Virtual reality and associated technologies in disability research and intervention

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ABSTRACT

This paper concerns the application of virtual reality and associated technologies (VRAT) in the disability research and intervention field. By reviewing a 144 studies presented at the International Conference Series on Disability, Virtual Reality and Associated Technologies (1996-2006), our analytic work examine the underlying conceptual frameworks of disability and methodological rationales used in selected papers. In the last 15 years, there was a paradigmatic shift from the medical to the biopsychosocial model of disability. Yet, our analyses indicate that such shift is not clearly reflected in the way VRAT have been addressing disability issues. The present manuscript offers recommendations regarding definition of goals, methodological procedures, and assessment rationales in order to stimulate discussions on how the use of VRAT can be improved in the field of disability research and practice

1. INTRODUCTION

Conceptual models provide a set of definitions and principles, which introduce specific ways of looking at certain aspects of reality. Depending on how a phenomenon is described and understood, different approaches may be selected to apprehend it or to address related issues.

Disability is an occurrence that has been portrayed, over time, from several perspectives. Such views framed distinct lines of scientific inquiry into both disability comprehension and intervention. Although individuals with significant physical or mental impairments have been part of human societies even before the evolution of Homo sapiens and the existence of rehabilitation practices are documented earlier than the twentieth century (Braddock & Parish, 2001), it was not until the late 1950s that conceptual frameworks for modelling disability appeared. As a field of theory and practice, first disability constructs were clearly influenced by clinical conceptualizations of disease (Yelin, 1992).

Reference to what is now described as the medical model "(…) implies that the locus of the disability is in the person and that disability is defined by the manifestation of a health condition in the form of anomalies or impairment of physical or mental structures" (Simeonsson, 2006, p. 73). The emphasis on pathology is, consequently, the prominent feature of current approaches inspired by the medical model. According to this outlook, individuals with disability experience restrictions and limitations in their daily lives due to disease, trauma, or other health condition and require some type of intervention provided by specific professionals to "correct", "remediate", or "compensate" for the problem (Jette, 2006).

Theorists and activists from the "disability movement" (e.g., Barton, 1996; Finkelstein, 1980; Oliver, 1996) brought up sound arguments against the medical model. Adopting a sociopolitical viewpoint, they articulated the perspective that disability was not a characteristic or an attribute of the person itself, but rather a result of discrimination and exclusion created by mainstream social environments. On this analysis, the contrast between impairment and disability became a key epistemic organizer for theorizing about disability and intervention practices. As Davis (2000) contends, "(…) disability is not so much the lack of a sense or the presence of a physical or mental impairment as it is the reception and construction of that difference. (…) Impairments are physical facts, but disability is a social construct. For example, lack of mobility is an impairment, but an environment without ramps turns that impairment into a disability" (p. 56). Seeing

disability as a social construction is indeed the basic assumption of what has been called the social model. Proponents of the social model define the degree to which an impairment is disabling in relation to societal barriers that restrict the participation of disabled people in the mainstream of social activities. Therefore, intervention efforts are focused on sociopolitical changes in order to abolish barriers, to increase access to resources, and to include disabled people into society on their own terms rather than adapt to it on other's people terms (Chen, 2007).

It seems unquestionable that "hostile" environments and disabling barriers which society (i.e., politicians, educators, architects, social workers, employers, health professionals, and others) erects dampen the quality of everyday life for many disabled people. However, the assumption that disability can be eradicated with appropriate social policies (e.g., Barnes, 1992) is undoubtedly an unrealistic expectation. It can be all too easy to believe that a person with disabilities could hold any job if only attitudes changed, the environment was accessible, or if the work was adequately organized. On the other hand, stating that disability is solely a social construction and that the body has nothing to do with it (e.g., Oliver 1996) does not acknowledge the limitations, the pain, or the discomfort, which may result from impairments that no amount of change in the social context can remove (Woodward, Witcher & Timms, 2005). The attempt to leave impairment out of account introduces a dualism that separates the body from the self. As Hughes and Paterson (1997) remark, this "(…) definitional separation of impairment and disability, which is now a semantic convention for the social model, follows the Cartesian western meta-narrative of human constitution" (p. 329).

In recent years, efforts have been made to develop new conceptual approaches with the purpose of bridging the gap between the medical and social models. Many scholars and practitioners recognize, now, the need to move towards a more holistic view of the disabled person, without making the mistake of reducing the complex notion of disability to one of its aspects (Williams, 2001). The focus on the *whole-person* is congruent with emergent biopsychosocial perspectives on disability.

