

Cybertherapy

Internet and Virtual Reality as Assessment and Rehabilitation Tools
for Clinical Psychology and Neuroscience

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1 Cybertherapy in Practice: The VEPSY Updated project

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Abstract: Rapid and far-reaching technological advances are changing the ways in which people relate, communicate, and live. Technologies that were hardly used ten years ago, such as the Internet, e-mail, and video teleconferencing are becoming familiar methods for diagnosis, therapy, education and training. This is producing an emerging field – *cybertherapy* – whose focus is the use of communication and information technologies to improve the health care processes.

To exploit and understand this potential was the aim of the “ Telemedicine and Portable Virtual Environment in Clinical Psychology” - VEPSY UPDATED – a European Community funded research project (IST-2000-25323, <http://www.cybertherapy.info>).

The chapter describes the clinical and technical rationale behind the cybertherapy applications developed by the project. Further, the actual role of virtual reality in the cybertherapy field is discussed, focusing on the advantages provided by its three different faces: technological, experiential and communicative.

1. Introduction

Since the development of methods of electronic communication clinicians have been using information and communication technologies in health care: telegraphy, telephony, radio and television have been used for distance medicine since mid 19th century [1]. However, rapid and far-reaching technological advances are changing the ways in which people relate, communicate, and live. Technologies that were hardly used ten years ago, such as the Internet, e-mail, and video teleconferencing are becoming familiar methods for diagnosis, therapy, education and training. This is producing an emerging field – *cybertherapy* – whose focus is the use of communication and information technologies to improve the health care processes.

To exploit and understand this potential is the overall goal of the “ Telemedicine and Portable Virtual Environment in Clinical Psychology” - VEPSY UPDATED – a European Community funded research project (IST-2000-25323, <http://www.cybertherapy.info>) whose specific goal was the development of different PC based cybertherapy solutions to be used in clinical assessment and treatment of social phobia, panic disorders, male sexual disorders, obesity and eating disorders [2].

The paper describes the clinical and technical rationale behind the cybertherapy applications developed by the project. Specifically the paper focuses its analysis on the possible role of VR in clinical psychology and how it can be used for improving therapeutic change.

2. The role of Virtual Reality in Cybertherapy

Within the emerging cybertherapy field, a central role could be played by virtual reality (VR). In fact, the possible impact of virtual reality on health care is even higher than the one offered by the new communication technologies [3]. In fact, VR is a technology, a communication interface and an experience [4]. This is why the research in the virtual reality field is moving fast. If we check the two leading clinical databases – MEDLINE and PSYCINFO – using the “virtual reality” keyword we can find 1023 papers listed in MEDLINE and 730 in PSYCINFO (all fields query, accessed 9 December 2003).

From the analysis of the retrieved papers we can find that the first health care applications of VR started in the early ‘90s by the need of medical staff to visualize complex medical data, particularly during surgery and for surgery planning [5]. Actually, surgery-related applications of VR fall mainly into three classes: surgery training, surgery planning and augmented reality for surgery sessions in open surgery, endoscopy, and radiosurgery. A couple of years later, the scope of VR applications in medicine has broadened to include neuropsychological assessment and rehabilitation [6, 7]. In general, VR has two faces.

For physicians and surgeons, the ultimate goal of VR is the presentation of virtual objects to all of the human senses in a way identical to their natural counterpart [8]. As noted by Satava and Jones [9], as more and more of the medical technologies become information-based, it will be possible to represent a patient with higher fidelity to a point that the image may become a surrogate for the patient – the *medical avatar*. In this sense, an effective VR system should offer real-like body parts or avatars that interact with external devices such as surgical instruments as near as possible to their real models.

For clinical psychologists and rehabilitation specialists the ultimate goal is radically different [10-12]. They use VR to provide a new human-computer interaction paradigm in which users are no longer simply external observers of images on a computer screen but are active participants within a computer-generated three-dimensional virtual world. Within the VE the patient has the possibility of learning to manage a problematic situation related to his/her disturbance [13]. The key characteristics of virtual environments for these professionals are both the high level of control of the interaction with the tool without the constraints usually found in computer systems, and the enriched experience provided to the patient [14]. Virtual environments are highly flexible and programmable [15]. They enable the therapist to present a wide variety of controlled stimuli, such as a fearful situation, and to measure and monitor a wide variety of responses made by the user. This flexibility can be used to provide systematic restorative training that optimize the degree of transfer of training or generalization of learning to the person's real world environment [16].

