detect synchronized post-synaptic potentials at specific locations, defined as local field potentials (Murphy, Guggenmos, Bundy, and Nudo, 2015). ECoG offers excellent signal quality, with high spatial resolution (~1 mm) and temporal resolution (<0.01 ms) (van Gerven et al., 2009). The use of ECoG for BCI applications, however, presents serious drawbacks, owing to its high cost and because of the risks associated with surgical operations, which are not always well tolerated by patients (Bamdad et al., 2015).

Research on the use of ECoG for BCI applications began with studies showing that primates could learn to regulate activity from the motor cortex to control computer cursors in two or three dimensions (Carmena et al., 2003; Homer, Nurmikko, Donoghue, and Hochberg, 2013; Musallam, Corneil, Greger, Scherberger, and Andersen, 2004; Santhanam, Ryu, Yu, Afshar, and Shenoy, 2006; Serruya, Hatsopoulos, Paninski, Fellows, and Donoghue, 2002; Taylor, Tillery, and Schwartz, 2002), and to control a prosthetic arm in three dimensions (Velliste, Perel, Spalding, Whitford, and Schwartz, 2008). Hochberg and collaborators (Hochberg et al., 2006) were the first to demonstrate that people with tetraplegia could use ECoG signals to control a robot in two dimensions. In the last years, arrays with submillimeter electrode sizes have been introduced to further increase the spatial specificity of ECoG (Leuthardt, Schalk, Roland, Rouse, and Moran, 2009; Murphy et al., 2015; Rouse, Williams, Wheeler, and Moran, 2013).

16.2.2 Electroencephalography

Similarly to ECoG, electroencephalography EEG detects electric fields that are a sum of synchronous electrical activity for a given region (Murphy et al., 2015). EEG, however, relies on multiple disc-shaped silver–silver chloride (Ag–AgCl) electrodes of dimensions in the range of 2–12 mm that are placed noninvasively along the scalp (Niedermeyer and Lopes da Silva, 2004). Although it is possible to record EEG signals on the order of milliseconds, the signal detection is relatively distant to the site of interest, and its spatial resolution (~10 mm) is therefore reduced compared to ECoG and other techniques (Babiloni, Cincotti, Carducci, Rossini, and Babiloni, 2001; Burle et al., 2015; Murphy et al., 2015; Nunez et al., 1994). EEG signals are also susceptible to contamination from muscular activity and artifacts owing to eye blinks (Wolpaw and McFarland, 2004).

### TABLE 16.1

Comparison of Different Techniques to Measure Brain Activity

<table>
<thead>
<tr>
<th></th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Portability</th>
<th>Cost</th>
<th>Invasiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECoG</td>
<td>&lt;0.01 ms</td>
<td>~1 mm</td>
<td>Not portable</td>
<td>Moderate</td>
<td>Very high</td>
</tr>
<tr>
<td>EEG</td>
<td>~0.05 ms</td>
<td>~10 mm</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>MEG</td>
<td>~1 ms</td>
<td>~5 mm</td>
<td>Not portable</td>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td>fMRI</td>
<td>~1 s</td>
<td>~1 mm</td>
<td>Not portable</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>NIRS</td>
<td>~1 s</td>
<td>~7 mm</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
EEG normally requires the use of a conductive gel to reduce skin impedance. Conductive gels often have poor long-term stability and can be uncomfortable for users (Krachunov and Casson, 2016). This represents an important obstacle in BCI application. More recently, dry EEG electrodes that do not require conductive gel are in development (Chi, Jung, and Cauwenberghs, 2010; Krachunov and Casson, 2016; Lopez-Gordo, Sanchez-Morillo, and Pelayo Valle, 2014; Pinegger, Wriessnegger, Faller, and Müller-Putz, 2016; Wang, Li, Chen, Duan, and Zhang, 2016; Zander and Kothe, 2011). Despite these limitations, EEG is currently the most used technique for brain signal acquisition in BCI, owing to its portability and low cost (Krachunov and Casson, 2016; Murphy et al., 2015).

A variety of signal analyses have been used for EEG-based BCIs (Chaudhary et al., 2016; Murphy et al., 2015). The more traditional approach is to identify the periods of event-related synchronization (ERS) and desynchronization (ERD) of sensorimotor rhythms associated with motor movements (overt or imagined) to control a BCI system (Farwell and Donchin, 1988; Kübler et al., 2005; McFarland, Sarnacki, and Wolpaw, 2010; Pfurtscheller, Brunner, Schlögl, and Lopes da Silva, 2006; Pfurtscheller, Müller, Pfurtscheller, Gerner, and Rupp, 2003; Pfurtscheller, Neuper, Flotzinger, and Pregenzer, 1997; Wolpaw and McFarland, 2004; Wolpaw, McFarland, Neat, and Forneris, 1991, Wolpaw et al., 2002).

Slow cortical potentials (SCP), which are measures of cortical polarization generally recorded from frontocentral brain regions, may allow moving cursors and selecting letters for communication, based on their positive or negative shift (Birbaumer, 1999; Birbaumer, Elbert, Canavan, and Roch, 1990; Birbaumer, Hinterberger, Kübler, and Neumann, 2003; Kübler et al., 2001).

The P300 event-related potential (ERP), occurring \( \sim 300 \) ms after an unexpected and/or task-relevant stimulus is often used for BCI spelling applications (Farwell and Donchin, 1988; Halder et al., 2010; Krusienski, Sellers, McFarland, Vaughan, and Wolpaw, 2008; Kübler et al., 2009; Mugler, Ruf, Halder, Bensch, and Kubler, 2010; Piccione et al., 2006; Pires, Nunes, and Castelo-Branco, 2011; Powers et al., 2015; Sellers and Donchin, 2006; Sellers, Krusienski, McFarland, Vaughan, and Wolpaw, 2006; Sellers, Vaughan, and Wolpaw, 2010). The advantage of using a system that relies on the P300 is that this component is easy to evoke and consistent (Powers et al., 2015). Moreover, users are typically able to evoke the P300 with relatively little training (Fazel-Rezai et al., 2012).

Steady-state visual evoked potentials (SSVEPs), which are recorded from the occipital cortex in response to high-frequency (\( > 6 \) Hz) periodic presentation of visual stimuli, can be used to allow users to select options on a screen or to control a prosthesis by focusing their attention on a target stimulus (Bin, Gao, Yan, Hong, and Gao, 2009; Lesenfants et al., 2014; Müller-Putz and Pfurtscheller, 2008; Müller-Putz, Scherer, Brauneis, and Pfurtscheller, 2005; Zhu, Bieger, Garcia Molina, and Aarts, 2010).

Error-related negative evoked potentials (ERNPs), occurring 200–250 ms after the detection of an error in a continuous stimulus–response sequence, allow users to signal errors in the communication process (Blankertz et al., 2003; Buttfield, Ferrez, and Millán, 2006; Chavarriaga and Millán, 2010; Chavarriaga, Sobolewski, and Millán, 2014; Ferrez and del R Millan, 2008; Kreilinger, Neuper, and Müller-Putz, 2012; Schalk, Wolpaw, McFarland, and Pfurtscheller, 2000; Spüler and Niethammer, 2015; Spüler et al., 2012).

### 16.2.3 Magnetoencephalography

MEG is a measure of the changes in the magnetic fields produced by electrical currents occurring naturally in the brain, which are sensed by superconducting quantum interference devices (SQUIDs) positioned in a helmet (Cohen, 1972). While maintaining the
relatively high temporal resolution of EEG, MEG has higher spatial resolution (∼5 mm) (Barnes, Hillebrand, Fawcett, and Singh, 2004; Cohen and Cuffin, 1983). New generation MEGs are provided with more than 250 sensors, leading to further improved spatial resolution and accessibility to source localization algorithms (Paggiaro et al., 2016).

MEG-based BCIs have been mostly used to investigate motor control of cursors and external devices (Hajipour Sardouie and Shamsollahi, 2012; Mellinger et al., 2007; Sacchet et al., 2012) and movement restoration in chronic stroke patients (Birbaumer and Cohen, 2007; Braun, Piccione, Silvoni, and Wildgruber, 2000; Buch et al., 2008). The advantages of MEG are counterbalanced by its lack of portability and high cost, and by the fact that it requires a magnetically shielded room (Paggiaro et al., 2016).

16.2.4 Functional Magnetic Resonance Imaging

Functional magnetic resonance imaging (fMRI) measures brain activity by detecting changes associated with cerebral blood flow, also referred to as hemodynamic response. The rationale for fMRI is that neuronal activation and cerebral blood are coupled, so that when a brain region is in use, blood flow to that region increases (Logothetis, Pauls, Augath, Trinath, and Oeltermann, 2001). To perform fMRI, a person is positioned inside a horizontal tube comprising a strong magnet generating a stable magnetic field. fMRI has a high spatial resolution, with accuracy within a millimeter. However, this technique presents the great disadvantage of being able to record only a scan every second, therefore presenting a low temporal resolution (Huettel, Song, and McCarthy, 2004).

The classification and modulation of brain responses related to affective states has been one of the most productive lines of research relying on fMRI-based BCIs (Buyukturkoglu et al., 2015; Caria, Sitaram, Veit, Beglioniemi, and Birbaumer, 2010; Caria Sitaram, and Birbaumer, 2012; Caria et al., 2007; Hamilton, Glover, and Gotlib, 2007; van der Heiden et al., 2014; Lee et al., 2011; Liberati et al. 2015a; Liberati et al., 2012, 2013; Posse et al., 2003; Ruiz et al. 2013a,b; Sitaram et al., 2011, 2014; Veit et al., 2012; Weiskopf et al., 2003). Other applications include the control of computer and robots (Lee, Ryu, Jolesz, Cho, and Yoo, 2009; Yoo et al., 2004) and stroke rehabilitation (Sitaram et al., 2012).

Similarly to MEG, the use of fMRI for BCI applications is limited owing to its high cost and lack of portability. In fact, it may be surprising that a technique that cannot be used in everyday life is used in BCI research. However, fMRI has the advantage of measuring responses from cortical and subcortical structures associated to emotional processing and located deep in the brain (Morgane, Galler, and Mokler, 2005; Vytal and Hamann, 2010). Hence, from the perspective of research on emotional modulation, as well as to increase knowledge on emotional differentiation in the brain, fMRI-based BCIs should be still considered useful.

16.2.5 Functional Near-Infrared Spectroscopy

Functional near-infrared spectroscopy (fNIRS) uses near-infrared-range light (typically of 650–1000 nm wavelength) to measure the concentration changes of oxygenated hemoglobin (HbO) and deoxygenated hemoglobin (HbR), which reflect blood concentration and therefore brain activity (Naseer and Hong, 2015; Villringer, Planck, Hock, Schleinkofer, and Dirnagl, 1993). fNIRIS-based BCIs commonly rely on brain activity recorded from the primary motor cortex and the prefrontal cortex. In general, motor imagery tasks are preferred (Naseer and Hong, 2015).

The main advantages of fNIRS systems are their portable nature, relative low cost, safety, and ease of use. Compared to EEG, fNIRS requires a shorter setup time and is less affected by
electrical artifacts from environmental and physiological sources (Heger, Herff, Putze, Mutter, and Schultz, 2014). Compared to fMRI, fNIRS is less expensive, portable, and more bearable for users (Cutini, Moro Basso, and Bisconti, 2012; Heger et al., 2014; Strait and Scheutz, 2014). Furthermore, compared to EEG and MEG systems, they are less susceptible to electrical noise (Mihara and Miyai, 2016; Naseer and Hong, 2015). However, the temporal resolution of fNIRS is limited, as there are several seconds of delay between the neural activation associated with the hemodynamic response and NIRS signal changes (Mihara and Miyai, 2016).

The development of fNIRS-based BCIs is relatively recent (Naseer and Hong, 2015). Coyle and collaborators (Coyle, Ward, and Markham, 2007; Coyle, Ward, Markham, and McDarby, 2004) were the first ones to demonstrate the possibility to detect motor imagery through fNIRS for BCI applications. Sitaram et al. (Sitaram et al., 2007) showed that fNIRS signal patterns during execution movement and motor imagery could be distinguished with the accuracy of 80% and above. Several other studies have shown that motor imagery tasks could be used for successful fNIRS brain signal classification (Fazli et al., 2012; Holper and Wolf, 2011; Kaiser et al., 2014; Mihara et al., 2012; Naseer and Hong, 2013; Stangl, Bauernfeind, Kurzmann, Scherer, and Neuper, 2013). Naito and collaborators (Naito et al., 2007) performed the first investigation on the use of fNIRS-based BCIs with persons with ALS, suggesting that this technique could allow discriminating between affirmative and negative responses in this patient population.

16.2.6 Hybrid BCIs

Recently, so-called “hybrid” BCIs that exploit the advantages of different approaches and techniques have been developed (Breitwieser, Pokorny, and Müller-Putz, 2016; Buccino, Keles, and Omurtag, 2016; Lin, Cinetto, Wang, Chen, Gao, and Gao, 2016; Luhmann, Wabnitz, Sander, and Muller, 2016; Pfurtscheller et al., 2010; Putze et al., 2014; Wu, Li, and Wang, 2016). A hybrid BCI can either use (i) two different signals (e.g., electrical and hemodynamic, magnetic and hemodynamic, electrical and magnetic); (ii) one brain signal associated with two mental strategies (e.g., motor imagery and spatial visual attention or visual stimuli and auditory stimuli); or (iii) one brain signal and another input (e.g., the electrocardiogram, electromyogram, skin conductance, or eye gaze) (Paggiaro et al., 2016; Pfurtscheller et al., 2010). For instance, combining EEG and fMRI leads to the advantage of having both a high temporal resolution and a high spatial resolution (Paggiaro et al., 2016). To improve the temporal resolution of fNIRS-based BCIs, these can be used in combination with EEG (Pfurtscheller et al., 2010).

Although the use of hybrid BCIs has several advantages and potentially leads to more robust results, it should be considered that the addition of redundant information or unreliable modalities may be detrimental to classification accuracy (Putze and Schultz, 2014). Moreover, the use of a brain signal with other types of input such as eye movement and muscular activity is not feasible with users who are in an advanced state of immobility.

16.3 BCIs for Communication

16.3.1 Potential Users

Most BCI research focuses on restoring communication in severely paralyzed individuals (Wolpaw et al., 2002; Birbaumer and Cohen, 2007; Birbaumer, 2006), such as those affected
by locked-in syndrome (LIS). LIS is a condition of quadriplegia and anarthria that leads to a state of complete paralysis, without cognitive impairment (Posner, Saper, Schiff, and Plum, 2007). Possible causes of LIS include ALS, brainstem stroke, multiple sclerosis, and traumatic brain injury (TBI). Persons affected by LIS often present residual ocular and muscular movements, which may be used for communication, for example, using eye tracking systems (Calvo et al., 2008), speech generating devices (Caron, 2016; Hynan, Goldbart, and Murray, 2015) or mechanical switches (Lancioni et al., 2005, 2008, 2012). In 1979, Bauer and colleagues (Bauer, Gerstenbrand, and Rumpl, 1979) identified two additional stages of the LIS condition, namely incomplete LIS and complete LIS (CLIS). In the incomplete LIS, some residual movements, such as finger or facial movements, are still preserved and may therefore be used for communication. However, in the CLIS state, paralysis is complete, and even eye movements are impaired.

Several studies have shown that the access to basic communication systems leads to an improved quality of life in persons with motor impairment (Lulé et al., 2009; Matuz, Birbaumer, Hautzinger, and Kübler, 2010; Robbins, Simmons, Bremer, Walsh, and Fischer, 2001; Simmons, Bremer, Robbins, Walsh, and Fischer, 2000). Persons with ALS often consider the ability to correspond with family members and caregivers as more important than retaining strength and physical mobility, and relational and psychological factors are in some cases regarded as more critical than health factors (Felgoise et al., 2009; Simmons et al., 2000).

Persons in the CLIS state ultimately become unable even to communicate their most basic needs (Birbaumer et al., 1999). Because of their inability to communicate, they may be misdiagnosed as being in a vegetative state or in a coma (Gallo and Fontanarosa, 1989), and are in some cases recognized as being conscious only after several years (Laureys et al., 2005). Nevertheless, LIS/CLIS patients in a medically stable condition and with appropriate medical care have a life expectancy of several decades (Doble, Haig, Anderson, and Katz, 2003). To this date, attempts to use BCI devices with persons in CLIS have generally been unsuccessful (Chaudhary, Birbaumer, and Ramos-Murguiiday, 2016). Kübler and Birbaumer (2008) reported that persons in CLIS do not achieve a sufficient control of their EEG signals. The reasons of this failure could at least in part derive from cognitive deficits or abnormal neuroelectrical processes. Birbaumer et al. (2012) suggested that the loss of contingency between an intention and a feedback—a condition caused by immobility—leads to a lack of immediate reinforcement, which prevents instrumental learning even when cognition is preserved. In other words, if thoughts and intentions are never followed by their anticipated consequences, intentions and goal-directed thinking are likely to be extinguished. Alternative learning paradigms (e.g., based on classical conditioning instead of operant conditioning), as well as the use of other neuroimaging techniques, may be necessary to allow communication in persons with CLIS. So far, there have been only few case reports of successful communication with persons in CLIS using a fNIRS-based BCI, with an above-chance-level correct response rate over 70% (Chaudhary, Xia, Silvoni, Cohen, and Birbaumer, 2017; Gallegos-Ayala et al., 2014). If replicated in further investigations, these findings could represent an important step toward the abolition of CLIS in ALS.

16.3.2 Development

The first successful applications of noninvasive BCIs for communication with persons with LIS was through the use of SCPs, which allowed selecting letters on a computer screen (Birbaumer et al., 1999, 2000, 2003; Kübler and Birbaumer, 2008; Kübler et al., 2001; Neumann, Kübler, Kaiser, Hinterberger, and Birbaumer, 2003). Typically, users are
presented with two target goals at the top and at the bottom of a screen. A cursor moves
toward the top or the bottom of the screen, based on the negative or positive SCP ampli-
tudes of the user. To reinforce the association between brain control and cursor during the
training phase, a positive feedback (e.g., a smiling face) appears at the center of the screen
when the cursor reaches the correct target. Users are considered to have achieved a good
performance level in the training phase when they have performed correctly in approxi-
mately 75% of the trials (Kübler et al., 2001). When this level of accuracy is reached, they
are provided with a language support program (LSP), in which letters of the alphabet are
presented. To select a letter, users have to move the cursor downward by producing cortical
positivity. A successful use of SCPs for communication typically requires 3–8 weeks of
training, but can in some cases take months. Moreover, the speed of letter selection is rela-
tively slow, allowing the writing of one letter per minute, and the error rate is high even for
highly trained patients (rarely above 80% accuracy) (Birbaumer, 2006; Kübler et al., 2001).

Another type of BCI that is extensively used for communication is the P300 Speller, a
system that works by intensifying rows and columns of a matrix that contains the letters of
the alphabet and other commands (Figure 16.3) (Farwell and Donchin, 1988). A single let-
ter or command is identified by two intensifications: one corresponding to a row, one cor-
responding to a column. When the user focuses his/her attention on a letter or command
that is intensified by the matrix, the P300 is elicited and detected by the system. The major-
ity of persons with ALS, even at advanced stages of the disease, are able to learn brain
self-regulation and use a P300 ERP to control a BCI (Sellers et al., 2010). Different appli-
cations of the P300 speller include the control of Internet browsers and emails (Bensch
et al., 2007; Karim et al., 2006; Mugler et al., 2010; Pasqualotto et al., 2015; Yu, Li, Long, and

![FIGURE 16.3](apple-p.png)

The P300 Speller. In the P300 Speller, rows and columns of a matrix containing the letters of the alphabet and
other commands are intensified in a randomized order. When the user focuses his/her attention on a letter or
command that is intensified by the matrix, the P300 is elicited and detected by the system. A single letter or
command is identified by two intensifications: one corresponding to a row, one corresponding to a column.
Gu, 2012) and “brain painting” applications that allow users to create free form drawings (Münßinger et al., 2010; Zickler, Halder, Kleih, Herbert, and Kübler, 2013).

The restoration of communication with persons in CLIS remains one of the greatest challenges in the development of BCIs. Birbaumer (Birbaumer, 2006) suggested that a paradigm shift from operant learning—which requires users to voluntarily modify a behavior—to classical conditioning, is necessary to overcome the failure of persons in CLIS to achieve BCI control. To obtain classical conditioning, a stimulus that does not normally elicit an evident response (“neutral stimulus”) is associated with a “significant” stimulus, defined as unconditioned stimulus (US), which is able to evoke a response. If the neutral stimulus is presented repeatedly with the US, it can become a conditioned stimulus, producing a conditioned response. In the last years, several classical conditioning BCI paradigms have been developed, in which affirmative (“yes”) and negative (“no”) responses are associated with unconditioned stimuli (e.g., electrical stimuli, pink vs. white noise, pleasant vs. unpleasant sounds, etc.) to facilitate their recognition (Furdea et al., 2012; van der Heiden et al., 2014; Liberati et al., 2012, 2013; De Massari et al., 2013; Ruf et al. 2013a,b). Because BCI paradigms based on classical conditioning do not require extensive training or an intact cognitive system, they could be suitable also for persons with cognitive impairment or dementia (Liberati et al., 2012, 2013).

16.4 BCIs for Motor Restoration and Rehabilitation

16.4.1 Potential Users

Several studies aim at restoring movement in persons affected by severe injuries of the motor system, such as stroke, traumatic brain injury, or spinal cord injury, which can lead to paralysis or hemiparalysis of the limbs (Chaudhary et al., 2016; Paggiaro et al., 2016). BCIs can provide AT that enable patients with severe motor impairment not only to communicate, but also to bridge intention to skilled motor action, controlling body actuators such as wheelchairs, robotic arms, and prosthetics. Moreover, BCIs that restore motor function are also used as neurorehabilitation methods to enhance neuroplasticity in persons with impaired mobility (Donati et al., 2016; Pichiorri et al., 2015; Ramos-Murguialday et al., 2013).

