Andrea Gaggioli, Emily A. Keshner, Patrice L. (Tamar) Weiss, Giuseppe Riva (Eds.)
Advanced Technologies in Rehabilitation.
Empowering Cognitive, Physical, Social and Communicative Skills through Virtual Reality, Robots, Wearable Systems and Brain-Computer Interfaces
Amsterdam, IOS Press, 2009

Rehabilitation as Empowerment: The Role of Advanced Technologies

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Abstract. Rehabilitation is placing increasing emphasis on the construct of empowerment as the final goal of any treatment approach. This reflects a shift in focus from deficits and dependence to assets and independence. According to this approach, rehabilitation should aim to improve the quality of the life of the individual by means of effective support to his/her activity and interaction. Here we suggest that advanced technologies can play a significant role in this process. By enhancing the experienced level of "Presence" - the non-mediated perception of successfully transforming intentions into action - these emerging technologies can foster optimal experiences (Flow) and support the empowerment process. Finally, we describe the "NeuroVR" system (http://www.neurovr.org) as an example of how advanced technologies can be used to support Presence and Flow in the rehabilitation process.

Keywords. Empowerment, Rehabilitation, Presence, Virtual Reality, NeuroVR

Introduction

The field of rehabilitation is placing increasing emphasis on the construct of empowerment as a critical element of any treatment strategy. This construct integrates perceptions of personal control, participation with others to achieve goals and an awareness of the factors that hinder or enhance one's efforts to exert control in one's life [1, 2]. The emphasis on empowerment reflects a critical shift in rehabilitation: from a focus on deficits and dependence toward an emphasis on assets and independence.

The International Classification of Functioning, Disability and Health (ICF) of the World Health Organization [3] defines disability as a "condition in which people are temporarily or definitively unable to perform an activity in the correct manner and/or at a level generally considered 'normal' for the human being." In this definition the focus is not on deficits but on assets: a person is disabled when he/she is not able to fully exploit his/her relationship with everyday contexts [4].

In this chapter we suggest that the new emerging technologies discussed in the book – with particular reference to robotics and virtual reality - have the right features for improving the rehabilitation process. These technologies can improve the quality of life of the disabled individual through an effective support of his/her activity and interaction [5].

1. Empowerment in Rehabilitation

"*Empowerment*" is a term that is becoming very popular in rehabilitation services. More and more rehabilitation programs claim to "empower" their clients. However, in practice, few researchers and clinicians have specifically targeted aspects of empowerment in rehabilitation programs. The main issue up until now has been the lack of guidelines to assess and enhance empowerment during the rehabilitation process.

In general, *empowerment* refers to processes and outcomes relating to issues of control, critical awareness, and participation [2]. How does this apply to rehabilitation?

According to Zimmerman and Warschausky [6] empowerment in rehabilitation should provide a sense of and motivation to control and the knowledge and skills to help the patient to adapt to and influence his/her own environment. This approach underlines the role of participation and control, supporting wellness versus illness, and competence versus deficiency. In this view, the final goal of rehabilitation is to help patients to become as independent as possible, by developing skills for changing conditions that pose barriers in their lives.

To put this approach into practice, the next step is the definition of clear empowerment outcomes. Table 1 provides a brief comparison of empowering processes, goals and outcomes across the different levels of analysis (intrapersonal, interactional and social) involved in a typical rehabilitation program.

Our analysis will focus on the first two levels – intrapersonal and interactional. We believe that it is at these levels that emerging technologies can play a critical role.

The *intrapersonal* component refers to how the patients think about themselves[6]. At the intrapersonal level, the main goals of the rehabilitation process are to help the individual in gaining control over his/her life. Specifically, the patient needs to recover his/her decision-making power through full access to information and resources.

How is it possible to evaluate the success of an intrapersonal rehabilitation strategy? According to the psychological literature, the key outcome variables are [6]:

- *self-efficacy*: this refers to perceptions about one's ability to achieve the desired outcomes;
- *sense of control*: this refers to perceptions about one's ability to regulate and manage the different domains of his/her personal experience.

Table 1. Empowerment outcomes in rehabilitation

Levels	*Process*	*Goals*	*Outcomes*
Patient (Intrapersonal)	Receiving help from therapist to gain control over his/her life	To have decision-making power To have access to information and resources	Self-efficacy Sense of control
Therapist/Caregiver (Interactional)	Helping patients and their family to evaluate/understand their actual skills/situation Helping patients gain control over their lives	To change perceptions of patient's competency and capacity to act Not to feel alone; to feel part of a group	Critical awareness Participatory behaviors
Health Care Institution/System (Social)	Providing opportunities for patients to develop and practice skills	To effect change in one's life and one's community	Effective resource management

The *interactional* component refers to how people think about and relate to their social environment. This component of any empowering rehabilitation strategy involves the transactions between people and the environments (family, clinical setting, work, etc.) that they are involved in. On the one hand, it includes the decision-making and problem-solving skills necessary to actively engage in one's environment. On the other, it includes the ability to mobilize and obtain resources.

