Virtual Reality Exposure Therapy for Posttraumatic Stress Disorder

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Abstract. Posttraumatic Stress Disorder (PTSD) is a chronic, debilitating, psychological condition that occurs in a subset of individuals who experience or witness life-threatening traumatic events. This chapter describes the underlying theoretical foundations and existing research on virtual reality exposure therapy (VRE), a recently emerging treatment for PTSD. Three virtual reality scenarios used to treat PTSD in combat veterans and survivors of terrorism – *Virtual Vietnam*, *Virtual Iraq*, and *BusWorld* – are presented, along with a case study of an individual treated using *BusWorld*. The future of VRE and its potential for use with telemedicine and the Internet for treatment of PTSD are also discussed.

Keywords. Virtual reality exposure therapy; *Virtual Iraq; Virtual Vietnam; BusWorld*.

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Overview

Posttraumatic Stress Disorder (PTSD) is a chronic, debilitating, psychological condition that occurs in a significant minority of persons who experience or witness life-threatening traumatic events. PTSD is characterized by re-experiencing, avoidance, and hyperarousal symptoms that occur over time and lead to significant disruption in one's life (American Psychiatric Association, 1994). Today, symptoms of PTSD are recognized in a subset of those who survive auto accidents, sexual assaults, terrorist attacks, natural disasters, wars, and in first responders and medical professionals who care for survivors during the immediate aftermath of the trauma.

Impressive advances in treating PTSD have been made in the past decade with respect to cognitive behavioral therapy (CBT). CBT can involve a variety of treatment programs including: exposure procedures, cognitive restructuring procedures, anxiety management programs, and their combinations. Reviews of the existing literature on the treatment of PTSD are quite positive regarding CBT (Bisson & Andrew, 2007; Institute of Medicine, 2008; Solomon, Gerrity & Muff, 1992; Van Etten & Taylor, 1998). This chapter presents an overview of the most recent development in CBT – virtual reality exposure (VRE) therapy – and ways it can be merged with the Internet to advance treatment of PTSD.

Theoretical Foundations of Virtual Reality Exposure Therapy

Exposure to traumatic events is a common experience, with estimates ranging between 37% and 92% of the general population (Breslau, Davis, Peterson, & Schulz, 1998). Prospective studies indicate that PTSD symptoms are almost universal in the immediate aftermath of trauma. The majority of individuals will have symptoms of re-experiencing, avoidance, and hyperarousal initially following the trauma, and then these reactions will extinguish over time. The symptoms of PTSD should be considered part of the normal reaction to trauma, as they occur almost universally following severe enough traumas. In a prospective study of victims of rape, 94% met symptomatic criteria for PTSD in the first week following the assault (Rothbaum, Foa, Riggs, Murdock, & Walsh, 1992). Those who responded normally to the assault showed steadily decreasing PTSD symptoms over time beginning soon after the trauma; however, those who did not showed a slightly different pattern: their PTSD symptoms declined in the first month following the assault, and then remained fairly steady across time. The researchers concluded that PTSD symptoms do not worsen; rather, survivors of trauma who develop PTSD don't extinguish their original fear reactions. This suggests that PTSD can be viewed as a failure of recovery caused in part by a failure of fear extinction following trauma (Rothbaum et al., 1992; Rothbaum & Davis, 2003).

Several theorists have proposed that conditioning processes are involved in the etiology and maintenance of PTSD. These theorists invoke Mowrer's (1960) two-factor theory, which posits that both Pavlovian and instrumental conditioning are involved in the acquisition of fear and avoidance behavior. Through a generalization process, many stimuli may elicit fear and avoidance. Emotional and physiological reactivity to stimuli resembling the original traumatic event, even years after the event's occurrence, is a prominent characteristic of PTSD and has been reliably replicated in the laboratory (e.g., Blanchard, Kolb, Gerardi, Ryan, & Pallmeyer, 1986; Pitman, Orr, Altman, & Longpre, 1996). Further, cognitive and behavioral avoidance strategies are hypothesized to develop in an attempt to avoid or escape these distressing conditioned emotional reactions. The presence of extensive avoidance responses can interfere with extinction by limiting the amount of exposure to the conditioned stimulus in the absence of the unconditioned stimulus (Foa, Hembree, & Rothbaum, 2007).

Emotional processing theory (Foa & Kozak, 1986) holds that PTSD emerges due to the development of a fear network in memory that elicits escape and avoidance behavior (Foa, Steketee, & Rothbaum, 1989). Mental fear structures include stimulus, response, and meaning elements. Any information associated with the trauma is likely to activate the fear structure. The fear structure in people with PTSD is thought to include a particularly large number of stimulus elements and is therefore easily accessed. Attempts to avoid this activation result in the avoidance symptoms of PTSD (Foat et al., 1989).