In particular, stroke is a major concern for public health. Approximately 80% of stroke survivors undergo a motor deficit and around 65% of those end up living with a chronic motor disorder, requiring the support of other people for their everyday activities (Alonso-Valerdi, Salido-Ruiz, and Ramirez-Mendoza, 2015; Chaudhary et al., 2016; Hendricks, van Limbeek, Geurts, and Zwarts, 2002; Lai, Studenski, Duncan, and Perera, 2002; Rothwell et al., 2004). Since the 1980s, the treatment of stroke has focused on prevention and acute therapy (Boninger, Wechsler, and Stein, 2014). However, conventional treatment strategies generally lead to limited or no recovery, and there is still no consensus on the adequacy of the different approaches (Chaudhary et al., 2016; Eliassen et al., 2008; Kwakkel, Kollen, van der Grond, and Prevo, 2003; Langhorne, Coupar, and Pollock, 2009; Paggiaro et al., 2016; Ramos-Murguialday et al., 2013; Young and Forster, 2007). The introduction of robotics and BCIs for rehabilitation is relatively recent (Boninger et al., 2014). Because chronic stroke leads to overuse of the healthy contralesional hemisphere and underuse of the ipsilesional
hemisphere, it is likely that the excitatory reorganization of the intact ipsilesional areas is hindered, preventing recovery of the affected motor system (Chaudhary et al., 2016; Ward, 2005). BCIs could promote top-down rehabilitation for stroke recovery by inducing reorganization of neural circuits (Belda-Lois et al., 2011; Chaudhary et al., 2016; Lucas and Fetz, 2013; Nishimura, Perlmutter, Eaton, and Fetz, 2013; Ramos-Murguialday et al., 2013).

Similar to stroke, spinal cord injury involves a damage in the central nervous system. However, in stroke, the lesions concern cortical and subcortical structures of the brain, which are known to be plastic; spinal cord injury is characterized by an irreparable nerve fiber lesion at the spinal level (Silvoni et al., 2011). Hence, movement restoration in persons affected by spinal cord injury would need to bypass the spinal cord lesion, rather than restoring cortical function.

16.4.2 Development

BCIs for motor restoration commonly rely on ERD, which occurs not only during overt movements, but also when movements are imagined (Murphy et al., 2015; Pfurtscheller et al., 1997; Szameitat, Shen, Conforto, and Sterr, 2012). The application of ERD-based BCIs has been tested in both healthy individuals and patient populations (Blankertz et al., 2004; McFarland et al., 2010; Pfurtscheller et al., 2003; Wolpaw and McFarland, 2004; Wolpaw et al., 1991).

To this date, BCIs for individuals with motor impairment mostly aimed to allow users to control external devices that could support them in daily life (Andersen, Kellis, Klaes, and Aflalo, 2014), such as wheelchairs (Galán et al., 2008; Nguyễn, Su, and Nguyễn, 2013; Rebsamen et al., 2010; Del R Millan et al., 2009) and robotic arms or hands for performing simple motor tasks such as grasping and moving objects (Bensmaia and Miller, 2014; Collinger et al., 2013; Hochberg et al., 2012; Pfurtscheller et al., 2010; Tabot, Kim, Winberry, and Bensmaia, 2015; Wang et al., 2013). The final objective of these applications would be to allow persons with severe motor disability to maintain autonomy and independence by controlling their environment (Aloise, Schettini, Aricò et al. 2011a,b; Babiloni et al. 2009; Cincotti et al., 2008; Kleih et al., 2011).

Pfurtscheller and collaborators (Pfurtscheller et al., 2003) first presented the case of a patient with spinal cord injury who learned to perform a hand grasping task, by controlling the delivery of electrical stimulation to hand and arm muscles using sensorimotor rhythm modulation. Hochberg and collaborators (Hochberg et al., 2006) reported that a patient with tetraplegia learned to move a cursor on a screen to control a robotic limb with neuronal spike activations of single cortical cells. In the following years, several BCIs for the motor restoration of paralyzed persons that aimed to promote the movement of a paretic upper extremity using motor imagery were proposed (Broetz et al., 2010; Buch et al., 2008; Caria et al., 2011; Curado et al., 2015; Daly et al., 2009; Hochberg et al., 2006; Pfurtscheller et al., 2003; Pichiorri et al., 2015; Prasad, Herman, Coyle, McDonough, and Crosbie, 2010; Ramos-Murguialday et al., 2013).

BCIs used to assist persons with motor disability in controlling external devices such as prostheses are not necessarily rehabilitation devices. This is evident when simply removing a device leads the paralyzed person to the previous state of immobility (Chaudhary et al., 2016; Gharabaghi, 2016). To this end, Silvoni and collaborators (Silvoni et al., 2011) refer to “substitutive strategies,” which include all the technologies used to bypass an interrupted neural pathway or connection, and brain activity is only used to operate an exogenous device, without explicitly promoting motor recovery (Gollee, Volosyak, McLachlan, Hunt,
Most of the BCIs for patients with motor impairment rely on visual feedback only (Andersen et al., 2014; Collinger et al., 2013; Hochberg et al., 2006, 2012; Kim, Simeral, Hochberg, Donoghue, and Black, 2008; Kim et al., 2011; Simeral, Kim, Black, Donoghue, and Hochberg, 2011; Truccolo, Friehs, Donoghue, and Hochberg, 2008). These BCIs are used to control the kinematics of paretic limb movement (i.e., velocity, acceleration, and position); but, since they do not involve proprioceptive feedback, they overlook kinetics (forces and torques) (Chaudhary et al., 2016). Although impressive, the movements generated using these BCIs are often slow and relatively inaccurate (Tabot et al., 2015). As evidenced in individuals with intact motor function, but with impaired somatosensation, who have difficulty in everyday life activities such as turning a doorknob or getting dressed, vision is a very poor substitute for touch and proprioception (Marsden, Rothwell, and Day, 1984).

Motor rehabilitation and functional restoration using BCIs could be favored by using contingent proprioceptive and somatosensory feedback (Alonso-Valerdi et al., 2015; Chaudhary et al., 2016; Gharabaghi, 2016; Grosse-Wentrup, Mattia, and Oweiss, 2011; Luauté and Laffont, 2015; Pichiorri et al., 2015). Somatosensation plays a crucial role in the dexterous manipulation of objects, as it conveys information about size, shape, and texture (Johansson and Flanagan, 2009; Tabot et al., 2015). Furthermore, somatosensation is involved in embodiment, as well as in emotional and social communication (Tabot et al., 2015). Importantly, proprioception can have a crucial role in a person’s ability to move without visual input (Boninger et al., 2014; Sainburg, Ghilardi, Poizner, and Ghez, 1995).

In some cases, the missing somatosensory input can be substituted by a mechanical stimulation of other body parts (Kuiken, Marasco, Lock, Harden, and Dewald, 2007) or by a direct stimulation of the somatosensory cortex using intracortical microstimulation (Andersen et al., 2014). Some prosthetics are now equipped with sensors that detect tactile and proprioceptive information, which could be transmitted to the user through stimulation of the nervous system, particularly of the primary somatosensory cortex (Bensmaia and Miller, 2014; Boninger et al., 2014; Tabot et al., 2013, 2015). These types of BCIs have been defined as bidirectional interfaces, as they not only read-out the brain signals related to intended movements, but they also provide the user with somatosensory feedback (Andersen et al., 2014; Burns et al., 2014; O’Doherty et al., 2011). It has been shown that
neural plasticity is better induced if the latency of the proprioceptive, somatosensory, and visual feedback does not exceed a few hundred milliseconds, whereas longer delays lead to less efficient learning (Buch et al., 2008; Xu et al., 2014). Further investigations are required to determine the optimal timings for maximizing learning.

Recently, Donati and collaborators (Donati et al., 2016) developed a neurorehabilitation paradigm aiming at restoring locomotion in persons affected by chronic spinal cord injury, combining intense immersive virtual reality training and walking with two EEG-controlled robotic actuators. Importantly, this technology included a custom-designed lower limb exoskeleton capable to deliver tactile feedback to the users (see here Chapter 18, “Exoskeleton: The New Horizon of Robotic Assistance for Human Motion”). This rehabilitation strategy resulted in an improvement in both somatic sensations and voluntary motor control below the level of the spinal cord lesions, possibly indicating that plasticity was triggered in both the cortex and the spinal cord.

Soekadar and collaborators (Soekadar et al., 2016) were the first to show that a hybrid EEG-electroculography-based hand exoskeleton could restore fully independent activities of daily living in quadriplegic patients, such as eating a meal in a restaurant or signing a document with a pen. The application of this hybrid BCI system did not require any extensive learning procedure, and could be used after a short calibration period of a few minutes.

16.6 BCIs and Usability

Most of the past BCI research has focused predominantly on the improvement of the technical features of BCI systems, such as information transfer rate and signal classification accuracy (Nicolas-Alonso and Gomez-Gil, 2012), rarely adopting a user-centered perspective (Blain-Moraes, Schaff, Gruis, Huggins, and Wren, 2012; Hill, Kovacs, and Shin, 2015; Pasqualotto et al., 2012; Zickler et al., 2009). As with every AT, however, it is essential to match person and technology to avoid dissatisfaction and abandonment (Federici and Borsci, 2014; Federici, Meloni, and Borsci, 2016; Louise-Bender, Kim, and Weiner, 2002; Pasqualotto, Simonetta, Federici, and Olivetti Belardinelli, 2009). Personal factors, such as personality, abilities, and beliefs, can serve as significant barriers or facilitators in the use of AT (Scherer Craddock, and Mackeogh, 2011; Scherer, Sax, Vanbiervliet, Cushman, and Scherer, 2005). In addition, the technology should be adapted based on the individual needs and health conditions of the user (Nijboer, Birbaumer, and Kübler, 2010; Nijboer, Plass-Oude Bos, Blokland, van Wijk, and Farquhar, 2014). Importantly, ATs should not be simply considered as deficit compensation systems, but involve personal well-being and social participation. It is important to emphasize that BCIs impact the relationship between users and their primary caregivers, who are necessarily involved in setting up and learning to use the BCI system (Liberati et al. 2015b). Therefore, only considering the use of BCIs in a real environment, together with family members and caregivers (Liberati et al. 2015b), can help meeting the users’ needs (Stephanidis and Salvendy, 1998). Nevertheless, only few studies have tested the use of BCIs in everyday life (Sellers et al., 2010).

The last years have seen a growing awareness of the necessity of adopting a user-centered approach in the development and evaluation of BCI systems. This approach includes assessing specific aspects of the user’s experience, such as usability, motivation, satisfaction, and improvement of the quality of life (Holz, Botrel, Kaufmann, and Kübler, 2015;
A recent focus group study that investigated the requirements of persons with ALS and their caregivers (Liberati, Pizzimenti et al., 2015) indicated how the intense training required to control a BCI can be perceived as very stressful and time consuming, therefore leading to a loss of motivation. Moreover, the failure of a BCI communication system in conveying messages adequately and at a sufficient speed may lead to anger, frustration, panic, and anxiety, disrupting the electrophysiological response and leading to further deterioration of BCI performance (Blain-Moraes et al., 2012; Holz et al., 2015; Liberati et al., 2015b; Reuderink, Poel, and Nijholt, 2011).

For neurodegenerative diseases, such as ALS, which see progressive and rapid decline in function, it is crucial to develop AT and BCI systems that can be used throughout the various stages of the disease. Because the new technology can be intimidating and difficult to adjust to, users should not be forced to continuously replace their devices with new ones (Liberati et al. 2015b). Ideally, a device would initially rely on a user’s residual motor function and allow him/her to familiarize with the technology. The system would then progressively also use EEG inputs that are not based on motor function, supporting the development of BCIs merged with existing AT (hybrid systems) (Caruso et al., 2013; Riccio et al., 2015; Schettini et al., 2015; Zickler et al., 2011).

Albeit often considered as marginal, another issue that should be considered when developing BCI systems is aesthetics. For instance, it is well known that traditional EEG-BCI systems are often not appealing to potential users, because of evident electrodes and cables. The development of dry electrodes and wireless technology could help facilitating BCI acceptance (Grozea, Voinescu, and Fazli, 2011; Popescu, Fazli, Badower, Blankertz, and Müller, 2007).

Concerning communication, Hill and collaborators (Hill et al., 2015) recently identified four critical issues that should be addressed in order to translate BCIs from laboratory settings to functional augmentative and alternative communication systems. As a first objective, translational research should identify the primary, secondary, and tertiary features of BCIs, in order to provide the most effective communication possible. Primary features are related to how the BCI can perform the functions of a natural language, that is, language representation methods such as alphabet-based spelling and word prediction, the selection and organization of vocabulary, and how messages are constructed. Secondary features concern the user interfaces (i.e., symbols, navigation, automaticity, and human factors), selection techniques (e.g., EEG), and outputs (e.g., speech, display, etc.). Tertiary features include peripherals and computer integration, technical support, and telerehabilitation features (e.g., integrated monitoring and feedback features, internet capabilities for video conferencing). The second objective of translational research should be to integrate BCI communication systems in the World Health Organization’s International Classification of Functioning, Disability and Health framework (2001), which emphasizes the classification and assessment of functioning and disability in everyday activities, providing a standardized framework for the description of health and health-related states. Using the International Classification of Functioning, Disability and Health (ICF) framework would allow establishing uniform terminology and improve communication across disciplines, countries, and stakeholders. The third objective of translational research should be to implement a language-based assessment and intervention, considering BCIs in the context of the patient’s communication needs and matching the system’s features to individual abilities (cognitive-linguistic skills, vision, hearing etc.). Finally, the fourth objective of translational research should be to assess performance and ensure that the patient benefits from intervention.
16.7 Affective and Adaptive BCIs

Several researchers have underlined the necessity of evaluating users’ affective and emotional states with regards to the control of BCI systems (Brouwer et al., 2015; Van Erp, Brouwer, and Zander, 2015; Liberati et al. 2015a). Picard (Picard, 2000) observed that the distance between user and machine can be reduced by considering emotions—a process defined as affective computing.

Although sensations such as anxiety and frustration can alter brain signals and disrupt BCI performance, the awareness of how emotions and affective states influence patterns of brain activity could lead to the development of so-called “adaptive” BCIs, able to interpret the user’s intention in spite of signal deviation. To this end, Blankertz and collaborators (Blankertz et al., 2003) observed that the objective of BCI developers should be to minimize the user’s effort by imposing the major learning load on the computer rather than on the person. In other words, future BCI application should aim to recognize the users’ affective states (e.g., frustration due to an error of the system), and adapt to them in real time. In the last years, so-called “passive BCIs” that assess users’ covert states by relying on spontaneous brain activity, without interfering with other cognitive tasks, have become more and more popular (Brouwer et al., 2015; Cotrina et al., 2014; Van Erp et al., 2015; Zander and Kothe, 2011).

We recently performed a comprehensive review on the use of neurophysiological signals reflecting users’ emotions and affective states in BCI contexts (Liberati et al. 2015a), showing that the affective BCI field is in rapid development, with a variety of combinations of different signal acquisition techniques and classification algorithms progressively being tested. BCI developers should particularly focus on improving affective state recognition in ecological settings.

16.8 Conclusions

The last years have seen a rapid advancement in the development and application of BCI systems as AT and rehabilitation methods. Several combinations of neuroimaging techniques, selection of neurophysiological feature approaches, and classification algorithms are currently being tested and improved. The increase of studies, publications, and funding dedicated to BCIs have contributed to the establishment of a large BCI community that includes researchers from a variety of backgrounds (medical, engineering, computer science, psychology, etc.), physicians, health practitioners, different patient populations, and caregivers. Different types of patients (amyotrophic lateral sclerosis, stroke, spinal cord injury, etc.) could benefit from the introduction of BCI systems for communication and motor rehabilitation in their everyday life.

At this stage, it is crucial for BCI developers to focus on the translation of BCI systems from laboratories to clinical/rehabilitative contexts and everyday applications (Hill et al., 2015), and to establish effective assessment procedures to limit users’ dissatisfaction and technology abandonment (Federici and Borsci, 2014; Federici et al., 2016; Louise-Bender et al., 2002; Pasqualotto et al., 2009). To this end, we suggest that the efficacy of BCIs should be assessed within the standard framework of the ICF (2001), as well as the matching person and technology (MPT) model (Scherer, 1998; Scherer and Craddock, 2002). The
Assistive Technology Assessment (ATA) process model integrates the ICF and MPT models, and could therefore provide an ideal evaluation procedure for the use of BCIs and its effect on the user’s quality of life (Federici, Scherer, and Borsci, 2014). On one hand, the ATA process relies on the user-driven and collaborative working methodology of the MPT model, which promotes a continuous dialogue between users and professionals/developers to shed light on individual needs. This user-centered process would guarantee that any activity in the AT/BCI service delivery center finds a direct correspondence to a user action, and vice versa. On the other hand, the ATA process encompasses the ICF view of human functioning, so that all the dimensions that affect the user’s functioning (e.g., health condition, contextual factors) would be evaluated when addressing a user’s request and when selecting the appropriate AT/BCI.

16.9 Summary

This chapter introduces the reader to BCIs, providing an overview of the different applications of these systems as AT for different patient populations. First, we provided a definition and description of BCI systems, and we described different electrophysiological and neuroimaging techniques through which brain activity can be recorded for BCI applications. Furthermore, we described different practical uses of BCIs, particularly for restoring communication and for motor rehabilitation of patients with impaired mobility. Finally, we tackled the issue of BCI usability and the need to develop BCIs that adapt to the user’s affective and cognitive state.

References


Luauté, J., and Laffont, I. 2015. BCIs and physical medicine and rehabilitation: The future is now. *Annals of Physical and Rehabilitation Medicine, 58*(1), 1–2.


Using Brain–Computer Interfaces for Motor Rehabilitation


Using Brain–Computer Interfaces for Motor Rehabilitation


17

Graphic User Interfaces for Communication

Maria Laura Mele, Damon Millar, and Christiaan Erik Rijnders

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17.1 Introduction

The potential of using gaze as an input channel in devices for control (Jacob, 1991) has been recognized since the early nineties, and is still considered a promising alternative to traditional input modalities that can play a key role for helping people with severe motor disabilities. Our eyes are the preferential means to explore and select the information that attracts our attention. In user interfaces, we need to visually locate and focus to the attentional objects before actively interacting with them: This behavior is most of the time non-intentional and not deliberate.

According to Duchowski (2007), interactive applications using gaze trackers as input devices may follow either selective or contingent methods. In selective interaction, gaze is directly used as an input control by “explicit” methods. In gaze-contingent interaction, the system adapts its behavior (e.g., the quality of the visual display) according to assumed attentive state or intentions of the user (e.g., fixation patterns), and we can call this as “implicit” control. Duchowski defines gaze-contingent as “a type of display system wherein the information presented to the viewer is generally manipulated to match the processing capability of the human visual system, often matching foveo–peripheral perception in real-time” (Duchowski, 2007, p. 284). In this chapter, only selective methods for
interaction by gaze will be described (for a review on gaze-contingent methods, please see Duchowski, 2007).

The literature commonly uses the terms “eye input,” “gaze input,” and “gaze control” to define systems wherein the eye movement is the principal input to control a device. Gaze input, as used in selective applications, separates the perceptual and control behaviors of the eye. A gaze system for selective application should be able to discriminate between the intentional inputs and the explorative behavior of the eyes. This double function of gaze input is one of the main issues confronting gaze-based systems, mainly because it leads to the “Midas Touch” problem, where selection is caused by performing explorative behavior, that is, the over-activation of the system under any single movement of the eye(s) (Jacob, 1991). Another main issue in selective gaze-based interaction is that focusing on one visual object or a group of visual objects at time requires both explorative behavior and interactive control of the interface, thus reducing the speed of interaction particularly in complex interfaces, such as text entry interfaces. Practitioners and researchers have tried to overcome these problems by designing methods and techniques to provide safe input techniques to interact with visual interfaces.

Several gaze-based interactive systems have been presented in the last 20 years, with a significant increase in the recent years. This chapter reviews the main interaction methods using gaze tracking as a primary input control, and particularly focuses its attention to a case study design of a gaze-input interface for alternative and augmentative communication.

17.2 Gaze-Based Interaction

Using the ocular-sensory-motor system to selectively control a device may overload the visual channel, because it is primarily used as a perceptual input channel, as well. Novel interaction techniques have been proposed in the literature to help practitioners avoid the overloading problem in gaze-input interaction and to apply gaze-interaction methods that are faster than traditional methods such as mouse or touch pointing.

Another problem when designing gaze-based control systems is that the ability to control and manipulate visual objects (e.g., icons or menus) only with the eyes is less accurate than the traditional mouse pointing. Natural gaze is typically intentionally used by humans to communicate with other human beings from the first month of life (Argyle and Cook, 1976). The state of the art shows that as gaze as input control is faster than using a mouse pointer (Sibert and Jacob, 2000), gaze control must overcome important challenges to be suited to everyday use and application.

