Chapter 11

Virtual Reality Applications for the Treatment of Combat-Related PTSD

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Introduction

Post Traumatic Stress Disorder (PTSD) is a chronic, debilitating, psychological condition that occurs in a subset 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). Historically, PTSD can be traced to at least the 17th century (Shalev and Rogel-Fuchs, 1993). Grinker and Spiegel (1945) characterized “war neuroses” including tremors, fearful expressions, marked startle reactions and “a child like appeal for help” (p. 5) in World War I and II veterans. This definition was originally codified into the Diagnostics and Statistics Manual Version Three (DSM-III) in 1980 (American Psychiatric Association, 1980). Today, symptoms of PTSD are recognized in subsets of those persons who survive auto accidents, sexual assaults, terrorist attacks, natural disasters, wars, and in those first responders and medical professionals who care for these survivors during the immediate aftermath of the trauma.

This chapter deals with the use of Virtual Reality (VR) specifically in combat veterans and will look toward the day when VR is used in both evaluative and therapeutic modalities. In what follows, we briefly review our operational definition of VR and the theoretical basis for using VR in a cognitive behavioral PTSD treatment. This is followed by a review of the literature on VR treatment with Vietnam Veterans and an explication of current research in Iraq/Afghanistan veterans.

Virtual Reality

Virtual reality (VR) offers a new human-computer interaction paradigm in which users are active participants within a computer-generated three-dimensional virtual world. VR environments discussed here differ from traditionally displayed programs in that computer graphics are displayed in a Head Mounted Display (HMD), and are augmented with motion tracking, vibration platforms, localizable 3D sounds within the VR 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 reported by those immersed in the virtual environment.

VR exposure is intended to be a component of a treatment program administered by a qualified professional. VR Exposure Therapy (VRET) is employed at the point in therapy when exposure therapy would normally be introduced and has the advantages of extending the range of options available to a clinician and introducing a shared experience with the participant. Such a shared experience is for practical purposes impossible without VR. For example, it would be impossible to get clinicians on the battlefield with combat PTSD patients and it is currently impossible to share the patients’ imagined scenes. VR offers both a variety of stimuli and a shared realistic experience without leaving the office. More control over exposure stimuli, an 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 advantages of using VR for exposure therapy. Thus far,

**Rationale for Treatment of PTSD in VR**

PTSD is a severe and often chronic, disabling anxiety disorder, which develops in some persons following exposure to a traumatic event that involves actual or threatened injury to themselves or to others. Prospective studies indicate that most traumatized individuals experience symptoms of PTSD in the immediate aftermath of the trauma. In a prospective study of rape victims, 94% met symptom criteria for PTSD in the first week following the assault (Rothbaum et al., 1992). Therefore, the symptoms of PTSD are part of the *normal reaction* to trauma. The majority of trauma victims naturally recover as indicated by a gradual decrease in PTSD symptoms severity over time. However, subsets of persons continue to exhibit severe PTSD symptoms long after a traumatic experience. Therefore, PTSD can be viewed as a failure of natural recovery that reflects in part a failure of fear extinction following trauma.

Consequently, 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. Consistent with this hypothesis, 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 et al., 1986; Pitman et al., 1987). 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 also interfere with extinction by limiting the amount of exposure to the conditioned stimulus (CS) in the absence of the Unconditioned Stimulus (UCS).

Conceptualizing PTSD within the framework of emotional processing theory, Foa, Steketee and Rothbaum (1989) suggested that the traumatic memory could be conceived as a mental fear structure comprising a network of information about the feared stimuli; information about verbal, physiological, and overt behavioral responses; and interpretative information about the meaning of the various stimuli and responses contained in the network. Foa and Kozak (1986) suggested that two conditions are required for the reduction of fear. First, the fear memory must be activated. That is, as suggested by Lang (1977), if the fear structure remains in storage and unaaccessed, it will not be available for modification. Second, information must be provided which includes elements "incompatible with some of those that exist in the fear structure, so that a new memory can be formed. This new information, which is at once cognitive and affective, has to be integrated into the evoked information structure for an
emotional change to occur” (p.22). Cognitive and behavioral therapy utilizing VR aims to reduce fear presumably by first activating the fear structure and then through the therapeutic process modifying it. VR exposure therapy (VRET) has been shown to be effective at accessing the fear structure as evidenced by emotional responses in participants across a wide range of studies.