Emotional processing theory proposes that successful therapy involves correcting the pathological elements of the fear structure, and that this corrective process is the essence of emotional processing. Two conditions have been proposed to be required for fear reduction. First, the fear structure must be activated. Second, new, corrective information must be provided that includes elements incompatible with the existing pathological components. Exposure procedures consist of confronting the patient with trauma-related information in order to activate the trauma memory. This activation provides an opportunity for the patient to integrate corrective information and modify pathological components of the trauma memory (Foa et al., 1989). Of particular relevance to PTSD treatment are studies demonstrating that fear activation during treatment promotes successful outcome (e.g., Foa, Riggs, Massie, & Yarczower, 1995; Pitman et al., 1996).

Several mechanisms are theorized to be involved in the specific changes relevant to improvement of PTSD (Foa et al., 2007). First, repeated imaginal reliving of the trauma is thought to promote extinction of conditioned fear reactions. Extinction reduces anxiety previously associated with the trauma memory and corrects the patient's erroneous belief that anxiety will persist forever unless avoidance or escape is realized. Second, deliberately confronting the feared memory blocks negative reinforcement of cognitive and behavioral avoidance of trauma-related cognitions, feelings, and reminders. Third, reliving the trauma memory in a therapeutic, supportive context incorporates safety information into the trauma memory, thereby enabling the patient to learn that remembering the trauma is not dangerous. Fourth, focusing on the trauma memory for an extended period helps the patient to differentiate the traumatic event from other, nontraumatic occurrences, thereby rendering the trauma as a specific event rather than as a representation of a dangerous world and of an incompetent self. Fifth, the process of imaginal reliving helps change the meaning of PTSD symptoms from a sign of personal incompetence to one of courage and mastery. Lastly, prolonged, repeated reliving of the traumatic event affords the opportunity to focus on details central to negative self-evaluations, thereby allowing modification of those evaluations. Many of these mechanisms also operate in exposure in vivo. However, the mechanism most salient during in vivo exposure is the correction of erroneous probability estimates of the danger and extinction of fearful responses to trauma-relevant stimuli (Foa et al., 2007).

One form of CBT employed with PTSD sufferers is exposure therapy, which assists patients in confronting their feared memories and situations in a therapeutic manner. A comprehensive review of CBT studies for PTSD found the strongest evidence for exposure therapy (Rothbaum, Meadows, Resick, & Foy, 2000). Exposure in imagination and in vivo to reminders of the trauma both appear to be therapeutic. Prolonged Exposure Therapy, developed by Foa & Rothbaum and their colleagues, incorporates imaginal exposure that has the patient recall the traumatic memories in the therapist's office. The patient is asked to return to the time of the trauma in his or her mind and to relive it in imagination. He or she is asked to close his or her eyes and describe the event out loud in the present tense, as if it were in the process of occurring. While this reliving is often painful for the patient initially, it quickly becomes less difficult with repeated exposure. The idea underlying this treatment approach is that the trauma needs to be emotionally processed in order to become less painful (Foa et al., 1989; Foa & Kozak, 1986). Detailed instructions for conducting exposure therapy with PTSD patients can be found in Foa et al. (2007), a Prolonged Exposure manual that has recently been translated into Spanish and Japanese.

Considered the gold standard treatment for PTSD, the efficacy of PE is widely documented in research (Foa et al., 2007). The most recent large-scale meta-analytic reviews and treatment guidelines have concluded that, among existing psychosocial therapies, the strongest evidence exists for exposure-based models (Institute of Medicine, 2008) The recent *Cochrane Review* article concluded that both individual and group trauma focused exposure therapy were effective in the treatment of PTSD (Bisson & Andrew, 2007). Additionally, the Institute of Medicine (2008) stated that "the committee finds that the evidence is sufficient to conclude the efficacy of exposure therapies in the treatment of PTSD" (p. 8), the only treatment they concluded had sufficient evidence to recommend its use.

Virtual Reality Exposure Therapy

Virtual Reality

In 1986, California inventor Jaron Lanier developed a system that he termed Virtual Reality that immerses the user into a custom-made three-dimensional (3D) experience. Virtual reality (VR) offers a human–computer interaction system in which users are no longer simply external observers of images on a screen; rather, they are active participants within a computer-generated 3D virtual world. The most common approach to the creation of a virtual environment is to outfit the user in a head-mounted display. Head-mounted displays consist of separate display screens for each eye, display optics, stereo earphones, and a head-tracking device. The user is presented with a computer-generated view of a virtual world which changes with head and body motion. For some environments, users also hold a second position sensor or interface controller that allows them to manipulate their environment and navigate throughout the virtual world. VR environments presented here differ from traditionally displayed programs in that computer graphics displayed in the head-mounted display are augmented with motion tracking, vibration platforms, localizable 3D sounds within the virtual reality space, and, in some scenarios, scent delivery technology to facilitate an immersive experience for participants.