17.2.1 Main Challenges of Gaze Interaction

Most user interfaces are designed for mouse or touch input, which have a definite moment of selection, such as a “click.” Most gaze-based controls try to emulate the click action by using eye blinks as a selection input command, even though closing the eyes is a considerably unnatural method to show an affirmative decision and eye movements do not typically ask for awareness during the interaction with a nonhuman-like technological system (Argyle and Cook, 1976). Moreover, most gaze-based command and decision actions are not distinct from exploration behavior. As Jacob highlights, “eye movements,
like other passive, non-command inputs (e.g., gesture, conversational speech) are often nonintentional or not conscious” (Jacob, 1991), so they must be interpreted carefully to avoid unwanted responses to unconscious actions. This issue, commonly called the Midas Touch problem, “requires either careful interface design to avoid this problem or some form of ‘clutch’ to engage and disengage the monitoring” (Jacob, 1991).

One of the main theoretical pillars of human factors work is that “the system is the interface” (Dillon, 1990), meaning that everything that stands behind the user interface must be invisible to the user. Practitioners should guarantee a good user experience, high accuracy, low and constant latency, high sampling frequency and tight connection between eye detection and input actions (Duchowski, 2007). The literature shows different strategies used to solve these issues. Most of the strategies do not directly guarantee a tight connection between eye detection and input actions but try to overcome accuracy limitations generally by using latency time (e.g., by requiring the user to fixate on an item for a “dwell time” to perform selection). In the following sections, the strengths and limitations of different fixation-based, gaze gesture-based, or combined techniques are examined.

17.2.2 Fixation-Based Techniques for Interaction

Dwell-based interaction uses dwell time as input command, and is the most popular method for controlling a visual interface by means of gaze. There is not an exclusive and optimal standard dwell time for inputs because, on one hand, longer times are perceived by users as unnatural waiting, while faster latencies lead to unintentional activations (Jacob, 1995). The research on text entry shows that users with no experience use long dwell time during the first interactions and then shorter thresholds as their skills and confidence with the input method becomes more accurate. So, it might be helpful to provide a gradual dwell time adjustment as an automatic function that follows the users experience development (Majaranta, Ahola, and Špakov, 2009).

The following sections describe the major issues of using dwell time as a command input in gaze-based interfaces: the size of the target and the choice of proper feedback events, which communicate to users that their action has been correctly done.

17.2.2.1 Target Size

Small sizes of graphical elements of an interface easily become a problem in accessing windowing environments. Target size is a common issue for dwell time techniques. A study by Lankford (2000) exploring the integration of the Windows environment with the Eye-Gaze Response Interface Computer Aid (ERICA) system,* found that small targets, such as the small buttons in the bar used to minimize window, are very difficult to select and may increase users’ errors and/or reduce interaction speed, probably because it is difficult for users to maintain fixation when their natural inclination is to scan a scene.

Most of the techniques used to solve the target size issue are based on zooming:

1. Semantic zooming techniques adjust the shape or content of objects on the basis of the scale. An example of Semantic zooming is a dwell-time-based technique proposed in 2005 by Špakov and Miniotas (2005) to select items from a standard-sized menu: once users fixate on a menu item, the surrounding area expands to accommodate the inaccuracy of gaze tracking. This technique reduces errors but

* http://wiki.cogain.org/index.php/Eye_Tracker_Erica
it increases selection time, and may not be accurate for the selection of densely placed targets, such as web interfaces or multiple choices placed close to the point of gaze, because the object to be expanded is ambiguous.

2. Graphical Zooming techniques are divided into the following: (a) separate zooming techniques, (b) direct zooming techniques, and (c) distortion-based zooming techniques.

   a. Separate zooming techniques provide a separate panel showing a zoomed part of the screen that displays a magnified view of the area around the focus of the gaze. In one method of separate zoomed window, the gaze-activated buttons can be generally activated with a mouse click. This technique is easy to implement and does not depend on interface element types (Istance, Spinner, and Howarth, 1996).

   b. Direct zooming techniques are based on a continuous zoom-selection method by presenting a window corresponding to the point of regard, while a smooth animation shows the content of the window by gradually increasing in size. Compared to two-step discrete selection, performing selections with direct zooming was found to be significantly faster, more accurate and less fatiguing, since it required a minor number of clicks, but the overall efficiency for the two techniques is essentially the same (Hansen et al., 2008). Continuous zooming interaction may be perceived more as tracking-like task than selection tasks.

   c. The continuous and multistep selection techniques could be integrated with each other, by allowing users to use the multistep zooming when dealing with considerably small targets or tasks requiring high accuracy, see, for example, Skovsgaard, Mateo, Flach, and Hansen (2010).

3. Distortion-based zooming techniques use direct zooming based on distortion, (e.g., the fisheye lens effect, which is able to extend visual field between 140° and 180°), by magnifying the display at the point of gaze and thereby facilitating the eye pointing and selection of the expanded targets. Differently from other zooming techniques, gaze-contingent fisheye allows users to keep an overview of the entire interface during visual search and have the fisheye present only when needed by morphing the fisheye into view as soon as the eye movement indicates change from saccadic movement to fixation on a target of interest. Compared to the omnipresent-fisheye and the nonexistent condition, the fisheye-on-demand condition performed significantly better in speed and accuracy (Ashmore, Duchowski, and Shoemaker, 2005), and therefore it is particularly suitable for visual inspection tasks. However, the fisheye breaks the original spatial relationship between items in the display, and may lead to perceptual mistakes.

17.2.2.2 Feedback

New gaze interfaces should provide users with appropriate feedback events assuring that the eye motion has been correctly interpreted, because control and perception both measure the same movement, so they can be ambiguous. Feedback should be in a sensory mode that does not affect gaze. In dwell time-based methods, the user’s selection occurs only after a given interval from the beginning of the fixation. General guidelines on feedback in graphic user interfaces (GUIs) may not be suitable for gaze-based interfaces. A study on the effects of feedback and dwell time on eye typing showed that the feedback
method affects speed, accuracy, and user experience. Visual-auditory feedback seems to significantly help eye typing, increase speed, and reduce errors compared to other feedback types such as visual only, speech only, and combined visual and spoken (Majaranta, MacKenzie, Aula, and Räihä, 2006).

Spoken feedback can be useful with techniques using long dwell time; however, it may increase error rate when used with short dwell time, particularly in eye-typing tasks, because people tend to pause the interaction flow to listen to the speech (Majaranta 2012). Extra feedback on the dwell time progress (commensurate with the expertise level) can be given (1) by a two-stage feedback, one feedback on the focus and one on selection, in order to allow users to interrupt selection before the dwell time runs out; (2) by visual animations, which help users in maintaining focus on the target, since longer fixations may seem not natural to them. However, when using short dwell time, the feedback should be simplified and match the dwell time, and extra feedback is not useful and may be confusing for users even though the perception of dwell time duration may be subjective. Given this subjective suitability, the user should be able to adjust both the duration and feedback parameters and attributes according to their needs.

There is some debate about which part of the focused target is better to present the feedback. Donegan and Oosthuizen (2006) highlight that users feel more confident when the feedback is shown right at the center of any focused gaze-responsive button instead of showing it where the gaze position is calculated. This is because even a slight inaccuracy of the eye-tracking system may confuse users’ navigation.

17.2.3 Gaze Gesture-Based Techniques for Interaction

Although fixation is the most obvious method to select a target with the eyes, using fixations can take much more time than the other basic form of eye movement, that is, saccades. This section shows some gaze gesture-based techniques using saccadic interaction.

Compared to fixation, sequences of saccades in target acquisition are potentially faster and may help in avoiding the Midas Touch problem, because the initial point of gaze in a saccadic sequence is not significant. Gaze gestures are short snippets from the user’s gaze path that can be also be used to form command actions. The literature offers different definitions for eye gestures: Drewes and Schmidt (2007) define a gesture as “a sequence of elements, which are performed in a sequential time order,” that is to say a sequence of consecutive eye movements. Another definition of gaze gesture is given by Møllenbach, Hansen, Lillholm, and Gale (2009), who define it as “a controlled saccade or a series of controlled saccades that cause an action when completed.”

Using Dvorak’s (2008, pp. 237–238) guidelines for gesture interfaces design, a gaze gestures interface should be as follows:

- Be easy to perform and remember
- Be intuitively mapped to the gesture semantics
- Be ergonomic
- Not physically stressing when used, even by frequent users
- Use relaxed muscle configurations whenever possible
- Use gestures that are sufficiently different from all others so there is no ambiguity

For gaze-based interfaces, the main problem in using gesture-based techniques is distinguishing saccades that are normally used for browsing of the screen from saccades that...
are instead used to control the screen. In 2007, a gesture detection algorithm was proposed aiming to distinguish between horizontal, vertical, and diagonal movements within a rectangular area on the screen (Drewes and Schmidt, 2007). The authors proved that the size of the area does not have a significant effect on the speed of gestures. The authors analyzed saccades during Internet browsing to investigate whether there are rare saccadic movements that can be used as universal gestures to invoke commands without interfering with frequently occurring saccades. Sequences of four strokes that occurred only rarely were found to be possible candidates for saccadic gestures that can be automatically distinguished from general browsing (Skovsgaard, Raiha, and Tall, 2012). However, as these are gestures rarely used in everyday life, we do not know if they are ergonomically suited to be used as command inputs or if they may be overloading or fatiguing for the user. For this reason, ergonomic and usability studies must be conducted to better evaluate the impact of unusual saccadic gestures on gaze control.

In 2010, Møllenbach, Lillholm, Gail, and Hansen (2010) proposed a single-stroke gestures designed to be performed with only one saccade, and analyzed the effects of stroke length and sampling rate. Both parameters had a statistically significant effect on the gesture completion speed.

As a saccade is a short movement between two fixations, fixations can be used for determining the shape of the gaze gesture and for differentiating the saccades from the gaze data. Unless the gaze gesture method is often presented as a dwell time-free method to interact, most of the gaze gesture studies use dwell time as well, as it may help to determine which fixations should be considered when determining the shape of the gaze gesture. In 2009, Heikkilä and Räihä published a survey on the different latencies proposed for gaze gestures, showing that results are highly variable from one study to another. As the authors report,

> Only two of the revised techniques use scalable gaze gestures, where the users themselves can decide on how small or large gestures they want to issue. In addition, most applications use gaze gestures that are location bound. This means that the user needs to issue the gaze gestures in a certain location, for example, in a separate window. These two aspects prevent the users from tuning the gaze gestures according to their own preferences (Heikkilä and Räihä, 2009, p. 5).

Moreover, the table highlights that “fixations are often used during the gaze gesture process to determine either the shape of the gaze gesture or the starting and ending points of the gaze gesture. Dwell times for these fixations vary, but they are usually adjustable” (Heikkilä and Räihä, 2009, p. 5).  
Majaranta et al. (2012) proposed different questions useful to explain the differences found in the Heikkilä’ and Räihä’s review. Those differences may be variables that are related to a gesture:

> Does it start from the beginning of the preceding fixation or from the first gaze point that does not belong to the preceding fixation? Does it end with the first gaze point in a specific area, the first gaze point of the ending fixation, the gaze point that allows the fixation to be detected, or the last gaze point that belongs to the ending fixation? Does it need to cross a line between two areas, or move between the areas, or follow a specific pattern? In the latter case, is the pattern visible on the screen, or does it need to be imagined by the person issuing the gesture? (Majaranta et al., 2012, pp. 86–87).

Answering to these questions for each study may be useful to explain the longer times obtained when participants were asked to accurately produce simple images with eye
gaze for a drawing application. The motivation to be accurate slowed down the users' performance.

Another study conducted in 2012 with able-bodied participants compared dwell selection with gaze gestures to investigate which of the two methods is more effective in game playing (Hyrskykari et al., 2012). Authors demonstrated that gaze gestures were more effective than dwell for selection of command icons in terms of numbers of errors, because gaze gestures can be made during game play without moving visual attention away from the center of screen. Gaze gestures may be a good interaction technique for discrete commands such as in those interfaces that require a quick number of commands with a high level of accuracy. Gaze gestures are less suited to continuous control adjustments, such as the direction of locomotion. Hyrskykari and colleagues (2012) found that neither of the gaze-only control interfaces, gestures or dwell selection gave participants the same sense of control as a mouse and keyboard, although this may be due to the fact that participants were inexperienced with gaze control interfaces.

All the studies reviewed in this section prove that careful design of application-specific gestures may be a promising approach to promote explicit gaze control. Even well-designed gaze interfaces require users to necessarily learn new and uncommon gestures and remember them. The novelty of gaze interfaces sets limitations on the number and complexity of the gestures. To make gaze user interfaces easier to use, different multimodal methods combining gaze with other gestures can be useful. For example, instead of using mouse clicks, some authors proposed to use blinking, (i.e., closing both eyes), or winking (i.e., closing just one eye). Several manufacturers or research prototypes support winking or blinking to control interfaces. Choosing winking or blinking has some limitations: (a) winking is not an easy explicit movement for humans; (b) intentional blinking and natural blinking may overlap, therefore other gestures such as prolonged blinks are required to create unambiguous input gestures, even though these combinations reduce the speed of interaction; (c) blinking affects the vergence of the eyes (Huckauf and Urbina 2008); and (d) selection by blinking may be fatiguing for the ocular muscles (Majaranta et al., 2012). Another multimodal command input modality can be given by voluntary pupil size. Ekman et al. (2008) showed that voluntary changes in pupil size could be detected on a statistically significant level, particularly with properly designed feedback. However, it is considerably hard to control and distinguish voluntary from involuntary changes in pupil dilation, and this approach is not typically recommended. Even facial muscles can produce a certain number of meaningful natural gestures such as frowning and smiling. Different studies show that, for people without disability, gaze-based looking and frowning was not significantly slower than the mouse when interacting with long distance screen movement (more than 12 cm) (Majaranta et al., 2012). Selection by smiling has been observed as significantly faster and more accurate than selection by frowning (Surakka et al., 2005).

### 17.2.4 Text Entry by Gaze

In 2007, Majaranta and Räihä (2007) categorized text entry methods into four classes according to the input techniques: (1) gaze typing, (2) discrete gaze gestures, (3) gaze writing, and (4) eye switches.

1. **Gaze typing**: Text entry by direct gaze pointing is an input method based on fixations on a virtual keyboard composed of letters, which can be selected one by one, using a switch, a blink, muscle activity, or dwell time. Dwell is typically set between 500 and 1000 ms for nonexpert users, and between 200 and 300 ms for
expert users (Majaranta et al., 2009). A visual or an auditory feedback typically follows letter selection, while it is being shown in a separate text field, typically either on the top or on the bottom of the virtual keyboard. Text entry by direct gaze pointing is the most adopted method, but it can cause an overload of the visual system as it requires to constantly shift the visual attention from the virtual keyboard to the separate text field.

2. Discrete gaze gestures: The direct pointing method allows a user to select a target character on the screen by gaze gestures that are based on a sequence of saccades followed by a brief fixation. Gaze gestures are based on relative changes in the direction of gaze; so, this method does not have accuracy and calibration issues (Drewes and Schmidt, 2007). As Majaranta points out, “gestures should be complex enough to differ from natural gaze patterns but still simple enough that people can easily learn and remember them” (Majaranta, 2012, p. 66).

3. Continuous gaze writing: Even when pointing at a target on a screen, our eyes constantly make small movements on the fixation point. In order to accommodate these small movements, gaze writing methods use the direction of continuous gaze gestures to select a certain choice on dynamic interfaces. The Communication by Gaze Interaction (COGAIN) association shows a list of eye-tracking systems used for text entry by gaze or gaze-based communication.* Even if continuous eye writing techniques are more efficient than the direct ones they require long training time and may still confuse novice users.

4. Eye switches: Text entry via eye switches uses blinks, winks, or coarse eye movements combined with scanning techniques. Generally, in these systems, the alphabet is positioned on a matrix that is automatically scanned line by line. Once the user chooses the line containing the target letter, the user then scans each letter on the selected line. The user can then select the target by blinking on it when it is highlighted. Compared to the other methods, text entry via eye switches is slow (around 2–6 words per minute–wpm) but this is principally due to the combined scanning method.

Generally, text entry by gaze is slow and, even when dwell time is replaced with faster methods such as gaze gestures, only a minimal speed gain is obtained. Language models and character and word prediction are particularly useful with ambiguous keyboards showing only a few buttons, and may help to reduce the number of keystrokes required to write words. However, word and letter prediction may cause a high perceptual and cognitive load, as they require the user to constantly shift their attention from the keyboard to the word list and repeated scanning of the list (Majaranta, 2012).

17.3 Case Study Design: A Predictive Graphic User Interface for Writing and Communicating by Gaze

Direct gaze typing is the most used gaze-based communication method in the human–computer interaction field. The direct gaze-typing technique provides a visual or an acoustic feedback immediately after a gaze selection, so that the typed letter appears in the text

* [wiki.cogain.org/index.php/Eye_Typing_Systems](wiki.cogain.org/index.php/Eye_Typing_Systems)
field typically positioned below or above the keyboard. The main problem related to direct gaze typing is that it might slow communication—human speech has high speed rates (150–250 wpm) compared to gaze-typing on-screen keyboards (10–15 wpm) (Majaranta, 2012).

The literature provides many word/phrase prediction models, which often force their users to frequently shift gaze from the on-screen keyboard to the predicted output list, thus increasing cognitive load (Majaranta, 2012). Limitations such as cognitive load and inefficiency of the system may lead users to progressively abandon assistive technology (Federici and Scherer, 2012). The abandonment of a gaze-based input technology also often happens because most of the eye-tracking software in the market runs under only one operating system and on only PC computers (Santos, Santos, Jorge, and Abrantes, 2014). Moreover, these systems are based on infrared illuminators, require calibration, and work only with certain positions of both users and camera device. Those limitations are in addition to the usability issues of the Graphic User interfaces, which are often optimized for working under certain requirements of the device.

To overcome the issues of gaze recognition, an engineering company called Cogisen (http://www.cogisen.com) developed a gaze-tracking system called Sencogi, which is particularly designed to be cross-platform, meaning that it can be used with any device and any operating system. The system works on a neuroscience-based image-processing platform with algorithms that are able to capture processes that are highly nonlinear, sparse, and high noise to signal. Cogisen’s gaze tracking is software-only, requires neither extra hardware nor any infrared illuminator, works with video taken from standard off-the-shelf cameras such as the cheap front cameras of smartphones, requires low computational efforts, has no requirements on the positions of the users or the camera, and is totally calibration free.

Together with the gaze-tracking software, Cogisen recently developed a gaze-based GUI for speech and language production (Mele, Millar, and Rijnders, 2015). The interface is optimized for gaze-tracking solutions that are flexible for full mobility and does not need calibration. Cogisen’s GUI is able to translate gaze inputs into words, phrases, and symbols. The GUI is an Alternative and Augmentative Communication (AAC) system for both face-to-face and distance communication (Millar and Scott, 1998). AAC methods provide methods to enhance speech and language production for communication, such as speech aids, or language and speech/writing difficulties. AAC systems are intended to address a broad range of functional needs for all health conditions, for example, cerebral palsy, head injury, and spinal cord injury. Cogisen’s AAC allows both face-to-face and distance communication by using verbal, pictorial, and iconic code for everyone, and in particular for people who are not able to read or write. The main logic behind the GUI is based on a method called a branched decision tree, which uses two main techniques: (1) a prospective and retrospective word prediction technique, and (2) a prediction method called Directed Discovery.

### 17.3.1 Gaze-Based Branched Decision Tree Technique

A decision tree is a tree-like graph of decisions. Branched decision trees are disposed in a way that not all choices are equally likely to be selected. A branched decision tree is a bifurcation tree in which each next round of choices is arranged to one side of the last choice, creating a directional depiction of the choices that have been made. The directional-ity allows a simple navigation back up the tree by looking toward the original choice. When making choices, the user’s eyes always move in one direction, allowing the user to chase
the solution. The technique prevents gaze shifting from an on-screen keyboard to predicted lists of items, thus creating a navigable trail back through the history of choices, which allows users to easily look back and undo decision mistakes. If a bifurcation tree has more choices than fit into the screen width, then the screen can scroll to the right. This logic is particularly useful to people who cannot move their limbs and torso, whose navigation is extremely compromised even by simple errors such as typing mistakes (Figure 17.1).

The gaze-based branched decision tree visualization method arrays consecutive rounds of alphabetic letters on the right side of each choice, and then depicts the choice in order to create a pathway of all the choices to create a word. The branched decision tree method uses (1) the prospective and retrospective word prediction technique, which allows the system to operate: (a) prospectively, to facilitate users to select the most likely next decision among all the others, and (b) retrospectively to predict what a user would have meant to type, given a certain gaze input. The branched decision tree method uses also (2) the Directed Discovery prediction method, which is based on the recognition of the spatial structures constituting items.

17.3.2 Gaze-Based Word Prediction Technique

Figure 17.2 shows a gaze-based keyboard depicting a range of letters in each round, with rounds continuing until a word or a phrase is formed (Figure 17.2). The logic behind a branched decision trees is that once certain letters or words have been selected, there is a higher likelihood that some other letters or words will be selected next. To make it easier to select the most likely next decision without precluding other less likely decisions, the Cogisen’s GUI emphasizes the more likely choices by changing visual properties such as the color or the contrast, or by drawing lines from the middle to the choices that are weighted by likelihood (Figure 17.3).

Figure 17.4 shows a proposed method for visually weighting likely choices on a gaze-based keyboard. The method uses drawing lines, which go from the middle toward the choices that are weighted by likelihood. The system is able to both prospectively and
retrospectively predict what a user is likely to decide, starting from a certain gaze input on the keyboard. The system combines post predictions with forward predictions to present complete decisions as choices before reaching the final round. The path that the eyes delineate is used by the system to calculate all the possible meanings and choose the most likely one, including a degree of error. For example, if the user quickly sweeps their eyes
through a gaze-based branch keyboard and selects an impossible combination of letters, then similar trajectories can be analyzed to see if they produce likely words, and all of these selections presented to the user at the final round to choose from (Figure 17.4). The system is also able to combine post predictions with forward predictions in order to immediately show any possible choice (Figure 17.5).