Again, how is it possible to evaluate the success of an interactional rehabilitation strategy? According to the psychological literature, the key outcome variables are [6]:

- *critical awareness*: this refers to one's understanding of the resources needed to achieve a desired goal, knowledge of how to acquire those resources, and skills for managing resources once they are obtained;
- *participatory behaviors*: this refers to one's social activities affording the opportunity for individual participation.

An increasing number of empirical studies are addressing empowerment in rehabilitation. These studies focus on a variety of participatory programs targeting a broad range of population groups and goals. Few authors, however, have investigated the role of technology in this process.

In this chapter, we argue that the advanced technologies presented in this book can enhance this process by supporting the experience of "Presence", defined as the "feeling of being there" [7]. The creation of a feeling of Presence can help patients to cope with their context in an effective and transparent way.

In this view, technologies are used for triggering a broad empowerment process within the optimal experience induced by a high sense of Presence [8].

2. Advanced Technologies in Rehabilitation: The Role of Presence

In recent years it has been possible to identify a clear trend in the design and development of rehabilitation technologies: the shift from a general user-centered approach to a specific activity-centered approach. In this last perspective, the goal of technology should be the improvement of the quality of life of the individual, through an effective support of his/her activity and interaction [4]. In this vision,

"…if a person is able to write a paper with a pen and another person is limited in the pen use but is able to write the same paper using a computer keyboard, none of them is defined as disabled. On the contrary if both of them will be in a condition in which the tool, that allows them to write the paper, is not available in a specific moment they will be both disabled in performing the activity." (p. 286).

This "compensatory" approach in rehabilitation is usually divided [9] into *person-oriented* and *environmentally oriented* interventions (see Figure 1).

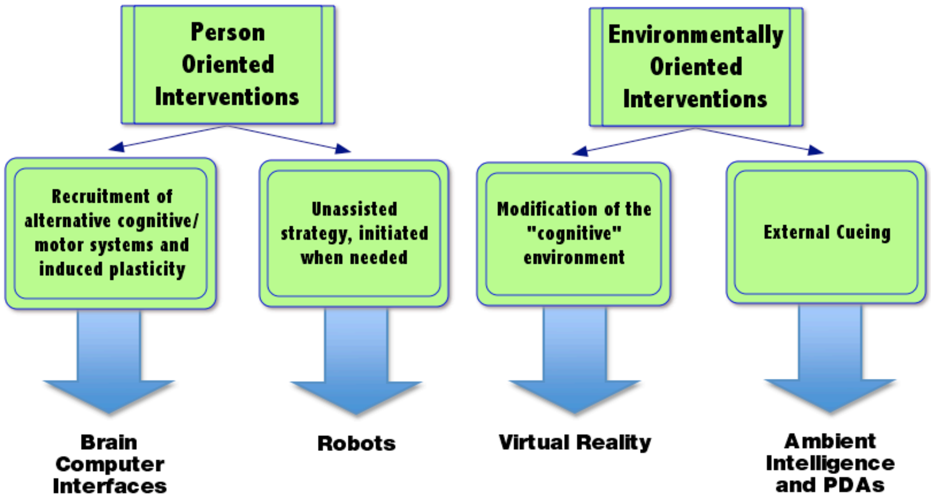

Figure 1. The role of advanced technologies in rehabilitation

Person-oriented interventions include the recruitment of alternate cognitive or physical resources to achieve a desired outcome. Environmentally oriented interventions offer external cues to the subject in order to improve his/her handling of the activity [10]. As noted by Crosson and colleagues [10], environmentally oriented interventions may be:

"*the only practical means for dealing with neurologically based deficits. Although not ideal, external modification can be effective in many circumstances"* (p. 53).

This viewpoint stresses the need of developing technological tools for providing alternative affordances in planning specific activities. Moreover, as noted by Kirsk and colleagues [9], any rehabilitation device has to support activity in a transparent way:

"In regard to device features, an ideal intervention will be one that is minimally intrusive, provides assistance without assuming unnecessary control, and does not demand of the user an uncharacteristic level of comfort with technological aids." (p. 201).

In summary, rehabilitation technologies become empowerment tools when they help people in coping with their context in an effective and transparent way. But how can we assess whether rehabilitation technologies meet these requirements? A possible answer to this question is "through Presence". We will detail this point in the next paragraph.

1.1 Presence: a first definition

The term "*Presence*" entered the general scientific debate in 1992 when Sheridan and Furness used it in the title of a new journal dedicated to the study of virtual reality systems and teleoperations: *Presence, Teleoperators and Virtual Environments.* In the first issue, Sheridan clearly refers to Presence as an experience elicited by technology use [11]: the effect felt when controlling real world objects remotely as well as the effect people feel when they interact with and immerse themselves in virtual environments.

However, as remarked by Biocca [12], and agreed upon by most researchers in the area, "while the design of virtual reality technology has brought the theoretical issue of Presence to the fore, few theorists argue that the experience of Presence suddenly emerged with the arrival of virtual reality." Rather, as suggested by Loomis [13], Presence may be described as a basic state of consciousness: the attribution of sensation to some distal stimulus, or more broadly to some environment. Due to the complexity of the topic, and the interest in this concept, different conceptualizations of Presence have been proposed in the literature.