In fact, VR offers a blend of attractive attributes for the psychologists and rehabilitators. The most basic of these is its ability to create a 3D simulation of reality that can be explored by patients. VR can be considered a special, sheltered setting where patients can start to explore and act without feeling threatened. In this sense the virtual experience is an "empowering environment" that therapy provides for patients [17]. As noted by Botella and colleagues [18] nothing the patients fear can "really" happen to them in VR. With such assurance, they can freely explore, experiment, feel, live, experience

feelings and/or thoughts. VR thus becomes a very useful intermediate step between the therapist and the real world.

Following this approach, we can try to define VR in terms of human experience [19] "a real or simulated environment in which a perceiver experiences telepresence," where telepresence can be described as the "experience of presence in an environment by means of a communication medium" (pp.78-80).

This position better clarifies the possible role of VR in cybertherapy: a communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in a single real-like experience.

This is possible because the key characteristic of VR, differentiating it from other media or communication systems, is the sense of *presence* [20, 21]. What is presence? Even if usually presence is defined as the "sense of being there" [19], or as the "feeling of being in a world that exists outside of the self" [22], it is now widely acknowledged that presence can be considered as a neuropsychological phenomenon [20, 23-28]. In particular, Riva and Waterworth described presence as a defining feature of self, related to the evolution of a key feature of any central nervous system [22]: the embedding of sensory-referred properties into an internal functional space. More in particular, without the emergence of the sense of presence it is impossible for the nervous system to separate between an external world and the internal one. If in simple organisms, this separation involved only a correct coupling between perceptions and movements, in humans it also requires the shift from meaning-as-comprehensibility to meaning-as-significance.

Meaning-as-comprehensibility refers to the extent to which the event fits with our view of the world (for example, as just, controllable, and nonrandom) whereas meaning-as-significance refers to the value or worth of the event for us [29]. Following this point, contributions to the intensity of the sense of presence come from three layers of the self recently defined by Damasio [30]: proto self, core self and autobiographical self. The more the three layers are integrated (focused on the same events) the stronger the intensity of the presence feeling [22]. This means that having two equally stimulating virtual environments, humans are more present in the one more relevant to their own goals.

3. VEPSY UPDATED: The cybertherapy rationale

VR is starting to play an important role as cybertherapy tool in clinical psychology [31, 32], that is expected to increase in the next years. According to a recent positioning paper on the future of psychotherapy [33], the use of VR and computerized therapies are ranked respectively 3rd and 5th out.

Up to now, the most common application of VR in clinical psychology is the treatment of phobias [34]. And the VEPSY Updated project, too, addressed phobias.

Particularly, the Spanish group headed by Cristina Botella focused on the treatment of panic disorder and agoraphobia. On the other side, the French clinical group headed by Patrick Legeron addressed the treatment of social phobia.

The overall rationale shared by the two groups is very simple: in VR the patient is intentionally confronted with the feared stimuli while allowing the anxiety to attenuate.

Because avoiding a dreaded situation reinforces all phobias, each exposure to it actually lessens the anxiety through the processes of habituation and extinction.

The use of VR exposure (VRE) offers a number of advantages over in vivo or imaginal exposure: can be administered in traditional therapeutic settings and it is more controlled, and cost-effective than in vivo exposure. Another advantage of VR is the possibility of carrying out exposure to bodily sensations (interoceptive) and situational exposure simultaneously. Traditionally, exposure for panic disorder involves exposure to

agoraphobic situations and interoceptive exposure that are performed in different sessions. VR allows the exposure of the patient to an agoraphobic situation (i.e. a train), and simultaneously, can elicit bodily sensations through visual or sound effects (blurry vision, pounding heart, etc). In different controlled studies VRE was as effective as in vivo therapy in the treatment of acrophobia [35, 36], spider phobia [37] and fear of flying [38-41].

The second part of the project focuses on obesity and eating disorders. Particularly, Riva and his clinical group lead by Bacchetta and Molinari [42, 43], are using the Experiential Cognitive Therapy (ECT) an integrated approach ranging from cognitive-behavioral therapy to virtual reality sessions in the treatment of eating disorders and obesity. In this approach VR is mainly used to modify body image perceptions.

What is the rationale behind this approach? Different studies show that body image dissatisfaction can be considered a form of *cognitive bias* [44, 45]. The essence of this cognitive perspective is that the central psychopathological concerns of an individual bias the manner in which information is processed. Usually, this biased information processing occurs automatically. Also, it is generally presumed that the process occurs almost outside the person's awareness unless the person consciously reflects upon his or her thought processes (as in cognitive therapy).