**FIGURE 17.4**
Post-prediction technique calculating all the selectable words or phrases starting from the user’s gaze path on the keyboard.

**FIGURE 17.5**
Branched decision tree keyboard showing predicted decisions as options in a nonfinal round.
17.3.3 The Directed Discovery Prediction Method

Cogisen’s GUI is based on a novel selection method called Directed Discovery. The method aims to adapt conditions where it is not possible to make selections from pre-existing objects, as it may happen with wide amounts of choices (e.g., a dictionary), with pictorial information such as drawing, or with abstract nontextual elements. In these situations, the Directed Discovery module shows users a range of blob-like choices, asking them to directly select the range of possibilities that they will decide on. The blob-like graphic shapes are subsequently linked to other shapes, and final choices.

The Directed Discovery method offers three different interaction techniques: (1) the Evolution technique and the (2) Directed Morph technique, which are both based on the branched decision tree method, and the (3) Sculpture technique, which provides single in-place mutations.

1. **Evolution technique**: In the Evolution technique, a text entry system is presented to the user whereby blob-like graphic elements are gradually mutated into the shape of the word required, until it matches the related word. This method is based on the fact that humans perceive words by their first, middle and last letters, which spatial relation gives them a peculiar shape, commonly called Bouma shape (Bouma, 1973; Bouwhuis and Bouma, 1979) (Figure 17.6).

2. **Directed Morph technique**: The directed Morph technique is a faster technique, which allows mutation based on prediction of the result. In this technique, the prediction system is based on the knowledge of the context. Indeed, a master list of domains such as emotions, activities, tasks rather than only perceptual categories is offered to users to work within a known sphere of knowledge (Figures 17.7 and 17.8). In a previous work, the authors of this chapter describe this method as follows:

   Prediction can occur more effectively if the prediction system has knowledge of context. A categorical search tree is offered to users to work within a known sphere of knowledge chosen from a master list of conceptual or semantic domains (e.g., emotions, activities, tasks, etc.) rather than only perceptual categories. The prediction system may use the knowledge of the context to predict the shape/object that is being selected. In one example of Directed Morph, a text entry system is proposed that whereby blob-like graphic elements are gradually resolved into words. Using prediction and context, a range of possible words may be offered alongside

**FIGURE 17.6**
Utilization of Evolution technique for communication by directing elements starting from different shapes and changing them until the word is selected.
other mutated blobs, allowing the correct word to be selected using fewer choices. (Mele et al., 2015, p. 71).

3. **Sculpture technique**: The third technique is suitable when users need to use pictorial and iconic stimuli to communicate. The Sculpture technique constructs the solution continuously and in-place, where the user’s gaze directly chooses the sites for modification (Figure 17.9). One form of sculpting is the parametric modification of

![FIGURE 17.7](image)

**FIGURE 17.7**
Utilization of Directed Morph technique by user for communication by directly creating elements starting from families of choices, based on some defining features and predictions of final choice.

![FIGURE 17.8](image)

**FIGURE 17.8**
Directed Morph technique. The figure shows blob-like shapes starting from knowledge-based predictions of choices rather than random shapes.

![FIGURE 17.9](image)

**FIGURE 17.9**
Sculpture technique by directly performing in-place selective mutation with gaze.
the element, in which the attributes of the object are modified until they no longer provoke the user’s eyes fixation (Figure 17.10). An alternative form of sculpture is using eyes as a form of guidance to locate an area of discrepancy. When a particular feature is missing or incorrect, it attracts the user’s visual overt attention to be selectively mutated by the users’ gaze (Figures 17.11 and 17.12).

**FIGURE 17.10**
Sculpture technique by directly performing mutation of graphic element, sculpting it by gaze.

**FIGURE 17.11**
Sculpture technique by directly performing parametric modification to discover the attribute that reduces gaze fixations.

**FIGURE 17.12**
Sculpture technique by simultaneously altering many parameters of many parts of shape.
17.3.4 Discussions

The Cogisen system here described is a graphic user interface, which is designed for gaze input by using novel interaction techniques that aim at encompassing the limits of emulating the click action by using eye blinks as a selection input command. The GUI uses a novel selection method called Directed Discovery, which visually provides ranges of blob-like choices linked each other in a subsequential direction toward final choices. This novel interaction method prevents eyes shifting from a display keyboard to the field where words of phrases are displayed, thereby reducing the perceptual and cognitive loads. This main method used by the Cogisen’s GUI is based on three interaction techniques, that is, the Evolution technique and the Directed Morph technique, both following the branched decision tree information visualization method, and the Sculpture technique. As Paragraph 2 illustrates, in most of the selection input GUIs provided in the literature, exploration behaviors are not clearly distinct from selection actions. The utilization of the branched decision tree method provides visual guides that allow exploration to be channeled and used as a selective method, thereby overcoming the Midas Touch problem simultaneously.

17.4 Conclusions

Developing a fast and intuitive communication gaze-input method is one of the main challenges of eye-tracking research. The primary problem concerning a gaze system for selective application is that it should be able to discriminate between explorative and intentional inputs. In the literature, many gaze-based interactive systems using gaze tracking as a primary input control have been shown. In particular, the chapter focuses on a case study design of gaze text-entry technology, that is, a predictive graphic user interface for writing and communicating by means of the eyes. The interface has been developed by Cogisen, who designed it using new information visualization methods and techniques aiming at preventing gaze shifting from a display keyboard to lists of graphic elements and simplifying item selection among wide sets of words and phrases. The system can be used by people with residual eye-motor abilities, residual language comprehension, decoding and production ability, and symbolic communication ability.

17.5 Summary

This chapter reviews the main methods and techniques applied to eye-tracking systems for using gaze as the principal input modality. Starting from an overview of the current unsolved challenges related to gaze-tracking interaction, the first section of the chapter illustrates the State of the Art methods for interaction based on fixation-based techniques and gaze-gesture techniques. Particular attention was given to the gaze text-entry methodology. The second section of the chapter shows a case study design of gaze text-entry technology, that is, a predictive graphic user interface for writing and communicating by gaze which may be particularly suitable for people with severe motor disability.
References


Exoskeleton: The New Horizon of Robotic Assistance for Human Gait

Marco Bracalenti, Fabio Meloni, and Stefano Federici

18.1 What Is an Exoskeleton?

18.1.1 State of the Art

An exoskeleton is an active mechanical device that is anthropomorphic in nature, is "worn" by an operator, fits closely to his or her body, and works in concert with the wearer's movements. Generally, the term "exoskeleton" is used to describe a device augmenting the performance of an able-bodied wearer. In contrast, the term "active orthosis" is described as a device that is used to increase the ambulatory ability of a person with disability, for example, someone suffering from a leg pathology. Occasionally, however, the term "exoskeleton" is also used to describe certain assistive devices that enclose the majority of the lower limbs (Dollar and Herr, 2008).

Gait disorders, classified in ICD-10 as "abnormalities of gait and mobility" (code R26), involve a reduction in autonomy and in the ability to move independently. They can arise from serious central nervous system (CNS) lesions owing to, for example, spinal cord injury (SCI), cerebrovascular accident, cerebral palsy, and infectious diseases (Dickstein et al., 2014; Lee et al., 2014). In most cases, a CNS lesion causes lifelong disability and restrictions in mobility. As a result, many patients remain nonambulatory and dependent on a wheelchair and often require support from a caregiver. Over time, lifelong inability to stand up and to walk may increase the risk of secondary complications, such as hypertension, osteoporosis, and bedsores. These comorbidities severely limit the individual's...
ability to carry out activities of daily living, restrict social participation, and affect quality of life and mood (Suzuki et al., 2005).

A novel neurorehabilitation therapy, which is different from the classical therapeutic techniques and based on robotic devices, has been developed; it is referred to as neurorobotic or neuroprosthetic training and includes devices such as the exoskeleton (Moreno et al., 2011). Spungen et al. (2013) maintain that robotics-assisted powered exoskeletons represent a relatively new technology that has been shown to be safe and effective in helping individuals with motor complete paraplegia to stand and walk. An exoskeleton allows a paralyzed person to overcome environmental barriers that preclude wheelchair use, such as stairs.

Initially, exoskeletons were used in order to assist with the recovery of upper limb movement (Chaigneau, Arsicault, Gazeau, and Zeghloul, 2008). Later, on the basis of the effectiveness in restoring upper limb movement, some researchers started to test these systems in gait disorder rehabilitation. First of all, efforts at lower limb rehabilitation used “Robotic Assisted Gait Training,” in which the patient can walk on a treadmill while a body weight support system sustains part of his weight. Consequently, exoskeletons were combined with this technology, in order to facilitate the recovery of motor patterns. Indeed, researchers observed that motor patterns of the hip, pelvis, and legs remained unchanged when users wore a robotic gait assisting exoskeleton (Kao, Lewis, and Ferris, 2010; Lee et al., 2014) that reduced the muscular effort required (Mooney, Rouse, and Herr, 2014). However, these first exoskeletons, which were implemented to assist paraplegic patients with lower limb movements, were passive ones (Rahman et al., 2006); that is, the exoskeleton moves the patient’s body on a predefined trajectory, regardless of what the patient is doing (Nef and Riener, 2012). Subsequently, the first active exoskeletons were built (Quintero, Farris, and Goldfarb, 2012) that enabled patients to move together with the robot in the desired direction (Nef and Riener, 2012). These allowed patients with gait motor disorders not only to stand bolt upright, but also to move autonomously in their surroundings.

The exoskeleton has been used to assist patients with SCI by restoring their functional abilities (Spungen et al., 2013) and to adapt physical activity in sports—as in the Rome marathon of March 22, 2015, when two paraplegic patients ran 1 km wearing exoskeletons (Fondazione Santa Lucia, 2015)—as well as to enhance strength and muscular endurance in military operations (Herr, 2009). Unlike the human skeleton, an exoskeleton supports the body weight externally, allowing the user to follow through and to strengthen and improve the coordination of the voluntary movements of the lower limbs. This technology has greater ecological validity than other types of neurorobotic techniques—for example, Robotic-Assisted Gait Training—as patients wearing an exoskeleton can walk and move autonomously for a long period of time and on a wide range of walking surfaces. The range of environments in which the exoskeleton can be used is also more extensive; it can be used in the workplace or at home, as well as in a rehabilitation space, supporting patients when performing functions critical to the activities of daily living.

18.1.2 Technical Data

Not all exoskeletons whose effectiveness in gait rehabilitation has been evaluated are currently commercially available. Nowadays, only six main multinational companies produce and commercialize active lower limb exoskeleton device; they are Ekso Bionics™, Cyberdyne™, ReWalk Robotics™, Parker Hannifin Corporation™, Rex Bionics™, and Honda™.

Ekso Bionics™: Ekso GT, the last generation of Ekso Bionics’ exoskeletons, is a wearable bionic suit that enables individuals with any amount of lower extremity weakness to stand
up and walk over ground with a natural, full weight bearing, reciprocal gait. Walking is achieved by shifting the user's weight to activate sensors in the device that initiates steps. Battery-powered motors drive the legs, replacing deficient neuromuscular function. It provides a means for people with even complete paralysis and minimal forearm strength to stand and walk. Moreover, it helps patients to relearn proper step patterns and weight shifts using a functionally based platform, and facilitates intensive increase of weight during the step over ground. Ekso can be used by patients with various levels of paralysis or hemiparesis owing to neurological conditions such as stroke, SCI or disease, traumatic brain injury, or other illnesses. Designed for utility and ease of use in a clinical setting, Ekso accommodates an unprecedented spectrum of patients in terms of motor ability.

Ekso's latest release has been designed for the needs of busy therapists treating a wide range of patients in a single day. The suit is strapped over the user's clothing with easy adjustments, enabling transition between patients in as little as five minutes. Step Generator software helps patients walking in their first session to quickly achieve work on gait patterning or step dosage. Progressive step modes help patients to develop their skills. It represents a tool to enforce proper biomechanical alignments and symmetrical gait patterns over ground.

- **Functioning**: The Ekso exoskeleton adopts a human–computer interface based on gesture, which exploits sensors, observes actions made to determine intentions, and acts accordingly.
- **Weight**: 23 kg.
- **Maximum speed**: 1.6 km/h.
- **Battery life**: over six hours.
- **Movements**: walking in a straight line, standing up from a sitting position, remaining raised for a long period of time, and sitting down from a standing position.
- **Crutches**: necessary for this exoskeleton.
- **Who can use**: people who can move independently from a wheelchair to a chair (height: 1.50 m–1.90 m; weight: not exceeding 100 kg).

**Cyberdyne**: Hybrid Assistive Limb (HAL) is able to read bioelectric signals by only attaching the originally developed detectors on the surface of the wearer’s skin. By consolidating various pieces of information, HAL recognizes the types of motions the wearer intends. In accordance with the recognized motions, HAL controls its power units. This function enables HAL to assist the wearer's movements as he or she intends and exerts more power than he or she ordinarily exerts. Moreover, when HAL has appropriately assisted the motions of “walking,” the feeling “I could walk!” is fed back to the brain. By this means, the brain gradually becomes able to learn the way to emit the necessary signals for “walking.” This leads to the important first step in walking by the physically challenged person, without being assisted by HAL.

- **Functioning**: HAL is characterized by two control systems. For instance, when a person attempts to walk, the brain sends electrical impulses to muscles. When they arrive at the muscles, faint bioelectrical signals appear on the skin surface. With the first of the two control systems, the “Bio-Cybernetic Control System,” HAL assists the wearer with an intended movement. In the event that no good bioelectrical signals are detectable owing to some problems in the CNS or in the muscles, HAL can be of use through the second of the two control systems, the “Robotic Autonomous Control System.”
• **Weight:** 23 kg (entire body type)—15 kg (legs-only type).
• **Maximum speed:** 1.6 km/h.
• **Battery life:** 2 hours and 40 minutes.
• **Movements:** standing up from a chair, walking, going up and down stairs.
• **Crutches:** necessary for this exoskeleton.
• **Who can use:** people with weakened muscles or people with disabilities caused by stroke and/or SCI.

ReWalk Robotics™: The ReWalk Personal System can be used at home, work, or other locations. It functions outdoors and on different surfaces or terrains. The ReWalk can facilitate patients in sitting, standing, turning and climbing, and descending stairs. The key prerequisites for use include the ability to use hands and shoulders, a healthy cardiovascular system, and a minimal bone density.

• **Functioning:** ReWalk control is based on motion sensors. Using sophisticated algorithms, movements of the upper limbs are analyzed and used to trigger and maintain the patterns of gait and other modes, such as going up stairs, and moving from a sitting to a standing position. In other words, ReWalk exoskeleton detects movements of the upper limbs. The buttons on a remote control allows the user to select various program settings and to choose the correct mode of movement: walking, climbing stairs, sitting, getting up, etc.
• **Weight:** 18 kg.
• **Maximum speed:** 3 km/h.
• **Battery life:** 8 hours. It can be recharged during the night.
• **Movements:** standing up, sitting, walking, going up stairs, climbing, and descending slopes.
• **Crutches:** necessary for this exoskeleton.
• **Who can use:** The system can accommodate a range of heights (160–190 cm) or weights (up to 100 kg). The key prerequisites for use include the ability to use hands and shoulders, a healthy cardiovascular system, and a minimal bone density.

Parker Hannifin Corporation™: Indego is a powered exoskeleton worn around the waist and legs, which allows individuals with SCI to stand and walk. At just 26 pounds, Indego’s design has no exposed cables or upper body apparatus and does not require bulky backpack-mounted components. Indego mirrors natural human movement, leans forward to initiate standing or walking, and leans backward to stop and sit. Moreover, Indego has a slim profile that is compatible with standard mobility aids and can be worn while seated in a wheelchair. Furthermore, a single-hand strapping and retention system allows Indego to be put on, taken off, and adjusted to fit without assistance. Designed from the beginning for personal use, the features of Indego make it well suited for use in a clinical setting, and for an easy transition to use at home.

• **Functioning:** With the Indego, patients with SCI or other motor problems strap their lower bodies into a piece of equipment similar in appearance to leg braces. Gyroscopes and accelerators anticipate a patient’s steps by subtle upper body motion, similarly to how a Segway works. Then, the Indego moves in concert with
the patient's leg to take a step. The wearer uses his or her muscles to do the work; the Indego provides a little extra help. Sensors determine how much power is needed, eventually decreasing as the patient grows stronger.

- **Weight**: 12.3 kg.
- **Maximum speed**: 3 km/h.
- **Battery life**: 4 hours.
- **Movements**: standing up, walking, walking on hard surfaces (including ramps and slopes).
- **Crutches**: necessary for this exoskeleton.
- **Who can use**: Indego comes in interchangeable sizes and can accommodate people from 155 cm to 193 cm in height, and up to 113.5 kg in weight.

**Rex Bionics™**: Designed for people with mobility impairments, REX is completely self-supporting and rapidly adjustable for each user. Rex Bionics is working with physiotherapists to develop the practice of robot-assisted physiotherapy. In a session of robot-assisted physiotherapy, REX lifts patients from a sitting position into a robot-supported standing position, allowing them to take part in a set of supported walking and stretching exercises designed by specialist physiotherapists.

- **Functioning**: REX is controlled by using a joystick, not through sensors; consequently, no movement or function of nerves is required to drive the exoskeleton.
- **Weight**: 38 kg.
- **Maximum speed**: 1.8 km/h.
- **Battery life**: 2 hours.
- **Movements**: standing up, walking, moving sideways, turning around, going up and down stairs, walking on hard surfaces (including ramps and slopes).
- **Crutches**: not necessary for this exoskeleton.
- **Who can use**: The system can accommodate a range of heights (142–195 cm), weights (up to 100 kg) and hip width (up to 380 mm). The key prerequisites for use include the ability to move autonomously and use a joystick.

**Honda™**: The Walking Assist Device features a function to influence the user to achieve efficient walking based on the inverted pendulum model, which is a theory of bipedal walking, and is designed as a device to be used in walking training. Three training modes are available: (i) following, the exoskeleton influences the user's walking motion based on the walking pattern of the user; (ii) symmetric, based on the walking pattern of the user, the device influences the user to achieve bilaterally symmetric motions such as bending and extending both legs, and (iii) step, the device influences the user's steps repeatedly to recover the rocker functions which enable the smooth shifting of weight.

- **Functioning**: The control computer activates motors based on data obtained from hip angle sensors during walking, to improve the symmetry of the timing of each leg lifting from the ground and extending forward, and to promote a longer stride for an easier walk.
- **Weight**: 2.7 kg, approximately.
- **Maximum speed**: n/a.
• **Battery life**: 1 hour.
• **Movements**: indoor or outdoor (except when raining) on flat floor/ground.
• **Crutches**: not necessary for this exoskeleton.
• **Who can use**: The system can accommodate a range of size-adjustable frames, making it possible for more people with various body sizes/types to use the Walking Assist Device.

### 18.2 Exoskeleton Effectiveness in Gait Rehabilitation

Given that the exoskeleton is a recently developed rehabilitative technology, nowadays there are not many studies in the scientific literature that have yet investigated its effectiveness in physical rehabilitation. Nevertheless, a recent literature review conducted by Federici et al. (2015) highlighted that the neurorehabilitative use of an exoskeleton to remedy gait disorders is safe and practical (Bishop, Stein, and Wong, 2012; Bortole et al., 2015; Kolakowsky-Hayner, Crew, Moran, and Shah, 2013; Nilsson et al., 2014), is not physically exhausting, and requires only a little cognitive (Neuhaus et al., 2011) or energetic (Asselin et al., 2015) effort. In addition, it is easy to learn (Strausser and Kazerooni, 2011), can increase mobility and functional abilities, and decreases the risk of secondary injuries (Aach et al., 2013, 2014; Asselin et al., 2015; Hartigan et al., 2015; Kolakowsky-Hayner et al., 2013; Raab, Krakow, Tripp, and Jung, 2016; Strausser, Swift, Zoss, and Kazerooni, 2010; Zeilig et al., 2012), as well as allows restoration of a gait pattern comparable to normal over ground walking (Esquenazi, Talaty, Packel, and Saulino, 2012; Farris, Quintero, and Goldfarb, 2011; Spungen et al., 2013; Sylos-Labini et al., 2014). In addition to the advantages indicated by the literature review, the exoskeleton can be considered as an ecological device, replacing wheelchairs for many hours at a time; it enables patients who cannot walk to regain a degree of walking mobility and to retard the onset of a wide range of secondary disabilities associated with the long-term use of wheelchairs. The exoskeleton can improve the autonomy of the patient, who is enabled to walk independently simply by wearing it. No other neurorehabilitative or therapeutic techniques and technologies provide such an extraordinary potential for autonomy.

Nevertheless, there are still some limitations in the neurorehabilitative use of an exoskeleton. First, the wearability criteria are considerably restrictive; its use is limited to people with specific values of height and weight (Esquenazi et al., 2012; Nilsson et al., 2014; Spungen et al., 2013; Sylos-Labini et al., 2014). Second, the neurorehabilitative use of an exoskeleton to restore gait disorders is characterized by the presence of a high rate of skin abrasions (Benson, Hart, Tussler, and van Middendorp, 2016). Third, it requires considerably complex and specialized training to use the exoskeleton autonomously at home. Fourth, it is still an extremely expensive device, hardly covered by private or public healthcare systems. For instance, the National Health Services in Europe generally support the use of the exoskeleton for a rehabilitation program in specialized medical centers, but never for a private individual’s use at home or in the workplace. A final limitation is the scarcity of experimental designs based on evidence that demonstrates the effectiveness of the exoskeleton compared to other rehabilitative techniques and technologies. Only two studies that adopted a randomized clinical trial design in the scientific literature compared exoskeleton use to conventional gait training (Stein, Bishop, Stein, and Wong, 2014;
Watanabe, Tanaka, Inuta, Saitou, and Yanagi, 2014); furthermore, the results of these two studies are contradictory. Finally, user experience with an exoskeleton in daily life activities generally did not meet subjects’ expectations in terms of perceived benefits and impact on quality of life (Benson et al., 2016).

