Anuario de Psicología
2009, vol. 40, nº 2, 171-192

Virtual reality as empowering environment for personal change: the contribution of the applied technology for neuro-psychology laboratory*

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When we exercise real choice, we gain increased control over our lives and are able to change ourselves. However for many subjects it is not easy to exercise effective choices: patients often don't have the knowledge, skills, assertiveness, or self esteem needed. In this situation Virtual Reality (VR), an artificial reality that projects the user into a 3D space generated by the computer, may offer a critical advantage to the therapist.

The enriched experience and the total level of control on its features, transform VR in an "empowering environment", where patients can start to explore and act without feeling actually threatened. The attempt of defining, developing and testing VR tools supporting personal empowerment is the main goal of the Applied Technology for Neuro-Psychology Laboratory –ATN-P Lab– at the Istituto Auxologico Italiano. The paper describes the actual work done by the

**Aknowledgements:* The present work was supported by the Italian MIUR FIRB programme (Project "IVT2010 – Immersive Virtual. Telepresence (IVT) for Experiential Assessment and. Rehabilitation - RBIN04BC5C) and by the European Union IST Programme (Project "INTREPID - A Virtual Reality Intelligent Multi-sensor Wearable System for Phobias' Treatment" - IST-2002- 507464).
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Original recibido: octubre 2008. *Aceptación final:* mayo 2009.

ATN-P Lab. in this area. Specifically, the open source "NeuroVR" system and its potential clinical applications –anxiety disorders, obesity and eating disorders– are presented and discussed.

Keywords: *empowerment, virtual reality, anxiety disorders, obesity and eating disorders.*

La realidad virtual como entorno fortalecedor para el cambio personal: la contribución del laboratorio de tecnología aplicada a la neuropsicología

La capacidad de elección nos proporciona control sobre nuestras vidas y nos ofrece posibilidades de cambio. Sin embargo, para muchas personas no es fácil realizar elecciones efectivas; por ejemplo, los pacientes carecen muchas veces del conocimiento, la habilidad, la asertividad o autoestima necesarias. En esas situaciones, la realidad virtual (RV), una realidad artificial que coloca al sujeto en un espacio generado por el ordenador, puede ser para el terapeuta un recurso decisivo.

La experiencia enriquecida y el control total sobre todos sus aspectos transforman la RV en un "entorno fortalecedor", en el que los pacientes pueden comenzar a explorar y actuar sin sentirse amenazados. El principal objetivo del "Applied Technology for Neuro-Psychology Laboratory" (ATN-P Lab), perteneciente al Instituto Auxologico Italiano, es intentar definir, desarrollar y probar aplicaciones basadas en RV que faciliten el fortalecimiento personal. En este artículo se describe el trabajo que se viene realizando sobre este tema en ese laboratorio. Se presenta y discute, específicamente, el sistema de código abierto denominado "NeuroVR", así como sus aplicaciones clínicas potenciales sobre los trastornos de ansiedad, la obesidad y los trastornos alimentarios.

Palabras clave: *fortalecimiento, realidad virtual, trastornos de ansiedad, obesidad, trastornos alimentarios.*

Since the early 1980s, when the computer scientist Jarom Lanier used the term for the first time, Virtual Reality (VR) has been usually described as an artificial reality that projects the user into a 3D space generated by the computer. An immersive virtual reality system uses a head mounted display (HMD) that provides the 3D imagery and some sort of tracking device, which may be the HMD itself for tracking head movement, or a "data glove" that tracks hand movements (figure 1). Because input devices sense the subject's reactions and motions, the computer can modify the synthetic environment accordingly, creating the illusion of interacting with, and thus being immersed within the environment.

Virtual Reality in Clinical Psychology

Even if VR is well known for its use with flight simulators and games, its use in health care has become more widespread. Healthcare virtual reality applications

Figure 1: An immersive Virtual Reality system used for the treatment of obesity

have experienced double-digit growth both worldwide and in the United States since the turn of the century, and the 2010 US market for virtual reality in surgery, medical education, therapy and other areas will grow to $290 million, according to a new report from research firm Kalorama Information (Heffner, 2007).

The growing interest in medical applications of VR is also highlighted by the increasing number of scientific articles published each year on this topic: searching Medline with the keyword "virtual reality", we found that the total number of publications has increased from 45 in 1995 to 286 in 2007, showing an average annual growth rate of nearly 15 per cent.

Several VR applications for the understanding, assessment and treatment of mental health problems have been developed in the last 15 years (Riva, 2005). Typically, in VR the patient learns to manipulate problematic situations related to his/her problem. For this reason, the most common application of VR in this area is the treatment of anxiety disorders (Emmelkamp, 2005).

Nevertheless, we believe that VR can be more than a tool to provide exposure and desensitisation (Riva, 2005). Specifically, we believe that VR can be an advanced clinical tool for personal empowerment.

Virtual reality as empowering environment

The idea of empowerment is the expansion of freedom of choice and action. It means increasing one's authority and control over the resources and decisions that affect one's life: when we exercise real choice, we gain increased control over our lives and are able to change ourselves.

However for many patients, the core problem is the inability to do so: they don't have the knowledge, skills, assertiveness, or self esteem required to exercise real choices able to change them. Often, they are aware of the pros of a choice but are also acutely aware of the cons. This balance between the costs and benefits can produce profound ambivalence that can keep patient stuck for long periods of time.