A first definition of "Presence" is introduced by the International Society of Presence Research (ISPR). ISPR researchers define "Presence" (a shortened version of the term "telePresence") as:

"a psychological state in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience" [14].

This definition suggests that rehabilitation technology should provide a strong feeling of Presence: the more the user experiences Presence in using a rehabilitation technology, the more it is transparent to the user, the more it helps the user in coping with his/her context in an effective way .

Nevertheless, the above definition has two limitations. First, what is Presence for? Why do we experience Presence? As underlined by Lee [15]:

"Presence scholars, may find it surprising and even disturbing that there have been limited attempts to explain the fundamental reason why human beings can feel Presence when they use media and/or simulation technologies." (p. 496).

Second, is Presence related to media only? As commented by Biocca [12], and agreed by most researchers in the area:

"while the design of virtual reality technology has brought the theoretical issue of Presence to the fore, few theorists argue that the experience of Presence suddenly emerged with the arrival of virtual reality."
(online: http://jcmc.indiana.edu/vol3/issue2/biocca2.html)

Recent insights from cognitive sciences suggest that Presence is a neuropsychological process that results in a sense of agency and control [16-18]. For instance, Slater suggested that presence is a selection mechanism that organizes the stream of sensory data into an environmental gestalt or perceptual hypothesis about current environment [19, 20].

Within this framework, supported by ecological/ethnographic studies [21-28], any rehabilitation technology, virtual or real, does not provide undifferentiated information or ready-made objects in the same way for everyone. It offers different opportunities and creates different levels of Presence according to its ability in supporting the users' intentions.

1.2 Presence: A Second Definition

Recent findings in cognitive science suggest that Presence is a neuropsychological phenomenon, evolved from the interplay of our biological and cultural inheritance, whose goal is the enaction of volition: Presence is the *perception of successfully transforming intentions into action (enaction)*.

Recent research by Haggard and Clark [29, 30] on voluntary and involuntary movements, provides direct support for the existence of a specific cognitive process binding intentions with actions. In their words [30]:

"Taken as a whole, these results suggest that the brain contains a specific cognitive module that binds intentional actions to their effects to construct a coherent conscious experience of our own agency." (p. 385).

Varela and colleagues [31] define "*enaction*" in terms of two intertwined and reciprocal factors: first, the historical transformations which generate emergent regularities in the actor's embodiment; second, the influence of an actor's embodiment in determining the trajectory of behaviors. As suggested by Whitaker [32] these two aspects reflect two different usages of the English verb "enact". On the one hand is "to enact" in the sense of "to specify, to legislate, to bring forth something new and determining of the future", as in a government enacting a new law. On the other is "to enact" in the sense of "to portray, to bring forth something already given and determinant of the present", as in a stage actor enacting a role. In line with these two meanings, Presence has a dual role:

- First, *Presence "locates" the self in an external physical and/or cultural space:* the Self is "present" in a space if he/she can act in it
- Second, *Presence provides feedback to the Self about the status of its activity*: the Self perceives the variations in Presence and tunes its activity accordingly.

First, we suggest that the ability to feel "present" in the interaction with a rehabilitation technology - an artifact - basically does not differ from the ability to feel "present" in our body. Within this view, "being present" during agency means that 1) the individual is able to successfully enact his/her intentions 2) the individual is able to locate him/herself in the physical and cultural space in which the action occurs. When the subject is present during a mediated action (that is, an action supported by a tool), he/she incorporates the tool in his/her peri-personal space, extending the action potential of the body into virtual space [33]. In other words, through the successful enaction of the actor's intentions using the tool, the subject becomes "present" in the tool.

The process of Presence can be described as a sophisticated but covert form of monitoring action and experience, transparent to the self but critical for its existence. The result of this process is a sense of agency: the feeling of being both the author and the owner of one's own actions. The more intense the feeling of Presence, the higher the quality of experience perceived during the action[34]. However, the agent directly perceives only *the variations* in the level of Presence: *breakdowns* and *optimal experiences* [16].

Why do we monitor the level of Presence? Our hypothesis is that this high-level process has evolved to control the quality of action and behaviors.

According to Csikszentmihalyi [35, 36], individuals preferentially engage in opportunities for action associated with a positive, complex and rewarding state of consciousness, defined by him as "optimal experience" or "Flow". The key feature of this experience is the perceived balance between great environmental opportunities for action (challenges) and adequate personal resources in facing them (skills). Additional characteristics are deep concentration, clear rules for and unambiguous feedback from the task at hand, loss of self-consciousness, control of one's actions and environment, positive affect and intrinsic motivation. Displays of optimal experience can be associated with various daily activities, provided that individuals perceive them as complex opportunities for action and involvement. An example of Flow is the case where a professional athlete is playing exceptionally well (positive emotion) and achieves a state of mind where nothing else is attended to but the game (high level of Presence). From the phenomenological viewpoint, both Presence and Flow are described as absorbing states, characterized by a merging of action and awareness, loss of self-consciousness, a feeling of being transported into another reality, and an altered perception of time. Further, both Presence and optimal experience are associated with high involvement, focused attention and high concentration on the ongoing activity. Starting from these theoretical premises, can we design rehabilitation technologies that elicit a state of Flow by activating a high level of Presence (maximal Presence) [4, 37, 38]? This question will be addressed in the following section.