The immersive nature of the VR environments typically leads to a strong sense of presence (i.e., of "being there") reported by those inside the virtual environment. A sense of presence is also essential for conducting exposure therapy (Foa et al., 2007). A specific form of exposure therapy, virtual reality exposure (VRE) therapy, immerses patients in a virtual environment to provide a sense of presence to facilitate emotional engagement with the traumatic memory. In this way, VRE is proposed to effectively elicit the fear structure and aid the emotional processing of fears (Rothbaum et al., 1995). The VR simulation also allows for the precise delivery and control of trauma-relevant exposure stimuli within a safe virtual environment.

Historical Background and Efficacy Research

In the early 1990s, psychologists began investigating whether exposure therapy for patients with anxiety disorders could be conducted effectively using VR. The first published study to apply VR to a psychological disorder indicated that VRE was effective in reducing participants' fear of heights. A new area for research and clinical practice was born (Rothbaum et al., 1995). Since that time, the application and value of VR for the treatment of cognitive, emotional, psychological, and physical disorders has been well-specified (Cukor, Spitalnick, Difede, Rizzo, & Rothbaum, 2009; Glantz, Rizzo, & Graap, 2003; Lange, Flynn, & Rizzo, 2009; Morris, Louw, & Grimmer-Somers, 2009; Rizzo, Schultheis, Kerns, & Mateer, 2004). Overall, VR has emerged as a viable therapeutic tool in the areas of assessment and intervention, especially for anxiety disorders, with the bulk of early research focusing on its efficacy in treating specific phobias (Garcia-Palacios, Hoffman, Carlin, Furness, & Botella, 2002). Several controlled studies over the last 10 years and two recent meta-analyses have documented its clinical efficacy as an exposure therapy treatment for anxiety disorders. In their investigation of 13 studies comparing VR treatment to in vivo exposure, Powers and Emmelkamp (2008) found a large effect size for VRE compared to controls (d = 1.1, p < .05) and a small effect size for VRE over in vivo treatments (d = 0.35, p < .05). Similarly, Parsons and Rizzo (2008) located 52 studies that had used VR, and evaluated 21 of these studies (with a total of over 300 total participants); they concluded that, overall, VR therapy appears to be well-supported.

Beginning in the late 1990s, psychologists collaborated with computer scientists to develop VR scenarios for treatment of PTSD in combat veterans and survivors of war and terrorism. In 1997, Rothbaum, Hodges, & Kooper released the prototype version of the *Virtual Vietnam* scenario for use as a gradual exposure therapy tool for Vietnam veterans with PTSD. The first use of VR for a Vietnam veteran with PTSD was reported in a case study of a 50-year-old, Caucasian male veteran meeting DSM-IV criteria for PTSD (Rothbaum et al., 1999). VRE was not combined with medication or other psychological treatments. Results indicated posttreatment improvement on all measures of PTSD, and maintenance of these gains was seen at a six-month follow-up. This case study was followed by an open clinical trial of VR for Vietnam veterans (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001). In this study, 16 male Vietnam veterans with PTSD were exposed to two virtual environments delivered in a head-mounted display: a virtual clearing surrounded by jungle scenery, and a virtual Huey helicopter; the various visual and auditory effects (e.g., rockets, explosions, day/night, yelling) were controlled by the therapist (see Figure 1 for scenes from *Virtual Vietnam*).

Figure 1. *Virtual Vietnam* scenarios. Adapted from *Virtually Better* (n.d.). Retrieved January 31, 2010, from www.virtuallybetter.com