A key principle of the biopsychosocial framework is that biological, personal, and environmental factors are interactively involved in human functioning. (Suls and Rothman, 2004). As recently operationalized within the As recently operationalized within the International Classification of Functioning, Disability and Health – ICF (WHO, 2001; 2007) – biological factors encompass all aspects of *body structures* (anatomical parts of the organism such as organs, limbs, and their constituents) and *body functions* (physiological and mental functions). Any significant loss or deviation at the level of bodily structures or functions is termed impairment. Although impairments may have origin in pathological processes, they "(…) do not necessarily indicate that a disease is present or that the individual should be regarded as sick. Impairments are broader and more inclusive in scope than disorders or diseases; for example, the loss of a leg is an impairment of body structure, but not a disorder or a disease" (WHO, 2007, p. 13).

The biopsychosocial approach recognizes the difference between people's capacity and performance – which in the ICF model are respectively used to qualify *activities* (execution of tasks or actions) and *participation* (involvement in real life situations). The capacity describes an individual's ability to act at his or her own highest level of functioning while performance portrays what the individual is actually able to do in his or her current environment. One can easily see how impairments may limit personal activities or restrict participation in communal life. However, the facilitating or restricting roles of the environment should also be accounted. Let us imagine the case of an individual with severe spinal injury. Suppose that this condition has generated impairments at the level of the lower limbs, disabling the functional use of the legs (paralysis). If by chance the individual has no available resources to reduce personal limitations in the execution of activities that require displacements and "navigation" through space, he or she would be particularly susceptible to experience disability. Yet, the provision of mobility aids and the arrangement of adequate environmental accommodations could be a viable way to decrease the gap between current capacities and the desired performance in daily life situations. The individual would thereby feel more independent and less likely to meet restrictions in his or her ability to participate in educational, employment, recreational and societal activities.

While acknowledging that disablement may involve dysfunctions at the biological level, the biopsychosocial framework adopts a *whole-person* approach, placing a special emphasis on the dynamic interaction between the individual and its environment. This notion of person-environment interaction is echoed in a change of focus from strict documentation and treatment of impairments, to a wider view that addresses independent functioning in daily living situations (Simeonsson, Pereira & Scarborough, 2003). Traditional (re)habilitation practices often involved a belief that individuals with disabilities should be trained to perform activities and tasks "normally". Most impairment-based interventions have taken "normality" as the guiding reference to decide about what is recommended and prescribed for each case (Ravaud & Stiker, 2001). Such understanding discards the perspective that autonomous functioning within the physical and social world – including the possibility of actively engaging in recreational and leisure

activities – might be the most valued goal for those who experience participation restrictions. In the context of human disability, a more comprehensive approach may imply encouraging the liberal use of "augmentative" supports such as mobility aids, alternative communication devices and related technological tools, which can play a significant role in the lives of people whose functional abilities are likely to be improved with such resources. For example, in some situations, it may be less relevant to train specific formal skills like "talking" or "walking" than to provide means for "being able to communicate effectively" or for "becoming autonomously mobile". In this sense, the biopsychosocial model asks to accept variation and to appreciate what disabled people can do to achieve personal and social valued outcomes in whatever ways are possible with their particular range of interests, skills, and limitations (Rosenbaum, et al., 1998).

During the past few years, there has been a fast expansion of technological resources designed to assist disabled individuals. In this context, the International Conference (series) on Disability, Virtual Reality and Associated Technologies (ICDVRAT), became an important forum where service providers, academics, and other experts examine how such technologies can be used in the area of disability research and practice. Held biennially since 1996, the ICDVRAT has built a community, which "(…) includes practitioners, educators, researchers, technologists and end users from schools, hospitals, disability service providers, rehabilitation institutes academic research, scientific institutes and technology development labs drawn from a variety of disciplines including medicine, healthcare, education, computer science, psychology and engineering" (Cobb & Sharkey, 2007, p. 51). The term "Associated Technologies" was added to the expression "Virtual Reality" to encompass a great variety of approaches and technologies.