According to Williamson and colleagues [44] body size overestimation can be considered as a complex judgment bias, strictly linked to attentional and memory biases for body related information: "If information related to body is selectively processed and recalled more easily, it is apparent how the self-schema becomes so highly associated with body-related information... If the memories related to body are also associated with negative emotion, activation of negative emotion should sensitize the person to body-related stimuli causing even greater body size overestimation" (pp.49-50).

It is very difficult to counter a cognitive bias. In fact, biased information processing occurs automatically and the subjects are unaware about it. So, for them, the biased information is real. They cannot distinguish between perceptions and biased cognitions.

Moreover, any attempt for convincing them is usually useless and sometimes produce a strong emotional defense. In fact, the denial of the disorder and resistance to treatment are two of the most vexing clinical problems in these pathologies [46, 47].

Given these difficulties there are only two different approaches to the treatment of body image disturbances [45]:

- *cognitive-behavioral strategies*: This approach is based on assessment, education, exposure and modification of body image. The therapy both identifies and challenges appearance assumptions, and modifies self-defeating body image behaviors [48-50].

- *feminist approach*: Feminist's therapists usually use experiential techniques, such as guided imagery, movement exercises, and art and dance therapy [51, 52]. Other experiential techniques include free-associative writing regarding a problematic body part, stage performance, or psychodrama [52, 53].

Unfortunately both approaches, even if effective in the long term, requires a strong involvement of the patient and many months of treatment.

The use of VR offers two key advantages. On one side, it is possible to integrate all different methods (cognitive, behavioral and experiential) commonly used in the treatment of body experience disturbances within a single virtual experience. On the other side, VR can be used to induce in the patient a controlled sensory rearrangement that unconsciously modifies his/her bodily awareness (body schema). When we use a virtual reality system we feel our self-image projected onto the image of the visual cues (i.e. a certain figure or an abstract point, such as cursors, which moves in accordance with the movement of our own hand) appearing in the video monitor, as a part of or an extension of our own hands [54].

As noted by Iriki and colleagues [55] "Essential elements of such an image of our

own body should be comprised of neural representations about the dimension, posture and movement of the corresponding body parts in relation to the environmental space. Thus, its production requires integration of somatosensory (intrinsic) and visual (extrinsic) information of our own body in space.” (p. 163). When this happens the information itself becomes accessible at a conscious level [56] and can be modified more easily.

In a case study a 22-year old female university student diagnosed with Anorexia Nervosa was submitted to the ECT treatment [57]. At the end of the 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.

Expanding these results, they carried different clinical trials on female patients [58-62]: 25 patients suffering from binge-eating disorders were in the first study, 20 in the second, and 18 obese in the third. At the end of the inpatient treatments, the patients of both samples modified significantly their bodily awareness. This modification was associated to a reduction in problematic eating and social behaviors.

The third clinical focus of the VEPSY Updated project was the treatment of male sexual disturbances. In particular, Optale and his team [63, 64] used immersive virtual reality to improve the efficacy of a psychodynamic approach in treating male erectile disorders.

In the proposed VE four different expandable pathways open up through a forest, bringing the patients back into their childhood, adolescence and teens when they started to get interested in the opposite sex. Different situations are presented with obstacles that the patient had to overcome to go on. VR environments are here used as a form of controlled “dreams” allowing the patient to express in a nonverbal way transference reactions and free associations related to the ontogenetic development of male sexual identity. General principles of psychological dynamisms such as the difficulty with separations and ambivalent attachments are used to inform interpretive efforts.

The obtained results - 30 out of 36 patients with psychological erectile dysfunction and 28 out of 37 patients with premature ejaculation maintained partial or complete positive response after 6-month follow up - show that VR seems to hasten the healing process and reduce dropouts. Moreover, Optale used *PET* scans to analyze regional brain metabolism changes from baseline to follow-up in patients treated with VR [65]. The analysis of the scans showed different metabolic changes in specific areas of the brain connected with the erection mechanism, suggesting that this method accelerated the healing process by reopening old brain pathways or consolidating them. The results also suggest that new mnemonic associations and rarely-used inter-synaptic connections, characterized by a particular magnitude of activation may be established, favoring satisfaction of natural drives [64].

4. VEPSY Updated: The technical rationale

To produce the cybertherapy applications used in its clinical application the VEPSY Updated project used PC based VR platforms. The following paragraphs both describe the rationale behind this choice and detail the technical characteristics of the VR platform chosen by the project.