In particular, as regards the specific types of exoskeleton cited above, Ekso is safe for those with a complete thoracic SCI in a controlled environment, in the presence of experts and that it may eventually enhance mobility in those without volitional lower extremity function (Kolakowsky-Hayner et al., 2013). Moreover, the HAL system is safe (Nilsson et al., 2014) and effective; paraplegic patients gained significant increases in over ground walking functional abilities (Aach et al., 2013, 2014), and a larger knee angle was measured during leg flexion (Kawamoto et al., 2010). In addition, diagnostic imaging displayed an augmented paired-pulse inhibition of somatosensory evoked potentials in both hemispheres following median nerve stimulation at the wrist. There was also a reduced somatosensory cortex (S1) activation of the activated area in both hemispheres after tactile stimulation of the index finger (Sczesny-Kaiser et al., 2013). Finally, even a gait training program with the single-leg version of HAL could facilitate independent walking more efficiently than conventional gait training (Watanabe et al., 2014). Furthermore, by using the ReWalk, paraplegic patients were able to walk independently, supervised by one person (Raab et al., 2016), and to achieve a level of walking proficiency that was close to that needed for limited community ambulation in an urban setting (Asselin et al., 2015; Benson et al., 2016; Esquenazi et al., 2012; Spungen et al., 2013); for example, for a distance of 100 m (Zeilig et al., 2012), with a fundamentally symmetrical gait (Talaty, Esquenazi, and Briceño, 2013). Daily use of the ReWalk exoskeleton seemed to increase activity energy expenditure, but this would be expected to have positive cardiopulmonary and metabolic benefits. The level of effort required to use the ReWalk exoskeleton system to ambulate appears to be acceptable and, as such, could be envisioned as a device that people with SCI would use in their daily lives (Asselin et al., 2015). Moreover, quality of life, mobility, risk of falling, motor skills, and control of bladder and bowel functions were improved after robot-assisted gait training (Raab et al., 2016). Nonetheless, the presence of skin abrasions was unexpectedly high and the use of the exoskeleton generally did not meet subjects’ expectations in terms of perceived benefits and impact on quality of life (Benson et al., 2016). In addition, results concerning Indego highlighted that the average walking speed was 0.22 m/s for persons with C5-6 motor complete tetraplegia, 0.26 m/s for T1-8 motor complete paraplegia, and 0.45 m/s for T9-L1 paraplegia. Distances covered in six minutes averaged 64 m for those with C5-6, 74 m for T1-8, and 121 m for T9-L1. Tetraplegic and paraplegic patients learned to use the Indego exoskeleton quickly and could manage a variety of surfaces. The walking speeds and distances achieved also indicated that some individuals with paraplegia could quickly become limited community ambulators using this system. Finally, the results of the experimental study conducted by Ikehara et al. (2011) about the Walking Assistance Device showed that it could reproduce the power of kicking motions at the ankle joints when controlled by the hybrid system.

18.3 Exoskeleton in the Assistive Technology Assessment Process

Assistive technologies (AT) are “any product (including devices, equipment, instruments and software), particularly produced or generally available, used by or for persons
with disability for participation, to protect, support, train, measure or substitute for body functions, structures and activities, or to prevent impairments, activity limitations or participation restrictions” (ISO, 2016). This definition, proposed by ISO since the 1999, was also adopted by the World Health Organization and revived in two outstanding documents on disability: the International Classification of Functioning, Disability and Health (ICF; WHO, 2001) and the Report on Disability (WHO and World Bank, 2011). The ISO’s definition of assistive products was also discussed at the GATE, the Global cooperation on Assistive Health Technology (a WHO initiative; http://www.who.int/disabilities/technology/gate/en/). GATE proposed a “positive approach” proposing to change the definition using a more positive wording, for example, “any product (including devices, equipment, instruments and software), particularly designed and produced or generally available, whose primary purpose is to maintain or improve an individual’s functioning and independence and to facilitate participation.”

These definitions highlight that what makes a device an assistive product, namely an AT, is the use of the product, rather than its intrinsic characteristics. For use of the product means who uses the AT (or for whom the AT is used), namely the person with disability, and the purpose of use, namely, to neutralize barriers (WHO, 2001), improve functioning, and promote well-being (WHO, 2016).

Therefore, AT plays a key role in facilitating the social integration and participation of people with physical, sensory, communication, and cognitive disabilities, by reducing the mismatch between the needs of a person and what an environment can offer (ISO and IEC, 2008).

According to the above mentioned AT definitions, the exoskeleton may with good reason be considered an AT when it is used by people with gait disorder in order to improve their motor functioning and promote well-being. However, despite its effectiveness in gait rehabilitation, the exoskeleton represents an AT that can scarcely be assigned, and therefore evaluated in the respective Assistive Technology Assessment (ATA) process, for private use. Indeed, as cited above, the use of the exoskeleton requires very complex and specialized training in order to allow for autonomous use at home that exceeds the ordinary competence of a center for technical aids. Moreover, it is still an extremely expensive device, hardly covered by private or public healthcare systems. For instance, the National Health Services in Europe generally support the use of the exoskeleton for a rehabilitation program in specialized medical centers, but never for a private individual’s use at home or in the workplace.

In the following section, we will present the activities conducted by an Italian neurorehabilitative center where two exoskeletons, Indego and Ekso, are employed for intensive gait rehabilitation training.

### 18.3.1 The Neurorehabilitation Program with Exoskeleton at an Italian Neurorehabilitative Center

#### 18.3.1.1 What Is Done

Only a few neurorehabilitative centers provide a program with exoskeletons in Italy, because of the recent development of this technology and the evidence-based efficacy of the neurorehabilitation program where the exoskeleton is employed. In addition, the National Health Service does not cover for a private individual’s use of the technology at home or in the work place. According to our knowledge of the functioning of Italian neurorehabilitative centers where the program with an exoskeleton is provided, the user with a serious gait disorder accesses the center in agreement with the National Health Service
that cover the expenses, in order to undergo a neurorehabilitation program. A form has to be completed by the user’s general practitioner (or physiatrist), who makes an explicit hospitalization request indicating the disease and the need of rehabilitative care. Subsequently, a neurologist and the center’s health management ascertain the pertinence of the rehabilitation demand.

Afterwards, a multidisciplinary team meeting evaluates the user’s data. As a rule, the multidisciplinary team is composed of a neurologist, a neuropsychologist, a cardiologist, a physiatrist, and a physiotherapist; each assesses specific inclusion and exclusion criteria for the exoskeleton neurorehabilitative use. Particularly, the neurologist examines user’s disease from a nosographical point of view,—for example, stroke (acute, post-acute or chronic; hemorrhagic or ischemic), SCI (complete or incomplete), traumatic brain injury, degenerative diseases (such as multiple sclerosis, or Parkinson’s disease)—and, assisted by the physiatrist and the physiotherapist, evaluates spasticity, residual strength, sensitivity, involuntary movements, dyskinesias, dystonia, and abnormal reflexes with specific neurological scales. The neuropsychologist assesses a potential cognitive decline (e.g., mild cognitive impairment, dementia) and psychological impairment (bodily self-perception, anxiety and mood). In addition, the cardiologist checks cardiac function, respiratory rate, and energy consumption during a physical effort.

To complete the elaboration of the functional profile, in order to define user’s inclusion to neurorehabilitative exoskeleton program, other clinical tests are performed in line with the international scientific literature.

Several other clinical assessments are suggested to define the eligibility of the user to neurorehabilitative exoskeleton program. Below, we briefly review the main studies.

In a study conducted with the ReWalk system, Esquenazi and colleagues (2012) suggest to include a dual-energy x-ray absorptiometry (DXA), electrocardiography, and leg long bone and lumbar spine x-rays to confirm joint integrity and absence of unhealed fractures or heterotopic ossification that may impede walking. Furthermore, a complete neurologic evaluation by a study co-primary investigator should be used to confirm the injury level, skin integrity, hemodynamic stability, adequate hip, knee and ankle range of motion (ROM), and a spasticity level of 3 or less using the Ashworth scale (Bohannon and Smith, 1987). The above information should be combined with the absence of osteoporosis on the basis of bone mineral density (BMD), measured from the right-limb femoral neck and the L2 to L4 spine. The same clinical assessment is suggested by the study of Talaty and colleagues (2013), which also employed the ReWalk. BMD t scores at the measured sites of greater than −2.5 is required based on the definition of osteoporosis from the World Health Organization (Kanis, Melton, Christiansen, Johnston, and Khaltaev, 1994).

In addition, in their study with the ReWalk, Asselin and colleagues (2015) suggest a physiatrist’s examination of BMD by DXA as part of the medical screening process. Each potential participant’s level of impairment should be evaluated by a trained physiatrist according to the American Spinal Cord Injury Association (ASIA) Impairment Scale (ASIA, 2000). The DXA scan is performed to obtain regional measurements of BMD at the proximal femur, distal femur, and proximal tibia. Finally, in a study where the Ekso was employed, Kolakowsky-Hayner and colleagues (2013) suggest using a Pre-Screening Tool in order to evaluate basic characteristics and eligibility of participants prior to neurorehabilitative training enrollment. Demographic data should include ASIA Impairment Scale status, Neurological Level of Injury (NLI) as defined by ASIA, age, gender, and date of injury. Other baseline data should include spasticity, ROM, upper and lower extremity motor function, proprioception, level of functional mobility (e.g., transfers), and measurements to screen for Ekso device appropriateness. Prior to application of the device, each
session should begin with the Physical Therapist (PT) assessing the participant’s skin, baseline pain utilizing the Subjective Pain Scale (SPS), and spasticity using the Ashworth scale.

After this, and after environmental evaluations, the multidisciplinary team selects the suitable technological product, so the matching process starts, in which there are the assistive solution proposal, user trial, and outcome evaluation. In an Italian center, the multidisciplinary team, as described above, assesses data collected in the previous step and selects the appropriate technological aid, for example, the exoskeleton or a robotics-assisted treadmill training (such as the “Lokomat”). Then, the rehabilitative process starts. At the end of this, there is a new multidisciplinary team meeting, aimed at evaluating the user’s gait improvements. Then, the user is dismissed.

18.3.1.2 What Is Missing

In Italian neurorehabilitative centers, even if the general practitioner/physiatrist reports user’s functional analysis, typically this form cannot include clinical measures (that are evaluated when the user comes into the institute) and psycho-socio-environmental evaluations. Consequently, it is also impossible to perform the user data evaluation step by the multidisciplinary team, as it requires team members, rather than to perform an aid-user matching, to conduct a functional assessment directed to determine the neurorehabilitative use—or not—of the exoskeleton. Moreover, there is not an environmental assessment process and, accordingly, a matching process. If the user is considered able to use the exoskeleton, the assistive solution is proposed; however, there are no user trials and outcome evaluations. Nowadays, there are no instruments that allow to measure the exoskeleton AT match. Furthermore, the multidisciplinary team can not consider the user agreement; once the exoskeleton rehabilitation program is completed, the assistive solution is not provided to the user (indeed, the National Health Services in Europe support the use of the exoskeleton for a rehabilitation program in specialized medical centers, but never for a private individual’s use at home or in the workplace). Finally, in Italy, centers are not expected to follow-up with users; at the end of the rehabilitation program, the multidisciplinary team assesses each rehabilitative outcome and, based on this assessment, suggests a specific number of future medical examinations, but there is no standardized follow-up protocol.

18.4 Conclusions

The neurorehabilitative use of an exoskeleton to restore gait disorders is safe and practical (Bishop et al., 2012; Bortole et al., 2015; Kolakowsky-Hayner et al., 2013; Nilsson et al., 2014), is not physically exhausting and requires only a little cognitive (Neuhaus et al., 2011) or energetic (Asselin et al., 2015) effort. In addition, it is easy to learn (Strausser and Kazerooni, 2011), can increase mobility and functional abilities, and decreases the risk of secondary injuries (Aach et al., 2014; Aach et al., 2013; Asselin et al., 2015; Hartigan et al., 2015; Kolakowsky-Hayner et al., 2013; Raab et al., 2016; Strausser et al., 2010; Zeilig et al., 2012), restoring a gait pattern comparable to normal over ground walking (Esquenazi et al., 2012; Farris et al., 2011; Spungen et al., 2013; Syllos-Labini et al., 2014).

Moreover, the exoskeleton can be considered as an ecological device that replaces wheelchairs, thus retarding the onset of secondary disabilities associated with the
long-term use of them. Its use improves the autonomy of the patient, giving those who are unable to walk independently the ability to move over the surrounding ground simply by wearing the exoskeleton and regain a degree of walking mobility.

Nevertheless, there are still some limitations in the neurorehabilitative use of an exoskeleton, such as restrictions on the height and weight of users (Esquenazi et al., 2012; Nilsson et al., 2014; Spungen et al., 2013; Sylos-Labini et al., 2014), its extremely expensive cost that is not covered by private or public healthcare systems, and the high risk of skin abrasions associated with its use (Benson et al., 2016). Moreover, using the exoskeleton autonomously at home requires very complex and specialized training. A last limitation is the scarcity of experimental research that demonstrates the effectiveness of the exoskeleton compared to other rehabilitative techniques and technologies. Indeed, only a few studies adopted a randomized clinical trial design that compared exoskeleton use to conventional gait training (Stein et al., 2014; Watanabe et al., 2014), obtaining contradictory results. Moreover, user experience with an exoskeleton in daily life activities generally did not meet subjects’ expectations in terms of perceived benefits and impact on quality of life (Benson et al., 2016).

Consequently, despite its effectiveness at gait rehabilitation, the exoskeleton represents an AT that can rarely be assigned, and therefore evaluated in an ATA process. Indeed, this has been highlighted in analysis of activities conducted by an Italian neurorehabilitative center where two exoskeletons, Indego and Ekso, are employed for an intensive gait rehabilitation training. While a neurorehabilitative center may apply some of the ATA process model (see Section 1) steps—such as Multidisciplinary team meeting and data evaluation, Setting setup, Technological aid selection and Environmental assessment process, and Matching process—other important steps are actually very difficult to be incorporated into a neurorehabilitative program with an exoskeleton—such as User data collection, User agreement, User support, and Follow-up.

18.5 Summary

This chapter is divided into three main subsections. The first focuses on what an exoskeleton is, describing the history of this robotic device as rehabilitative technology, and the state of the art of its use in neurorehabilitation. Additionally, the technical data of exoskeletons currently commercialized by six main multinational companies are presented. The second section focuses on the exoskeleton’s effectiveness in gait rehabilitation, reviewing the results of latest clinical research. The third section analyzes the exoskeleton as an AT, reporting the neurorehabilitative program with exoskeleton conducted by an Italian institute.

References


Exoskeleton: The New Horizon of Robotic Assistance for Human Gait


19

Assistive Technologies for Children with Autism Spectrum Disorder

Chiara Pazzagli, Giovanni Fatuzzo, Simone Donnari, Valentina Canonico, Giulia Balboni, and Claudia Mazzeschi

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19.1 Introduction

There is consensus across the international scientific community that autism is a spectrum disorder (ASD). This is characterized by a group of neurodevelopmental conditions marked by impairments in social interaction and communication, and restrictive, repetitive, and stereotyped patterns of behavior, interests, or activities (APA, 2013). In recent years, the prevalence rates of ASD have increased dramatically (Isaksen, Diseth, Schjølberg, and Skjeldal, 2013). The Centers for Disease Control and Prevention (2014) reported the prevalence of ASD in children in the United States as 1 in 68. At the same time, the views of society on ASD have changed, with more resources being invested in research and development of effective interventions, and a heightened interest in developing useful tools for people with disabilities has arisen in the field of Interactive Computer Technologies.
Recent trends in technology usage suggest that our lives are becoming increasingly connected to mobile technologies (Raine, 2014). These trends point to the development of innovative technologies to provide support in everyday life for people with typical development and for people with ASD, as well. The ISO 9999 classification of technical aids defines these as “any product, instrument, equipment or technical system used by a disabled person, particularly produced or generally available, preventing, compensating, monitoring, relieving or neutralizing” disability. In this regard, “any product or technology can be assistive” (WHO, 2001, p. 340).

Despite the research on the application of assistive technologies (AT) for children with ASD still being in its infancy, there is growing interest in this topic. Children with ASD suffer from communication disorders, and studies have shown that these children often analyze and receive visual information more effectively than auditory information. The use of AT in this area is considered particularly helpful as it focuses on the communication channel, which is a point of strength for this group (Fteiha, 2016). Furthermore, individuals with ASD prefer interventions, which involve interacting with technology as it causes them less anxiety than face-to-face or group-based work. Furthermore, AT enables a systematic approach to learning, which is particularly appropriate for the cognitive profile of individuals with ASD (Cassidy, Stenger, Van Dongen, Yanagisawa, Anderson, Wan et al., 2016).

Several studies evaluated and validated the use of AT for children with ASD (Kuo, Orsmond, Coster, and Cohn, 2014; Mazurek and Wenstrup, 2013; Shane and Albert, 2008). Parents and caregivers regularly report that children with ASD are drawn to AT, and researchers have noted the importance of devising treatments that take advantage of this fascination. AT can help individuals with ASD in their daily lives by facilitating improvements in academic teaching, in training on imitation skills and emotions recognition, and by mitigating social anxiety (which is a core issue in ASD) and fostering independence (Shic and Goodwin, 2015).

The objectives of the present chapter are to present an overview of scientific literature on AT for children with ASD in order to identify further areas that need to be addressed. The final objective is to present a novel tool called Painteraction, which emerged from clinical experience and is tailored to children with ASD.

19.2 Literature Overview

An analysis of the main studies that focused on treatments for persons with ASD using AT, which were published in the last 15 years was carried out, with priority being given to the review of papers and recent literature. Because the classification of AT differs among the reviewed studies, it was decided that this chapter should propose an overview of the literature that adopted a categorization of AT according to the type of instrument used: video modeling, mobile learning devices, robots, virtual and augmented reality, and serious games.

1. Video Modeling is a combination of the concept of modeling and video demonstration through visual signals (Dowrick, 1991).

2. Mobile Learning Devices are defined as all those portable gadgets, particularly smartphones and tablets, and all open-source apps that are alternative learning practices to other AT (Ismaili and Ibrahimi, 2016).
3. Robots, in particular social robots, are autonomous agents that can act in a socially appropriate manner based on their role in an interaction with a child with ASD (Welch, Lahiri, Sarkar and Warren, 2010). There are two different kinds of robots used in interventions with children with ASD: humanoid or human-like robots, which are used to teach social skills, and nonhuman-like robots, which are mainly used for recreational purposes.

4. Virtual Reality and Augmented Reality. The first can be defined as the use of interactive stimulations created through a device and presented to users that perceive stimulations to be similar to real life environments (Weiss, Rand, Katz, and Kizony, 2004). Augmented Reality differs as the individual continues to experience common physical reality while at the same time taking advantage of additional and/or manipulated information. The distinction between Virtual and Augmented Reality is therefore entirely artificial, as it is possible to consider them in a continuum of mediated reality (Milgram, Takemura, Utsumi, and Kishino, 1994).

5. Serious games encompass digital games that contain educational elements (Sawyer, 2007).

19.2.1 Video Modeling

Video Modeling (VM) is the oldest AT applied in interventions with ASD. There are numerous reviews of this type of intervention and several studies, which evaluate the efficacy and efficiency of VM interventions. Nowadays, VM is also widespread in interventions that make use of different kinds of AT as a training tool.

The VM intervention strategy consists of showing videos that present an appropriate method to perform a behavior in order to reach a certain goal. This type of VM can be considered an evolution of learning by imitation, which delimits the visual focus using video technology. Generally, most of the VM interventions include the use of videos, lasting up to three minutes, that show the method to perform a behavior and a reproduction of what has been seen on the video. The model to imitate can be a peer, a parent, or a teacher, as well as unknown adults.

The objective of VM strategies is to teach several skills and abilities, from social and communicative abilities (Charlop, Dennis, Carpenter, and Greenberg, 2010; Sherer, Pierce, Paredes, Kisack, Ingersoll, and Schreibman, 2001), to motor behavior and functional autonomy (Plavnick and Ferren, 2011; Shipley-Benamou, Lutzker, and Taubman, 2002), and even professional abilities or cognitive and emotive autoregulation (Bellini and Akullian, 2007).

Visual presentation of information is the preferred form of learning and support for children and adolescents with ASD (Shane and Albert, 2008). There is therefore a great deal of evidence showing how presenting information through videos is more efficient than a static presentation (Van Laarhoven, Kraus, Karpmann, Nizzi, and Valentino, 2010), and that big screens are typically more effective than small ones (Mechling and Ayres, 2012).

One of the most widespread VM strategies is self video modeling, which involves “an intervention utilizing the idea of feed-forward in which, through editing, the intervention portrays images of a skill not previously mastered in the child’s current repertoire” (Dowrick, 1999, p. 24). VM and self video modeling are not new to the field of education, with several studies in this area having been published over the years. For example, VM interventions have been applied to improve the capacity to relate to friends and teachers in their natural environment and to enhance the social initiation level in children with ASD (Charlop et al.,
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Shukla-Mehta and colleagues (2010) distinguish three VM strategies for the training of children with ASD: VM, self video modeling, and point-of-view video modeling (which requires videotaping elements of the environment or activity from the individual’s point of view). The authors explain the benefits of each as follows: “VM would be more effective for students with good attending skills and higher tolerance for auditory stimuli; self video modeling appears to be more effective for students who are motivated by viewing themselves on a tape and are more cooperative with the interventionist; point-of-view video modeling is more effective with students who display problem behavior during difficult transition routines and other unpredictable events” (p. 34). As an intervention cannot be generalizable to all individuals with ASD, the choice of the different kind of VM must be evaluated in the assessment phase, case by case, according to the abilities of each child and the objectives of the treatment.