Assuming that the proceedings archive of the ICDVRAT (available from the web site *www.icdvrat.reading.ac.uk*) provides a representative sample of the studies conducted in the field, our paper analyses a significant number of studies presented at the last conferences. Aiming to stimulate discussions on theoretical issues that may be useful to improve the application of VRAT in disability research and intervention, our review explores four major topics:

- The identification of the conceptual frameworks of disability that have been underlying the employment of VRAT in the examined studies.
- To what extent key components of functioning and disability (e.g., body functions and structures, activities, and participation) have been addressed in assessment or intervention processes mediated by VRAT.
- To what extent technological applications designed to deal with activity limitations have been including contextual factors focused on promoting participation.
- To what extent intervention research designs have been concerned with evaluating effects of VRAT applications through performance assessments in the real world

2. METHOD

2.1 Sample

A total of 144 papers were selected from the online proceedings archive of the International Conference Series on Disability, Virtual Reality and Associated Technologies. To be sampled, papers should explicitly document the use or explain the potential value of the described VRAT system in the assessment or the rehabilitation of persons with disabilities.

2.2 Procedure

Textual analysis (often called content analysis) is a standard methodology used to determine and quantify the presence of certain concepts within documents. To conduct such an analysis, contents of texts are examined and coded into categories according to their conceptual properties. Contents of the selected papers were analyzed through a coding scheme with a set of detailed instructions developed by the authors. Each paper was independently coded by three of the authors. Codes were compared and agreements were generally above the 90 % level in each coding category. Disagreements were discussed until divergences ceased.

2.3 Coding Scheme

The development of our coding scheme was based on a deductive approach, considering basic conceptual components of the examined papers. In the created system, coding categories were defined in five major sets: the *general classification* set, the *identifier* set, the *addressed components of human functioning* set, the *contextual factors* set, and the *performance assessment* set.

2.3.1 General Classification Categories. Disability paradigms or models are made up of several concepts, which reference the theoretical, definitional, and taxonomic views toward disability. Although prone to criticisms, we decided to use three classifiers to categorize the papers. The classifiers were developed taking into account the fundamental premises of the medical, the social and the biopsychosocial model (see table1).

Table 1. *Classifier categories used to assign studies to the medical, social, and biopsychosocial model.*

Medical	Disability is an individual phenomenon, resulting from underlying pathology, which is reflected by impaired functions. The target of intervention is primarily individual with no emphasis on families, schools, and employers. Purposes of interventions are rehabilitative, focused on body functions. Used or described technological applications are designed to address the improvement, the recovery, or the assessment of impaired functions.
Social	Disability is seen as a social construction and is defined as limit or loss of opportunities to take part in community life because of physical and social barriers. Targets of intervention are the communities, social attitudes, and political systems with the purpose of producing change in social, economic, and political structures.
Biopsychosocial	Synthesizes what is relevant in the medical and social models, without reducing the complex notion of disability to one of its aspects. Disability is seen as a consequence of complex interactions between health, personal and environmental factors. Disability is described in terms of difficulties in the execution of specific activities and tasks or constraints that individuals may experience in engaging in real life situations. Elements addressed in assessment/intervention are activities performance, participation, or environmental factors. Used or described technological applications are designed to promote individual's involvement in daily activities.

Because information provided in a number of papers was limited, coders had to use some inferential procedures to classify the studies. Surprisingly, such cases did not produce coding disagreements. As in the other sets of categories, detailed instructions regarding coding decisions are available from the authors.

2.3.2 Identifier Categories. The identifier set (see table 2) includes codes for processing information on how participants or potential users of technological applications have been characterized in each of the examined papers.

Table 2. *Identifier codes used to characterize participants or potential users of technological applications.*

Pathology	Specific use of a nosographic category (disease, disorder, injury…) to typify study participants or define potential users of a technological application
Impairment	Allusion to mental or physical impaired functions in order to typify study participants or define potential users of a technological application
Activity limitations	Mention to difficulties in the execution of specific activities and tasks as a way to typify study participants or potential users of a technological application
Participation restrictions	Indication of the constraints that individuals may experience in engaging in real life situations to typify study participants or potential users of a technological application

In one case (Maxhall et al., 2004) no category could be assigned because participants were non-disabled health professionals.