In this situation VR offers two critical advantages to the therapist (Schultheis & Rizzo, 2001):

1. The total level of control on the characteristics of the environment.
2. The enriched experience provided to the patient.

These features transform VR in an "empowering environment", a special, sheltered setting where patients can start to explore and act without feeling actually threatened (Botella *et al.,* 2007). 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 (Botella *et al.,* 2004).

The first scientific paper addressing the possible use of VR in clinical psychology was published in 1991 by Albert D. Farrell. Since then, several VR applications for the understanding, assessment and treatment of mental health problems have been developed in the last 15 years (Riva, 2005). Emerging applications of VR in psychotherapy include anxiety disorders (Gorini & Riva, 2008b), eating disorders and obesity (Perpiñà, Botella, & Baños, 2003; Riva, Bacchetta, Baruffi, Rinaldi, & Molinari, 1999; Riva, Bacchetta, Baruffi, Rinaldi *et al.,* 2000; Riva *et al.,* 2006; Riva, Bacchetta, Cesa, Conti, & Molinari, 2003), posttraumatic stress disorder (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001), sexual disorders (Optale, 2003), addictions (Bordnick, Graap, Copp, Brooks, & Ferrer, 2005; Bordnick *et al.,* 2008; Gatti *et al.,* 2008; Lee, Kwon, Choi, & Yang, 2007), persecutory delusions (Fornells-Ambrojo *et al.,* 2008), and pain management (Hoffman, 2004).

The main potential advantages offered by VR to the clinical practice are two.

On one side, 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. This immersive interface allows the patient to access more information about both him/herself and the world. More, this interface is "safe": through it the patient can freely explore, experience, feel, live, revive feelings and/or thoughts whether they are current or past. Nothing prevents him/her from constructing a new reality about him/herself and the world.

On the other side 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 (Vincelli, 1999; Vincelli, Molinari, & Riva, 2001). As underlined by Baños, Botella & Perpiñà (1999), the VR experience can help the course of therapy for «its capability of reducing the distinction between the computer's reality and the conventional reality». In fact, «VR can be used for experiencing different identities and... even other forms of self, as well» (p. 289). The possibility of structuring a large amount of realistic or imaginary controlled stimuli and, simultaneously, of monitoring the possible responses generated by the user of the technology offers a considerable increase in the likelihood of therapeutic effectiveness, as compared to traditional procedures (Gorini & Riva, 2008a). As noted by Glantz Durlach, Barnett & Aviles (1997): «One reason it is so difficult to get people to update their assumptions is that change often requires a prior step – recognizing the distinction between an assumption and a perception. Until revealed to be fallacious, assumptions constitute the world; they seem like perceptions, and as long as they do, they are resistant to change» (p. 96). Using the sense of presence induced by VR, it is easier for the therapist to develop realistic experiences demonstrating to the patient that what looks like a perception in fact is a result of his/her mind. Once this has been understood, individual maladaptive assumptions can then be challenged more easily.

The Applied Technology for Neuro-Psychology Laboratory

The attempt of defining, developing and testing VR tools supporting personal empowerment and change is the main goal of the Applied Technology for Neuro-Psychology Lab. *–ATN-P Lab–* at the Istituto Auxologico Italiano. The ATN-P Lab. was conceived in 1993 and created in 1995 by Professor Giuseppe Riva, who is still leading the lab. Its activity is split between two different physical sites: one in Milan (Italy) and the second one in Piancavallo, Verbania (Italy).

In its first decade, the Lab. pioneered much of the applications that enabled the diffusion of Virtual Reality and Internet in the field of health care. Specifically, its research work led to the development of a new scientific discipline –Cybertherapy– integrating innovative research ranging from clinical psychology and cognition, to mobile devices and simulation apparatus. According to ISI Web of Science, the ATN-P Lab. is the leading laboratory world-wide for numbers of publications in the field of Virtual Reality and its head –Giuseppe Riva– is the researcher in world with the highest number of peer-reviewed scientific papers in this field (see table 1).

In its second decade, the Lab. is focusing on the concepts of "presence" and "human adaptability" embedding the bits of the digital realm with the atoms of our physical world. This is producing expanded research in ambient intelligence, shared virtual world and "interreality" applications: the creation of an hybrid augmented experience merging physical and virtual worlds.

The key feature of the ATN-P Lab. is its interdisciplinary approach including cognitive scientists, clinical psychologists, programmers, 3D world developers, and biomedical engineers. ATN-P Lab. best-practice procedure model is based on experience gained from a great number of national and international projects. Strong emphasis is given to the role of prototyping and decisive orientation toward user goals.

TABLE 1: TOP TEN WORLD-WIDE RESEARCHERS IN THE VIRTUAL REALITY FIELD
(DATA OBTAINED USING THE ISI WEB OF SCIENCE ANALYZE FEATURE,
"VIRTUAL REALITY" TOPIC, ACCESSED DECEMBER, 23, 2008)

Researcher	*Scientific Papers Published (ISI Journals only)*	*% over 6163 (total published papers)*
Riva, G.	56	0.91 %
Darzi, A.	44	0.71 %
Kim, S.I.	35	0.57 %
Botella, C.	29	0.47 %
Hoffman, H.G.	29	0.47 %
Satava, R.M.	29	0.47 %
Gallagher, A.G.	28	0.45 %
Wiederhold, B.K.	28	0.45 %
Aggarwal, R.	27	0.41 %
Slater, M .	27	0.41 %

In the next pages we will describe the actual work done by the ATN-P Lab. in this area. Specifically, the open source “NeuroVR” system and its actual clinical applications will be presented and discussed.