VRET refers to several behavioral and cognitive behavioral treatment techniques that involve exposure to feared stimuli (i.e., thoughts, images, objects, situations, or activities) in order to reduce pathological (unrealistic) fear, anxiety, and anxiety disorder symptoms. In the treatment of PTSD, exposure therapy usually involves prolonged, imaginal exposure to the patient’s memory of the trauma and in vivo exposure to various reminders of the trauma. This approach is believed to provide a context in which one can begin to therapeutically process the emotions that are relevant to the trauma as well as to provide extinction training allowing the fearful symptoms to decrease even in association with the feared stimuli. While the efficacy of imaginal exposure has been established in multiple studies with diverse trauma populations (Rothbaum, Meadows, Resick et al., 2000; Rothbaum & Schwartz, 2002), many patients are unwilling or unable to effectively visualize the traumatic event. In fact, avoidance of reminders of the trauma is inherent in PTSD and is one of the defining symptoms of the disorder. It is often reported that, “…some patients refuse to engage in the treatment, and others, though they express willingness, are unable to engage their emotions or senses.” (Difede & Hoffman, 2002) (p. 529). Research on this aspect of PTSD treatment suggests that the inability to emotionally engage (in imagination) is a predictor for negative treatment outcomes (Jaycox, Foa, & Morral, 1998).

During a course of treatment using prolonged exposure (PE), typically four treatment components are administered over 9-12 sessions lasting 90-120 minutes each: (1) psychoeducation about the symptoms of PTSD and factors that maintain PTSD and the rationale for exposure therapy, (2) training in controlled breathing or other stress reduction techniques that patients may use as a stress management skill though it should be noted that patients are discouraged from using it during exposure exercises, (3) prolonged imaginal exposure to the trauma memory conducted in therapy sessions and repeated as homework, and (4) prolonged in vivo exposure implemented as homework. There is substantial evidence that exposure programs are highly effective in the treatment of PTSD. There is no compelling evidence that any CBT program is more effective than exposure therapy, and no evidence for the usefulness of adding other components to exposure therapy (Foa, Rothbaum, & Furr, 2003).

In summary, there is evidence that symptoms of PTSD are present within a very short period after exposure for trauma and may in fact be part of the normal coping process. However, a minority of individuals develop a chronic disorder that interferes with functioning. There is strong evidence for exposure therapy in the treatment of PTSD and a coherent theoretical model that has been tested clinically and has suggested efficacious approaches to the treatment of PTSD. Such approaches have been applied using VR environments controlled by therapists to accompany the imaginal exposure in patients with PTSD.
Virtual Reality Exposure Therapy (VRET) For Combat-Related PTSD

The application and value of Virtual Reality for the treatment of cognitive, emotional, psychological and physical disorders has been well specified (Glantz, Rizzo & Graap, 2003; Rizzo, Schultheis, Kerns & Mateer, 2004) and a number of controlled studies over the last 10 years have documented its clinical efficacy as an exposure therapy treatment for anxiety disorders (Wiederhold & Wiederhold, 2004). 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). Results indicated post-treatment improvement on all measures of PTSD and maintenance of these gains at a 6-month follow-up. Examples of stimuli from these environments are included in Figures 1-4 below.

Figures 1 & 2. The landing zone clearing in the Virtual Vietnam Scenario.


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 PTSD patients were exposed to two HMD-delivered virtual environments, a virtual clearing surrounded by jungle scenery and a virtual Huey helicopter, in which the therapist controlled various visual and auditory effects (e.g. rockets, explosions, day/night, yelling). After an average of 13 exposure therapy sessions
over 5-7 weeks, there was a significant reduction in PTSD and related symptoms (See Table 1).