2.3.3 Addressed Components of Human Functioning Categories. This is a major set of categories that concerns the components addressed in assessments/interventions with VRAT systems (see table 3). To identify the representative components of functioning and disability, we used the linking rules proposed by Cieza (2005) to connect paper contents to the dimensions of body functions, activities and participation. These rules allow us to link and systematically compare meaningful concepts of the examined studies to the above-mentioned components. However, as Badley (2008) contends, there is not a clear distinction between activity and participation. To surmount this difficulty, the author suggests the use of the terms *acts*, *tasks*, and *societal involvement*. Acts are basic activities. Examples of acts include walking, standing, thinking, talking, and griping. Acts serve as a link between body functions and structures and tasks as they concern the impact of impairments on functioning. Tasks relate to purposeful things that people do in daily life in specific contexts. Tasks include most of what is comprehended by the terms "activities of daily living" or

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"instrumental activities in daily living". Tasks usually comprise coordinated, sequenced, and often synchronized acts. So for example, the task of dressing may require a range of acts such as reaching, holding, grasping and so on. Societal involvement concerns the individual as a player in socially or culturally recognized areas of human endeavour. Examples of societal involvement include involvement in work and employment, in leisure activities, in parenting, and in community or civic life.

Table 3. *Components of human functioning.*

Body functions and structures	As defined in WHO (2001; 2007), Body Functions are physiological functions of body systems (including psychological functions), and Body Structures are anatomical parts of the body such as organs, limbs and their components.
Activity (acts or tasks)	Acts are basic activities like walking, standing, , talking and griping. Tasks relate to the purposeful things that people do in daily life in a specific context, and usually comprise coordinated, sequenced and often synchronized acts.
Participation (societal involvement)	Concerns the individual as a player in socially or culturally recognized areas of human endeavour. Examples include roles such as work and employment, leisure, parenting, and community, social and civic life.

These three components – acts, tasks, and societal involvement – make possible to differentiate between activities and participation in two distinct ways. Bradley (2008) suggests the possibility of taking acts on one side, keeping tasks together with societal involvement to represent participation. On the other hand, the split could be made between tasks and societal involvement, equating participation with societal involvement. On this study, we followed the second option, assuming that participation is equivalent to engagement in social roles and that activity is related to the performance of acts and tasks.

2.3.4 Categories for Contextual Factors. Inclusion of contextual factors focused on promoting participation was examined through the categories described in table 4.

Table 4. *Contextual factors.*

Settings similar to everyone in society	Real world settings or of loyal reproductions of real physical/social contexts similar to everyone in society (such as supermarkets, streets, restaurants)
Individualized contexts	Real world settings or of loyal reproductions of real physical/social contexts that are or duplicate a specific living context of the individual.

2.3.5 Assessing Performance in the Real World. This analysis examines whether intervention research designs have been concerned with evaluating effects of VRAT applications through performance assessments in the real world.

2.4 Data Analysis

For reasons of brevity, studies are not referenced in the performed analyses. All examined papers can be found on line at the proceedings archive of the conference series.

3. RESULTS

3.1 Selected Papers and the Total Number of Documents

As formerly indicated, we adopted a large criterion to select papers. In order to be sampled, a study should document the use or just describe and explain the potential use of a VRAT application in the assessment or rehabilitation of persons with disabilities.

Table 5 shows that there was a general increase in the proportion of the selected documents from 1996 to 2006. This finding reflects the fact that papers focused on broad considerations about applying technologies in the field of disability gave progressively place to problem-driven approaches in which intervention targets and end-users were more precisely specified.

Table 5. *Percentages of sampled documents in each of the examined years.*

	TOTAL NUMBER	SAMPLED NUMBER	PERCENTAGE
1996	30	16	53.33 %
1998	31	16	51.61 %
2000	42	31	73.81 %
2002	34	24	70.59 %
2004	43	27	62.79 %
2006	40	30	75.00%
TOTAL	220	144	65.54 %

3.2 Conceptual Frameworks of Disability Underlying the Use of VRAT Applications

The social model defines disability as a limit or loss of opportunities to take part in community life because of physical and social barriers. Intervention practices focus on the societal conditions that create disadvantage for people whose individual characteristics are outside the social norm. Thus, for the social model, intervention goals address changes in the fundamental economic, communal, and political structures of society. Given the contents and scopes of the examined papers, no one could be unmistakably assigned to the social model.

Considering the basic conceptual components of the medical and biopsychosocial approaches, our analyses showed a predominance of biopsychosocial-oriented studies in the 144 scrutinized publications. However, proportions presented in Figure 1 reveal an atypical progression trend in the adoption of both models across the years.