The VR research carried out by the ATN-P Lab.

Anxiety Disorders

As we have seen in the previous paragraphs, VR is mostly used to help patients to cope with problematic situations related to their problem. For this reason, the typical application of VR in clinical psychology is the treatment of anxiety disorders (Gorini & Riva, 2008b), i.e., fear of heights, fear of flying, and fear of public speaking (Emmelkamp, 2005; Wiederhold & Rizzo, 2005; Wiederhold & Wiederhold, 2003).

Indeed, VR exposure therapy (VRE) has been proposed as a new medium for exposure therapy (Riva, 2005) that is safer, less embarrassing, and less costly than reproducing the real world situations.

The rationale is simple: in VR the patient is intentionally confronted with the feared stimuli while allowing the anxiety to attenuate. Avoiding a dreaded situation reinforces a phobia, and each successive exposure to it reduces the anxiety through the processes of habituation and extinction.

VRE offers a number of advantages over in vivo or imaginal exposure (Gorini & Riva, 2008b). First, VRE can be administered in traditional therapeutic settings. This makes VRE may be more convenient, controlled, and cost-effective than in vivo exposure. Second, it can also isolate fear components more efficiently than in vivo exposure. For instance, in treating fear of flying, if landing is the most fearful part of the experience, landing can be repeated as often as necessary without having to wait for the airplane to take-off. Finally, the immersive nature of VRE provides a real-like experience that may be more emotionally engaging than imaginal exposure.

In this area the ATN-P Lab. research work addressed two different pathologies: panic disorder and generalized stress disorders.

Panic Disorders with Agoraphobia

Panic Disorder with Agoraphobia (PDA) is an anxiety disorder in which there are repeated attacks of intense fear and anxiety, and a fear of being in places where escape might be difficult, or where help might not be available. The use of a multicomponent cognitive-behavioral treatment strategy for panic disorder with agoraphobia is actually one of the preferred therapeutic approaches for this disturbance. This method involves a mixture of cognitive and behavioral techniques that are intended to help patients identify and modify their dysfunctional anxiety-related thoughts, beliefs and behavior.

The ATN-P Lab. developed a new treatment protocol for PDA, named Experiential-Cognitive Therapy (ECT) that integrates the use of virtual reality (VR) in a multicomponent cognitive-behavioral treatment strategy (Choi *et al.,* 2005; Vincelli *et al.,* 2003; Vincelli, Choi, Molinari, Wiederhold, & Riva, 2000). The goal of ECT is to decondition fear reactions, to modify misinterpretational cognition related to panic symptoms and to reduce anxiety symptoms. This is possible in an average of eight sessions of treatment plus an assessment phase and booster sessions, through the integration of Virtual Experience and traditional cognitive-behavioral techniques. ECT is based on the 4-zone Virtual Environments for Panic Disorders-VEPD-virtual reality system. The four zones reproduce different potentially fearful situations: an elevator, a supermarket, a subway ride, and large square. In each zone the characteristics of the anxiety-related experience are defined by the therapist through a setup menu.

This approach was tested in a controlled study involving 54 consecutive PDA patients (DSM-IV R diagnosis) aged 35-53 (Vincelli *et al.,* 2003; Vincelli, Molinari, & Riva, 2006). The selected subjects were randomly divided in three groups: ECT group, that experienced the Cognitive Behavioral Therapy (CBT)-Virtual Reality assisted treatment (eight sessions), a CBT group that experienced the traditional Cognitive Behavioral approach (12 sessions) and a waiting list control group. The data showed that both CBT and ECT could significantly reduce the number of panic attacks, the level of depression and both state and trait anxiety. However, ECT obtained these results using 33% fewer sessions than CBT. This datum suggests that ECT could be better than CBT in relation to the “cost of administration”, justifying the added use of VR equipment in the treatment of panic disorders.

Generalized Anxiety Disorders

Generalized anxiety disorder (GAD) is a psychiatric disorder characterized by a constant and unspecific anxiety that interferes with daily-life activities.

Its high prevalence in general population and the severe limitations it causes, point out the necessity to find new efficient strategies to treat it. Together with the cognitive-behavioural treatments, relaxation represents a useful approach for the treatment of GAD, but it has the limitation that it is hard to be learned. To overcome this limitation the ATN-P Lab. proposed the use of virtual reality (VR) to facilitate the relaxation process by visually presenting key relaxing images to the subjects (Gorini & Riva, 2008a). The visual presentation of a virtual calm scenario can facilitate patients' practice and mastery of relaxation, making the experience more vivid and real than the one that most subjects can create using their own imagination and memory, and triggering a broad empowerment process within the experience induced by a high sense of presence. The protocol they developed, actually under testing in the Intrepid European Union Funded research project (http://www.intrepid-project.org), was based on 7 weeks of Applied Relaxation (AR) training (2 sessions per week). Patients will be taught coping skills which enable them to relax rapidly, in order to counteract and possibly eliminate the anxiety reactions. In the present protocol they are using two different virtual environments included in the open-source software NeuroVR (for more info see next section “NeuroVR: an open-source software for empowerment and personal change”).

For the relaxation sessions, the Green Valley, a very relaxing environment showing a mountain landscape around a calm lake is presented together with a relaxing narrative and soft sounds (birds' songs, water flowing, etc). Patients are asked to walk around the lake, to observe the nature and, after few minutes, to virtually seat on a comfortable deck chair, in order to become easily relaxed.

