Annual Review of Cybertherapy and Telemedicine

Interactive Media in Training and Therapeutic Intervention

Editors:

Brenda K. Wiederhold, PhD, MBA, BCIA
Giuseppe Riva, PhD, MS, MA

Interactive Media Institute

VFX 3D

Critical Reviews

Virtual Reality in Mental Health

G. Riva, Ph.D. [1-2], M. Alcañiz [3], L. Anolli, Ph.D. [2], M. Bacchetta, Psy.D. [1],
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G. Castelnuovo, M.S. [1], G. Cesa, M.S. [1], S. Conti, M.S. [1], C. Galimberti, Ph.D. [2],
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R. Troiani, M.S. [14], C. Weddle, M.S. [15]

[1]Applied Technology for Neuro-Psychology Lab., Istituto Auxologico Italiano, Verbania, Italy
[2]Department of Psychology, Catholic University, Milan, Italy
[3]MedIClab- Universidad Politécnica de Valencia, Valencia, Spain
[4]DIST, University of Genoa , Genoa, Italy
[5]Universitat Jaume I, Castellon de la Plana, Spain
[6]Laboratorio Sperimentale di Psicologia, Istituto Auxologico Italiano, Verbania, Italy
[7]GREYC, Université de Caen, Caen, France
[8]Associazione Medici Psicoterapeuti, Venice, Italy
[9]Universidad de Valencia, Valencia, Spain
[10]ELSAG, Genoa, Italy
[11]Department of General Psychology, University of Padua, Padua, Italy
[12]TSD Projects, Milan, Italy
[13]Unité de Thérapie Comportementale et Cognitive, Hôpital Sainte-Anne, Paris, France
[14]VRHealth, Milan, Italy
[15]PREVI, Valencia, Italy

Abstract: *The possible impact of VR on mental health has the potential to be even more than what is currently offered by new communication technologies such as the Internet. In fact, VR is simultaneously a technology, a communication interface, and an experience: a communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in a single life-like experience. Using VRT, it is possible to offer exposure therapy, the most effective form of behavioral therapy for many conditions, and to integrate it with other traditional psychotherapy methods in order to improve their effectiveness. However, the "best" evidence in evaluating the efficacy of a therapy or treatment approach are the results of randomized, controlled clinical trials. To this end the paper discusses the results of the VEPSY UPDATED - http://www.cybertherapy.info - controlled clinical trials. In these trials involving a total of 388 patients - the largest-ever controlled study in VR therapy - different virtual environments were developed and tested to be used in the clinical assessment and treatment of social phobia, panic disorders, male sexual disorders, obesity, and eating disorders.*

INTRODUCTION

The possible impact of Virtual Reality (VR) on mental health could be even more than the impact of new communication technologies like Internet. In fact, VR is at the same time a technology, a communication interface, and an experience.[1] It is a communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in single life-like experiences.

Previous work has shown that even relatively unsophisticated virtual reality tools can prove valuable in psycho-neurological assessment and rehabilitation.[2,3] To date, however, the use of VR-technologies has been limited to single locations – typically hospital or rehabilitation centers. In theory, new multi-user VR technologies, combined with rapid increases in Internet bandwidth and performance as well as steep reductions in the cost of hardware and soft-

ware, making it possible to bring distributed VR environments directly to clients' homes, thereby offering improved access for users who are inadequately served by current approaches. In order to achieve this goal, it will first be necessary to overcome a number of clinical, ergonomic, technological, and organizational challenges. The main contribution of the European Community funded "Telemedicine and Portable Virtual Environment for Clinical Psychology" – VEPSY UPDATED research project to innovation in this area is to design, test, and validate solutions to these challenges.[4]

The main objective of the project is to prove the technical and clinical viability of using virtual reality therapy (VRT) in clinical psychology. In particular, the project designed and developed four clinical modules and their associated clinical protocols to be used for the assessment and treatment of the following disorders:

- panic disorder and agoraphobia
- male impotence and premature ejaculation
- obesity, bulimia, and binge-eating disorders
- social phobia

In fact, VR offers a blend of attractive attributes for psychologists. 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.[2] As noted by Botella and colleagues,[5] nothing the patients fear 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.

This paper describes the clinical and technical rationale behind the clinical 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.

VEPSY UPDATED: THE TECHNICAL APPROACH

To produce the VR applications used in its clinical trials, 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.

The Emergence of PC-based Virtual Reality

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 for the creation of low-cost VR systems. While the cost of a basic desktop VR system has not changed much, the functionality has improved dramatically 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 3.5 Ghz Pentium III/Athlon with 256 Mb of RAM can provide a convincing virtual environment, while a dual 3.5 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.[3]

Immersion technology is also becoming more affordable. For example, it is possible to have a basic HMD with gyroscopic head-tracking built-in for less than $1200. 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 expensive. A HMD with VGA quality and 3D video produced by a Korean manufacturer is now about $1,500. 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 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.

VEPSY UPDATED: The Hardware

All the VR-based clinical modules were developed to be used on the following PC platforms:

- *Pentium IV/Athlon XP desktop VR system:*
  - 2500 mhz or better
  - 256 mega RAM or better
  - Minimum specification for the graphic engine: ATI Radeon 9600 128MB VRam or Nvidia GeForce 5600 128Mb VRam
- *Pentium IV/Athlon based portable VR system:*
  - 1500 mhz or better
  - 128 mega RAM or better,
  - Minimum specification for the graphic engine: ATI Radeon 9600 32Mb VRam or Nvidia GeForce 5600 Go 32Mb VRam

The hardware also includes:

- *A head-mounted display (HMD) subsystem.* The HMDs used are:
  1. 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 180,000 pixels (PLM-A35: 800H x 225V) or 520,000 pixels (PLM-S700: 832H x 624V) to each eye. Sony has designed its Glasstron so that no optical adjustment is needed aside from tightening 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 Inter-Trax 30 serial gyroscopic tracker (Azimuth: ±180 degrees; Elevation: ±80 degrees, Refresh rate: 256Hz, Latency time: 38ms ± 2).