Table 1. Pre- and Post-Treatment, and 3- and 6-month Follow-up (FU) Means (SD)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Baseline (N=9)</th>
<th>Post-Tx (N=9)</th>
<th>3 Mo FU (N=5)</th>
<th>6-Mo FU (N=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPS Total Score</td>
<td>68.00 (15.26)</td>
<td>57.78 (20.61)</td>
<td>54.6 (17.47)</td>
<td>47.12 (17.04)</td>
</tr>
<tr>
<td>% Decrease Range</td>
<td>p=.0727</td>
<td>p=.0256*</td>
<td>p=.0021*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-15%</td>
<td>-27%</td>
<td>-31%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+41% to −38%</td>
<td>-13% to −48%</td>
<td>-15% to −67%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p=.2812</td>
<td>p=.0231*</td>
<td>p=.0103</td>
<td></td>
</tr>
<tr>
<td>CAPS Cluster C Avoidance</td>
<td>28.22 (8.18)</td>
<td>24.78 (10.74)</td>
<td>23.20 (7.33)</td>
<td>17.25 (9.35)</td>
</tr>
<tr>
<td></td>
<td>p=.2814</td>
<td>p=.0507</td>
<td>p=.0116*</td>
<td></td>
</tr>
<tr>
<td>CAPS Cluster D Arousal</td>
<td>23.44 (4.47)</td>
<td>19.11 (8.91)</td>
<td>22.00 (4.69)</td>
<td>18.75 (5.31)</td>
</tr>
<tr>
<td></td>
<td>p=.1163</td>
<td>p=.0777</td>
<td>p=.0021*</td>
<td></td>
</tr>
<tr>
<td>IES Total Score</td>
<td>42.89 (10.20)</td>
<td>36.11 (21.64)</td>
<td>19.4 (14.71)</td>
<td>29.88 (19.39)</td>
</tr>
<tr>
<td></td>
<td>p=.3988</td>
<td>p=.0327*</td>
<td>p=.0912</td>
<td></td>
</tr>
<tr>
<td>IES Intrusion</td>
<td>20.33 (6.10)</td>
<td>16.11 (8.56)</td>
<td>8.00 (9.07)</td>
<td>13.88 (10.48)</td>
</tr>
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<td></td>
<td>p=.2126</td>
<td>p=.0135*</td>
<td>p=.0949</td>
<td></td>
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<tr>
<td>IES Avoidance</td>
<td>22.55 (7.88)</td>
<td>20.00 (15.43)</td>
<td>11.40 (5.86)</td>
<td>16.00 (10.61)</td>
</tr>
<tr>
<td></td>
<td>p=.6259</td>
<td>p=.1585</td>
<td>p=.1412</td>
<td></td>
</tr>
<tr>
<td>Beck Depression Inventory</td>
<td>26.11 (11.36)</td>
<td>21.77 (10.12)</td>
<td>25.6 (12.28)</td>
<td>17.85 (11.01)</td>
</tr>
<tr>
<td></td>
<td>p=.09</td>
<td>p=.38</td>
<td>p=.01*</td>
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After VRET, the majority of patients’ ratings of their global improvement indicated improvement. At 6 months, 6 of 8 reported improvement. Clinician’s ratings of patients’ global improvement as measured by the Clinical Global Improvement Scale (CGI) indicated that 5 of 6 showed improvement immediately after the study while one appeared unchanged. At 6 months, 7 of 8 were rated as demonstrating some improvement. Clinician-rated PTSD symptoms as measured by the Clinician-Rated PTSD Scale (CAPS), the primary outcome measure, at 6 month follow-up indicated an overall statistically significant reduction from baseline in symptoms associated with specific reported traumatic experiences. Eight of 8 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 (IES) were significantly lower at 3 months than at baseline but not at 6 months, although there was a clear trend toward fewer intrusive thoughts and somewhat less avoidance.

The authors concluded that VRET led to significant reductions in PTSD and related symptoms and was well tolerated. No person de-compensated due to exposure to the VREs. No participant was hospitalized during the study for complications related to the treatment. Most of those who dropped out of the study were provided opportunities for other treatment within the PTSD Clinical Team clinic at the Atlanta VA Medical Center and did not appear to suffer any
long-term problems attributable to their participation. This preliminary evidence suggested that VRE was a promising component of a comprehensive treatment approach for veterans with combat-related PTSD.

Positive findings in the study of Vietnam veterans has led other groups to propose VR environments to facilitate PTSD treatment in civilians. For example, subsequent to the September 11, 2001 terrorist attacks on the World Trade Centers (WTC) in New York, Difede and Hoffman (2002) constructed a scenario in which civilians, firefighters and police officers with PTSD could be exposed to the events in VR. In their first report, a case study was presented using VR to provide exposure to the trauma memory with a patient who had failed to improve with traditional exposure therapy. The authors reported significant reduction of PTSD symptoms after repeatedly exposing the patient to explosions, sound effects, virtual people jumping from the burning buildings, towers collapsing, and dust clouds and attributed this success partly due to the increased realism of the VR images as compared to the mental images the patient could generate in imagination. Positive treatment outcomes from a wait-list controlled VR study with patients who were not successful in previous imaginal therapy are currently under review by this group (Joanne Difede, personal communication, December 13, 2005). These early results suggest that VR was a useful technology to apply for the treatment of PTSD and that it may be a promising component of a comprehensive treatment approach for persons with combat-related PTSD.

Two other groups are currently beginning the development and initial user-centered testing of VR scenarios to treat PTSD in survivors of war and terrorist attacks (Gamito et al., 2005; Josman et al., 2005). In Portugal, there is an estimated 25,000 survivors with PTSD from their 1961-1974 wars in Mozambique, Angola and Guiné (Gamito et al., 2005). This research group has constructed a single VR “ambush” scenario by modifying a common PC-based combat game. They report having recently conducted an initial user-centered test with one PTSD client who has provided feedback suggesting the need for the construction of a system that provides more graduated delivery of anxiety provoking trigger stimuli. In Israel, Josman et al. (2005) is currently implementing a terrorist “bus bombing” PTSD treatment scenario in which the client is positioned in an urban cafe across the street from the site where a civilian bus may explode. The system controls allow the client to sit in the outdoor cafe and be exposed to a range of progressive conditions--from the street being empty with no bus or sound effects--to the bus passing in an uneventful manner with or without sound--to the bus arriving and exploding with full sound effects. This research has only recently commenced and no clinical data are currently available.