For the second part of the protocol, patients are exposed to specific stressful virtual environments that simulate real-life situations: a crowded place, a classroom, an apartment, and so on. Each of these environments can be modified by the therapist with objects, persons and multimedial components depending on the patients' needs.

The end of the randomized clinical trial now running is expected for the end of 2009.

Obesity and Eating Disorders

In the treatment of anxiety disorders VR is mainly used for exposure and desensitisation However, it seems likely that VR can offer more to clinical psychology (Riva, 2005). As noted by Glantz and colleagues (Glantz *et al.,* 1997), «VR technology may create enough capabilities to profoundly influence the shape of therapy» (p.92).

In fact, immersive VR can be considered an “embodied technology” for its effects on body perceptions (Lambrey & Berthoz, 2003; Riva, 2008; Vidal, Amorim, & Berthoz, 2004; Vidal, Lipshits, McIntyre, & Berthoz, 2003). First, VR users become aware of their bodies during navigation: their head movements alter what they saw. The sensorimotor coordination of the moving head with visual displays produces a much higher level of sensorimotor feedback and first person perspective (egocentric reference frame).

For example, through the use of immersive VR, it is possible to induce a controlled sensory rearrangement that facilitates the update of the biased body image. This allows the differentiation and integration of new information, leading to a new sense of cohesiveness and consistency in how the self represents the body. The results of this approach is very promising and has been tested by ATN-P Lab. in the treatment of obesity and eating disorders.

Obesity

For many, obesity is just a problem of energy input and expenditure: more energy input than expenditure. However, the clinical practice and epidemiological data clearly show that weight control is more complex than expected by this simple equation. This is particularly true in morbid obesity, a form of severe obesity in which a person's Body Mass Index is over 40. If we compare the definitions and diagnostic criteria for “dependence” and “addiction” with the situation of many severe obese subjects, it is apparent that they match very well. Further, different neurological studies confirm this similarity: both addiction and obesity patients have a deficiency of dopamine receptors. Nevertheless, when we compare many of the actual obesity treatments with the ones used in the area of addictions it is possible to find relevant differences: obesity treatments neither consider different levels of type and intensity of care, nor a multidimensional approach. To overcome these limitations, the ATN-P Lab. proposed a biopsychosocial approach in which the genetic influence (lack of dopamine receptors) is matched by psychosocial issues (pressure for thinness and diet as main body image dissatisfaction treatment).

The main outcome of this effort is the Experiential-Cognitive Therapy (ECT) for Obesity (Riva, Bacchetta, Baruffi, Cirillo, & Molinari, 2000; Riva *et al.,* 2006): a relatively short-term, integrated, patient oriented approach that focuses on individual discovery (Riva, Bacchetta, Baruffi, Rinaldi, & Molinari, 1998b; Riva *et al.,* 1999; Riva, Bacchetta, Baruffi, Rinaldi *et al.,* 2000). It shares with the cognitive-behavioral approach the use of a combination of cognitive and behavioral procedures to help the patient identify and change the maintaining mechanisms (Cooper, Fairburn, & Hawker, 2003). However, it considers morbid obesity as a peculiar form of addiction. So, as in the cognitive-behavioral treatment of addictions (Carroll, 1998) the two main goals are the functional analysis of the maintaining mechanisms and the required skill training (relapse prevention). Moreover, the proposed approach contains the following four distinctive elements none of which, alone, is unique to this approach:

1. *The use of virtual reality (VR).* VR helps the therapist in providing the two below features of ECT approach: body experience treatment and empowerment. The use of a VR treatment makes it possible to use the psychophysiological effects induced by the virtual experience on the body schema for therapeutic purposes (Riva, 1998a, 1998b). Moreover VR has the right features to support empowerment, since it is a special, sheltered setting where

patients can start to explore and act without feeling threatened (Botella, Perpiñà, Baños, & García-Palacios, 1998).

2. *Its focus on the body experience*, a major reason patients want to lose weight (Rosen, 1996). Differently from the Cooper protocol, the experience of the body is not addressed only as potential obstacle to the acceptance of weight maintenance (Cooper *et al.,* 2003). This approach suggests a functional vision of the body considered only as an intentional object, an image, a mental representation. The proposed approach does not agree with this vision. Following the emerging "embodied cognition" approach (Bermúdez, Marcel, & Eilan, 1995; Clancey, 1997; A. Clark, 1997; Gallagher, 2003) ECT considers body image as an integral part of the subjects' identity. As noted by Gallagher (Gallagher, 1995) the body experience is not neutral but it places constraints on intentional consciousness: «changes or distortion introduced at the level of body schema result in changes or distortions in intentional consciousness» (p. 239).