After an average of 13 exposure therapy sessions over five to seven weeks, there was a significant reduction in PTSD and related symptoms. After VRE, the majority of patients' global ratings indicated improvement. Clinician ratings of patients' global improvement as measured by the Clinical Global Improvement Scale (Guy, 1976) indicated that five out of six showed improvement immediately after the study while one appeared unchanged. At six months, seven out of eight were rated as demonstrating some improvement. Clinician-rated PTSD symptoms as measured by the Clinician-Rated PTSD Scale (Blake et al., 1998), the primary outcome measure, at the six-month follow-up indicated an overall statistically-significant reduction from baseline in symptoms associated with specific reported traumatic experiences. Eight out of eight participants at the six-month follow-up reported reductions in PTSD symptoms ranging from 15 to 67%. Significant decreases were seen in all three symptom clusters. Patient self-reported intrusion and avoidance symptoms as measured by the Impact of Events Scale were significantly lower at three months than at baseline, but not at six months (although there was a clear trend toward fewer intrusive thoughts and somewhat less avoidance). The authors concluded that virtual reality exposure therapy led to significant reductions in PTSD and related symptoms and was well-tolerated. No study participants decompensated due to the VR exposure or were hospitalized during the study for complications related to the treatment (Rothbaum et al., 2001). This preliminary evidence suggested that virtual reality exposure therapy could be a promising component of a comprehensive treatment approach for veterans with combat-related PTSD.

Positive findings in the study of Vietnam veterans have led other groups to propose VR environments to facilitate PTSD treatment in civilians. These groups have commenced system development and initial user-centered pilot testing of VR scenarios to treat PTSD in survivors of war and terrorist attacks. In Portugal, Gamito and colleagues (2005) developed a VR application in response to the estimated 25,000 survivors with PTSD from the 1961-1974 wars in Mozambique, Angola, and Guiné. This research group constructed a virtual reality ambush scenario by modifying a common PC-based combat game. They report having recently conducted an initial user-centered test with one PTSD patient who provided feedback suggesting the need for a system that provides more graduated delivery of anxiety-provoking trigger stimuli (Gamito et al., 2005).

In the aftermath of the September 11, 2001, terrorist attacks on New York City, many thousands of World Trade Center (WTC) survivors were deemed to be at high-risk for developing PTSD. In response to this, a group of researchers developed a virtual WTC for treating survivors (Difede & Hoffman, 2002; Difede & Eskra, 2002; Difede, Cukor, Jayasinghe, & Hoffman, 2006) that gradually, yet systematically, exposes the client to a simulated attack on the WTC. Positive VR treatment results from a waitlist controlled study that included patients who were not successful in previous imaginal therapy were recently published by Difede et al. (2007). Similarly, Josman and colleagues (2006) are currently implementing a "bus bombing" PTSD treatment scenario for civilian survivors of terrorist attacks in Israel. Finally, in response to the growing numbers of Veterans returning with PTSD from Operation Iraqi Freedom, development of a *Virtual Iraq* scenario was commenced in 2005 at the University of Southern California (Rizzo, Reger, Gahm, Difede, & Rothbaum, 2009) and is currently the focus of ongoing research being conducted by Gerardi, Rothbaum, Ressler, Heekin, and Rizzo (2008) at Emory University, and at other clinical sites (Reger & Gahm, 2008; Rizzo, Reger, Difede, et al., 2009).

Detailed descriptions of VRE systems currently being implemented in the treatment of PTSD in Operation Iraqi Freedom veterans (*Virtual Iraq*) and survivors of terrorist attacks in Israel (*BusWorld*) are presented subsequently.

Virtual Iraq

PTSD has been estimated to affect up to 18% of veterans returning from Operation Iraqi Freedom. Due to the nature of this conflict, the war in Iraq is thought to present unique and chronic stressors, including civilian threats such as guerilla warfare and terrorist actions (Hoge et al., 2004). Soldiers and marines must maintain constant vigilance to deal with unpredictable threats like roadside bombs, and to distinguish safe civilians from potential combatants. In addition to this, an unprecedented number are now surviving serious wounds (Bilmes, 2007). Since PTSD is a disorder that, once manifested, often results in a chronic course, early and efficient intervention options must be identified. Presenting treatment in a form which is acceptable to military personnel is also a priority, as concern about the stigma of treatment remains an issue that prevents soldiers from seeking the help they may require (Hoge et al., 2004). The current generation of military personnel are likely to be familiar with simulation technology used in gaming and for training purposes by the military, and may be comfortable participating in a virtual reality treatment as an alternative to traditional talk therapy.

Figure 2. *Virtual Iraq* (Afghanistan City and Desert Humvee scenarios). Adapted from *Virtually Better* (n.d.). Retrieved January 31, 2010, from www.virtuallybetter.com

The *Virtual Iraq* environment was developed using input from veterans returning from Iraq and Afghanistan, and from military information experts. It allows for the simultaneous delivery of visual, audio, vibrotactile, and olfactory stimuli to create an immersive and multisensory experience for the user. The environment includes two general scenario settings with different user perspective options: a Middle Eastern city, and a Humvee driving down a desert highway alone or in a convoy (see Figure 2 for scenes from *Virtual Iraq*). All scenario settings are adjustable for time of day or night, degree of light illumination, and weather conditions. The current environment includes different trigger stimuli: (a) auditory (e.g., weapons fire, explosions, vehicle noise, wind, human voices, helicopter flying overhead); (b) static visual (e.g., wrecked vehicles); (c) dynamic visual (e.g., distant views of vehicle movement); and (d) dynamic audiovisual (e.g., nearby human and vehicle movement, explosions, insurgent attacks).