1.3 The Presence Levels

How can we achieve a high level of Presence during interaction with a rehabilitation technology? The answer to this question requires a better understanding of what intentions are.

According to folk psychology, the intention of an agent performing an action is his/her specific purpose in doing so. However, the latest cognitive studies clearly show that any action is the result of a complex intentional chain that cannot be analyzed at a single level [39-41].

Pacherie identifies three different "levels" or "forms" of intentions, characterized by different roles and contents: distal intentions (D-intentions), proximal intentions (P-intentions) and motor intentions (M-intentions):

- *D-intentions (Future-directed intentions)*. These high-level intentions act both as intra- and interpersonal coordinators, and as prompters of practical reasoning about means and plans: "helping my elderly father" is a D-intention, the object that drives the activity "finding a nurse" (see Figure 2) of the subject.
- *P-intentions (Present-directed intentions)*. These intentions are responsible for high-level (conscious) forms of guidance and monitoring. They have to ensure that the imagined actions become current through situational control of their unfolding: "posting a request for a nurse" is a P-intention driving the action "going to the hospital's bulletin board (see Figure 2),
- *M-intentions (Motor intentions).* These intentions are responsible for low-level (covert) forms of guidance and monitoring: we may not be aware of them and have only partial access to their content. Further, their contents are not propositional: in the operation "putting the post on the board" (see Figure 2), the motor representations required to move the arm are M-intentions.

Any intentional level has its own role: *the rational (D-intentions), situational (P-Intention) and motor (M-Intention) guidance and control of action.* They form an intentional cascade [40, 41] in which *higher intentions generate lower intentions.*

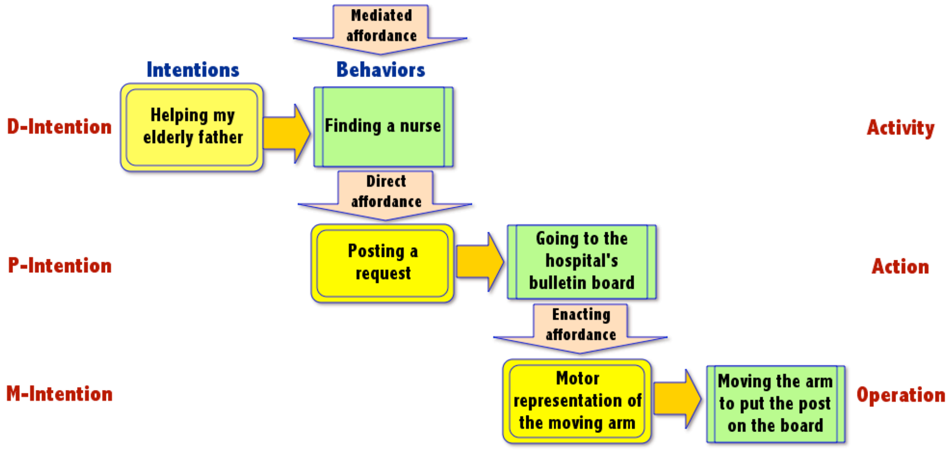

Figure 2. The intentional cascade

We previously defined Presence as *the perception of successfully transforming intentions into action (enaction)*. However, even if we experience a single feeling of Presence during the enaction of our intentions, the three-level structure of the intentional cascade suggests that Presence - on the process side - can be divided into three different layers or sub-processes (for a broader and more in-depth description see [21, 42]), described in Figure 3:

- *Extended Presence* (D-Intentions/Activities): The role of "Extended Presence" is to *verify the relevance to the Self of possible/future events in the external world (Self vs. possible/future external world)*. The more the Self is able to identify mediated affordances (that cannot be enacted directly) in the external world, the higher the level of extended Presence will be.
- *Core Presence* (P-Intentions/Actions): This can be described as *the activity of selective attention made by the Self on perceptions (Self vs. present external world)*. The more the Self is able to identify direct affordances (that can be enacted directly with a movement of the body) in the external world, the higher the level of core Presence will be.
- *Proto Presence* (M-Intentions/Operations): This is the process of internal/external separation *related to the level of perception-action coupling (Self vs. non-Self)*. The more the Self is able to use the body for enacting direct affordances in the external world, the higher the level of proto Presence will be.

As underlined by Dillon and colleagues [43], converging lines of evidence from diverse perspectives and methodologies support this three-layered view of Presence. In their analysis they identify three dimensions common to all the different perspectives, relating to a "spatial" dimension (M-intentions), a dimension relating to how consistent the media experience is with the real world, "naturalness" (P-intentions), and an "engagement" dimension (D-intentions).