3. Its focus on the empowerment process. Following the traditional CBT protocol, ECT considers a critical goal of the therapy the ability of the patient in defining a realistic target weight range, in monitoring eating behaviors and in managing the frustration related to weight fluctuations. However, differently from CBT, ECT does not consider these abilities as behavioral skills only. Specifically, ECT agrees with the DiClemente position (DiClemente, 1986) that describes them as part of a broader individual dimension, defined "control self-efficacy": «an individual's ability to control the addictive behavior in a variety of provocative situations» (p. 303). Bandura (Bandura, 1989, 1997) proposed the concept of self-efficacy as an explanation of behavior and behavior change. People tend to avoid activities they believe exceed their coping abilities and un-dertake those they consider themselves capable of handling. Efficacy expectations influence the decision to attempt a behavior, the length of time it will be attempted, and the effort, which will be involved (Bandura, 1989). Low efficacy expectations in the face of obstacles will result in persons experiencing serious doubts or giving up, while high efficacy expectations will result in greater efforts being extended to achieve desired results. Following this approach, the main strategy to raise self-efficacy is "empowerment", the process of helping people feel a sense of control over their lives. Within this process ECT addresses three critical dimensions (Menon, 1999):

a) Perceived control: includes beliefs about authority, decision-making skills, availability of resources, autonomy in the scheduling and performance of work, etc.

b) Perceived competence: reflects role-mastery, which besides requiring the skillful accomplishment of one or more assigned tasks, also requires successful coping with non-routine role-related situations.

c) Goal internalization: this dimension captures the energizing property of a worthy cause or exciting vision.

4. *It is based on different types and intensity of care*. If needed the patient can enter, for some time, a medically-managed intensive inpatient treatment (ASAM, 1996). In this view, the choice between an inpatient or outpatient

treatment, and between individual or group sessions, is a critical part of the therapeutic strategy.

To test this approach Riva and his group (Riva *et al.,* 2006) have recently conducted the largest randomised controlled VR trial to date with 211 morbidly obese patients. This trial compared Experiential Cognitive Therapy with nutritional and cognitive-behavioral approaches along with waiting list controls. At the 6 and 12 months follow-up ECT, in contrast to the other approaches, resulted in improvements in both the level of body image, satisfaction and self-efficacy; and in the maintenance of weight loss.

Eating Disorders

A specific version of the ECT protocol was also developed for the treatment of eating disorders (Castelnuovo *et al.,* 2005): Anorexia Nervosa (Riva, Bacchetta, Baruffi, Rinaldi, & Molinari, 1998a) and Binge Eating Disorders (Riva, Bacchetta, Baruffi, Rinaldi *et al*., 2000; Riva *et al*., 2003). In particular, the main difference in the ECT protocol is related to the focus on body image dissatisfaction.

Eating Disorders refer to a range of problems characterized by abnormal eating behaviors and beliefs about body image (Levine & Piran, 2004) and shape (Body Image Disturbances-BIDs). BIDs include three different components (Vocks, Legenbauer, Ruddel, & Troje, 2007):

1. A cognitive-affective component including negative thoughts and feelings about the body.
2. A behavioral component including avoidance of body-related situations.
3. A perceptual component referring to the overestimation of one's own body dimensions.

Evidence from psychology and neuroscience indicates that our spatial experience, including the bodily one, involves the integration of different sensory inputs within two different reference frames (Galati *et al.,* 2000): egocentric and allocentric.

Egocentric representations are referred to the body of the observer, or to relevant body part: they allow the subject to locate objects relative to the body centre.

A*llocentric (or exocentric) representations* are referred to space external to the perceiver: they allow people to handle relationships centred among objects and identify objects.

On one side, these frames influence the way memories are stored and retrieved, too (Amorim, 2005; Robinson & Swanson, 1993): the rememberer may "see" the event from his or her perspective as in normal perception (*field mode*), or "see" the self engaged in the event as an observer would (*observer mode*).

On the other side, they influence the ability of representing and recalling our body: an egocentric representation of how our body looks is matched by an allocentric one, used by our brain in different situations (Amorim, 2005; Juurmaa & Lehtinen-Railo, 1994): from spatial cognition to social perception.

Riva suggests that subjects with BIDs are locked to an allocentric representation of their body (*Allocentric Lock Hypothesis*), stored in long-term episodic memory (figure 2). For a more detailed description of this hypothesis see below.