Olfactory and tactile stimuli may also be delivered simultaneously to the audiovisual content as a means of further customizing the virtual environment and creating a multimodal sensory experience. Scents may be employed as direct stimuli (e.g., scent of burning rubber) or as cues to help generally immerse users in the world (e.g., ethnic food cooking). When activated, the scent is released from an airtight chamber into an air stream provided by four electric fans so that it moves past the user and diffuses throughout the room. Scents currently in use include: (a) burning rubber; (b) cordite; (c) garbage; (d) body odor; (e) smoke; (f) diesel fuel; (g) Iraqi spices; and (h) gunpowder. Vibration adds another sensory component to augment the user's sense of presence in the virtual environment. The sound files embedded in the software provide vibrations, via a bass-shaker platform that the user sits or stands upon, that are consistent with relevant visual and audio stimuli in the scenario. For example, gunfire and explosions can be accompanied by this sensation and the vibration can be varied as when a virtual vehicle moves across uneven terrain.

These sensory features are delivered through a clinical interface that allows the clinician to select a VR scenario in which to place the patient. The patient does not see the clinician, but hears his or her voice through a microphone attached to the head-mounted display. The VR scenarios are customized to approximate the traumatic content that is clinically relevant for graduated exposure. Patients are exposed to specific scenario settings based on an assessment of their needs and their individual combat-related experiences. Once the scenario is selected, different user perspectives and navigation options allow the clinician to further customize the interaction. The clinical interface allows the therapist to administer relevant stimuli in order to modulate patient anxiety as is required for a therapeutic exposure. As with traditional imaginal exposure therapy, sound clinical judgment is required to determine how much and what type of exposure is needed to produce a therapeutic effect.

Initial analyses of results from the first 20 people to complete the *Virtual Iraq* treatment in an open clinical trial at an active duty military base have produced clinically meaningful and statistically significant outcomes with the use of VRE on standard PTSD and related anxiety assessment measures. Sixteen of the 20 people who completed the treatment no longer met DSM criteria for PTSD at post-treatment on a self-report measure of PTSD (Rizzo, Reger, Difede, et al., 2009). Another ongoing study being conducted by Rothbaum, Gerardi, Bradley, and Friedman (in press) is combining a cognitive enhancing medication with VRE for Iraq veterans with PTSD. Treatment involves six sessions, five of which incorporate VRE, preceded by the patient taking one pill of either 50 mg of D-cycloserine (an NMDA partial agonist that had been shown to facilitate extinction training with animals), placebo, or alprazolam (Xanax, a short acting anti-anxiety agent of the benzodiazepene class). Assessments include interviews, self-report measures, and a psychophysiological evaluation that involves startle assessment during blue screen ("baseline") and during three 2-minute clips of the *Virtual Iraq* (humvee turret view, humvee in a convoy, foot patrol in a city; see Figure 2). A case study of the first pilot patient treated with *Virtual Iraq* indicated a 56% decrease in Clinician-Rated PTSD Scale scores (Gerardi et al., 2008).

Busworld: Exposure to Terrorism in Israel

Terrorism-related attacks reached a peak in Israel between 2001 and 2006, with 1139 fatalities and 6700 wounded civilians (Freedman, 2009). The number of attacks in 2001 reflected a greater than 300% increase relative to the previous year (Israel Ministry of Foreign Affairs, 2008). A phone-based survey of adults across Israel was conducted at two time-points – 19 months after the onset of the terrorism wave (Bleich, Gelkopf, & Solomon, 2003), and again after 44 months (Bleich, Gelkopf, Melamed, & Solomon, 2006). In the first survey, 16.4% of respondents had had direct exposure to a terrorist attack, and an additional 37.3% had been indirectly exposed (via a relative or friend). Nine percent of this sample manifested PTSD. This rate remained consistent at the second time-point and is constant across studies (Kaplan, Matar, Kamin, Sadan, & Cohen, 2005).