Design and Development of The Full Spectrum Virtual Iraq/Afghanistan PTSD Therapy Application

In 1997, researchers at Georgia Tech released the first version of the Virtual Vietnam VR scenario for use as an exposure therapy tool for treating PTSD in Vietnam veterans. This occurred over 20 years following the end of the Vietnam
VR for Combat Related PTSD

War. During those intervening 20 years, in spite of valiant efforts to develop and apply traditional psychotherapeutic approaches to PTSD, the progression of the disorder in some veterans significantly impacted their psychological well being, functional abilities and quality of life, as well as that of their family members and friends. The tragic nature of this disorder also had significant ramifications for the U.S. Dept. of Veteran Affairs healthcare delivery system often leading to designations of lifelong service connected disability status. The Virtual Vietnam scenario landmarked the first time that VR was applied to the treatment of PTSD and this initial effort produced encouraging results.

In the early 21st century the conflicts in Iraq and Afghanistan again drew US military personnel into combat. In the first systematic study of mental health problems due to these conflicts, Hoge et al., (2004) reported that “...The percentage of study subjects whose responses met the screening criteria for major depression, generalized anxiety, or PTSD was significantly higher after duty in Iraq (15.6 to 17.1 percent) than after duty in Afghanistan (11.2 percent) or before deployment to Iraq (9.3 percent)” (p.13). With this history in mind, the University of Southern California Institute for Creative Technologies (ICT) and Virtually Better, Inc. (VB) have initiated a project that is creating an immersive virtual environment system for the treatment of veterans from the Iraq and Afghanistan Wars diagnosed with combat-related PTSD. This project has now been funded as part of a larger multi-year effort by the U.S. Office of Naval Research. The VR treatment environment is being created from a cost effective approach to recycling virtual graphic assets that were initially built for the U.S. Army-funded combat tactical simulation scenario entitled Full Spectrum Command, which later inspired the creation of the commercially successful X-Box game, Full Spectrum Warrior. Increasingly, the military has been able to take advantage of simulation technology, primarily for training soldiers. Such software is often referred to as mission rehearsal simulations and the USC ICT has been at the forefront of constructing such software since the late 1990’s. The presence of expertise in designing combat simulations, the graphics technology adapted from the X-Box game and the collaboration with VB has led to an opportunity to once again apply VR to combat related PTSD, albeit this time within a tighter timeframe than the technology allowed for Vietnam era PTSD.

Technical Background and Development History

One of the primary aims of the current project is to use the already existing ICT Full Spectrum Warrior graphic assets as the basis for creating a clinical VR application for the treatment of PTSD in returning Iraq/Afghanistan War military personnel (go to: ftp://ftp.ict.usc.edu/arizzo/PTSD%20Materials/ for video demos of the content). The ICT Games Project has created two training tools for the U.S. Army to teach leadership and decision making skills. Full Spectrum Command (FSC) is a PC application that simulates the experience of commanding a light infantry company. FSC teaches resource management, adaptive thinking, and tactical decision-making. Full Spectrum Warrior, developed for the Xbox game console, puts the trainee in command of a nine-person squad. Trainees learn small unit tactics as they direct fire teams through
VR for Combat Related PTSD

a variety of immersive urban combat scenarios. These tools were developed through collaboration between ICT, entertainment software companies, the U.S. Army Training and Doctrine Command (TRADOC), and the Research, Development, and Engineering Command, Simulation Technology Center (RDECOM STC). Additionally, Subject Matter Experts from the Army’s Infantry School contributed to the design of these training tools.

The current VR PTSD application is designed to run on two Pentium 4 notebook computers each with 1 GB RAM, and a 128 MB DirectX 9 compatible graphics cards. The two computers are linked using a null Ethernet cable. One notebook runs the therapist’s control application while the second notebook drives the user’s head mounted display (HMD) and orientation tracker. We are exploring the usability of three different Head Mounted Displays (HMDs) for use in this application aiming to find the best instrument available to conduct deliver this treatment at the lowest cost. This design goal is important in order to promote maximum accessibility to this system in the future. The three HMDs that are being tested for this purpose are: 1. The 5DT HMD 800 capable of 800x600 (SVGA) resolution (see for specs: http://www.5dt.com/products/phmd.html); 2. The Icuiti v920 HMD capable of 640x480 (VGA) resolution (see for specs: http://www.icuiti.com/); and 3. The eMagin OLED z800 HMD capable of 800x600 (SVGA) resolution (see for specs: http://www.emagin.com/). The Intersense InertiaCube2 tracker is being used for 3 Degree Of Freedom (pitch, roll and yaw) head orientation tracking and the user navigates through the scenario using a USB gamepad device. It should also be noted that while we believe that the HMD display approach will provide the optimal level of immersion and interaction characteristics for this application, the system is be fully configurable to be delivered on a standard PC monitor or within a large screen projection display format. The application is built on ICT’s FlatWorld Simulation Control Architecture (FSCA). The FSCA enables a network-centric system of client displays driven by a single controller application. The controller application broadcasts user triggered or scripted event data to the display client. The client’s real-time 3D scenes are presented using Numerical Design Limited’s (NDL) Gamebryo graphics engine. The content originally used in Full Spectrum Warrior was edited and exported to the engine using Alias’ Maya software.