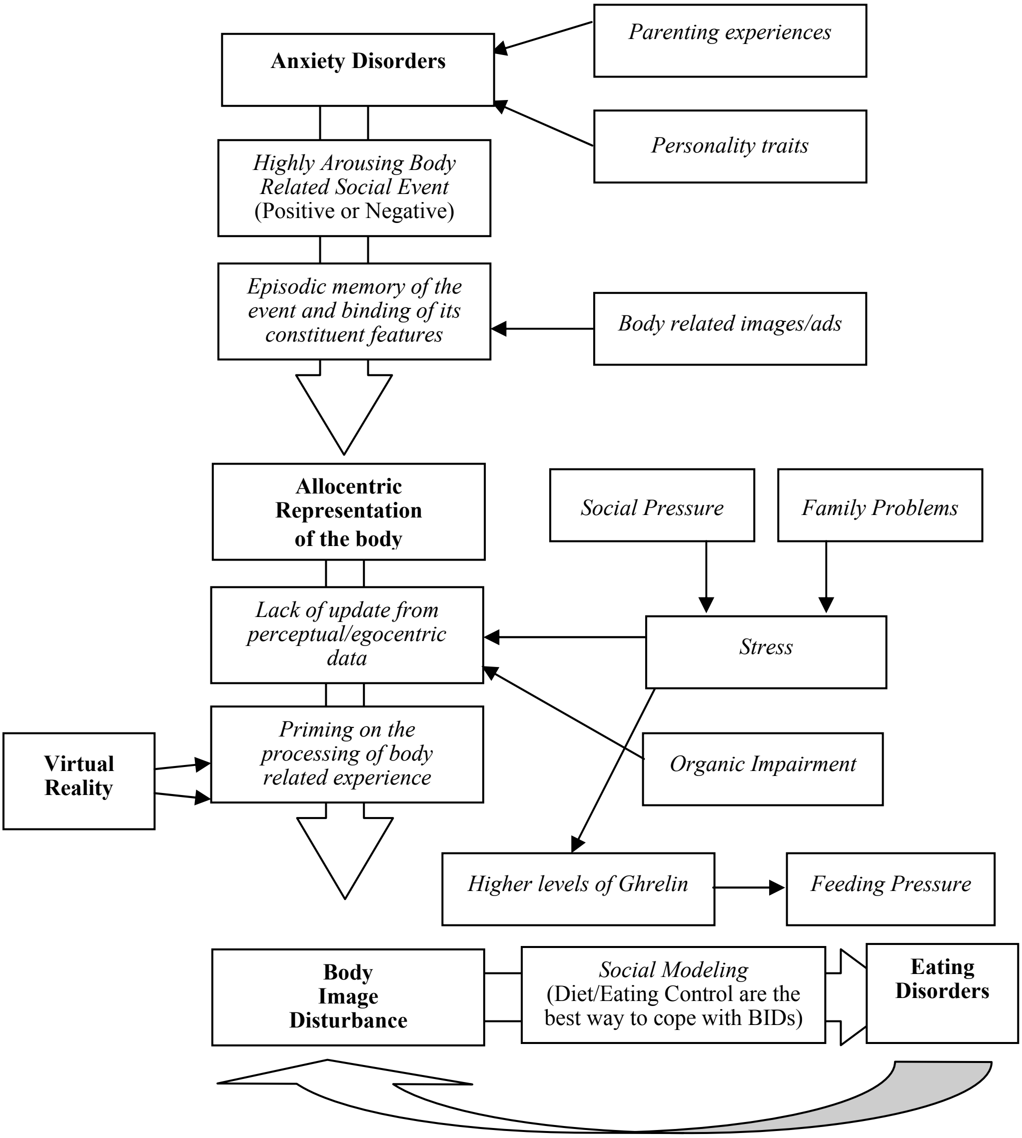

Figure 2: The Allocentric Lock Hypothesis.

The Allocentric Lock Hypothesis

Anxiety disorders, such as social anxiety or agoraphobia, are commonly observed in patients with EDs, and frequently predate the emergence of this disturbance (Cash, Phillips, Santos, & Hrabosky, 2004; Godart *et al.,* 2006; Hinrichsen, Waller, & Dhokia, 2007).

But what is their role in the development of EDs? Anxious subjects tend to evaluate specific situations as being excessively dangerous. When this happens, they shift attention away from the situation and become highly self-focused (D'Argembeau, Van der Linden, d'Acremont, & Mayers, 2006).

Clark & Wells (Clark & Wells, 1995) propose that this self-processing occurs as an impression of appearance from an "observer perspective": seeing oneself as if from an external point of view. Research by Wells & Papageorgiou (Wells & Papageorgiou, 1999) showed that, in recalling anxiety-provoking social situations, individuals with social phobia and agoraphobia are more likely to take an observer perspective whereas control subjects are more likely to take a field perspective. A similar result was obtained by Osman and colleagues (Osman, Cooper, Hackmann & Veale, 2004) in a sample of patients with body dysmorphic disorder.

Given the importance of negative weight/body experiences in the development of EDs we can suppose that subjects with BIDs stored in long-term episodic memory an allocentric (*observer view*) representation of their body, after one or more highly arousing social experiences related to it, such as teasing (Buhlmann, Cook, Fama, & Wilhelm, 2007). For instance, Kvalem and colleagues (Kvalem, von Soest, Roald, & Skolleborg, 2006) showed that self-reported intensity of the emotional reaction was a significant predictor of appearance evaluation: it is mainly teasing rated as hurtful that has an impact on body esteem.

As suggested by episodic memory theories (Mather, 2007) the arousal associated with an object (e.g. someone telling me "your legs are fat") elicits focused attention that enhances binding of its constituent features facilitating the development of an overall representation of the body (e.g. "I'm fat"). It is important to underline that the most important factor in this process seems to be how arousing the experiences are rather than their valence (Matger, 2007).

This suggests that positive arousing social experiences (e.g. being praised for my legs after being crowned beauty queen) may have a similar effect than negative ones.

A second claim of our hypothesis is that this representation influences any further body-related experience. How does this happen?

Coslett and colleagues (Coslett, Saffran, & Schwoebel, 2002) showed that the knowledge of our body is a distinct and dissociable semantic category based on the mapping between language (and other knowledge representations) and the knowledge of body configuration and biomechanics. This suggests that changes in the representation of the body also affect spatial perceptions, motor behavior and intentional actions.

A more detailed explanation comes from the model of spatial cognition proposed by Byrne and colleagues (Byrne, Becker, & Burgess, 2007). This model uses the interaction between egocentric and allocentric representations to account for the interaction between long- and short-term memory processes in spatial cognition. Specifically, long-term spatial memory involves the generation of allocentric representations in the hippocampus and surrounding medial temporal lobe structures. Instead, short-term spatial memory and imagery are modelled as egocentric representations of locations in the precuneus, driven either by perception or by long-term memory. Within this framework, the process of spatial encoding and retrieval requires a translation between the allocentric long-term memory and the egocentric spatial updating, which occurs via a coordinate transformation in the posterior parietal and retrosplenial cortices.