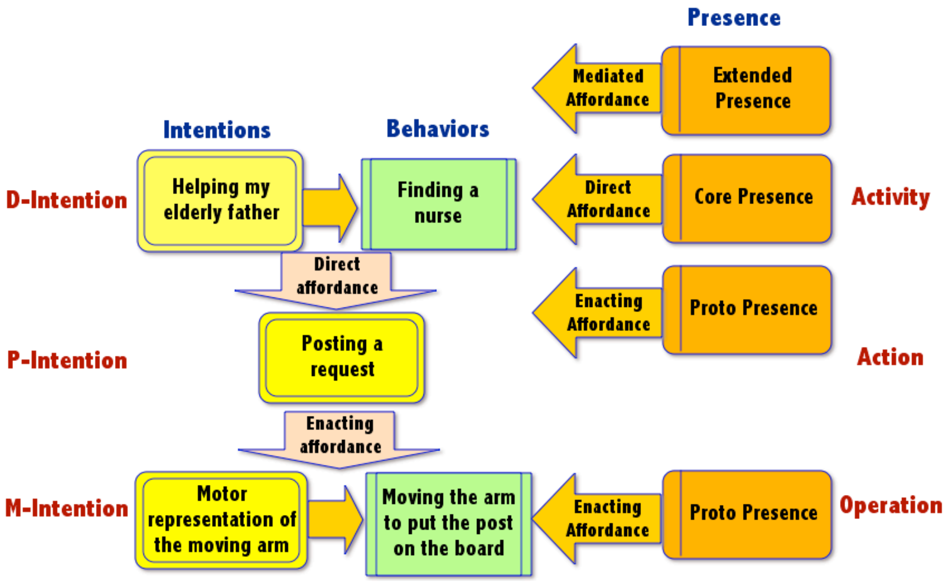

Figure 3. Activity and Presence

The role of the different layers will be related to the complexity of the activity done: the more complex the activity, the more layers will be needed to produce a high level of Presence (Figure 3).

At the lower level – operations – proto Presence is enough to induce a satisfying feeling of Presence. At the higher level – activity – the media experience has to support all three layers.

As suggested by Juarrero [44] high level intentions (Future Intentions/Objects) channel future deliberation by narrowing the scope of alternatives to be subsequently considered (cognitive reparsing). In practice, once the subject forms an intention, not every logical or physically possible alternative remains open, and those that do are encountered differently: once I decide to do A, non-A is no longer a viable alternative and should it happen, I will consider non-A as a breakdown [45].

1.4 How to design rehabilitation technologies that foster Presence and Flow

This perspective allows us to predict under which mediated situations the feeling of Presence can be enhanced or reduced.

First, minimal Presence results from an almost complete lack of integration of the three layers discussed above, such as is the case when attention is mostly directed towards contents of extended consciousness that are unrelated to the present external environment (e.g., I'm in the office trying to write a letter but I'm thinking about how to find a nurse for my father). By the same reasoning, maximal Presence arises when proto Presence, core Presence and extended Presence are focused on the same external situation or activity [28]. Maximal Presence thus results from the combination of all three layers with a tight focus on the same content. This experience is supported by a rehabilitation technology that offers an optimal combination of form and content, able to support the activity of the user in a meaningful way.

The concepts described above are summarized by the following points:

1) *The lower the level of activity, the easier it is to induce maximal Presence.* The object of an activity is wider and less targeted than the goal of an action. So, its identification and support is more difficult for the designer of a rehabilitation technology. Furthermore, the easiest level to support is the operation. In fact, its conditions are more "objective" and predictable, being related to the characteristics (constraints and affordances) of the artifact used: it is easier to automatically open a door in a virtual environment than to help the user in finding the right path for the exit. At the lower level – operations – proto Presence is enough to induce a satisfying feeling of Presence. At the higher level – activity – the media experience has to support all the three levels.
2) *We have maximal Presence when the environment is able to support the full intentional chain of the user*: this can explain i) the success of the Nintendo Wii over competing consoles (it is the only one to fully support M-intentions); ii) the need for a long-term goal to induce a high level of Presence after many experiences of the same rehabilitation technology.
3) *Subjects with different intentions will not experience the same level of Presence, even when using the same rehabilitation technology*: this means that understanding and supporting the intentions of the user will improve his/her Presence during the interaction with the technology.
4) *Action is more important than perception*: I'm more present in a perceptually poor virtual environment (e.g. a textual MUD) where I can act in many different ways than in a real-like virtual environment where I cannot do anything.

2. Transformation of Flow in Rehabilitation using Advanced Technologies

As we have seen previously, authentic rehabilitation implies the active participation of patients in their contexts, their exposure to opportunities for action and development and their freedom to select the opportunities which they perceive as most challenging and meaningful for the subject [46, 47]. According to this vision, a critical asset potentially offered by advanced technologies to the rehabilitation process is that they can foster optimal (Flow) experiences triggering the empowerment [48].