19.2.2 Mobile Learning Devices

Mobile Learning Devices (MLD) are defined as “learning mediated via handheld devices and potentially available anytime, anywhere. Such learning may be formal, may be informal” (Kukulska-Hulme and Shield, 2008, p. 275). Recently, MLD have been used in therapy to target social deficits, in particular eye contact, in children with ASD (Autism Speaks Inc., 2015), and to acquire a verbal repertory more easily (Lorah and Parnell, 2014).

Augmentative and Alternative Communication (AAC) is one of the most employed MLD. AAC includes a set of techniques, strategies, and technologies that are used to simplify and increase communication in persons who have difficulties using the most common communication channels, mainly oral language and writing. AAC techniques for individuals with ASD include picture exchange, picture exchange communication system, speech generating devices, and voice output communication aids. The first two are very well-known techniques, developed by Bondy and Frost (1994), and evaluated in the last 20 years. Speech generating devices and voice output communication aids are “electronic devices that rely on the speaker’s pressing of a picture, word, or symbol depicting an item, activity, response or statement on an electronic screen with enough force to evoke a synthetic speech output” (Lorah and Parnell, 2014, p. 3793).

While speech generating devices vary greatly in terms of cost and technological capabilities, modern MLD such as smartphones, tablets, and Ipods are more readily available to individuals with ASD and, as they are more flexible and attractive, are even more customizable (Kagohara, Van der Meer, Ramdoss, O’Reilly, Lancioni, Davis et al., 2013; Lancioni, O’Reilly, Cuvo, Singh, Sigafoos, and Didden, 2007; Lorah, Parnell, Shaefer Whitby, and Hantula, 2015).

Although MLD are widely considered to be more cost efficient than other AT, there has been a lack of research which evaluates the effectiveness of these technologies to enhance social skills. Lorah and Parnell (2014) stated that the literature is still in a “state of flux” and that there are not enough studies to justify a meta-analysis. Furthermore, in the reviewed literature, despite the presence of several studies concerning the efficiency of specific apps for children with ASD, no clear decision has been made about the kinds of apps that are more appropriate for specific diseases.

To address this gap, Ismaili and Ibrahimi (2016) proposed a recent review of the most commonly used apps based on the type of pathology addressed and the cost of the app itself. They reported that for children with ASD the most functional and affordable app is...
“JABTalk,” which is a free vocal speech application that converts portable devices into AAC ones. It is designed to help children with ASD and those with problems in vocal speech to communicate. Another similar app is “TapToTalk,” which helps children with disabilities or ASD to communicate through presentation and interaction with images, along with the vocal repetition of their meaning. In conclusion, the lack of research evaluating the effectiveness of MLD is due to the continued need to find individualized apps for specific disorders. Furthermore, the lack of multilanguage apps and properly trained personnel, along with the high costs, limit the MLD used in interventions with children with ASD.

19.2.3 Robots

Thanks to today’s technological successes in the field of artificial intelligence, recent research has recommended the use of robots as clinical tools to improve the social skills of children with ASD (Diehl, Schmitt, Villano, and Crowell, 2012). There are two types of robots mainly used in interventions with children with ASD: human-like and nonhuman-like robots. Their use depends on the intervention and research objectives. While humanoid robots are capable of stimulating and promoting social behaviors in persons with ASD, nonhuman-like robots are effective in teaching specific skills because of the interest children with ASD have in exploring the mechanical parts of robots (Hashim, Fikry, Ismail, Musa, Hashim, Ahmad et al., 2014).

The majority of studies concerning the use of humanoid robots are in the field of Socially Assistive Robotics, a novel interdisciplinary branch that aims to use robots to help individuals through social interaction. Humanoid robots are used to facilitate social interaction and/or emotional expression, to train in social abilities, and to provide companionship. Particularly, for children with ASD, social robots can provide verbal and nonverbal body language that helps in social interaction, also facilitating imitation and joint attention (Scasellati, Admoni, and Mataric, 2012). Several prototypes of social robots have been used, such as mobile robots, creature-like robots (also animal-like), robot dinosaurs, and humanoid robots (designed to be human-like).

Studies using these robots have the main purpose of increasing joint attention abilities in order to enhance imitation abilities, which are crucial to develop social relationships. For example, Warren and colleagues (2013) showed in a pilot study how the interaction with a “NAO” (a humanoid robot), which had been programmed to provide dynamic, adaptive, and autonomous interactions during imitation tasks, increased in children with ASD joint attention as well as their capacity to focus on tasks.

Recently, Sang-Seok and colleagues (2016) proposed a robot-assisted behavioral intervention system capable of facilitating social skills for children with ASD and examined its feasibility and effectiveness in ASD treatment. The robot was used to maintain eye contact with the child and help him to recognize emotion through a human–robot interaction that is less disturbing than a human–human one. Particularly, the authors compared two different kinds of robots in order to analyze the flexibility of the robot-assisted intervention in the training of social abilities with children with ASD. One is the iRobiQ, a child-sized robot designed with an attractive appearance and with an LCD monitor with a touch screen on the front. It provides facial expressions owing to its LED on the front; it has several children's songs, dances, and daily routine animations that can be modified as required. The other is a clinical assistive robot (CARO) particularly designed to perform simple emotional interchanges based on eye expression (happiness, surprise, sadness, anger, fear, aversion, and disappointment) for children with ASD. The CARO interacts in a similar manner to
iRobiQ and enables the child to be at the same height as the robot so that eye contact and focus can be maintained. Sang-Seok and colleagues (2016) found that when different robots were used during the treatment, there was an increase in the amount of eye contact, an improvement in emotion recognition, and a progressive increase in correct answers to the robot’s prompts. Sang-Seok and colleagues (2016) explained these results as being due to the correct configuration of the provided stimulation, thus confirming the hypothesis that the proposed system could be an efficient tool to stimulate the active participation of children with ASD. As the observed enhancement in joint attention decreases over time owing to habituation to the stimulus, the authors underlined the need to design novel artificial intelligence that could better interact through continuous modeling of the behavior based on the explicit needs of the child. As the authors commented, more evidence-based clinical studies in long-term treatments with large sample sizes are required.

In conclusion, it would be desirable for a social robot to detect affective changes and respond in an affect-sensitive manner to the child in order to maintain an optimally positive social interaction. The development of a supportive social interaction can lead to an increase in learning opportunities and their generalization in daily life (NRC, 2001). Furthermore, in many of their current forms, humanoid robots are limited in performing sophisticated actions, eliciting responses from individuals, and adapting their behavior as humans would do. As Warren and colleagues (2013) stated, “it’s both unrealistic and unlikely that in the immediate future robotic technology will constitute a sufficient intervention paradigm addressing all areas of impairment for all individuals with ASD” (p. 3733).

19.2.4 Virtual Reality and Augmented Reality

This field of technological tools has been extensively of interest of scientific technology, providing the development of more and more sophisticated tools. Virtual reality (VR) technology can be defined as “the sum of the hardware and software systems that seek to perfect an all-inclusive, immersive, sensory illusion of being present in another environment, another reality; a virtual reality” (Biocca and Delaney, 1995, p. 63). Biocca and Delaney (1995) defined VR as “a medium for extension of body and mind” (p. 58).

Nowadays, VR technology is totally immersive. It includes the use of associated devices such as helmet, gloves, and a VR suit. However, it is expensive and can only be used in particular research settings. There are also semi-immersive VR systems, such as motion-capture systems like Wii or Kinect, which are considerably cheaper. These have been more widely developed and in some cases used in therapy with children and teenagers with ASD (Levac et al., 2010).

Recently, VR systems have been used in interventions with individuals with ASD through human–computer interaction tasks mediated by VR (Kuriakose and Lahiri, 2015; Parson, 2015; Tartaro and Cassell, 2007). This was made possible because VR has many strengths, such as malleability, controllability, replicability, editable sensors, and the ability to individualize the treatment and the reinforcing strategies.

In the reviewed studies, many VR systems were used with children with ASD to train in social abilities because of their efficiency and their ease of retrieval and use. Owing to the relatively new development of these technologies for therapeutic purposes with children with ASD, no reviews in the field of VR and Augmented reality (AR) have yet been published. Numerous studies are still at a preliminary testing phase, and there is still a need to define general patterns in order to evaluate the efficacy and efficiency of treatments.

Of particular interest is a novel instrument developed for children with ASD named “Block Challenge,” a two-player collaborative virtual environment game in which children
have to verbally communicate and collaborate with, and understand the perspective of, the other child in order to be successful in completing the game (Parsons, 2015). Data from the preliminary observational study showed that “Block Challenge” activates the reciprocity of the child and promotes interactions among children using the other’s point of view, together with scaffolding behaviors between teachers and children.

Thanks to recent discoveries in the field of new technologies, it is expected that novel devices will be more cost efficient and accessible to all. One of the most impressive discoveries is AR, which is a reality mediated by a device, characterized by an enrichment of sensory perception through information that would not be perceptible, which is manipulated and conveyed electronically. While using VR, the user receives an overwhelming amount of information from the device to the point of being completely immersed in a reality where natural sensory perceptions are replaced by others. In contrast, in AR the individual continues to experience the common physical reality by taking advantage of additional and/or manipulated information at the same time.

There are two mediums through which AR can be experienced: a mobile device and a computer. For the first medium, such as a smartphone, the viewer is equipped with a geolocation system and a video player. Through the smartphone’s camera, the surrounding environment is framed in real time and the augmented contents are added—these vary from geolocated points of interest to 3D elements.

Escobedo and colleagues (2014) proposed the use of an AR system for object identification that allows teachers to superimpose digital content on top of physical objects. The “Mobis,” Mobile Object Identification System, is a mobile AR application for smartphones that allows children with ASD to be trained in object discrimination. The system can be set at any time by the teacher, specifying the level of difficulty, but it also continuously detects each child’s progress and increases or decreases the level and amount of prompting in real time. When the child successfully identifies the selected object, a reward is provided (such as a short video of Mario Bros dancing). Otherwise, suggestions on how to do better are provided through audio messages, vibrations, and geometric shapes. Participants reported that the “Mobis” was “useful, exciting, and easy to use.” For the authors, the results highlight the possibility of using AR systems as a visor to uncover digital content. This technology can be of great support to children with ASD by enhancing therapy goals with easy interaction, potentially moving the therapy away from the setting to the natural environment where children live and interact. Escobedo and colleagues (2014) also analyzed the impact of the “Mobis” on attention. They discovered an increase of 20% on the time spent by children doing a task, together with a better level of engagement with people and objects. The system improved both selective (62%) and sustained (45%) attention. This further confirms the potential for the use of this system in a school environment to help in focusing on tasks and reducing disruptive behavior. The “Mobis” also promoted positive emotions during the intervention, teaching children to be tolerant and respectful of others, and helping them to wait for their turn to therapy. All these positive changes in children’s behavior help them to better fit into society and integrate into social groups.

19.2.5 Serious Games

The importance of play in learning was suggested by Vygotskij. He set out a social constructivist theory, which included the notion of a zone of proximal development (Vygotskyij, 1934). In the past, the design of serious games was based on the precepts of behavioral psychology but developers now draw on various psycho-pedagogical models.
Over recent years, considerable interest has been devoted to the pursuit of learning through so-called serious games. Serious games have multiple definitions. In studies with children with ASD, an emphasis on the learning dimension is generally adopted: “Serious games are focused on the integration of educational objectives with specific evidence-based game mechanics known to support learning and generalization of learning” (Whyte, Smyth, and Scherf, 2014, p. 3821). In persons with ASD, serious games enable the individual to develop perception, attention, and memory, providing also behavioral changes through learning by doing (Arnab et al., 2012).

The use of serious games in the therapy of children with ASD is considered valid because it furnishes strong motivational reinforcement and guarantees the customization of learning (Whyte, Smyth, and Scherf, 2014). To fulfill their purpose, serious games must meet specific conditions: they must use engaging stories to promote a complete immersion in the task, have objectives aimed at developing specific skills, and provide reinforcements and evaluations in progress toward the objective to be achieved. Furthermore, they must have different levels of difficulty, which must increase but be adaptable to the needs, and provide individualized learning skills to offer different choices based on the performance of the user during the game (Kapp, 2012).

Whyte and colleagues (2014) reviewed 16 studies published between 1995 and 2014 that use novel technologies and have gaming elements. The authors suggested that there was a need to improve interventions through the inclusion of long-term goals incorporated in a coherent narrative of individualized learning. Furthermore, improvements must be made in the inclusion of specific generalization activities and opportunities for self-reflection on the tasks conducted that enhance the transfer of knowledge from the intervention with the technological device to the person’s daily life. The authors emphasized the importance of developing and using these instruments as they are a cost efficient alternative to other AT and can be used outside of the therapeutic context.

Zakari and colleagues (2014) reviewed 40 studies from 2004 to 2014 of clinical cases and games designed for different learning objectives. They found that 70% of the serious games analyzed for persons with ASD were designed for PC use. However, playing through smartphones and tablets has become more and more common owing to the touch screens of these devices, which focus the child’s attention and facilitate the interaction with the tool (Yan, 2011).

Concerning learning objectives, Zakari and colleagues (2014) noticed that 54% of the reviewed studies were oriented to the improvement of social and communication skills and another 26% were designed to improve social conversation, learn new words, or for speech therapy intervention. However, the authors found that games designed to improve sensory elaboration disorders, to teach first aid, and to develop imaginative play had a lower percentage of employment in games for persons with ASD. The authors felt there was a need to reconsider the use of these games because sensory elaboration disorders are ubiquitous in the majority of individuals with ASD and can be used as diagnostic markers or to track the progress of treatment. Concerning the game-play aspects, the review showed that 80% of the studies had designed games or applications to entertain or assist children with ASD. Through the game, the intervention links an enjoyable activity to learning, thus contributing to the simultaneous development of different abilities. The remaining 20% of the studies analyzed the existing games to evaluate the use of serious games, such as games based on physical activity and body movements.

In conclusion, the use of serious games in interventions with children with ASD may provide different opportunities for cost-effective teaching tools that can be used in different settings to supplement traditional teaching methods. As Whyte and colleagues
(2014) stated, the development and use of serious games have important implications for interventions as they increase competence in specific skills in a safe and supportive environment. Unfortunately, there is limited evidence of generalization from computer-based instruction to daily life, particularly for cognitive training programs.

19.3 How They Work: From Ideation to Application

Several approaches and methods using AT have become available for the therapy and special education of children with ASD. However, much has yet to be improved to achieve significant success in treating persons with ASD.

The majority of the interventions using AT have not been validated outside the context of proof of concept (Buocenna et al., 2014). One of the main gaps is related to generalization and transfer of the learned skills to real-world contexts. The failure of learners to generalize skills is due to at least two reasons: on one hand, it is related to the core characteristics of ASD, such as rigidity in routines and difficulties with pragmatic aspects of communication, along with the considerable heterogeneity of ASD; on the other hand, it is also due to the specific type of teaching strategies and programs often used with persons with ASD (McCleery, 2015). Many of the existing technologies have limited capabilities in their performance, and this limits the effectiveness of treatments for individuals with ASD.

As stated earlier, a general weakness is the small and not representative sample sizes (from 6 to 10 children on average, often composed of high-functioning ASD) and the lack of a control group. This limits the evidence that computer-based training can improve autism symptomatology and the generalization of the results. Moreover, it clearly shows the need for more interdisciplinary design and use of AT, proceeding step by step from laboratory to daily life.

On the laboratory side, the design of new AT needs to be more grounded on the real needs of persons with ASD and adaptable to the specificities of the functioning of the person with ASD. Moreover, the needs of clinicians and operators involved in the individual first aid should also be considered in order to better coordinate all the environments with which the subject is in contact.

On the clinical side, there is a need to use more customized technological tools because nowadays, for the purpose of efficiency, commercialized tools (such as VR video games) are used and adapted to clinical practice. Moreover, providing a diagnosis of functioning level, instead of a simple nosographic one, can highlight strengths and weaknesses of the individual with ASD, allowing the clinician to better customize the intervention.

McCleery (2015) highlighted the need to identify domains of functioning for which technology will have maximum impacts on quality of life and independent living. The author indicates the need to tailor the intervention’s methods and technologies in order to address both the particular challenges and the particular needs of individuals with ASD.

19.4 A New Intervention Proposal: Painteraction

A novel technological tool named Painteraction was recently developed from an original idea by Donnari (2015), which was funded by Fondazione Charlemagne Onlus. The
tool emerged from the difficulties that a therapist can meet during an interaction with a nonverbal, low functioning child with ASD. Painteraction has already been presented in numerous conferences worldwide. The Atlas Centre will apply it in two funded Erasmus + projects (Tablo, 2015; Create, 2016) with long-term patients and refugee populations, and it has also been cited twice by the UN newsletter as a new type of intervention for social inclusion of people affected by symptoms from across the autism spectrum.*

19.4.1 Development of the Tool

The following are the key elements of Painteraction:

1. Intuitive understanding of “how it works” and ease in managing the tool
2. Screen acting like a mirror
3. Visual feedback of movements
4. Sensorial integration: movement, visual feedback, and sound
5. Different applications for a tailored treatment
6. Data recording

1. *Intuitive understanding of “how it works” and ease in managing the tool:* From the initial phase of development, it was considered crucial to avoid VR equipment such as helmets and remote controllers given that not every child with ASD tolerates such devices or has the motor skills to operate them safely and effectively. The development of the motion-sensitive device Kinect at an affordable price represented a huge opportunity to interact with a screen just by using bare hands and body movements. Kinect is Microsoft’s motion sensor videocamera for the XboxOne gaming console. The device provides a natural user interface that allows users to interact intuitively with voice and gestures without any intermediary device, such as a controller.

2. *Screen acting like a mirror:* From testing different tablet applications and video games, it became clear that screen mirroring the room and the users (the child with ASD and therapist) made it much easier for the child to accept the presence of the therapist, to look at him/her not in the eyes but on the screen, to start interacting together, and even accept physical contact. From this perspective, the screen could be seen as a sort of “third space” (Ogden, 1994), where the relationship between child and therapist could be safely developed. Moreover, the screen reproduces the real room where the action happens, but at the same time it is also a frame that contains a more complex reality and reduces it to a “manageable size.”

3. *Visual feedback of movements:* Since the very first experiences, the possibility of receiving visual feedback of body movements appeared a strong key element as it could catch a child’s attention and help them to immediately understand how the software worked. Moreover, by watching their own images on the screen and experimenting with the visual effects of their body movements (e.g., watching

themselves while rocking or incessantly rotating one hand), the children could often find a purpose in every movement. In this manner, they were enabled to overcome stereotypical gestures and use their body movement for a definite purpose, for example, to generate a trail of light that was visible on the screen.

4. **Multisensory and motor integration: movement, visual feedback, and sound:** Some children with ASD have sensory processing and sensory integration dysfunctions that affect their motor skills and their sensory system (sight, hearing, smell, taste, touch, vestibular, and proprioceptive). The motion responsive technology provides the integration of different sensorial inputs because it is based on software that can connect the motion input to visual and audio feedbacks.

5. **Different applications for a tailored treatment:** Technology should offer more tools to address the different kinds of autism spectrum disorders because every intervention should be tailored to the specific needs and skills of the individual. The Painteraction system aims to do this by offering different applications that allow the therapist to better understand the approach that is preferred by the specific child.

6. **Data recording:** This technology thus offers the opportunity to keep track of small changes during the therapy. Data stored in a cloud can be retrieved from researchers to perform assessment and evaluation. Moreover, data can be used for supervising the therapists.

### 19.4.2 Painteraction Technological System

The design and development of Painteraction was realized at Atlas Centre—Sementera ONLUS by the clinician, art therapist Simone Donnari with the support of Magali Rochat, who holds a Ph.D. in Neuroscience. In 2015, Leva Engineering srl (Torino, Italy) started development of the Painteraction System, and this was coordinated by the biomedical engineer Valentina Canonico. The technological approach was based on a complex system in order to address a number of different requirements. The main components are as follows: working place, web server, and web portal.

#### 19.4.2.1 Working Place with Interactive Applications

Working place consists of a television screen, a personal computer, and two sensors. The first one is Kinect, the motion sensing input device. The second one is a heart rate monitor bracelet.

The software Painteraction has four interactive applications: Trails, Paint, Physics, and Vowels:

- **Trails:** Luminous trails are generated by hand movements. The child and therapist can see themselves on the screen and receive visual feedback from their hand movements. It is extremely intuitive, very appealing, and fun, particularly for younger children. Sound feedback can be added to the trails (Figure 19.1).

- **Paint:** By simply using hand movements, a child can draw by picking colors from a menu. Colors can also be associated with basic emotions represented by emoticons. The color lines are transparent, and, behind the drawing, it is possible for the child to see themselves on the screen. A sound effect can be added to the colors (Figure 19.2).
Physics: The application allows an interaction with a virtual ball bouncing around in response to full body motions (Figure 19.3).

Vowels: Vowels emitted by a user are sensed and transformed into cultured shapes that appear on the screen close to the user’s mouth. It is also possible to make drawings with one’s own voice (Figure 19.4).