On one side, retrieval from long-term memory, cued by knowledge of position and orientation relative to one or more landmarks, is translated by the Papez's circuit in an egocentric representation. Through this process, the allocentric representation of the body can influence the egocentric one, including body dimensions and motor patterns (Vocks *et al.,* 2007). On the other side, the update of an allocentric memory requires the reactivation of population of boundary vector cells located within parahippocampal cortex. If, for some reasons, this process is impaired, the subjects are not able to update the contents of the allocentric representation of their body: they are locked to it.

How this may happen? It is well known that the hippocampus plays a critical role in spatial memory ability (Astur, Taylor, Mamelak, Philpott, & Sutherland, 2002; McLaughlin, Gómez, Baran, & Conrad, 2007): damage to the hippocampus corresponds with spatial memory impairments. More, Ramos showed that an impaired hippocampus produces a serious deficit in the consolidation of an allocentric spatial memory (Ramos, 2000). The damage lead to a weak representation of the learned spatial information in the neocortex, thus impeding the long-term retention of information.

A growing body of evidence has demonstrated that stress, and in particolar chronic stress, can cause hippocampal damage (McLaughlin *et al*., 2007; Vyas, Mitra, Shankaranarayana Rao, & Chattarji, 2002). Specifically, chronic stress produces consistent and reversible changes within the dendritic arbors of CA3 hippocampal neurons (Conrad, 2006; McLaughlin *et al.,* 2007), characterized by decreased dendritic length and reduced branch number. This process disrupts hypothalamic-pituitary-adrenal axis activity, leading to dysregulated glucocorticoid release that, combined with hippocampal CA3 dendritic retraction, contributes to impaired spatial memory (Conrad, 2006).

Unlocking the virtual body: the role of virtual reality

Starting from the above rationale, the ECT protocol for eating disorders uses VR to update the allocentric representation of the body. Different previous VR experiments showed the ability of VR in activating the hippocampal area: Burgess and colleagues (Burgess, Becker, King, & O'Keefe, 2001) examined in a VR experiment the neural systems involved in the retrieval of the spatial context of an event. The measured activation showed the buffering of the location of scene elements in successively translated frames of reference (allocentric, body-centered, head centered) between the parahippocampus and the precuneus. In summary, may be possible to use VR to induce a controlled sensory rearrangement that facilitates an update of the allocentric representation of the body. Here, too, some previous studies offer a preliminary support to this hypothesis (Myers, Swan-Kremeier, Wonderlich, Lancaster, & Mitchell, 2004).

Following this vision the proposed protocol uses the changes in body experience produced by VR to facilitate the changes in body image. In particular, the protocol applies, within a VR environment, some elements (for a detailed description of the VR component see Thompson and colleagues: Thompson, Heinberg, Altabe, & Tantleff-Dunn, 1999, pp. 322-325) of the protocol for body image disturbances defined by Cash (Cash, 1996, 1997). As showed by previous experimental research, VR is effective in producing fast changes in body experience (Murray & Gordon, 2001) and in body dissatisfaction (Perpiñà *et al*., 2003; Riva, Bacchetta, Baruffi, & Molinari, 2002; Riva, Bacchetta, Cesa, Conti, & Molinari, 2004).

For instance, a 22-year old female university student diagnosed with Anorexia Nervosa (Weight: 43 kg; Height: 160 cm; B.M.I.: 16.8) was tested using this approach (Riva *et al.,* 1999). At the end of the 8-week in-patient treatment, the subject increased her bodily awareness joined to a reduction in her level of body dissatisfaction. Moreover, the patient presented a high degree of motivation to change.

Given the positive results, this approach was tested in a larger sample composed by patients with binge eating disorders (BED). In a randomized sample composed by 36 BED patients Riva and his team compared the outcome of the ECT protocol with the ones obtained by CBT and nutritional groups only (Riva *et al*., 2003). The results showed that 77% of the ECT group quit binging after 6 months versus 56% for the CBT sample and 22% for the nutritional group sample. Moreover, the ECT sample reported better scores in most psychometric tests including EDI-2 and body image scores.

NeuroVR: an open-source software for empowerment and personal change

Although it is undisputable that VR has come of age for clinical and research applications, the majority of them are still in the laboratory or investigation stage. In a recent review, Riva (2005) identified four major issues that limit the use of VR in psychotherapy:

1. The lack of standardisation in VR hardware and software and the limited possibility of tailoring the virtual environments (VEs) to the specific requirements of the clinical or the experimental setting.
2. The low availability of standardised protocols that can be shared by the community of researchers.
3. The high costs (up to 200,000 €) required for designing and testing a clinical VR application.
4. VEs in use today not being user-friendly, as expensive technical support or continual maintenance are often required.

To address these challenges, ATN-P Lab. designed and developed NeuroVR (http://www.neurovr.org), a cost-free virtual reality platform based on open-source software, that allows non-expert users to easily modify a virtual environment (VE) and to visualise it using either an immersive or non-immersive system. The NeuroVR system is now used by the ATN-P Lab. in all the ECT protocols described in the previous chapters.

The NeuroVR platform is implemented using open-source components that provide advanced features; this includes an interactive rendering system based on OpenGL, which allows for high quality images. The NeuroVR Editor is realised by customising the user interface of Blender, an integrated suite of 3D creation tools available on all major operating systems; this implies that the program can be distributed even with the complete source code. Thanks to these features, clinicians and researchers have the freedom to run, copy, distribute, study, change and improve the NeuroVR Editor software, so that the whole VR community benefits.