  2. 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 360,000 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. Also included is 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 method of motion: by pressing the upper button the operator moves forward, and by 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 tools 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, consisting mainly of faster processors and enhanced multimedia support. Both solutions allow the support of end-users in their living environment.

VEPSY UPDATED: The Software

Each module was created using the software Virtools Dev. 2.0 (http://www.virtools.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 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' rendering engine supports DirectX, OpenGL, Glide, and software rendering, although hardware acceleration is recommended.

VEPSY UPDATED: The Clinical Rationale

Up till now, the most common application of VR in clinical psychology is the treatment of phobias. The VEPSY Updated project also addressed phobias. Particularly, the Spanish group headed by Cristina Botella focused on the treatment of panic disorder and agoraphobia. 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: it can be administered in traditional therapeutic settings, and it is more controllable 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 can simultaneously 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,[6,7] arachnophobia,[8] and fear of flying.[9-12]

The second clinical focus of the VEPSY Updated project was the treatment of male sexual disturbances. In particular, Optale and his team[13,14] 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 experience feelings of attraction. Different situations are presented with obstacles that the patient had to overcome in order to continue. VR environments in this case are 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 a partial or complete positive response at the 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.[15] 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.[14]

The third part of the project focuses on obesity and eating disorders. Particularly, Riva and his clinical group led by Bacchetta and Molinari[16,17] are using Experiential Cognitive Therapy (ECT) in 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*.[18,19] The essence of this cognitive perspective is that the central psychopathological concerns of an individual influence 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,[18] body size overestimation can be considered a complex judgment bias, strictly linked to attention 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."

It is very difficult to counter a cognitive bias. In fact, as biased information processing occurs automatically, the subjects are unaware of it. So, for them, the biased information is real. They cannot distinguish between perceptions and biased cognitions. Moreover, any attempt at convincing them of their error is usually useless and sometimes produces 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.[20,21]

Given these difficulties, there are only two different approaches to the treatment of body image disturbances:[19]

- *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.[22-24]
- *Feminist Approach*: Feminist therapists usually use experiential techniques such as guided imagery, movement exercises, and art and dance therapy.[25,26] Other experiential techniques include free-associative writing regarding a problematic body part, stage performance, or psychodrama.[26,27]

Unfortunately both approaches, even if effective in the long term, require dedicated patient involvement and many months of treatment.

The use of VR offers two key advantages. First, it is possible to integrate all the methods (cognitive, behavioral, and experiential) commonly used in the treatment of body experience disturbances within a single virtual experience. Second, 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) appearing in the video monitor as a part or an extension of our own hands.[28] As noted by Iriki and colleagues,[29] "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." When this happens the information itself becomes accessible at a conscious level[30] and is easier to modify.

In a case study, a 22-year old female university student diagnosed with Anorexia Nervosa was submitted to the ECT treatment.[31] At the end of the in-patient treatment, the subject increased her bodily awareness, which was joined with a reduction in her level of body dissatisfaction. Moreover, the patient presented a high degree of motivation to change. Expanding these results, they carried out different clinical trials on female patients:[32-35] 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 had significantly modified their bodily awareness. This modification was associated with a reduction in problematic eating and social behaviors.

CONCLUSIONS

How is it possible to change a patient? Even if this question has many possible answers according to the specific psychotherapeutic approach, change generally comes through an intense focus on a particular instance or experience.[36] 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, and the enhancement of experience awareness in experiential therapies.

What are the differences between them? According to Safran and Greenberg,[37] 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 a 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.[38] The existence of two different cognitive systems is clearly shown 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.[36] 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 be able later in therapy to make use of bottom-up emotional processing. In this situation, a critical advantage VR provides.

VR can be considered a sophisticated communication interface.[39] Even if the three applications developed by the VEPSY Updated project have very different rationales, all use VR as a communication interface, able to collect and integrate different inputs and data sets in a single life-like experience. Used it accordingly, it 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 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[40-42] that can be used to help the patient differentiate between perception and cognition. As noted by Glantz and colleagues:[43] "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." 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.

The project was developed and validated in different controlled clinical trials including the different virtual environments used in the clinical assessment and treatment of social phobia, panic disorders, male sexual disorders, obesity, and eating disorders. The controlled trials involved a total of 388 patients, the largest-ever controlled study in VR therapy.[44]

From a scientific point of view, the project's most important achievement was the successful integration of virtual reality therapy with traditional psychotherapy approaches, such as cognitive-behavioral therapy and psychodynamic therapy. This resulted in integrated clinical protocols that were tested in rigorously controlled clinical trials. Results have been published in many books and scientific journals such as *Clinical Psychology and Psychotherapy*, *Behavior Therapy and Experiential Psychiatry*, *Eating and Weight Disorders*, *CyberPsychology and Behavior*, and MIT's *Presence*. The quality of both the scientific and clinical work was ensured by the supervision of well-recognized experts who carried out peer evaluations of the work done by VEPSY partners.

However, significant efforts are still required to move VR 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 that therapists will continue to investigate applying these tools in their day-to-day clinical practice.[45] In fact, in most circumstances, the clinical skills of the therapist remain the key factor in the successful use of VR systems.

ACKNOWLEDGMENT

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CONTACT

Giuseppe Riva, Ph.D.
Università Cattolica del Sacro Cuore
Largo Gemelli 1
20123 Milan, Italy
Ph/Fax: +39-02-58216892
E-mail: auxo.psylab@auxologico.it