19.4.2.2 WebServer and Cloud Data Storage

During the interactive sessions, videos and heart rate signals are saved in a cloud data storage (Figure 19.5).
A website was designed to manage the access and privilege levels of different kinds of users. Users are not only therapists, trainees, researchers but also parents, or teachers involved in the care of the same children with ASD. For parents and teachers, the website offers a private space where they can share images, videos, and messages in order to improve their communication and help them to build a network around the children. Therapists can use this space to share selected parts of the sessions in order to inform on what happens during the therapies. Parents and therapists review selected videoclips of previously recorded sessions, and the parents are encouraged to comment on salient aspects of the interaction. Through this medium, the therapist provides information to support the quality of the interaction while also enhancing the reflective capacities of the

**FIGURE 19.3**
Physics.

**FIGURE 19.4**
Vowels.

**19.4.2.3 Web Portal**

A website was designed to manage the access and privilege levels of different kinds of users. Users are not only therapists, trainees, researchers but also parents, or teachers involved in the care of the same children with ASD. For parents and teachers, the website offers a private space where they can share images, videos, and messages in order to improve their communication and help them to build a network around the children. Therapists can use this space to share selected parts of the sessions in order to inform on what happens during the therapies. Parents and therapists review selected videoclips of previously recorded sessions, and the parents are encouraged to comment on salient aspects of the interaction. Through this medium, the therapist provides information to support the quality of the interaction while also enhancing the reflective capacities of the
parents. Furthermore, keeping the parents involved and informed has an important effect on the therapy trend. Researchers demonstrated that the therapy outcome is related to parents’ involvement (Baker, Seltzer, and Greenberg, 2011; Bhagat, Jayaraj, and Haque, 2015).

Therapists, trainees, and researchers can retrieve data and videos of the sessions from the website and receive a visual recap of the time spent using every single application. This can give a hint about the favorite approach of each child and can be useful for the therapist to reflect on and fine-tune interventions. How a child responds to the proposal of the different applications, for example, if he/she likes or dislikes audio feedback at low or high volume, if he/she prefers luminous bright trails or painting with faded colors, gives important information about his or her sensory profile. Getting to know the sensory profile helps in developing and tailoring the therapy. Session chronology thus represents a powerful tool to evaluate the therapy trend and the procedure to improve it.

19.4.3 State of the Art and Future Improvements

19.4.3.1 How Painteraction Works

To avoid sensory overload while interacting with people with ASD, it might be preferable to give one sensorial input at a time (Ben-Sasson et al., 2009; Case-Smith, Weaver and Fristad, 2015; Fteiha, 2016). Nonetheless, having a safe place and a safe screen frame where it is possible to experiment different sensorial integrated inputs might be the reason why many of the children who have so far tested Painteraction were attracted and not scared by different sensorial feedbacks while moving their bodies.

Video games present a safe environment in which to put in effort, experiment, fail, and try new strategies in a manner that children might not dare in real life. Painteraction was designed to realize a delicate balance between what the software removes (the room is contained in a screen, the audio and video feedbacks can be modulated) and what the software adds (sensorial integration).
This balance brings to mind the “hug machine” of Temple Grandin, an adult with ASD (Grandin and Scariano, 1986), where the machine provided a variable pressure stimulation in a confined situation that reduced other sensorial inputs. The results in Painteraction are similar to the outcomes of both desensitization techniques, often employed to cope with sensorial issues in ASD and sensorial integration techniques (Koegel, Openden and Koegel, 2004). Painteraction aims at realizing a sensory motor and affective rehabilitation.

The importance of involving the motor system in autism rehabilitation was suggested by Rizzolatti and Gallese, who were two of the discoverers of Mirror Neuron System in 1988 (Pellegrino et al., 1992). The Mirror Neuron System is involved in translating perceived goal-directed actions onto their motor program. Research on the Mirror Neuron System suggests that the brain areas involved in perception and production of motor acts overlap, and that these brain areas are also involved in the understanding of action intentions (Gallese, Rochat, and Berchio, 2013; Rizzolatti and Craighero, 2004). As a set of ASD symptoms (impairment in communication, language, and the capacity to understand others) appears to match the functions mediated by the mirror mechanism, mirror neurons have been investigated in children with ASD. Recent data suggest that children with ASD have a deficit in the chained organization of motor acts and, as a consequence, they are unable to activate it during action observation. For this reason, there is in autism a disassociation between the capacity to understand the what of an action (performed by the basic mirror neurons mechanism) and the why of it (depending on the integrity of the chained motor organization) (Rizzolatti and Fabbri-Destro, 2010).

Moreover, evidence suggests that the mirror system is extremely plastic and so a specific motor experience modifies its responsiveness (e.g., Calvo-Merino, Grèzes, Glaser, Passingham and Haggard 2006); that the formation of motor memories is strongly facilitated when the participants both observe and perform the same movement (e.g., Stefan, Classen, Celnik and Cohen, 2008) and that the mirror responses triggered by a corresponding movement can be modified by repetitively coupling the performed movement with the observation of a noncongruent movement (Catmur, Walsh and Heyes, 2007). According to Rizzolatti, the deficit in the chained organization of motor acts could be reactivated by a sensory motor rehabilitation such as by using cooperative videogames (Rizzolatti and Fabbri-Destro, 2010; Rizzolatti, Fabbri-Destro and Cattaneo, 2009).

The experience in Painteraction is to some extent similar to dance movement therapy; from the movement, and the possibility of watching the movement on the screen similar to that in a mirror, a therapeutic relationship develops between the child and the therapist (Winters, 2008). For these reasons, it is expected an impact of Painteraction on sensory motor integration in the domains linked to an impaired mirror mechanism such as understanding of others’ intentions, sensations, and emotions.

19.4.3.2 The Study Protocol Hypotheses

At present (March 2017), the pilot testing phase is almost complete and a pilot study is to commence in cooperation with the University of Perugia and the University of Parma, Italy, in order to investigate Painteraction outcomes for children, their families, and the surrounding environment.

The primary objective of the study protocol is to evaluate the efficacy of Painteraction for children with ASD aged between 4 and 12. Particularly, the objective is to determine whether the intervention results in more sensory motor integration. The primary hypothesis is that an intervention with Painteraction will bring about a higher rate of sensory motor integration in children with ASD after treatment and at follow-up—1 year
after the end of the intervention. As one of the gaps in most studies in the evaluation of the efficacy of sensory integration is the absence of neurophysiological measures (Bonggat and Hall, 2010), this study aims to detect them along with a psychological assessment. Furthermore, Kinect data will be analyzed by an algorithm that determines the distance between the body of the child with ASD and the therapist. It is assumed that an increased sensory motor integration means more social participation and a reduction in social anxiety, as highlighted by Baker and colleagues (2008) and Pfeiffer and colleagues (2011). For these reasons, it is expected that one of the outcomes of the intervention is a reduction of body distance.

A secondary hypothesis being tested is that an intervention with Painteraction will lead to an increase in adaptive behavior (Baker, Lane, Angley and Young, 2008; Lane, Young, Baker and Angley, 2010). Particularly, three domains of adaptive behavior will be assessed: conceptual skills, social skills, and practical skills (Tassé et al., 2012). Along with adaptive behavior, changes in behavioral and emotional problems will be measured.

Finally, the third tested hypothesis is that, using video feedback on selected videoclips, parents’ involvement in periodic sessions will decrease their anxiety related to parenting and increase their capacity to reflect upon their child’s behavior. Numerous findings have reported increased levels of parenting stress, psychological distress, and attachment-related anxiety in families raising children with ASD, particularly when behavioral problems are present, and these have also highlighted the importance of family adaptability for children with ASD outcomes (Baker et al. 2011; Hayes and Watson 2013; Keenan, Newman and Gray, 2016; Lopez, 2016; Pozo and Sarria 2015; Zaidman-Zait et al., 2014). Incorporation of data onto parental factors in evaluating therapy outcomes helps to fill the gap about the parental domain in the treatment and the follow-up, which is often a neglected area (Bhagat, Jayaraj, and Haque, 2015). Furthermore, as highlighted by Slade (2009), parents of children with ASD have great difficulty reflecting on their child’s mental states. Difficulties in dyadic communication with their children make parents feel they are incompetent and ineffective. In addition, the social avoidance of a child with ASD is often misinterpreted as rejection by the parents. In Painteraction interventions, during the periodic sessions with parents, the therapist’s encouragement of the parents to follow and understand children’s behavior is expected to enhance parental reflective functioning. Recent evidence supports the hypothesis that parental reflective functioning is responsive to a brief therapeutic treatment, with the use of video feedback playing a significant role in contributing to the changes observed between the parent and child (Sealy and Glovinsky, 2016).

Neurophysiological and psychological tools will be administered in the pre-intervention phase, at three monthly intervals, and in the post-intervention phase. Measures will be administered again in the follow up at one year after the end of the intervention. Kinetical data from Kinect videos will be analyzed and an algorithm will determine the distance between the body of the child with ASD and the therapist.

19.5 Conclusion
The number of articles on the application of AT for children with ASD has risen substantially since 2001 (Ploog, Scharf, Nelson and Brooks, 2013). Evidence from a meta-analysis of technology-based intervention studies with pre-post design showed the overall effectiveness of such training on children with ASD (Grynszpan, Weiss, Perez-Diaz, Gal, 2014).
As previously reported, a problem that often arises is that several approaches and methods that use AT have not been particularly developed for the ASD population. Following Parsons (2015), three requirements must be met to ensure that an AT is designed for this population. First, the educational objective should be focused on the core areas of difficulty characteristic of ASD diagnosis, like impairments in social interaction and communication. Second, AT should be adapted to accommodate autism-specific characteristics and communication strengths/preferences incorporating the views of parents, practitioners, and children with ASD into their development. Finally, it would be considered the context in which changes are intended to take place in order to generalize and transfer the learned skills to real-world contexts.

As Odom and colleagues (2010) highlighted, there is a need for technologies research to translate findings into practice, which would consider generalization in multiple contexts and practical goal attainment. For this purpose, studies that focus not only on the evaluation of the outcome but also on the process are necessary. Studies on process can improve the understanding of the autism spectrum itself and thus help to fine-tune interventions from the laboratory to the clinic, and then on to the daily lives of individuals (Shic and Goodwin, 2015). In order to monitor progress during and after the intervention, there is a need for a system for sensory elaboration evaluation and a system of analysis and/or display of data about the users (Zakari, Ma and Simmons 2014).

The comparative analysis in the literature review highlights the difficulties in proving that a single tool is “useful” or “effective” in interventions and therapies with individuals with ASD. This is due to the fact that symptoms from across the autism spectrum present a large variety. Furthermore, there is, quite often, a miscommunication between clinicians and designers-developers on how to respond effectively to the needs of the children and families. The new technologies can meet many of these needs but multidisciplinary teams are necessary to make the instruments more flexible and suitable for each child, allowing their editability. Children with ASD are attracted to visual media displayed on a screen and demonstrate a number of skills in activating and watching content that interests them (Shane and Albert, 2008). However, downside to the use of PCs, videogames and smart phones is that they could represent an opportunity for these children to spend time alone and remain socially isolated (Mazurek and Wenstrup, 2013).

Whyte and colleagues (2014) suggest that future interventions and studies should include observational measures related to communicative and social interactions in order to assess whether the application of AT for children with ASD leads to improved interactions with people in face-to-face settings. To continue to make progress in this field, the inclusion of observational measures of real social interactions is highly recommended.

The new technological tool presented in this chapter, Painteraction, is grounded on clinical experience and its development has been customised by selecting what children with ASD considered interesting and what actually stimulated them. An evaluation of not only the outcome but also the process is planned in the pilot study in order to better fine-tune the intervention to the needs of the child and parents. With the help of a multidisciplinary team, the main objective of increasing sensory motor integration in children with ASD will be evaluated through observational measures in order to understand the expected improvements that occur in social participation. Further, parents’ involvement in the intervention, and its evaluation, represents an attempt to address the often neglected parental domain.

In conclusion, as children with ASD have difficulties engaging in reciprocal shared behavior and communication, the application of AT could be helpful in supporting them to make progress in these areas. Improvements are required to achieve significant success in
treating persons with ASD, but it is clear that interventions using AT represent an emerging field of research, with important implications for how interventions can be enhanced for individuals with ASD.

19.6 Summary

Children with ASD have difficulties engaging in reciprocal shared behavior and communication. AT could be helpful in supporting them to make progress in these areas. This chapter provided an overview of scientific literature on treatments for children with ASD using AT published in the last 15 years. Priority was given to recent and reviewed papers. In reporting studies, a categorization of AT was used based on the type of instrument: video modeling, mobile learning devices, robots, virtual and augmented reality, and serious games. A novel tool that emerged from clinical experience and that was tailored to children with ASD needs, called Painteraction, was then presented. The key elements of Painteraction, the technological system, the way it works, and the study protocol hypotheses were discussed. Improvements required to achieve significant success in treating persons with ASD were reported. In conclusion, interventions using AT represent an emerging field of research. Their expected outcomes are improvements in interventions for individuals with ASD.

References


Create—Creative Therapy in Europe. 2016. Erasmus+ Project Number: 2016-1-UK01-KA204-024526.


Kukulska-Hulme, A., and Shield, L. 2008. An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. *ReCALL*, 20, 271–289.


Assistive Technologies for Children with Autism Spectrum Disorder


Sawyer, B. 2007. The “serious games” landscape. Presented at the Instructional and Research Technology Symposium for Arts, Humanities and Social Sciences, Camden, USA.


Tablo—Training staff in the use of arts for the benefit of people with long-term conditions. 2015. Erasmus+ Project Number: 2015-1-UK01-KA202-013436.


20 Technology Developments in Music Therapy

Wendy L. Magee and Thomas Wosch

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20.1 Introduction to Music Therapy

Since the beginning of mankind sound and music have been used in healing (Wigram, Pedersen, and Bonde, 2002). This is illustrated through traditional healing practices such as shamanistic rituals, reflected in writings from ancient cultures spanning Arabia, Europe, and the Orient, as well as rooted in religious practices in Judaism and Christianity. Music therapy as a professional discipline in postmodern societies is grounded in developments during the 1950s in Europe, the United States, and South America. At that time, a number of models were developed by pioneers who created models using both clinical practice or theoretical contexts.

There are numerous approaches in music therapy (MT), including the Alvin Model (Alvin, 1975), Analytical Music Therapy (Priestley, 1975), the Benenzon Model (Benenzon, 1982), the Bonny Method of Guided Imagery and Music (Bruscia and Groke, 2002), Behavioural Music Therapy (Madsen, Cotter, and Madsen, 1968), Creative Music Therapy (Nordoff and Robbins, 1977), and the Schwabe Approach (Schwabe, 1974, 2007). Each of these approaches uses music differently in interventions, which, in turn, influences how technology might be integrated into practice. However, we will draw on just two of these models as a framework for this chapter.
Analytical Music Therapy, developed by Mary Priestley in the United Kingdom, “combine(s) a psychoanalytical and psychotherapeutic understanding of the transference phenomena between the client and the therapist with the understanding of meaning and form of expressions in musical improvisations” (Wigram et al., 2002, p. 122). The musical material may be that of the client’s alone (i.e., the client playing an instrument or vocalizing on her/his own with the therapist in the role of active listener), or of the client and music therapist together (i.e., the client sings and/or plays an instrument in dialogue with the therapist who sings and/or plays an instrument). In Analytic Music Therapy, the client actively makes music through improvising “in a totally free way … (that) requires no musical ability or training, and is not evaluated according to musical criteria” (Wigram et al., 2002, p. 131). This method is called “Free Improvisation” in which the client can shape sounds him or herself, thus increasing the resources and strengths of client. The music therapist supports these developments in sharing “an empathic and sensitive musical frame” (Wigram et al., 2002, p. 132). Behavioral Music Therapy, developed by Clifford Madsen in the United States, is grounded in behavioural therapies. In this approach, music is used entirely differently “… (1) as a cue, (2) as a time and body movement structure, (3) as a focus of attention and (4) as a reward” (Madsen, 1999). This approach includes high complexities of human behavior, and it is mainly based on learning principles (Madsen, 1999).

This brief overview about the beginning of modern MT illustrates that it is a highly diverse and plural therapy in its grounding and the types of interventions. Thus, a single definition of MT needs to be comprehensive to reflect different models and cultures. The World Federation of Music Therapy states that it is “… the professional use of music and its elements as an intervention in medical, educational, and everyday environments with individuals, groups, families, or communities who seek to optimize their quality of life and improve their physical, social, communicative, emotional, intellectual, and spiritual health and well-being. Research, practice, education, and clinical training in MT are based on professional standards according to cultural, social, and political contexts” (World Federation of Music Therapy, 2011, para 2). However, a common theme is that interventions are grounded in person-centered concepts to improve a client’s health and well-being. Music is created and applied in these interventions in different methods. The client and therapist create and make music together in dialogue. This can be recreating a song that is familiar and meaningful to the client or creating an improvisation together. The therapist guides a therapeutic process for the client to support and change the client’s perception, self-esteem, emotional experience, behavior, coping, social, motor, communication, or cognitive skills. Moving to music, listening to music (known as receptive methods), writing a song or a song text, and drawing to music are all possible. The most commonly used tools in all these methods are acoustic musical instruments and human voice. The use of technology in MT is less frequently described and thus, less understood. However, using technology in MT is a novel and growing perspective for MT.

Today, MT serves almost all fields of health, education, and social services across the life span. Its application starts in neonatology and ends in dementia care and palliative care. Music therapy serves people with developmental needs (Hintz, 2013), with mental health needs (Eyre, 2013), with social disorders and needs (e.g., Stige and Aarø, 2012), who have medical needs (Spintge, 2012), with neurological disorders (Magee, Clark, Tamplin, and Bradt, 2017) or disorders of ageing (Ridder, Stige, Quale, and Gold, 2013), or who are facing crisis caused by war or other societal traumas (Heidenreich, 2005). In the last two decades, there has been a steady growth in research and the development of evidence-based interventions in MT reflected by the number of outcome studies of MT interventions (Geretsegger, Elefant, Mössler, and Gold, 2014; Mössler, Chen, Heldal, and Gold, 2011).
20.2 Indicators for Using Technology in Music Therapy: Why Use Technology in Music Therapy?

Music therapy intervention seeks to involve both the client and therapist exploring sounds and music together as active agents of music making in interactive dialogue. Acoustic musical instruments (e.g., pitched and non-pitched percussion, piano, guitar, and other stringed instruments) and the human voice are central to this practice. That is, the client will typically be vocalizing/singing or making sounds on an instrument, and the therapist simultaneously uses her/his voice or instrumental sounds to frame, develop, challenge, or support the client’s musical gestures and sounds. However, when working with people with complex motor or sensory needs, “traditional” acoustic instruments such as those listed are often considerably unresponsive or just simply inaccessible. Using acoustic instruments, small or inconsistent or weak movements can result in inadequate sounds or sounds that lack aesthetic qualities. Worse still, the client’s physical efforts (that are often considerable) may result in no sound at all. Although music is a highly motivational tool to use in therapy, a lack of musical reward after the enormous physical effort required to play an instrument can be highly demotivating. Similarly, sensory problems, particularly pain caused by conditions such as burns, may limit the range of music instruments that can be used to produce a full and satisfying musical sound.

When working with people with motor and sensory needs, electronic and digital music technologies provide greater success in making sounds and a wider choice of sounds to be generated. Electronic and digital music technologies encompass a range of electronic music-making devices (e.g., electric pianos or drums), music software that may or may not be activated through assistive devices such as switches or sensors, digital apps that create music, and music recording and listening devices (Krout, 2014). All of these will be discussed in more detail later. Enabling a choice of sounds is crucial to success in using music in therapeutic interactions. The sounds and music generated should be developmentally and culturally appropriate so as to optimize client motivation. That is, the sounds or music produced should fit the person’s musical identity taking on board her/his preferences for music genre, ethnicity, age, and social identity (Magee, 2014b). Most importantly, two important criteria guide decisions in music technology: access and sensitivity. If technology enables the client access to being an active agent in music making more than acoustic instruments, it is clearly indicated. Furthermore, technology is also indicated if it enables the client to produce a more satisfying and aesthetically pleasing sound.

20.3 An Overview of Technologies Used in Music Therapy

The array of music technologies that fall within the given definition of assistive technology (AT) used in this book (World Report on Disability, 2011) is vast. Some of these technological musical instruments require external assistive devices to activate sounds and others have built-in features that function as assistive devices. Assistive devices provide an interface for a person to interact with the equipment that she/he wants to use and function to enhance the person’s independence in achieving a task. However, the very nature of electronic music instruments (e.g., electric keyboards and guitars, drum machines) qualifies these as “assistive technology” given that amplification is used to detect tiny manipulations on an instrument
that has undergone some modification already for a nondisabled population. Five categories of music technologies are commonly used in health, education, and community settings: (i) self-contained devices that create musical sounds; (ii) devices for recording music; (iii) devices for listening to music; (iv) software for music composition, arranging, notation, improvisation, and sequencing; and (v) a number of other additional devices (Krout, 2014). Music technologies are used with people across the life span (Magee et al., 2011), ranging from neonates (Cevasco, 2014), through children (Lindeck, 2014), adolescents (Martino and Bertolami, 2014), young adults (Adams and LaJoie, 2014), and older adults (Kubicek, 2014). The range of populations and settings in which music technology is used in MT is similarly as vast, spanning acute medical settings, special schools, psychiatric settings, rehabilitation centers, and hospice and palliative care (Magee, 2014b; Magee and Burland, 2008). In this chapter, we will focus on technologies that are more aligned with AT including assistive and self-contained devices that create musical sounds and a number of software interfaces that have been devised particularly for single switch or eye gaze interfaces.