Due to the numerous bus-related terrorism attacks in Israel from 2000 onwards, Josman and colleagues (2006) developed a special environment called *BusWorld*. In *BusWorld*, participants wear a VR helmet and are immersed in a virtual world in which the visual illusion is one of being on a city sidewalk in Israel with a bus-stop just across the road (see Figure 3 for scenes from *BusWorld*). There are a number of different levels of graded exposure which the therapist controls via a keyboard. At the first level, no bus appears at the bus stop. At the second level, a bus advances and emerges around the corner, then stops without incident at the bus stop. At level three, the bus pulls up and suddenly explodes, without accompanying sound effects or fire. Additional levels add sound and visual effects to the explosion, such as a raging fire, screaming and crying (in Hebrew), police sirens, and flashing lights of emergency vehicles. *BusWorld* was designed using information gathered during interviews with Israeli PTSD patients and therapists, and using texture maps developed from digital photos taken in Israel. Actual photos of bus-bomb scenes were used to guide the special effects used in *BusWorld* (Josman et al., 2006).

Figure 3. Jersualem city scenario in *BusWorld* showing stages of exposure to a bus explosion. Adapted from *Firsthand Technology* (n.d.). Retrieved April 1, 2010, from www.firsthand.com

Josman, Reisberg, Weiss, Garcia-Palacios, and Hoffman (2008) conducted a preliminary analog feasibility study using 30 healthy, asymptomatic volunteers to evaluate whether increasingly intense VR exposure to a bus-bomb attack could successfully elicit increasingly high levels of anxiety in a nonclinical population. The therapist's ability to manipulate the therapy-induced levels of anxiety is a vital element of effective exposure therapy. For this reason, four progressively intense levels of the *BusWorld* simulation were presented, with the goal of ultimate future implementation with patients with PTSD who survived or witnessed a bus-bomb attack. Participants' sense of control over the *BusWorld* environment, ratings of environment realism, clarity of feedback within *BusWorld*, and Subjective Units of Distress ratings differed significantly as a function of exposure level, such that increased markers of anxiety were induced at greater levels of exposure. The results of this analog study provide an initial validation of the potential of *BusWorld* for providing graded exposure to trauma stimuli for use in VR-based exposure therapy for individuals suffering from PTSD related to bus-bomb attacks (Josman, Reisberg, Weiss, Garcia-Palacios, & Hoffman, 2008).

Case Study: BusWorld

At noon on July 2, 2008, in busy downtown Jerusalem, a Palestinian construction worker attacked an Israeli woman and infant in a car with a bulldozer, killing the 54-year-old female driver and crushing the car. Two fully-loaded public buses were also flipped, trapping civilian passengers inside. Several more cars were crushed before the assailant was apprehended and shot by a SWAT officer. Three women were killed and dozens of people were injured in the attack. Josman, Freedman, Garcia-Palacios, Weiss, and Hoffman (2009) conducted a case study of a patient, *R*, who survived and sought psychological treatment following this event. *R*, a 29 year-old, college-educated male, reported no psychiatric history prior to the attack. At assessment, *R* was diagnosed with PTSD, a major depressive episode (including suicidal ideation with no concrete plans), and obsessive-compulsive disorder (OCD). The OCD had been subclinical prior to but worsened after the attack. *R* received 12 sessions of a virtual reality treatment protocol using *BusWorld* (Josman, Freedman, Garcia-Palacios, Weiss, & Hoffman, 2009). Treatment involved VRE to *BusWorld*, prolonged imaginal exposure to other reactivated traumatic events, and multimedia exposures to avoided situations (with no concomitant medication). Guided by his therapist, the patient entered an immersive, computer-generated virtual world to return to the scene of the traumatic event in order to help him gain access to his memories of it, process and reduce the intensity of the emotions (fear/anger) associated with his pathological memories, and change unhealthy thought patterns. Traumatic memories of childhood abuse and of the bulldozer terrorist attack were treated using imaginal exposure while the patient was in the *BusWorld* virtual environment. The patient showed large posttreatment reductions in PTSD symptoms and his Clinician Administered PTSD Scale scores dropped from 79 pre-treatment to zero immediately post-treatment; these scores were still at zero six months later (Josman et al., 2009).

The patient reported that VRE helped him recall and habituate to his traumatic memories and stop avoiding trauma-related reminders. It is noteworthy that *R* endorsed improvement following *BusWorld* although his traumatic event was a bulldozer attack. This suggests that the virtual environment effectively facilitated extinction to his fear memory. During his final session, *R* remarked:

> Every day I pass by the place of the attack at least twice. I think of what happened and continue on my way. This week, for the first time since the

attack, I went on the same bus I took when the attack happened. I sat on the 'unsafe' side and said to myself 'I'm doing this and everything is all right.' Josman et al., 2009, p. 621).

This study provided first-time evidence for the efficacy of VRE in treating PTSD triggered by a terrorist attack in Israel (Josman et al., 2009).