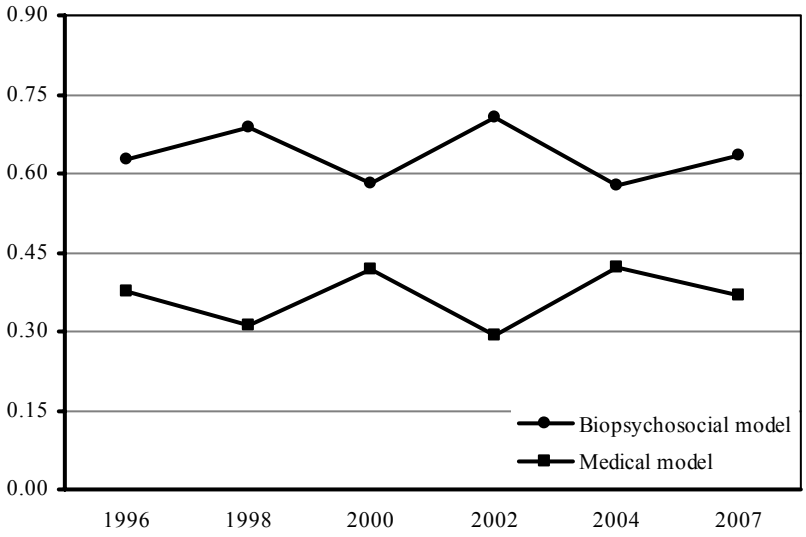

Figure 1. *Proportion of studies representing the medical or the biopsychosocial view in each of the sampled years*.

Actually, the relative amount of papers embracing the key notions of the aforementioned orientations remained more or less stable over time, suggesting that different coexisting perspectives have been sustaining the employment of VRAT in the field of disability research and practice.

3.2 Addressed Components of Human Functioning

Activities were the most addressed component of functioning in the examined studies (see Fig. 2). Consistent with the significant number of approaches based on the medical model, body functions were an important focal point of assessments and interventions mediated by VRAT applications in a substantial percentage of papers (34.03 %).

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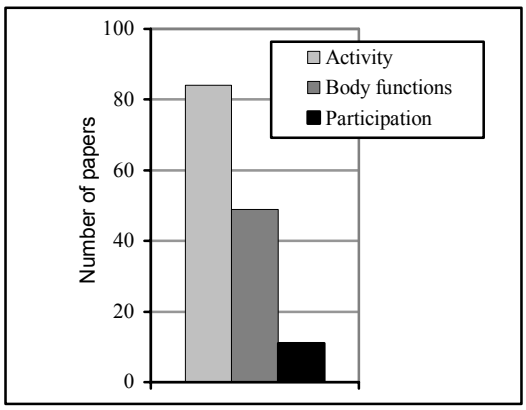

Figure 2. *Number of studies addressing Activity, Body Functions, and Participation with VRAT applications.*

Mentions to the participation component appeared in only 7.64% of the sampled studies. Moreover, coherent to the fact that we could not find any approach conceived within the theoretical realms of the social model, no paper described participation restrictions (i.e., constraints that individuals may experience in engaging in real life situations) to characterize participants or potential users of technological applications. Regarding such characterization, allusions to pathology (i.e., nosographic category) and to mental or physical impaired functions appeared respectively in 31.25% and in 56.94% of the papers; references to difficulties in the execution of specific activities and tasks (activity limitations) appeared in only 11.81% of the examined cases. Overall findings reported in this section remained quite stable across the years, with little and atypical variations.

3.3 Inclusion of Contextual Factors

As previously described (see Table 4), contextual aspects refer to real settings or to loyal reproductions of existent physical/social contexts. These reproductions – mostly provided in VE platforms – include settings similar to everyone in society (e.g., supermarkets, streets…) or individualized contexts (e.g., home, school…) that duplicate characteristics of a specific environment.

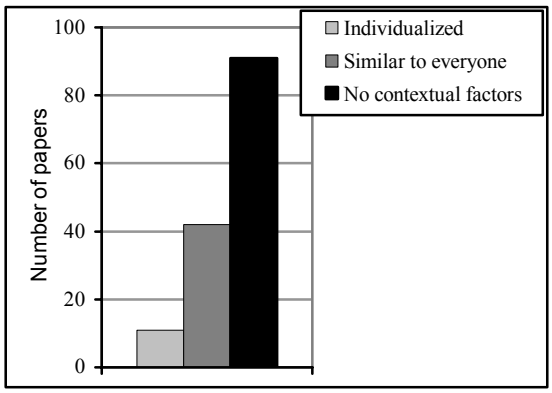

Figure 3. *Number of studies of studies including contextual factors in VRAT applications.*

Figure 3 show that a large majority of the studies did not incorporate contextual factors (63.19 %). Individualized contexts (7.64 %) were less included than "replicas" of settings similar to everyone (29.17 %).