20.3.1 Voice Output Communication Aids

The most basic (yet effective) method of using assistive devices in MT is with voice output communication aids (VOCA) that record either a single message or a sequence of multiple messages when activated. These are widely used in Speech Therapy intervention (see Chapter 13) to lay the foundation for higher-level communication, however, are invaluable for recording musical messages within Music Therapy. Zigo (2014) describes how the use of VOCAs enables the technology user to have an active voice in MT sessions: the therapist records client-specific messages on the VOCA by singing the participant's name or using spoken statements that address the client's broader communication goals (e.g., "I want to play!"). Additionally, musical motifs can be recorded onto VOCAs enabling participants who cannot access acoustic instruments to have an active part as a musician in a therapy group. As Zigo (2014) indicates, musical material can be “… recorded and rerecorded easily and instantly and the variety of sounds, rhythms, and melodies that are possible are limitless” (p. 157). Multiple message devices provide greater versatility through opportunities for sequential melodic phrases, instrumental sounds, or rhythmic patterns, thus giving the technology user a wider range of expression that is more reflective of music making.

20.3.2 Self-Contained Devices That Create Musical Sounds

This category includes tablets and other devices with touch sensitive screens as well as MIDI musical instruments including several special instruments that have been developed particularly for populations with special needs. MIDI is an acronym for music instrument digital interface. MIDI is a standard that describes the capability of a musical instrument to connect electronic musical instruments and computer equipment. It enables information about music specific parameters (e.g., instrument sound; volume; pitch) to be transported digitally. Two electronic musical instruments in particular are useful with MIDI interfaces: the electric piano and the electronic drum kit. Both these technologies have been modified from their original acoustic forms to provide interfaces that are well suited to differing physical abilities, such as movements that are limited in the range of motion or strength. Thus, the digital instruments are more sensitive than acoustic ones.

Touch sensitive screens have similarly revolutionized the way that music can be made within MT sessions for people with complex needs. The vast array of apps available for both android and iOS platforms meet the criteria to appeal to people across the lifespan (Magee
et al., 2011), and many of these are suitable for solo leisure activities. Rather than game-oriented apps, the most useful apps for MT intervention are those that can enable the client to play instrumental sounds in a similar manner as they would play an instrument. Many of these play musical sounds that enable the app to be treated like an instrument, for example, percussive sounds, sounds of familiar acoustic instruments, and sounds that mirror synthesized electronic sounds. It is the touch sensitive nature of the screens in particular that enables access to many people who previously could not be an active agent in music making owing to movements that are considerably weak, considerably small, or unable to perform “activate and release” movements that are required of most traditional musical instruments. Lightweight hand-held technology devices with shallow depth and small screens enable optimal positioning to meet a range of needs. With the myriad of music-creating apps that are available, it is possible to produce sounds of excellent quality that are aesthetically satisfying even with minimal activation. Most importantly, people with no musical training gain immediate access to music making, even with severe physical limitations that normally would inhibit the ability to do so.

A number of self-contained music-creating devices with controllers have been developed particularly for people with different needs. The MIDICreator (http://www.midicreator-resources.co.uk) is a sound module and generator that is activated through a range of external controllers including mechanical and proximity switches. The musical sounds generated include preprogrammed musical patterns and individual musical sounds. Midicreator is particularly useful when working with people with complex physical needs (Lindeck, 2014). The Soundbeam (http://www.soundbeam.co.uk) is another self-contained music generating device that uses sensors that emit ultrasonic beams, which, when interrupted, are translated into sounds. It also comes with preloaded soundsets that span a wide range of musical idioms, and can generate an endless option of instrumental sounds using an external sound module. It has been found useful with a number of populations including children with complex physical needs (Lindeck, 2014) and sensory needs (Martino and Bertolami, 2014), as well as for children and adolescents with emotional disorders (Krout, 1994).

### 20.3.3 Music Software Activated by Assistive Devices and Eye Gaze Technology

Several software packages have been devised particularly for people who use single switches or eye gaze technology that prove particularly useful in the MT setting. Regular music software programs for music composition (e.g., Cubase, Logic, and even Garageband) are powerful software applications for composing and recording. However, the software remains inaccessible for single switch users. Typically people using single switches have one single active movement through one field (i.e., vertical or horizontal) that is used to activate an AT device, for example, an eye blink, a single breath exhalation, a thumb or finger movement that is small, a hand squeeze, head tilt, or jaw movement. As the range of the person’s movement typically does not encompass movement through two fields (i.e., vertical and horizontal), the use of more typical devices, such as the computer mouse, keyboard, or joystick, cannot be supported. Most music software relies on access through mouse or keyboard. The heavy level of dependence for people with extremely complex needs highlights the need for software for single switch users in MT to allow a client “the opportunity to independently create music without assistance” (Nagler and Lee, 1989, p. 228).

The exclusion from a school music program of students who relied on technology to access the curriculum prompted assistive technologist Jon Adams to develop several music software programs particularly for single switch users at Massachusetts Hospital School
in Braintree, MA in the early 1990s. These programs enabled the students to become active participants in the wide range of school music ensembles offered, including band, rock ensemble, and hand chime ensemble. This accessible software, from the “Switch In Time” range, produces musical material through switch activation that varies in complexity, from creating a single “electronic tone bell” sound or a specific chord within a designated place in music ensembles, to musical material that is less time specific, enabling improvising music with dynamic sound and pitch assignments (Adams and LaJoie, 2014). The success of these music programs enabled young people with special needs to form a “switch section” of the school band. Furthermore, the ensuing ensemble “The Headbangers” led to switch-user music ensemble performances off campus and offered the students opportunities to gain fame as part of a rock band.

One further music program that is particularly useful for switch users is MIDGRID (http://midgrid.fullpitcher.co.uk/). MIDGRID presents an on-screen “grid,” the cells of which can each be assigned a musical note, sound, phrase, or entire song. The musical sound in a cell is activated by selecting a specific cell. It is simple to program and allows great musical flexibility and versatility, dependent on the participant’s switch use. It has been found a valuable tool for working with people with highly complex needs in MT (Kirk, Abbotson, Abbotson, Hunt, and Cleaton, 1994).

Recent years have witnessed the application of eye gaze technologies (see here Chapter 17) in combination with music technologies. The Adaptive Use Musical Instruments (AUMI; http://deeplestening.org/adaptiveuse) is a movement-to-music system with a virtual music instrument that is freely accessible online (Oliveros, Miller, Heyen, Siddall, and Hazard, 2011). It operates through interface software that is activated by eye gaze. It produces both pitched keyboard sounds and a range of percussion instrument sounds. AUMI was first developed to enable children with needs stemming from a variety of developmental diagnoses successful access to and full participation in music making in a drum class in school settings. Since then, AUMI has been incorporated into MT interventions in rehabilitation settings with children with complex neurological disabilities to address cognitive, emotional, and motor goals (Oliveros et al., 2011). In hospital and educational settings, AUMI is just another instrument used alongside acoustic instruments to enable the children to become active agents in music making within MT improvisation.

Other musical instrument prototypes drawn on brain–computer music interfaces (BCMI) activated through eye gaze (see Chapter 17). Miranda, Magee, Wilson, Eaton, and Palaniappan (2011) report on the trial of a proof-of-concept BCMI with a woman with Locked-In Syndrome. The patient grasped the concept quickly and rapidly demonstrated skill at controlling the BCMI. Using the steady state visual evoked potential system, the user selects sections of a computer screen that correspond to musical features (e.g., melody, melodic direction) and can modify the music through altering the intensity of the gaze, as well. This case demonstrated the potential for and value of a system that can enable someone even with the most severe disabilities to create music despite severe physical limitations. The prototype has been developed further to enable small ensemble performance opportunities.

20.4 Technology in Music Therapy Assessment

Technology in MT assessment is a future perspective for the clinical practice of MT. Only a small number of MT assessment tools include technology or are completely
automatized, and these assess vocal responses or musical responses on instruments. The Voice Assessment Profile (VOIAS—Storm, 2013) assesses depression in a protocol of voice exercises where the client vocalizes. The VOIAS includes technological voice measurement Using the Music Information Retrieval toolbox (MIR-toolbox—Lartillot, 2013) and the speech therapist’s toolbox PRAAT (Dutch for “speaking”—Lieshout, 2003). This software generates images of and measurements of the client’s voice during therapeutic vocal exercises that can be evaluated by the music therapist. MIR images display features of timbre such as “spectrum, brightness, spectral centroid and spectral spread” (Storm, 2013, p. 195) and PRAAT images display features of “pitch contour” (Storm, 2013, p. 195) of the client’s voice. The findings identified depressive patterns in these images of voice graphs. However, a fully automatized assessment of VOIAS needs “… a construction of a simpler version of the psychoacoustic program based on either the MIRtoolbox or PRAAT …” and “… further investigation of the psychometric properties of VOIAS …” (Storm, 2013, p. 369).

Another music therapy assessment tool includes technological measurement of musical interaction in clinical improvisation, and it is based on the Music Therapy Toolbox. Measuring a client’s musical responsiveness in improvisation is a highly time-consuming and challenging task for a music therapist, requiring repeated careful listenings to audio recordings and transcription. However, the Music Therapy Toolbox (MTTB) is software that was developed for comprehensive measurement of clinical improvisation (Erkkilä, 2007; Jonscher and Wosch, 2012). MTTB measures 20 musical features including, for example, velocity, tempo, articulation, and pulse clarity of both the client’s and of the therapist’s musical playing in both clinical improvisation on midi-instruments (Erkkilä, 2007) and on acoustic musical instruments (Jonscher and Wosch, 2012). This measurement of acoustic musical instruments fits current best clinical practice in MT. Technology and midi-instruments are less commonly used currently in clinical MT practice. Acoustic instruments are the traditional tools used and so measurement of wave data is both novel and important.

Figure 20.1 is one example of one musical feature (velocity, which indicates loudness or volume in MTTB) depicting 138 seconds from a clinical improvisation. The red line presents an image of the client’s playing, and the blue line represents the therapist’s music. The labels of “leader, follower, partner, leader, resister and independent musical behaviour” differentiate six roles within “intermusical or interpersonal relationship” (Bruscia, 1987, p. 444; see also: Wosch, 2007; Scholtz, Voigt, and Wosch, 2007; Gruschka, Wosch, Sembdner, and Frommer, 2011; Wosch and Erkkilä, 2016). In second 48 of Figure 20.1, it can be seen that the client’s music becomes softer in volume, followed in second 54 by the

![Figure 20.1](image_url)

FIGURE 20.1
therapist also reducing the volume of her/his music. In this part of the clinical improvisation, the client is the leader and the therapist is the follower in the musical feature of loudness (velocity). However, velocity is only one feature of 20 potential musical features of MTTB. Ascribing a role within musical interactions, for example, of “leader” or “follower” within musical interactions, is a task for human analysis, and not a software capability. On the one hand, there is a need for an algorithm for assessing the six roles. On the other hand, there is a need for an algorithm to identify the main musical feature in each clinical improvisation. This can be based on Bruscia’s “salience profile... a composite description of which musical elements are most prominent and exert the most influence over the other elements.” (Bruscia, 1987, p. 441).

There are clear benefits for a client’s treatment: there are a limited number of standardized assessment tools in MT, and very few of these are useful for analysis of complex music interactions that are typical in music interventions. Assessment tools in MT are largely observational tools (Schumacher and Calvet, 2007; Jacobsen, 2012). Analyzing musical interactions through behavioral observation alone is time intensive and highly complex. However, using software to analyze therapeutic music making between client and therapist provides images and detailed real-time events, all of which are invaluable for effective treatment evaluation and planning in MT. Moreover, in one case example (Scholtz et al., 2007, p. 76), the resources of a client with oppositional behavior disorder was not perceived by the music therapist, because the responses were considerably short and small. With the assessment, it is imaged (being follower in one feature) and the therapist can work with it. In this case, the assessment of considerably small details shortened the treatment of the client.

The use of technology in MT assessment and evaluation is in its infancy. However, the very promising developments described in this chapter highlight its relevance and potential to practice. In addition, the calibration of the application of AT in MT is a topic of current research and development in MT (FHWS, 2016).

20.5 Case Illustration: Incorporating Music Technology in Interdisciplinary Care of a Person with Complex Needs

The following case vignette is composited from several real life cases to illustrate how MT can contribute to interdisciplinary care of a person with complex needs, complimenting other uses of technology in such a complex case. Providing care for this type of patient typically involves direct collaboration with the team occupational therapist and speech therapist, as well as indirect collaboration with a hospital technology team involving an AT specialist, engineering, occupational therapy, speech and language therapy, and physiotherapy.

20.5.1 Client Background

The client was a 27-year old female who had sustained profound traumatic brain damage in a road traffic accident. Prior to her accident, she had completed graduate university studies and worked as a public servant. She was admitted to a specialist unit providing assessment, intervention, and long-term planning for people with complex needs stemming from acquired profound brain damage within a hospital providing neuropalliative
care for adults. Owing to significant motor and cognitive impairments, she was fully dependent for all aspects of activities of daily living, had no means for communication, was fed via gastrostomy tube, and presented with fluctuating arousal for short periods only (15–25 minutes). Her capacity for language comprehension was unknown. At the time of admission to the facility 12 weeks post injury, a diagnosis of disorder of consciousness was confirmed as she was showing inconsistent behavioral responsiveness to her environment. Thus, the priority overall goal was to determine whether or not the client was aware of her environment and able to respond purposefully to her environment. People with such complex needs require assessment from treatment teams that are experienced with complexity, as motor impairments, sensory impairments, or poor motivation can often mask residual abilities. Treatment teams skilled in working with these patients understand that creative approaches are essential to ensure optimal conditions that can achieve accurate diagnosis, and thus patient-centered care.

20.5.2 Assessment
Interdisciplinary assessments using standardized measures determined that the client was most responsive within the auditory domain. Music therapy was an integral part of her treatment program from the outset to help with planning rewarding auditory stimuli to be used in interventions. Absent behavioral responsiveness to visual stimuli suggested visual impairment, and neuroimaging confirmed this with absent brain responses to visual stimuli. Interdisciplinary interventions optimized presenting stimuli within the auditory domain, and although speaking to the client fell within this scope, the client’s capacity for language comprehension was unknown. The team also wanted to determine whether considerably small active movements in the client’s right thumb and right foot were volitional and purposeful. If one or both of these movements were deemed volitional, then it would indicate that technology might provide a means for communication using assistive devices, dependent on whether the client also had the cognitive capacity for learning and some residual language comprehension. Purposeful object use through the ability to use a switch functionally would also confirm that the client was aware rather than having a disorder of consciousness.

20.5.3 Goals of Intervention
The team determined that a primary goal was to assess the client’s ability to use a single switch with her right thumb. Her right thumb movement was able to both squeeze toward her fist and extend away from the fist. This opened up the possibility of trialing a small plate single switch to determine her awareness of cause and effect. She also demonstrated some upward flexion right-foot movements that were less consistent. Based on the consistency of her responses, the team prioritized her thumb movements. If she demonstrated awareness of cause and effect using the switch, we could explore whether we could train her to use the single switch using some type of musical reward with an ultimate goal of linking this to yes/no communication.

20.5.4 Training Switch Use
The first goal was to train the client with cause and effect using a single switch. Initial collaborative efforts between occupational therapy and speech and language therapy
had introduced a small plate switch positioned between her thumb and fist, which omitted a high-pitched sound when activated. Verbal commands were used to “press the switch,” that resulted in a sound, and “let go,” that would deactivate the sound. Having verbal commands that resulted in a clear auditory result (sound/no sound) was essential to ensure that switch activation was purposeful and due to volitional movement rather than spontaneous movement. In this case, however, the client’s responses were so inconsistent that it could not be determined if she was able to understand the verbal commands or whether the sound emitted from the switch was simply not motivating for her.

In the following sessions, MT was integrated into the treatment where we linked the small plate switch to MIDIgrid software that played the musical sounds using an external high quality speaker. We hypothesized that the musical “reward” played on switch activation would provide an opportunity to assess her use of the switch without verbal commands. It also enabled observation of her functional switch use to activate a more personally motivating auditory reward. Her sister reported that the client was an avid listener to jazz and fusion music. A single activation of the switch through thumb compression resulted in a single sustained musical chord for 5 seconds that was harmonically complex (typical of jazz idioms) played on a synthesizer timbre (sound). The chord had a relatively slow attack, meaning that it began quietly so as to avoid a startle, but then increased in volume comparatively quickly during the course of its sustain before fading. Switch deactivation through thumb release resulted in silence.

On demonstrating to the client through physical assistance how to use the switch to generate the musical chord, a change in her facial gesture and localization was instantly noted, indicative of heightened arousal and a change in affect. We gave her a verbal command to “press the switch” on one occasion to observe her independent behavior. Before we could prompt her to deactivate the switch, she spontaneously deactivated the switch as the sound was fading, and reactivated it again. On the second activation, she held the switch down until the music faded entirely. Once the sound had ended entirely, she deactivated the switch and then activated it again. She repeated this pattern four times, each time waiting for the musical sound to die out before deactivating and reactivating the switch. On the fifth activation, the music therapist vocalized quietly with the chord, adding in melodic interest. This continued for four activations in total. At this point, after eight independent activations, she stopped and seemed to be fatigued. Team assessment agreed that she had demonstrated independent functional object use through purposeful activation of the switch to play music.

In the following session, the team decided to explore whether music technology could provide a musical reward to train her foot movement and determine its purposefulness. As her movement (upward foot flexion) had limited range and strength, a different music technology was used that could meet these motor limitations better than a switch positioned with a mounting arm: we used the Soundbeam, a device that converts movements into sound through interruptions of ultrasonic pulses emitted from a sensor (Millman, 2008). It is particularly helpful when working with people with movements that are extremely limited in range of motion and strength as its settings can be programmed so that even a considerably small movement can generate a full scale (a recognizable pattern of music for most people). The client’s foot movement ranged approximately 3 cm. The Soundbeam was programmed, with its sensor positioned above the foot, so that the client’s complete movement could potentially play the eight notes of an entire blues scale. As with the single plate switch the day before, the occupational therapist modeled the movement to the patient by assisting her foot to make the
movement and generate the sound. However, we did not observe the response of recognition as we had seen with the small plate switch. The movement was assisted two more times by the occupational therapist before we observed whether the client generated the movement independently with a verbal command of “move your foot.” Although there was some small movement in the foot that generated musical sounds, the client demonstrated no evidence of cause and effect. Repeated verbal commands did not elicit a response. The team assessed that the lack of somatosensory feedback for the client, owing to the Soundbeam using a noncontact sensor, failed to provide relevant feedback that could train the client in awareness of cause and effect. The Soundbeam was not deemed to meet this client’s complex needs.

In the third session with MT, occupational therapy, and speech and language therapy, the goal was to provide a forum for rehearsal of switch use activated by hand movement and to continue assessment of the consistency of switch use. Thus far, the intervention involving MT had been the most successful for ascertaining consistent switch use. Again, the MIDIgrid programme was used in conjunction with a single plate switch; however, we changed the musical activity. This time, each activation of the switch resulted in a percussive sound that sustained for approximately one second. We wanted to observe her spontaneous and independent use of the switch within a music-making activity: after demonstrating the use of the switch through physically facilitating her to activate the switch so that she could hear the sounds generated, the music therapist sung and played a familiar song on the guitar. We sought to observe her activation of the switch within the music, whether she activated the switch during the music only, whether she continued to play after the music stopped, and any patterns of switch activation during the music. During the opening verse of the music, she activated the switch several times in a manner that seemed somewhat random. However, at the start of chorus (often the most familiar and emotionally stimulating part of a song), her switch activation became more regular. At the start of each measure, she activated the switch once, thus playing the first “beat” of each measure of the chorus (approximately once every four seconds). This response was important clinically, as it demonstrated her awareness of environmental stimuli (the music played by the therapist), an awareness of cause and effect (when she pressed the switch she made a sound), and a social relationship in real time (playing in synchrony with the therapist’s music, at a specific point in time on repeated occasions). This continued through the next verse as well, and into the start of the second chorus during which she stopped playing, although the music played by the music therapist continued. We realized that fatigue once more seemed to prevent her playing more frequently (e.g., more than just the first beat of a measure) and for a longer duration.

20.6 Conclusions

In this case, incorporating music technology activated by assistive devices provided access to being an active agent in the therapeutic process and the music making. Traditional tools (acoustic music instruments) could not meet the client’s needs in this manner. This preliminary work gave a portal through which the treatment team was able to determine that the client was aware through her purposeful and functional use of the switch. This was further supported through her nonverbal interaction within active music making (playing
on the first beat of each measure) that also demonstrated awareness. Music provided a motivational medium for the client and, at a point when the team could not determine the client's residual language functioning, music provided a nonlanguage medium that enabled the client to demonstrate social awareness (playing the first beat of a measure). Music therapy provided a forum for rehearsing switch activation.

20.7 Summary

This chapter describes the developments in the field of Music Therapy concerning technology, and particularly the value of ATs for enabling independent music making in therapeutic settings for people with complex needs. Music Therapy engages an individual or group of individuals in active music making in dialogue with a trained therapist to meet goals directed at improving physical, social, communicative, emotional, intellectual, and spiritual health and well-being. When working with people with complex motor and sensory needs, acoustic musical instruments limit the person's independence and fail to respond adequately to provide optimal sounds that are aesthetically pleasing. Using electronic and digital music technologies, encompassing self-contained devices that create musical sounds, music software, and assistive devices enhances the person's independence and enables individuals with complex needs to become an active agent in musical dialogues in interaction with others. Furthermore, technology expands the repertoire of available musical sounds and possible genres, enhancing cultural authenticity in the cocreated musical events. Music software is also contributing to the development of technological assessment in Music Therapy. Music Therapy can contribute to the AT team's understanding of clients with complex needs drawing on the motivational aspects of music in combination with technology to enable a client's access to active music making within goal-oriented activities.

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