Olfactory and tactile stimuli are also being added into the experience of the virtual Iraq environment. The olfactory stimuli are delivered via the Scent Pallet®, developed by Envirodine Studios, Inc. (http://www.envirodine.com/). The Scent Pallet® is a computer peripheral, USB device that uses up to 8 scent cartridges, a series of fans and a small air compressor to deliver scents to participants. The scents can be computer controlled by placing triggers into the VR programs (e.g., participant walks by a fire and smells smoke), delivered via key press by the clinician, or simply turned off to decrease sensory impact within the virtual environment. Scent is activated in this application, by triggers programmed into the environment via the ICT FlatWorld Simulation Control Architecture (Pair et al., 2006). Scents may be employed as direct stimuli (e.g., scent of burning rubber) or as general cues to help immerse persons in the world (e.g., ethnic food cooking). This allows for the simultaneous delivery of these
stimuli with visual and audio events to create a more realistic multi-modal experience for the client in order to enhance the sense of presence in the environment. The amount of scent to be released is specified in seconds. For example, one could have a one second burst of concentrated scent delivered which would provide a subtle hint of the scent as when passing by a flower garden. Conversely, the machine could be programmed to deliver a longer burst of scent such as might be experienced when approaching someone wearing cologne. The scents are concentrated and gelled much like an air freshener cartridge and enclosed within the Scent Palette in an airtight chamber that fills with compressed air. When activated, the scent is released into an air stream provided by 4 electric fans so that it moves past the user and then dissipates into the volume of the room. The scents that have been selected for this application thus far include burning rubber, cordite, garbage, body odor, smoke, diesel fuel, Iraqi spices and gunpowder. Scent has been shown to be related to emotional responding and it is believed that the addition of scent will allow clinicians a greater range of options for manipulating the realism within the virtual environment.

The addition of tactile input in the form of vibration is designed to add another sensory modality to the virtual environment, again to enhance presence. Vibration is obtained through the use of a Logitech Force-Feedback Gamepad and from sound transducers (Aura Bass Shakers, Aura Sound, Inc., http://www.aurasystems.com/) located beneath the client's floor platform driven by an audio amplifier. The sound files embedded in the software are customized to provide vibration consistent with relevant visual and audio stimuli in the scenario. For example, explosions and gunfire can be accompanied by this additive sensation and the vibration can also be varied as when a virtual vehicle moves across seemingly uneven ground.

Clinical Application Control Options: Scenario Settings, User Perspectives, Trigger Stimuli & The Clinical Interface

Prior to acquiring the funding required to create a comprehensive VR application to address a wide range of possible combat-related PTSD experiences, we created a prototype virtual environment designed to resemble a middle-eastern city (see Figures 5-6). This Virtual Environment (VE) was designed as a proof of concept demonstrator and as a tool for initial user testing to gather feedback from both Iraq War military personnel and clinical professionals. This feedback has been used to refine the city scenario and to drive development of other relevant scenario settings. Current ONR funding has now allowed us to evolve this existing prototype into a full-featured version 1.3 application that is currently undergoing user-centered design feedback trials with non-PTSD soldiers at the Naval Medical Center - San Diego (NMCSD) who have returned from an Iraq tour of duty. As well, user centered feedback is also being collected on this version within an Army Combat Stress Control Team in Iraq (see Figure 16). The vision for the project includes not only the design of a series of diverse scenario settings (i.e. city, outlying village and desert convoy scenes), but as well, the
creation of options for providing the user with different first person user perspective options. These choice options when combined with real time clinician input via the “Wizard of Oz” clinical interface is envisioned to allow for the creation of a user experience that is specifically customized to the varied needs of clients who participate in treatment. This is an essential component for giving the therapist the capacity to modulate client anxiety as is required for an exposure therapy approach. Such experience customization and real time stimulus delivery flexibility are key elements for these types of VR exposure applications.