3.4 Performance Assessments in the Real World

Ecological concerns should be central in interventions addressing disabilities. The ultimate goal of any therapy or training is to improve functioning so that the client will be able to achieve participation in their real world environments by overcoming, adapting to, or minimizing the environmental barriers (Kizony et al. 2004). Thus, one crucial point was to examine to what extent studies had been concerned with evaluating effects of VRAT applications through assessments in the real world. Only a residual number of papers

(4.86%) reported such evaluation, indicating that issues regarding evaluation of daily activities and participation in the real world were seldom addressed.

4. DISCUSSION

The present paper used textual analysis to examine some of the basic conceptual grounds that have been underlying the employment of VRAT applications in the field of disability research and practice. Our analyses focused on a significant number of documents available from the proceedings archive of the International Conference (series) on Disability, Virtual Reality and Associated Technologies. These documents were selected, assuming that they stand as a representative sample of the studies produced in the domain. In the discussion that follows, we reference only a small number of the analyzed papers. Their choice was in most cases arbitrary, serving illustrative purposes. Others could be chosen, but it was not possible reference them all.

A variety of theoretical perspectives has been proposed to understand, explain, and address disability problems. According to our review, the majority of the examined papers seem to embrace key fundamental assumptions of the so-called biopsychosocial model. Yet, crucial premises of the medical model also appear as chief conceptual organizers in a very significant number of approaches. It is noteworthy that the incidence of studies representing both orientations remains relatively stable along the sampled years. Apparently, such finding suggests that VRAT applications are being implemented within the realms of different outlooks. However, different perspectives do not necessarily reflect the coexistence of irreconcilable worldviews. The biopsychosocial model contends that disability is an occurrence that involves complex interactions between biological, personal, and environmental factors. Although such factors are inextricably connected, one has to acknowledge that some aspects of disability are preponderantly internal to the individual. Consequently, in some cases, impairment-based interventions can be valuable strategies to address disablement processes (Bowen et al., 2003). As a guiding framework, the biopsychosocial approach challenges practitioners to evaluate comprehensively all aspects of a problem and to take knowledgeable decisions concerning the most relevant levels at which address interventions.

The biopsychosocial framework highlights the meaning of person-environment interactions, placing special emphasis on aspects that may enhance individuals' capacity to execute actions and tasks. Mentions to VRAT applications for reducing activity limitations are predominant in the examined studies. Most of these studies describe devices designed to facilitate the interaction and navigation on computers and internet systems (e.g., Caffrey and McCrindle, 2004, Battersby et al., 2004), communication aids for persons with aphasia (e.g., Ahlsén and Geroimenko, 1998), or technologies to provide assistance in wheelchair control (Mori et al., 2002). Others use VE for training everyday activities, such as preparing coffee (Hilton et al., 2000), street crossing (e.g. Katz et al., 2004; Lam et al., 2004), or shopping (e.g. Cromby et al., 1996).

Results indicate a poor incidence of studies dealing with participation issues. Yet, a few number of approaches present technological solutions aimed to reduce exclusion. Among other examples, we mention the case of the *meeting support system* designed to help persons with hearing impairments to attend reunions without the need of note-takers or sign interpreters (Shikata et al., 2006). Though still in an early stage of technology development, the system holds the promise of enabling users to distinguish the mainstream content of meeting discussions from the irrelevant chattering which usually takes place in those kinds of context. Interventions focused on participation require the use of strategies to habilitate environments. An example of *environmental habilitation* is documented in a report that describes how computer technology and human machine interfaces were used to provide multissensorial experiences for attendants of classical orchestra music concerts (Brooks, 2004). Specifically addressed to individuals with hearing impairments – who exclude themselves from these events – the intervention did in fact enhance the experience for not only the impaired members of the audience, but also for the other attendants. This observation is in line with the argument that fostering participation through *environmental habilitation* strategies should bring benefits for those to whom the intervention is intended and for those to whom the accommodations are not necessarily required. Inclusion – seen as an end-result of non-restricted participation – means that people with disabilities "are allowed" to take part in the mainstream of social activities (Chen, 2007). Therefore, one feature of inclusive environments is that they should be designed in order to enrich experiences for everyone.