The NeuroVR Editor

The majority of existing VEs for psychotherapy are proprietary and have closed source code, meaning they cannot be tailored from the ground up to fit specific needs of different clinical applications (Riva, 2005). NeuroVR addresses these issues by providing the clinical professional with a cost-free VE editor, which allows non-expert users to easily modify a virtual scene to best suit the needs of the clinical setting.

Using the NeuroVR Editor (see figure 3), the psychological stimuli/stressors appropriate for any given scenario can be chosen from a rich database and easily

Figure 3. A screen-shot taken from the NeuroVR Editor.

placed into the pre-designed virtual scenario by using an icon-based interface (no programming skills are required). Specifically, the therapist can add audio, 3D and video objects (Chroma Key is supported) to the pre-defined scenario using a simple point-and-click interface.

This feature allows the therapist to enhance the patient's feeling of familiarity and intimacy with the virtual scene –i.e., by using photos or videos of objects/people that are part of the patient's daily life– thereby improving the efficacy of the exposure. More, the audio and video objects can be activated both by the therapist using a keyboard, or by the user through a collision detection algorithm.

The NeuroVR Editor is built using a custom graphical user interface (GUI) for Blender. The GUI allows hiding all the richness and complexity of the Blender suite, so as to expose only the controls needed to customise existing scenes and to create the proper files to be viewed in the player.

Currently, the NeuroVR library includes different pre-designed virtual scenes, representing typical real-life situations, e.g. the supermarket, the apartment, the park. These VEs have been designed, developed and assessed in the past ten years by a multidisciplinary research team in several clinical trials, which have involved over 400 patients (Riva, Botella, Légeron, & Optale, 2004). On the basis of this experience, only the most effective VEs have been selected for inclusion in the NeuroVR library.

An interesting feature of the NeuroVR Editor is the possibility to add new objects to the database. This feature allows the therapist to enhance the patient's feeling of familiarity and intimacy with the virtual scene, i.e., by using photos of objects/people that are part of the patient's daily life, thereby improving the efficacy of the exposure (Riva *et al.,* 2004).

The NeuroVR Player

The second main component of NeuroVR is the Player, which allows the user to navigate and interact with the VEs created using the NeuroVR Editor.

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 ad-hoc code to handle the simulations.

The whole player is developed in C++ language, targeted for the Microsoft Windows platform but fully portable to other systems if needed. When running simulations, the system offers a set of standard features that contribute to increase the realism of the simulated scene. These include collision detection to control movements in the environment, realistic walk-style motion, advanced lighting techniques for enhanced image quality and streaming of video textures using alpha channel for transparency.

The player can be configured for two basic visualisation modalities: immersive and non-immersive. The immersive modality allows the scene to be visualised using a head-mounted display, either in stereoscopic or in mono-mode; compatibility with head-tracking sensor is also provided. In the non-immersive modality, the virtual environment can be displayed using a desktop monitor or a wall projector. The user can interact with the virtual environment using either keyboard commands, a mouse or a joypad, depending on the hardware configuration chosen.

Conclusions

As we have seen in the paper, the research work carried out by the Applied Technology for Neuro-Psychology Lab. (ATN-P Lab.) in the last fifteen years strongly supports the use of virtual reality (VR) as empowering environment for personal change: VR has been used successfully in both uncontrolled and controlled trials for the treatment of anxiety disorders, eating disorders and obesity.

The idea of empowerment is the expansion of freedom of choice and action. It means increasing one's authority and control over the resources and decisions that affect one's life: when we exercise real choice, we gain increased control over our lives and are able to change ourselves.

However for many subjects it is not easy to exercise effective choices: patients often don't have the knowledge, skills, assertiveness, or self esteem needed. In this situation Virtual Reality (VR), an artificial reality that projects the user into a 3D space generated by the computer, may offer a critical advantage to the therapist.

The enriched experience and the total level of control on its features, transform VR in an "empowering environment", a special, sheltered setting where patients can start to explore and act without feeling actually threatened. With such assurance, patients can freely explore, experiment, feel, live and experience feelings and/or thoughts.

Even if the potential impact of VR in clinical psychology is high, the majority of the existing clinical VR applications are still in the laboratory or investigation stage. To address this challenge the ATN-P Lab. has designed and developed NeuroVR (http://www.neurovr.org), a cost-free virtual reality platform based on open-source software, which allows non-expert users to easily modify a virtual environment and to visualise it using either an immersive or non-immersive system.

However, even after fifteen years of work in this area, new challenges are appearing for the ATN-P Lab. Currently, most of the existing VR applications for mental health are based on single PCs located in the office of a therapist. However, the enormous diffusion of the World Wide Web and the introduction of the Web 2.0 have facilitated the development of new forms of collaborative interaction between multiple users based on 3-D virtual worlds. Compared with conventional VR system, 3D shared virtual worlds like Second Life (http://www.secondlife.com) may convey greater feelings of presence, facilitate the clinical communication process, positively influence group processes and cohesiveness in group-based therapies, and foster higher levels of interpersonal trust between therapists and patients (Gorini, Gaggioli, & Riva, 2007; Gorini, Gaggioli, Vigna, & Riva, 2008).

In conclusion, despite technical, ethical, and economic issues, we suggest that virtual worlds, used as an adjunct to face-to-face settings, may represent a valid opportunity for improving the efficacy of existing clinical protocols. Our hope is that the present paper will stimulate a discussion within the clinical community about the potential, the applications, and the eventual risks that virtual reality can offer to clinicians and therapists

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