**Scenario Settings**

The software has been designed such that clients can be teleported to specific scenario settings based on a determination as to which environments most closely match the client’s needs, relevant to their individual combat related experiences. All scenario settings are adjustable for time of day or night, weather conditions and lighting illumination. The following are the scenario settings that are being created for the application:

1. **City Scenarios** – In this setting, we are creating two variations. The first city setting (currently developed in our prototype version 1.2) has the appearance of a desolate set of low populated streets comprising of old buildings, ramshackle apartments, warehouses, a mosque, factories and junkyards (see Figures 5-9). The second city setting has similar street characteristics and buildings, but will be more highly populated and have more traffic activity, marketplace scenes and monuments.

2. **Checkpoint** – This area of the City Scenario is being constructed to resemble a traffic checkpoint with a variety of moving vehicles arriving, stopping and then moving onward into the city.

3. **City Building Interiors** – Some of the City Scenario buildings will have interiors modeled that will allow the client to navigate through them. These interiors will have the option of being vacant (see Figure 9) or be inhabited by various numbers and types of virtual human characters.

4. **Small Rural Village** – This setting consists of a more spread out rural area containing ramshackle structures, a village center and much decay in the form of garbage, junk and wrecked or battle-damaged vehicles. It will also contain more vegetation and have a view of a desert landscape in the distance that is visible as the user passes by gaps between structures near the periphery of the village.

5. **Desert Base** – This scenario is being designed to appear as a desert military base of operations consisting of tents, soldiers and an array of military hardware.

6. **Desert Road Convoy** – This scenario consists of a paved roadway that will eventually connect the City, Village and Desert Base
scenarios. The view from the road currently consists of desert scenery and sand dunes (see Figures 10,12,13) with occasional areas of vegetation, ramshackle structures, battle wreckage, debris and an occasional virtual human figure standing by the side of the road.
The VR system is designed such that once the scenario setting is selected, it is possible to select from a variety of user perspective and navigation options. These are being designed in order to again provide flexibility in how the interaction in the scenario settings can be customized to suit the client’s needs.

User perspective options in the final system will include:

1. Client walking alone on patrol from a first person perspective (see Figures 5-6,9).
2. Client walking with one soldier companion on patrol. The accompanying soldier will be animated with a “flocking” algorithm that will place him always within a 5-meter radius of the client and will adjust position based on collision detection with objects and structures to support a perception of realistic movement. (see Figure 7).
3. Client walking with a patrol consisting of a number of companion soldiers using a similar “flocking” approach as in #2 above (see Figure 8). These flocking options are under development and will be integrated during year two of this project.
4. Client view from the perspective of being either inside of the cab of a HUMVEE or other moving vehicle or from a more exposed position in a gun turret above the roof of the vehicle. Options are provide for automated travel as a passenger through the various setting scenarios (see Figures 11-13) or at the driving column that allow for user control of the vehicle via the gamepad controls. The interior view will also have options for other occupant passengers that will have ambient movement. This view is also adjustable to support the perception of travel within a convoy or as a lone vehicle.
5. Client view from the perspective of being in a helicopter hovering above or moving over any of the scenario settings (see Figure 14).

In each of these user perspective options, we are considering the wisdom of having the client possess a weapon. This will necessitate decisions as to whether the weapon will be usable to return fire when it is determined by the clinician that this would be a relevant component for the therapeutic process. Those decisions will be made based on the initial user and clinician feedback from the version 1.2 application.

**Trigger Stimuli**

The specification, creation and addition of trigger stimuli will likely be an evolving process throughout the life of the application based on relevant client and clinician feedback. We began this part of the design process by including options that have been reported to be relevant by returning soldiers and military subject matter experts. For example, Hoge et al., (2004), in their study of self-reported anxiety, depression and PTSD-related symptomatology in returning Iraq War veterans, present a useful listing of combat related events that were commonly
experienced in their sample. These events provided a useful starting point for conceptualizing how relevant trigger stimuli could be presented in a VR environment. Such commonly reported events included: “Being attacked or ambushed, Receiving incoming artillery, rocket, or mortar fire, Being shot at or receiving small-arms fire, Shooting or directing fire at the enemy, Being responsible for the death of an enemy combatant, Being responsible for the death of a noncombatant, Seeing dead bodies or human remains, Handling or uncovering human remains, Seeing dead or seriously injured Americans, Knowing someone seriously injured or killed, Participating in de-mining operations, Seeing ill or injured women or children whom you were unable to help, Being wounded or injured, Had a close call, was shot or hit, but protective gear saved you, Had a buddy shot or hit who was near you, Clearing or searching homes or buildings, Engaging in hand-to-hand combat, Saved the life of a soldier or civilian.” (p. 18). From this and other sources, we have begun our initial effort to conceptualize what is both functionally relevant and pragmatically possible to include as trigger stimuli in the virtual environment.