The same principle applies to assistive-type technologies. Many people with disabilities use assistive technologies to enhance their level of independence and to increase their participation in educational, employment, recreational, and community activities. Unfortunately, these devices lag behind mainstream products in terms of innovation, availability, quality, and cost. The trading system for assistive technologies is characterized by small markets, special manufactured products and small companies, with limited resources. To overcome these challenges, the design of assistive devices should seek universal rather than

particular usability. Even though we can find occasional considerations about methodological strategies regarding development of guidelines for *universal design* (e.g., Pareto and Snis, 2006), this issue has not been systematically addressed and discussed in the sampled studies.

Contextual aspects appear predominantly in approaches that use full-immersive VE. Many of these systems are based on everyday activities such as taking the bus, going shopping, or visiting a café. As argued elsewhere (Rose et al., 2005), the advantage of using VR environments lies on their potential to simulate many real-life and imaginary situations, providing the opportunity for more ecologic assessments and training. They have also the flexibility to enable sensory presentations, manipulate the task complexity, and adapt response requirements to the users' capacity. Furthermore, they provide activity settings in which users can practice skills safely, without experience potentially dangerous real world hazards. Interaction with environmental factors is a fundamental aspect of the scientific understanding of disability. Environmental factors range from physical dimensions (e.g., geography, spatial human-made arrangements) to social attitudes, community organizations, economic systems, and laws. Using VE in disability research and practice makes more sense when interactions between physical factors and personal variables are considered. Since most applications provided *settings similar to everyone in society*, consideration of the idiosyncratic qualities of such environments was probably impoverished. Thus, one of the challenges in designing VE scenarios is to use parameters adjustable to each user (see Andersson et al., 2006).

Virtual reality training has been used as a therapeutic tool for individuals with disabilities. On the other hand, social attitudes are components of the environment and negative attitudes may create restricting participation barriers. Maxhall et al. (2004) used VE to improve empathy in professionals who care for patients with strokes. The scenario looked like a normal apartment that could be experienced with some of the perceptual distortions caused by strokes. The simulated environment was effective in influencing positively subjects' empathy. This study is unique in the examined sample, because no other has ever addressed attitudes in surrounding social environments of people with disabilities.

A very small number of studies have been concerned with evaluating effects of VRAT applications through performance assessments in the real world. Examples are demonstrations of successful transfer of training from virtual environments to the real world (e.g., Cobb et al., 1998; Cromby et al., 1996; Katz et al., 2004). In part, this is due to the fact that many reported research "has not yet reached the stage at which evidence in practice can be demonstrated" (Cobb and Sharkey, 2007, p. 63). Such findings also suggest that one key principle of rehabilitation – i.e., treatments should maximize functioning and independent living in the real world – has yet to be incorporated in the mainstream of research designs.

5. REFERENCES

U Andersson, P Josefsson and L Pareto (2006), Challenges in designing virtual environments training social skills for children with autism. In *Proceedings of the 6th International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, T Brooks, S Cobb (Eds), Esbjerg, pp. 35-42.

E Badley (2008), Enhancing the conceptual clarity of the activity and participation components of the International Classification of Functioning, Disability, and Health, *Social Science & Medicine* **20**, *1*, pp. 1-11.

C Barnes (1992), *Disabling imagery and the media*, Halifax, Ryburn/BCODP.

L Barton (1996), *Disability and Society: Emerging Issues and Insights*, London, Longman.

S J Battersby, D J Brown, P J Standen, N Anderson and M Harrison (2004), Design, development and manufacture of novel assistive and adaptive technology devices, In *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, R J McCrindle, D Brown (Eds), Oxford, pp. 283−290.

D Braddock and S Parish (2001), An institutional history of disability. In G.L. Albrecht, K.D. Seelman, & M. Bury (Eds.), *Handbook of Disability Studies,* Thousand Oaks, Sage, pp. 11-68

A Caffrey and R J McCrindle (2004), Developing a multimodal web application, In *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, R J McCrindle, D Brown (Eds), Oxford, pp. 165−172.

F Chapireau (2005), The environment in the international classification of functioning, disability and health, *Journal of Applied Research in Intellectual Disabilities*, **18**, *4*, pp. 305-311.

J J Chen (2007), Functional capacity evaluation and disability, *The Iowa Orthopaedic Journal*, **27**, *1*, pp. 121-127.

A Cieza, S Geyh, S Chatterji, N Kostanjsek, B Üstün and G Stucki (2005), ICF linking rules: an update based on lessons learned, *J Rehabil Med*, **37**, *2*, pp. 212-218.