Optimal experiences promote individual development. As underlined by Massimini and Delle Fave, [49]:

"To replicate it, a person will search for increasingly complex challenges in the associated activities and will improve his or her skill, accordingly. This process has been defined as cultivation; it fosters the growth of complexity not only in the performance of Flow activities but in individual behavior as a whole." (p. 28).

This process can be also activated after a major trauma. As noted by Delle Fave [50], to cope with dramatic changes in daily life and to access environmental opportunities for action, individuals may develop a strategy defined as *transformation of Flow:* the ability of the subject to use an optimal experience for identifying and exploiting new and unexpected resources and sources of involvement.

Figure 4. Transformation of Flow

We hypothesize that it is possible to use advanced technologies to activate a transformation of Flow to be used for rehabilitative purposes [8]. The proposed approach is the following (Figure 4): first, to identify an enriched environment that contains *functional* real-world demands; second, using the technology to enhance the level of Presence of the subject in the environment and to induce an optimal experience; third, allowing cultivation, by linking this optimal experience to the actual experience of the subject.

It is well known that process of sequential development of the brain and the sequential development of function, is guided by experience. The brain develops and modifies itself in response to experience. Neurons and neuronal connections (synapses) change in an activity-dependent fashion. Thanks to specific experiences, the brain can even relocate functions to new areas if the primary site is destroyed [51, 52]. For example, stroke victims can gain control over movements with therapy designed to disable their abler body (Constraint-Induced Movement therapy) forcing the brain to establish new circuits to control the areas with little or no control [53, 54]. The only continuing limitation seems to be that some areas of the brain are only open to maximum flexibility during short periods of life.

Apparently the *transformation of Flow* approach could be able to open new plasticity phases, thus improving the possibility of recovery of the subject. Below are reported some examples of technology-driven transformation of Flow.

2.1 Multi-Sensory Environment

A first example of the proposed approach is the Multi-Sensory Environment (MSE) method used in the rehabilitation of neurological disabilities, learning disabilities and older people with dementia [55-57]. The concept of multi-sensory environments (Snoezelen) was developed in the 1980’s at the Haarendael Institute, Holland: MSEs are purpose-built units or rooms using advanced sensory stimulating equipment that targets the five senses of sight, hearing, touch, taste and smell. Their goal is the stimulation of the primary senses to generate pleasurable sensory experiences in an atmosphere of trust and relaxation without the need for intellectual activity. Exposure to an MSE occurs through the agency of the caregiver, nurse or therapist who facilitates the development of a relaxing and supportive environment [58].

The results from a randomized controlled trial (N = 50) showed the efficacy of this approach in the treatment of older people with dementia [59]. In particular, the use of a Multi-Sensory Environment appeared to have a greater influence on aspects of communication in comparison to one-to-one activity and led to improvements in behavior and mood at a four-week follow-up.

Moreover, positive results were obtained in the treatment of children recovering from severe brain injury [60] and in the management of Rett disorder [61].

As underlined by Collier [55], the best results in using MSEs are achieved under transformation of Flow (p. 364):

"…the MSE should include an appropriate level of stimulation that challenges the individual to reach their maximum potential (sensory stimulation versus sensory deprivation). The activity should be designed to address individual sensory needs, such as offering a stronger stimulus if initial attempts are unnoticed, and be offered alongside familiar activities and routines to enhance sensory awareness. The activity should occur on a regular basis and offer a 'just right challenge' as the person with brain injury will find it easier to cope with the demands of the environment if adequate stimulation is provided… Finally, if the complexity of the activity, individual needs, and MSE demands are matched, engagement in this activity may be achieved."

2.2 Robots

The development of robots that interact socially with people and assist them in everyday life has been a long-term goal of modern science [62, 63]. Within this broad area of research, robotic psychology and robotherapy focus on the psychological meaning of person–robotic creature communication and its intertwining with psycho-physiological and social elements. As suggested by Libin & Libin [63]:

"Robotherapy is defined as a framework of human–robot interactions aimed at the reconstruction of a person's negative experiences through the development of coping skills, mediated by technological tools in order to provide a platform for building new positive experiences." (p.370).

Recent research suggests that now, after more than 25 years of research, low-level information, such as animacy, contingency, and visual appearance, can trigger long-term bonding and socialization both in children [64] and in the elderly [65]: rather than losing interest, the interaction between users and the robot improved over time.

Interestingly, the results highlighted the particularly important role that haptic behaviors (motor intentions) played in the socialization process [64]: the introduction of a simple touch-based contingency had a breakthrough effect in the development of social behaviors toward the robot.

Also, as predicted by our model, the ability to address all levels of Presence in the interaction with the rehabilitative robot helps in maintaining patients' interest high during execution of the assigned tasks [66].