Advantages and Disadvantages of VRE

VR is employed at the point in therapy when exposure therapy would normally be introduced, and has several advantages over other exposure approaches. First, VR offers a type of shared experience between the therapist and participant that is not possible elsewhere. For example, it is impossible to bring clinicians on the battlefield with combat PTSD patients, though it is currently impossible to share all PTSD patients' imagined scenes. Second, VR extends the range of options available to a clinician by allowing the opportunity for exposures to situations that are difficult or costly or time-consuming in real life. For instance, using a virtual airplane, the therapist can expose the patient to the airport and spend time taking off, flying in smooth and turbulent weather, and landing, repeatedly, without leaving the office, and all within the typical therapy hour. Third, in VR, the therapist can adjust the situation to create the perfect exposure for the patient; for example, he or she can guarantee that there will be no turbulence until the patient is ready to confront turbulence therapeutically. Fourth, VRE augments the patient's imaginative capacities with visual, auditory, olfactory, and even haptic computer-generated experiences. In this way, VR provides a sensory-rich and evocative therapeutic environment that may be particularly helpful for patients who are reluctant to recall feared memories, have difficulty emotionally engaging in the traumatic memory, or are not very good at imagining situations. Fifth, VRE may have special appeal for members of the digital generation who may not otherwise participate in therapy. Wilson, Onorati, Mishkind, Reger, and Gahm (2008) recently found that one in five military personnel who reported not being interested in therapy would consider VRE. This suggests that VRE may provide a means of reaching 20% of this particular population who may not otherwise seek or participate in treatment. The ability to repeat needed exposures, opportunities to monitor patients' responses in multiple domains, and less exposure of the patient to possible harm or embarrassment are other clinical benefits of using VR for exposure therapy (Wilson, Onorati, Mishkind, Reger, & Gahm, 2008).

Another advantage of VR is that the control it offers can add methodological rigor to clinical studies. In VR, one can control the exact dose of exposure to a specific stimulus and guarantee that each participant receives the exact same exposure to the exact same stimulus. This was a distinct advantage in translational research of the first clinical test (Ressler et al., 2004) of a treatment for a specific phobia in humans that combined D-cycloserine with exposure therapy. Participants underwent two VRE therapy sessions (suboptimal exposure) using a virtual elevator and were instructed to take a single pill before the therapy session, for a total of two pills during the course of the study. Participants who received D-cycloserine in conjunction with VRE had significantly less fear within the virtual environment, reported significantly more improvement in their overall acrophobic symptoms at the three-month follow-up, and displayed significantly more improvements in psychophysiological measures of anxiety than the placebo group (Ressler et al., 2004)

There are limitations to VRE as well. First, virtual environments are costly to develop, and the required hardware is more expensive than treatment in an office without VR. Second, as with any form of technology, there can be malfunctions in the software or hardware that interrupt session flow. Clinicians using VR require extra training in using the VR equipment and program, and must be able to use it flawlessly with patients. Third, VR patients can sometimes get distracted by the technology when it doesn't exactly simulate their experience, and use this discrepancy to avoid emotionally engaging in their traumatic memory. Therapists administering VRE must manage technological difficulties and avoidance while facilitating the patient's emotional processing of their traumatic memory. An additional limitation is that sensory stimuli used in VR are restricted to those available through existing software and may omit sights, sounds, smells, and tactile sensations that are salient for a particular individual. It is important for the therapist to use VR to invoke the trauma memory in its entirety and encourage the participant to describe the traumatic memory with as much detail as possible. For these reasons, it is important to only use VR applications where they afford some advantages and not just because they are sensational or available.

Virtual Reality Exposure Therapy and the Internet

Recent technological advances in computer science and telemedicine warrant consideration of ways that VR can be merged with the Internet to augment existing therapies and expand treatment options available to clinicians. First, patients with access to the VR can practice exposures for homework between visits with a therapist to habituate more quickly to feared or avoided stimuli (e.g., take-off on a plane, a traumatic memory, etc.). Second, VR can also be applied distally as teletherapy. Since therapists are not present in most virtual environments, they do not need to be in the same room or geographical location. Merging VR with telemedicine enables clinicians to treat individuals who do not have access to a local cognitive-behavioral therapist and who want or must obtain treatment (e.g., a navy pilot who has developed a fear of flying but who has been ordered to fly a plane).