4.1 PC based cybertherapy

Even if the history of VR is based on expensive graphic workstations, the significant advances in PC hardware that have been made over the last three years, are allowing the appearance of low cost VR systems. While the cost of a basic desktop VR system has not

changed much, the functionality has improved dramatically, both in terms of graphics processing power and VR hardware such as head-mounted displays (HMDs). The availability of powerful PC engines based on Intel's Pentium IV, AMD's Athlon and Motorola's Power PC G4, and the emergence of reasonably priced 3D accelerator cards allow high-end PCs to process and display 3D simulations in real time.

A standard Celeron/Duron 2 Ghz system with as little as 128 Mb of RAM can offer sufficient processing power for a bare-bone VR simulation, a 2.6 Ghz Pentium III/Athlon with 256 Mb of RAM, can provide a convincing virtual environment, while a dual 3.2 Ghz Pentium IV XEON configuration with OpenGL acceleration, 512 Mb of RAM and 128/256 Mb of VRAM running on Windows XP Professional, can match the horsepower of a graphics workstation [4].

Immersion is also becoming more affordable. For example, it is possible to have a basic HMD with gyroscopic head tracking for less than \$1200 and has built in. For instance, Olympus (Japan) distributes its basic video headset for about \$600 without head tracking. Two years ago HMDs of the same quality were about 10 times more costly. A HMD with VGA quality and 3D video produced by a Korean manufacturer is now about \$2,500. However, this price will probably decrease during the next five years.

Presently, input devices for desktop VR are largely mouse- and joystick-based.

Although these devices are not suitable for all applications, they can keep costs down and avoid the ergonomic issues of some of the up-to-date I/O devices such as 3D mice and gloves. Also, software has been greatly improved over the last three years. It now allows users to create or import 3D objects, to apply behavioral attributes such as weight and gravity to the objects, and to program the objects to respond to the user via visual and/or audio events.

4.1 VEPSY UPDATED: The Software

Each module was created by using the software Virtools Dev. 2.0 (<http://www.virttools.com>). Based on a building-block, object-oriented paradigm, Virtools makes interactive environments and characters by importing geometry and animation from several animation packages, including Discreet 3D Studio MAX (<http://www.discreet.com>), Alias Wavefront Maya (<http://www.aliaswavefront.com>), Softimage (<http://www.softimage.com>), and Nichimen Nendo and Mirai (<http://www.nichimen.com>), and combining them with an array of more than 200 basic behaviors. By dragging and dropping the behavior blocks together the user can combine them to create complex interactive behaviors.

The Virtools toolset consists of Virtools Creation, the production package that constructs interactive content using behavior blocks; Virtools Player, the freely distributable viewer that allows anyone to see the 3D content; Virtools Web Player, a plug-in version of the regular player for Netscape Navigator and Microsoft Internet Explorer; and the Virtools Dev for developers who create custom behaviors or combine Virtools with outside technology. Virtools Dev includes a full-blown software development kit (Virtools SDK) for the C++ developer that comes with code samples and an ActiveX player which can be used to play Virtools content in applications developed with tools such as Frontpage, Visual Basic or Visual C++.

Content created with Virtools can be targeted at the stand-alone Virtools Player, at web pages through the Virtools Web Player, at Macromedia Director, or at any product that supports ActiveX. Alternatively, the Virtools SDK allows the user to turn content into stand-alone executable files. Virtools's rendering engine supports DirectX, OpenGL, Glide and software rendering, although hardware acceleration is recommended.

4.2 VEPSY UPDATED: The Hardware

All the VR-based clinical modules were developed around on the following PC platforms:

- *Pentium IV/Athlon XP desktop VR system:*
 - o 2600 mhz or better,
 - o 256 mega RAM or better,
 - o minimum specification for the graphic engine: ATI Radeon 9600 XT 64MB VRam or Nvidia GeForce FX 5600 Ultra 64Mb VRam
- *Pentium IV/Athlon based portable VR system:*
 - o 2600 mhz or better,
 - o 256 mega RAM or better,
 - o minimum specification for the graphic engine: ATI Radeon 9600 mobile 64Mb VRam or Nvidia GeForce FX Go 5600 64Mb VRam

The hardware also includes:

- *a head mounted display (HMD) subsystem.* The HMDs used are:
 - o Glasstron PLM-A35/PLM-S700 from Sony Inc (<http://www.sel.sony.com/SEL/>). The Glasstron uses LCD technology (two 0.7" active matrix color LCD's) displaying 180000 pixels (PLM-A35: 800H x 225V) or 520000 pixels (PLM-S700: 832H x 624V) to each eye. Sony has designed its Glasstron so that no optical adjustment at all is needed, aside from tightening a two ratchet knobs to adjust for the size of the wearer's head. There's enough "eye relief" (distance from the eye to the nearest lens) that it's possible to wear glasses under the HMD. The motion tracking is provided by Intersense through its InterTrax 30 serial gyroscopic tracker (Azimuth: ± 180 degrees; Elevation: ± 80 degrees, Refresh rate: 256Hz, Latency time: 38ms ± 2).
 - o VFX-3D from Interactive Imaging Systems Inc (<http://www.iisvr.com>). The VFX-3D uses LCD technology (two 0.7" active matrix color LCD's) displaying 360000 pixels (800H x 400V) to each eye. The HMD doesn't require any optical adjustment. It can be easily worn using the patented flip-up visor. Included is also an accelerometer based serial tracker (Pitch & Roll Sensitivity ± 70 degrees ± 0.1 degrees; Yaw Sensitivity 360 degrees ± 0.1 degrees)
- *a two-button joystick-type input device* to provide an easy way of motion: pressing the upper button the operator moves forward, pressing the lower button the operator moves backwards. The direction of the movement is given by the rotation of operator's head.

To ensure the broadest user base, all the VR modules have been developed as shared telemedicine tool available through Internet (see paragraph below) by using a plug-in for the most common browsers (Explorer and Navigator) and as portable tools based on Speed-Step notebook PCs (Pentium IV/Duron, 16MB VRam and 256 Mb Ram). This choice ensures wide availability, an open architecture and the possibility of benefiting from the improvements planned for these machines by INTEL and AMD, mainly faster processors and enhanced multimedia support. Both solutions allow the support of end-users in their living environment.

5. Conclusions

VR can be considered a sophisticated cybertherapy tool that supports the communication process between patient and therapists [69]. Even if the three applications developed by the VEPSY Updated project have a very different rationale, all use VR as a communication

interface, able to collect and integrate different inputs and data sets in a single real-like experience. Using it accordingly, is possible to target a specific cognitive or emotional system without any significant change in the therapeutic approach. For instance, behavioral therapists may use a VE for activating the fear structure in a phobic patient through confrontation with the feared stimuli; a cognitive therapist may use VR situations to assess situational memories or disrupt habitual patterns of selective attention; experiential therapists may use VR to isolate the patient from the external world and help him/her in practicing the right actions; psychodynamic therapists may use VEs as complex symbolic systems for evoking and releasing affect.

In general VR can be an important support tool to the change process. Change in therapy usually comes through an intense focus on a particular instance or experience [66].

Within this general model we have the insight-based approach of psychoanalysis, the schema-reorganization goals of cognitive therapy, the functional analysis of behavioral activation, the interpersonal relationship focus of the interpersonal therapy, or the enhancement of experience awareness in experiential therapies.

What are the differences between them? According to Safran and Greenberg [67], behind the specific therapeutic approach we can find two different models of change: bottom-up and top-down. Bottom-up processing begins with a specific emotional experience and leads eventually, to change at the behavioral and conceptual level, whereas top-down change usually involves exploring and challenging tacit rules and beliefs that guide the processing of emotional experience and the behavioral planning. These two models of change are focused on two different cognitive systems, one for information transmission (top-down) and one for conscious experience (bottom-up), both of which may process sensory input [68]. The existence of two different cognitive systems is clearly showed by the dissociation between verbal knowledge and task performance: people learn to control dynamic systems without being able to specify the relations within the system, and they can sometimes describe the rules by which the system operates without being able to put them into practice.

Even if many therapeutic approaches are based on just one of the two change models, a therapist usually requires both [66]. Some patients seem to operate primarily by top-down information processing, which may then prime the way for corrective emotional experiences. For others the appropriate access point is the intensification of their emotional experience and their awareness of both it and related behaviors. Finally, different patients who initially engage the therapeutic work only through top-down processing, may able later in the therapy to make use of bottom-up emotional processing. In this situation, a critical advantage can be provided by VR.

In fact, one of the main results of the VEPSY Updated project was the use of VR as an *advanced imaginal system*: an experiential form of imagery located between imagination and reality [31, 32, 70] that can be used to help the patient in differentiate between perception and cognition. As noted by Glantz and colleagues [71]: “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, the therapist can actually demonstrate to the patient that what looks like a perception doesn't really exist. Once this has been understood, individual maladaptive assumptions can then be challenged more easily.

However, significant efforts are still required to move cybertherapy into routine clinical use. Clearly building new and additional virtual environments - possibly networked and integrated in portable devices such as PDAs or cellular phones - is important so therapists will continue to investigate applying these tools in their day-to-day

clinical practice [6]. In fact, in most circumstances, the clinical skills of the therapist remain the key factor in the successful use of cybertherapy systems.

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