2.3 Virtual Reality

The basis of the Virtual Reality (VR) idea is that a computer can synthesize a three-dimensional *(3D)* graphical environment from numerical data [67]. Using visual, aural or haptic devices, the human operator can experience the environment as if it were a part of the world. A VR system is the combination of the hardware and software that enables developers to create VR applications. The hardware components receive input from user-controlled devices and convey multi-sensory output to create the illusion of a virtual world. The software component of a VR system manages the hardware that makes up VR system.

Many researches using VR underline the link between this technology and optimal experiences. However, given the limited space available, we focus on the ones that are most relevant to the contents of this chapter.

A first set of results comes from the work of Gaggioli [46, 47]. Gaggioli compared the experience reported by a user immersed in a virtual environment with the experience reported by the same individual during other daily situations. To assess the quality of experience the author used a procedure called Experience Sampling Method (ESM), which is based on repeated on-line assessments of the external situation and personal states of consciousness [47]. Results showed that the VR experience was the activity associated with the highest level of optimal experience (22% of self-reports). Reading, TV viewing and using other media – both in the context of learning and of leisure activities – obtained lower percentages of optimal experiences (15%, 8% and 19% of self-reports respectively).

To verify the link between advanced technologies and optimal experiences, the "V-STORE Project" investigated the quality of experience and the feeling of Presence in a group of 10 patients with Frontal Lobe Syndrome involved in VR-based cognitive rehabilitation [68].They used the ITC-Sense of Presence Inventory [69] to evaluate the feeling of Presence induced by the VR sessions. Findings highlighted the association of VR sessions with both positive affect and a high level of Presence.

Miller and Reid [70] investigated the personal experiences of children with cerebral palsy engaging in a virtual reality play intervention program. The results show that participants experienced a sense of control and mastery over the virtual environment. Moreover, they perceived experiencing Flow and both peers and family reported perceived physical changes and increased social acceptance. These results were confirmed in two later studies with the same population group [71, 72].

The other hypothesis we suggested in this chapter is that the transformation of Flow may also exploit the plasticity of the brain producing some form of functional reorganization [73]. Optale and his team [74-76] investigated the experience of subjects with male erectile disorders engaging in a virtual reality rehabilitative experience. The results obtained - 30 out of 36 patients with psychological erectile dysfunction and 28 out of 37 clients with premature ejaculation maintained partial or complete positive response after 6-month follow up - showed that this approach was able to hasten the healing process and reduce dropouts. However, the most interesting part of the work is the *PET* analysis carried out in the study. Optale used *PET* scans to analyze regional brain metabolism changes from baseline to follow-up in the experimental sample [77]. The analysis of the scans showed, after the VR protocol, different metabolic changes in specific areas of the brain connected with the erection mechanism.

Recent experimental results from the work of Hoffman and his group in the treatment of chronic pain [78-81] might also be considered as fostering this vision. Hoffman and colleagues verified the efficacy of VR as an advanced distraction tool [82] in different controlled studies. The result showed dramatic drops in pain ratings during VR compared to controls [83]. Further, using a functional magnetic resonance imaging (fMRI) scanner they measured pain-related brain activity for each participant when virtual reality was not present and when virtual reality was present (order randomized). The team studied five regions of the brain known to be associated with pain processing - the anterior cingulate cortex, primary and secondary somatosensory cortex, insula, and thalamus - and found that during VR the activity in all regions showed significant reductions [84]. In particular, the results showed direct modulation of human brain pain responses by VR distraction: the amount of reduction in pain-related brain activity ranged from 50 percent to 97 percent.

Interestingly, as predicted by our model, the level of pain reduction was directly correlated to the level of Presence experienced in VR [79, 85]: the more the Presence, the less the pain.

3. Transformation of Flow in Virtual Reality: The NeuroVR project

Although VR certainly has potential as a rehabilitation technology [86] [87, 88], most of the actual applications in this area are still in the laboratory or at investigation stage. In a recent review [89], Riva identified four major issues that limit the use of VR in this field:

- the lack of standardization in VR hardware and software, and the limited possibility of tailoring virtual environments (VEs) to the specific requirements of the clinical or experimental setting;
- the low availability of standardized protocols that can be shared by the community of researchers;
- the high costs (up to 200,000 US$) required for designing and testing a clinical VR application;
- most VEs in use today are not user-friendly; expensive technical support or continual maintenance is often required.

To address these challenges, we developed *NeuroVR* (http://www.neurovr.org) in 2007 – a free virtual reality platform based on open-source elements [90]. The software allows non-expert users to adapt the content of 14 pre-designed virtual environments to the specific needs of the clinical or experimental setting. The key characteristics that make NeuroVR suitable as rehabilitation tool are the high level of control over interaction with the tool, and the enriched experience provided to the patient.

These features transform NeuroVR into an “empowering environment”, a special, sheltered setting where patients can start to explore and act without feeling threatened. Nothing the patient fears can “really” happen to them in VR. With such assurance, they can freely explore, experiment, feel, live, and experience feelings and/or thoughts.