With advances in technology, VR presents new opportunities for the advancement of cybertherapy. Existing forms of cybertherapy incorporate virtual people (*avatars*), group therapy, and interactions over the Internet. It is also possible to use globally shared virtual worlds like *Second Life* (www.secondlife.com) to introduce exposure therapy to individuals not yet ready to face stimuli in vivo. In a virtual world, a client can operate an avatar that will engage in roles and activities that the client would avoid in reality. Thus, one potential use of virtual worlds for treatment of PTSD is for a client to expose their avatar to reminders of the trauma. This can provide a gentle introduction to feared stimuli that may facilitate eventual confrontation in vivo when the client is ready and willing. It also provides an opportunity for clients to practice using anxiety management strategies in preparation for exposure in vivo. Lastly, the potential for VR to standardize treatment delivery is enormous. There are several possibilities for creating smart systems that can deliver VR in an automated, customized way that may reduce health care and training costs. Such smart systems may also aid in the delivery and dissemination of standardized, evidence-based treatments (Ćosić, Popović, Kukolija, Horvat, & Dropuljić, 2009).

There are potential disadvantages to administering VRE over the Internet as well. As with any telemedicine, some patients may prefer to have live contact in the same room with the therapist. In addition to this, there are technological challenges to delivering VRE over the Internet. First, the therapist and patient must have the equipment necessary to facilitate treatment. Both the therapist and patient need to have an Internet connection via a web camera and T1 line to communicate (i.e., see and hear each other) in real time. Therefore, it is not feasible to treat patients residing in remote locations where Internet access is not readily or consistently available. Second, someone trained in VR technology must be available in person during the treatment session to oversee equipment use and trouble-shoot technological glitches that may arise. For example, a trained technician is needed to ensure that the head-mounted display is accurately fitted, that the scent machine is turned on, and that scent canisters are filled, as well as to tend to problems that may occur with the software. For this reason, adequate training and planning are required for successful implementation of VRE over the Internet that would allow practitioners to disseminate this treatment to a broader population in need.

The Future of VR in Mental Health

Outside of psychiatry, VR is mainly used in training and resource development. The National Aeronautics and Space Administration (NASA; USA) uses VR to train astronauts; the military uses VR to train service members in specific missions and tactics; architects use VR to design spaces with specific needs and uses (e.g., for those with physical disabilities). In general and within psychiatry, the potential uses of VR for training have not been fully exploited. Examples of its use include teaching public speaking skills and condom negotiation and drug refusal skills to high-risk populations. Also, the potential for applying VR to child education is enormous.

Within the mental health system, there have already been advances in developing virtual patients for training clinicians (Kenny, Parsons, Gratch, Leuski & Rizzo, 2007; Rizzo, Parsons, Buckwalter, & Kenny, in press). Since VR can be used to assess and predict posttreatment reactions, it can provide a standard activation paradigm that, if applied to a large number of people, could be used to establish normative reactions to compare to individual responses. For example, VR may be used to assess returning military personnel in order to predict future adjustment problems and to identify those who may require intervention. Conceptualizing VR as an activation paradigm presents many opportunities to combine it with medications in a controlled manner to evaluate its impact before users are placed into a potentially dangerous situation. For example, if medications are developed to reduce drug craving, they could be tested in VR prior to real-world application, since VR exposure to drug cues has been shown to increase craving in nicotine addicted and in crack cocaine addicted individuals (Bordnick et al., 2004).

The question remains as to whether VRE is more or less effective than Prolonged Exposure in the treatment of PTSD. Studies are ongoing, so this question remains unanswered for now. Direct comparisons have generally found comparable outcomes across different cognitive-behavioral treatments (e.g., cognitive therapy versus exposure therapy). Similarly, studies comparing combined and individual treatment programs (e.g., exposure therapy plus stress inoculation training vs. exposure therapy alone) found comparable outcomes for the constituent and combined treatments (Foa, Rothbaum, & Furr, 2003). To date, VRE and Prolonged Exposure have not been compared in a randomized clinical trial for treatment of PTSD; however, three studies compared VRE to in vivo exposure for other anxiety disorders – one for acrophobia (Emmelkamp et al., 2002) and two for the fear of flying (Rothbaum, Hodges, Smith, Lee, & Price, 2000; Rothbaum et al., 2006). Results of these trials consistently showed that VRE was as effective as standard in vivo exposure in reducing anxiety and avoidance. Longitudinal data showed that treatment gains were maintained at a six-month follow-up (Emmelkamp et al., 2002; Rothbaum, Hodges, et al., 2000) and 12 months post-treatment (Rothbaum, Hodges, Anderson, Price, & Smith, 2002).

Thus far, VRE has proven to be an effective treatment for a variety of anxiety disorders, including PTSD, with several applications currently in use and even more potential uses. The VR experience is vivid, controllable, acceptable to most and preferred by some users. In clinical trials, gains have been observed in treatment and have shown to be maintained in real-world functioning. Both in general and within the arena of mental health, the future of VR is ever-expanding.

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