There appears to be at least four general classes of trigger stimuli that are relevant for this application: 1. Auditory (i.e., weapons fire, explosions, vehicle noise, wind, human voices), 2. Static Visual (i.e., human remains, wounded civilians and combatants, wrecked vehicles), 3. Dynamic Visual (i.e., distant views of human and vehicle movement), 4. Dynamic Audiovisual (i.e., nearby human and vehicle movement, battlefield engagement with enemy combatants). Thus far in the Version 1.2 prototype, we have created a variety of auditory trigger stimuli (i.e., incoming mortars, weapons fire, voices, wind, etc.) that can be actuated by the clinician via mouse clicks on a clinical interface. We can also similarly trigger dynamic audiovisual events such as helicopter flyovers above the user's position and verbal orders from a commanding officer who is gesturing in an excited manner. The creation of more complex events that can be intuitively delivered from a clinicians’ interface while providing a client with options to interact or respond in a meaningful manner is one of the ongoing focuses in this project. Perhaps it may be of value to actually immerse the user in varying degrees of combat in which they may see members of their patrol (or themselves) get wounded or in fact have the capability to fire a weapon back at enemy combatants. However, such trigger options will require not only interface design expertise, but also clinical wisdom as to how much and what type of exposure is needed to produce a positive clinical effect. These issues will be keenly attended to in our initial clinical trials.

The Clinical Interface

In order to deliver and control all of the above features in the system, a “wizard of oz” type clinical interface was created (see Figure 15). This interface is a key element in the application, as it needs to provide a clinician with a usable tool for selecting and placing the client in VR scenario locations that resemble the contexts that are clinically relevant for a graduated exposure approach. As important, the clinical interface must also allow the clinician to further customize
the therapy experience to the client’s individual needs via the systematic real-time delivery and control of “trigger” stimuli in the environment. This is essential for fostering the anxiety modulation needed for therapeutic habituation.

In our initial configuration, the clinician uses a separate computer monitor/mouse or tablet laptop to display and actuate the clinical interface controls. While the results from our initial user feedback trials is currently guiding the interface design, our initial candidate setup provides four quadrants in which the clinician can monitor ongoing user status information, while simultaneously directing trigger stimulus delivery. The upper left quadrant contains basic interface menu buttons used for placement of the client (and immediate removal if needed) in the appropriate scenario setting and user perspective. This quadrant also contains menu keys for the control of time of day or night, atmospheric illumination, weather conditions and initial ambient sound characteristics. The lower left quadrant will provide space for real-time display of the patients’ heart rate and GSR readings for monitoring of physiological status when that feature is integrated. The upper right quadrant contains a window that displays the imagery that is present in the user’s field of view in real-time. And the lower right quadrant contains the control panel for the real-time delivery of specific trigger stimuli that are actuated by the clinician in an effort to modulate appropriate levels of anxiety as required by the theory and methodology of exposure-based therapy. The overall design of the system is such that once the scenario setting is selected, the clinician can then adjust the time of day, weather options, ambient sounds, scent and vibration configurations and user perspective. Once these options are selected, the client can experience this customized environment setting while the clinician then may focus on the judicious delivery of trigger stimuli. These interface options have been designed, with the aid of feedback from clinicians, with the goal to provide a usable and flexible control system for conducting thoughtfully administered exposure therapy that can be readily customized to suit the needs of the client.

Conclusions

War is perhaps one of the most challenging situations that a human being can experience. The physical, emotional, cognitive and psychological demands of a combat environment place enormous stress on even the best-prepared military personnel. Such stressful experiences that commonly occur in warfighting environments have a considerable likelihood for producing significant numbers of returning soldiers at risk for developing PTSD. The initial data coming from both survey studies and anecdotal observations suggest that a large population of returning soldiers from the Iraq/Afghanistan conflicts are in fact reporting symptoms that are congruent with the diagnosis of PTSD. It is our view that this situation requires our best efforts to find ways to maximize treatment access and efficacy and VR is a logical and attractive medium to use to address these aims.

Continuing advances in VR technology, along with concomitant system cost reductions, have supported the development of more usable, useful, and accessible VR systems that can uniquely target a wide range of psychological
disorders (Rizzo & Kim, 2005). The unique match between VR technology assets and the needs of various clinical treatment approaches has been recognized by a number of authors and an encouraging body of research has emerged, particularly in the area of exposure therapy for anxiety disorders (Glantz, Rizzo & Graap, 2003; Rizzo, Schultheis, Kerns & Mateer, 2004; Zimand et al., 2003). As well, a growing body of research has suggested that VR is a powerful medium through which a professional may extend the clinical options available to treat clients with PTSD. Technological advances have made the presentation of compelling multi-sensory experiences in VR a reality and the use of such tools is being investigated in several ongoing trials for survivors of the Vietnam, Iraq and Afghanistan conflicts. VR tools are also improving with advances in video game technology in the areas of graphics processing, development software, interface tools and some emerging developments in display technology. Essentially many high-end digital game scenarios are in fact, well-done virtual environments and this emerging reality has helped to accelerate the development and quality of our VR PTSD system. Although cost factors limit the creation of custom virtual environments specific to the unique experiences of every person, it is possible to construct flexible archetypic VR worlds for groups of clients that have survived traumatic situations that lend themselves to abstraction and some degree of commonality. Examples considered in this chapter include Vietnam (helicopter and Landing zone scenarios), the World Trade Center (street view of the terrorist attack), Terrorist Bus bombings (street view in Israel) and a range of scenes in VR Iraq/Afghanistan with six general scenario settings.