S V G Cobb, H R Neale & H Reynolds (1998), Evaluation of virtual learning environments, In *Proceedings of the 2nd European Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, F D Rose and J Lindström (Eds), Skövde, pp. 17-23.

S V G Cobb and P M Sharkey (2007), A decade of research and development in disability, virtual reality and associated technologies: review of ICDVRAT 1996-2006. *International Journal of Virtual Reality,* **6**, *2*, pp.51-68.

E D Coyle, M Farrell, R White & B Stewart (1998), Design of a non-contact head-control mouse emulator for use by a quadriplegic operator, In *Proceedings of the 2nd European Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, F D Rose and J Lindström (Eds), Skövde, pp. 35-43.

J J Cromby, P J Standen, J Newman & H Tasker (1996), Successful transfer to the real world of skills practised in a virtual environment by students with severe learning disabilities, *In Proceedings of the 1rst European Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey (Ed.) Maidenhead, pp. 103-107.

L J Davis (2000), 'Dr Johnson, Amelia and the Discourse of Disability in the Eighteenth Century' 'in H. Deutsch and F. Nussbaum (Eds), *Defects: Engineering the Modern Body, Anne Arbor*, The University of Michigan Press.

V Finkelstein (1980), *Attitudes and Disability*, Geneva, World Rehabilitation Fund.

D Hilton, S Cobb and T Pridmore (2000), Virtual reality and stroke assessment: therapists perspectives, In *Proceedings of the 3rd International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, A Cesarani, L Pugnetti, A Rizzo (Eds) Alghero, Sardinia, , pp. 181−188.

N Katz, H Ring, Y Naveh, R Kizony, U Feintuch and P L Weiss (2004), Interactive virtual environment training for safe street crossing of right hemisphere stroke patients with unilateral spatial neglect. In *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, R J McCrindle, D Brown (Eds), Oxford,, pp. 51-56.

M Maxhall, A Backman, K Holmlund, L Hedman, B Sondell and G Bucht (2004), Participants Responses to a Stroke Training Simulator, In *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies,* P M Sharkey, R J McCrindle, D Brown (Eds), Oxford, pp. 225-230.

M Oliver (1996), *Understanding disability: From theory to practice*, London, UK: MacMillan Press Ltd.

L Pareto and U L Snis (2006), Understanding users with reading disabilities or reduced vision: Towards a universal design of an auditory, location-aware museum guide. In *Proceedings of International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, T Brooks, S Cobb (Eds), Esbjerg, pp. 247-254.

J F Ravaud and H J Stiker (2001), Inclusion/exclusion: an analysis of historical and cultural meanings. In Albrecht, G. L., Seelman, K.D. and M Bury, M. (Eds.) *Handbook of Disability studies*, Thousand Oaks, California, Sage Publications, pp. 490-512.

F Rose, B Brooks and A Rizzo (2005), Virtual Reality in Brain Damage Rehabilitation: Review, *CyberPsychology & Behaviour*, **8**, *3*, pp. 241-262.

P Rosenbaum, S King, M Law, G King, J Evans (1998), Family-centred services: A conceptual framework and research review, *Physical and Occupational Therapy in Pediatrics*, **18**, *1*, pp. 1-20.

R Shikata, T Kuroda, Y Tabata, Y Manabe and K Chihara (2006), Development of vision based meeting support system for hearing impaired, In *Proceedings of the 6th International Conference on Disability, Virtual Reality and Associated Technologies*, P M Sharkey, T Brooks, S Cobb (Eds), Esbjerg, pp. 53-58.

R J Simeonsson (2006), Defining and classifying disability in children, In M J Field, A M Jette and L M Martin (Eds), *Disability in America*. National Academic Press: Washington, pp. 67-86.

R J Simeonsson, S Pereira and A Scarborough (2003), Documenting delay and disability in early development with the WHO-ICF. *Psicologia*, **17**, *1*, pp. 31-41.

G Williams (2001), Theorizing disability, In G Albrecht, K D Seelman, and M Bury (Eds.), *Handbook of Disability Studies*, Thousand Oaks, Sage Publications, Inc., pp. 123-144.

World Health Organization. (2001), International Classification of Functioning, Disability and Health: ICF, Geneva: World Health Organization.

World Health Organization. (2007), International Classification of Functioning, Disability and Health – Version for Children and Youth: ICF-CY, Geneva: World Health Organization.

E Yelin (1992), *Disability and the displaced worker*, New Brunswick, NJ: Rutgers University Press.