Following the feedback of over 700 users who downloaded the first version, we developed a new version – NeuroVR 1.5 – that improves the possibility for the therapist to enhance the patient’s feeling of familiarity and intimacy with the virtual scene by using external sounds, photos or videos. The NeuroVR Editor is built using Python scripts that create a custom graphical user interface for Blender. The Python-based GUI allows all the richness and complexity of the Blender suite to be hidden, thus revealing only the controls needed to customize existing scenes and to create the proper files to be viewed in the player. NeuroVR Player leverages two major open-source projects in the VR field: Delta3D (http://www.delta3d.org) and OpenSceneGraph (http:// www.openscenegraph.org). Both are building components that the NeuroVR player integrates with an ad-hoc code to handle the simulations.

NeuroVR software was designed with the goal of enabling therapists to create virtual environments that can enhance the feeling of Presence and support the transformation of Flow. To accomplish this goal, the design process followed the requirements derived from the three-layered theory of Presence summarized in par. 3.4 and developed in [8] and [19]:

1) *The lower the level of activity, the easier it is to induce maximal Presence.* The object of an activity is wider and less targeted than the goal of an action. The virtual exercises developed with NeuroVR can simulate a number of fine-grained activities, such as opening the fridge, grabbing the water and closing the fridge. These activities may in turn broken down to an even finer level – depending on the goals and the complexity of the exercise.

2) *We have maximal Presence when the environment is able to support the full intentional chain of the user*. The virtual environments developed using NeuroVR support the three hierarchical levels indicated by the Presence theory [19]:
    - *Extended Presence*: NeuroVR allows the presentation of mediated affordances that supports the Self in generating complex action plans;
    - *Core Presence*: the VE can be programmed to present the patient with direct affordances. For instance, it is possible to program the appearance/disappearance of virtual objects/images that that trigger the attention of the user. These objects/images can be activated by user's actions and behavior or by therapist's commands.
    - *Proto Presence*: the combined use of sensors and actuators supports perception-action coupling and permits the patient to use his/her body for enacting direct affordances in the virtual environment. Movements can in turn be captured and recorded by means of different input devices and wearable sensors (i.e. head tracking).

3) *Subjects with different intentions will not experience the same level of Presence, even when using the same rehabilitation technology*. Since the reduction of psychomotor performance can vary significantly among patients suffering from neurological damages, complexity of virtual exercises can be tailored to match the level of impairment of each patient. In this way, even patients with a low level of cognitive functioning can successfully accomplish virtual exercises, thereby increasing their feeling of presence, empowerment and motivation for therapy.

4) *Action is more important than perception*: NeuroVR was explicitly designed to find an optimal trade-off between perceptual realism and naturalness of interaction. Whilst finding this trade-off was not an easy task, the level of realism supported by the player is at least adequate to provide patients with the feeling of "being there". As several Presence scholars have pointed out [24], [25], [32] the experience of Presence depends to a greater extent on the ability of a medium to support users' action in a transparent and natural way, and is affected to a lesser extent by the quantity and quality of realism cues depicted in the simulated environment.

4. Conclusions

The field of rehabilitation is placing increasing emphasis on the construct of empowerment as a critical element in any treatment approach. This construct integrates perceptions of personal control, participation with others to achieve goals, and a critical awareness of the factors that hinder or enhance one's efforts to exert control in one's life [1, 2].

In this chapter we suggested that the new emerging technologies discussed in the book – from Virtual Reality to Robotics – have the right features to improve the course of rehabilitation. Specifically, we claim that they are able to improve the quality of life of the individual, by improving his/her level of "Presence".

To be precise, by enhancing the experienced level of Presence, emerging technologies can foster optimal (Flow) experiences triggering the empowerment process (transformation of Flow). The vision underlying this concept arises from "Positive Psychology" [91]. According to this vision, rehabilitation technologies should include positive peak experiences because they serve as triggers for a broader process of motivation and empowerment. Within this context, the *transformation of Flow* can be defined as a person's ability to draw upon an optimal experience and use it to marshal new and unexpected psychological resources and sources of involvement.

Although different technologies can be used to achieve this goal, one of the most promising is Virtual Reality. On the one hand, it can be described as an advanced form of human–computer interface that allows the user to interact with and become immersed in a computer-generated environment in a naturalistic fashion. On the other, VR can also be considered as an advanced *imaginal* system: an experiential form of imagery that is as effective as reality in inducing emotional responses.

To this end, we developed NeuroVR, an "empowering rehabilitation tool" that allows the creation of virtual environments where patients can start to explore and act without feeling threatened [92, 93]. Nothing the patient fears can "really" happen to them in VR. With such assurance, they can freely explore, experiment, feel, live, and experience feelings and/or thoughts. VR thus becomes a very useful intermediate step between the therapist's office and the real world [94].

Clearly, further improving NeuroVR and building new virtual environments is important so that therapists will continue to investigate the application of these tools in their day-to-day clinical practice. In fact, in most circumstances, the clinical skills of the rehabilitator remain the key factor in the successful use of VR systems.

Future research should also deepen analysis of the link between cognitive processes, motor activities, Presence and Flow. This will allow the creation of a new generation of rehabilitation technologies which are truly able to support the empowerment process.

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