One of the more foreboding findings in the recent Hoge et al., (2004) report, was the observation that among Iraq/Afghanistan War veterans, “...those whose responses were positive for a mental disorder, only 23 to 40 percent sought mental health care. Those whose responses were positive for a mental disorder were twice as likely as those whose responses were negative to report concern about possible stigmatization and other barriers to seeking mental health care.” (p. 13). While military training methodology has better prepared soldiers for combat in recent years, such hesitancy to seek treatment for difficulties that emerge upon return from combat, especially by those who may need it most, suggests an area of military mental healthcare that is in need of attention. To address this concern, perhaps a VR system for PTSD treatment could serve as a component within a reconceptualized approach to how treatment is accessed by veterans returning from combat.

One option would be to integrate VR-delivered combat exposure as part of a comprehensive “assessment” program administered upon return from a tour of duty. Since past research is suggestive of differential patterns of physiological reactivity in soldiers with PTSD when exposed to combat-related stimuli (Laor et al., 1998, Keane et al., 1998), an initial procedure that integrates a VR PTSD application with psychophysiological monitoring could be of value. If indicators of such physiological reactivity are present during an initial VR exposure, a referral for continued assessment and/or care could be negotiated and/or suggested. This could be provided in a format whereby the perceived stigma of independently seeking treatment could be lessened as the soldier would be...
simply involved in some form of “non-combat reintegration training” in a similar fashion to other designated duties to which they would participate.

VR PTSD therapy may also offer an additional attraction and promote treatment seeking by certain demographic groups in need of care. The current generation of young military personnel, having grown up with digital gaming technology, may actually be more attracted to and comfortable with participation in a VR application approach as an alternative to what is viewed as traditional “talk therapy” (even though such talk therapy would obviously occur in the course of a recommended multi-component approach for this disorder). The potential for a reduction in the perceived stigma surrounding treatment has been anecdotally reported by practitioners who use VR to treat civilians with aerophobia (fear of flying) (Wiederhold & Wiederhold, 2004). These observations indicate that some patients have reported that prior to treatment, they had “just lived with the problem” and never considered seeking professional treatment. Upon hearing of VR therapy for fear of flying, often via popular media reports, they then sought out VR exposure treatment, typically with resulting positive outcomes.

In addition to the ethical factors that make an unequivocal case for the importance of exploring new options for assessment and treatment of combat-related PTSD, economic drivers for the Department of Veterans Affairs healthcare system and the military also provide incentives for investigating novel approaches in this area. As of September 2004, there were 13,524 Gulf War Veterans receiving compensation for PTSD from the Department of Veterans Affairs (VA Fact Sheet, 12/2004). In addition to the direct costs for benefit compensation, medical care usage by persons with PTSD is estimated to be 60% higher than average (Marshall, Jorm, Grayson & O’Toole, 2000) and lost income-based tax revenues raise the “hidden” costs even higher. These figures make the initial development and continuing infrastructure costs for running PC-based VR systems pale by comparison. The military could also benefit economically by way of reduced turnover of soldiers with mild PTSD. These personnel might be more likely to reenlist if their mental health needs were addressed soon after combat in a progressive manner via earlier VR assessment and treatment. As well, such a VR tool initially developed for exposure therapy purposes, offers the potential to be “recycled” for use both in the areas of combat readiness assessment and for stress inoculation. Both of these approaches could provide measures of who might be better prepared for the emotional stress of combat. For example, novice soldiers could be pre-exposed to challenging VR combat stress scenarios delivered via hybrid VR/Real World stress inoculation training protocols as has been reported by Wiederhold & Wiederhold (2005) with combat medics.

Finally, one of the guiding principles in our development work concerns how VR can extend the skills of a well-trained clinician. This VR approach is not intended to be an automated treatment protocol that could be administered in a “self-help” format. The presentation of such emotionally evocative VR combat-related scenarios, while providing treatment options not possible until recently, will most likely produce therapeutic benefits when administered within the context
of appropriate care via a thoughtful professional appreciation of the complexity and impact of this disorder.

References


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