Development of a VR Therapy Application for Iraq War Veterans with PTSD

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Abstract. Post Traumatic Stress Disorder (PTSD) is reported to be caused by traumatic events that are outside the range of usual human experiences including (but not limited to) military combat, violent personal assault, being kidnapped or taken hostage and terrorist attacks. Initial data suggests that 1 out of 6 returning Iraq War military personnel are exhibiting symptoms of depression, anxiety and PTSD. Virtual Reality (VR) exposure therapy has been used in previous treatments of PTSD patients with reports of positive outcomes. The aim of the current paper is to specify the rationale, design and development of an Iraq War PTSD VR application that is being created from the virtual assets that were initially developed for the X-Box game entitled *Full Spectrum Warrior* which was inspired by a combat tactical training simulation, *Full Spectrum Command*.

1. Introduction

In 1997, researchers at Georgia Tech released the first version of the Virtual Vietnam VR scenario for use as a graduated exposure therapy treatment for Post Traumatic Stress Disorder with Vietnam veterans. This occurred over 20 years following the end of the Vietnam War. During that interval, in spite of valiant efforts to develop and apply traditional psychotherapeutic approaches to PTSD, the progression of the disorder in some veterans severely impaired their 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. Veteran's Administration healthcare delivery system often leading to designations of lifelong service connected disability status. Just recently, the first systematic study of mental health problems due to the Iraq conflict revealed 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)"* [1]. With this history in mind, the USC Institute for Creative Technologies (ICT) has initiated a project that is creating an immersive virtual environment system for the treatment of Iraq War veterans diagnosed with combat-related PTSD. The proposed treatment environment is based on a creative approach to recycling virtual assets that were initially built for a combat tactical simulation scenario entitled *Full Spectrum Command*, which later inspired the creation of the commercially available X-Box game, *Full Spectrum Warrior*. This paper will briefly present the vision, rationale, technical specifications, clinical interface design and development status of the Full Spectrum PTSD treatment system that is currently in progress at the USC ICT.

2. Post Traumatic Stress Disorder

According to the DSM-IV [2], PTSD is caused by traumatic events that are outside the range of usual human experiences such as military combat, violent personal assault, being kidnapped or taken hostage, terrorist attack, torture, incarceration as a prisoner of war, natural or man-made disasters, automobile accidents, or being diagnosed with a life-threatening illness. The disorder also appears to be more severe and longer lasting when the event is caused by human means and design (bombings, shootings, combat, etc.). Such incidents would be distressing to almost anyone, and is usually experienced with intense fear, terror, and helplessness. Typically, the initiating event involves actual or threatened death or serious injury, or other threat to one's physical integrity; or witnessing an event that involves death, injury, or a threat to the physical integrity of another person. Symptoms of PTSD are often intensified when the person is exposed to stimulus cues that resemble or symbolize the original trauma in a *non-therapeutic* setting. Such *uncontrolled* cue exposure may lead the person to react with a survival mentality and mode of response that could put the patient and others at considerable risk.

Prior to the availability of VR therapy applications, the existing standard of care for PTSD was *imaginal* exposure therapy. Such treatment typically involves the graded and repeated imaginal reliving of the traumatic event within the therapeutic setting. This approach is believed to provide a low-threat context where the patient can begin to therapeutically process the emotions that are relevant to the traumatic event as well as de-condition the learning cycle of the disorder via a habituation/extinction process. While the efficacy of imaginal exposure has been established in multiple studies with diverse trauma populations [3-4], 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*." [5]. Research on this aspect of PTSD treatment suggests that the inability to emotionally engage (*in imagination*) is a predictor for negative treatment outcomes [6].

The use and value of Virtual Reality for the treatment of cognitive, emotional, psychological and physical disorders has been well specified [7-8]. 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 [9]. Results indicated post-treatment improvement on all measures of PTSD and maintenance of these gains at a 6-month follow-up. This case study was followed by an open clinical trial of VR for Vietnam veterans [10]. 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. Similar positive results have also recently been reported for VR applied to PTSD resulting from the attack on the World Trade Center [5]. In this report, a case study was presented using VR to provide re-exposure to the trauma with a patient who had failed to improve with traditional exposure therapy. The authors reported significant reduction of PTSD symptoms by 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. Such early results suggest that VR may be a valuable technology to apply as a component within a comprehensive treatment approach for persons with combat-related PTSD.

3. Full Spectrum Warrior Background and Development History

The primary aim of the current project is to use the already existing ICT Full Spectrum Warrior graphic assets (go to: http://www.ict.usc.edu/disp.php?bd=proj_games_fsw for video demo) as the basis for creating a clinical VR application. 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 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), orientation tracker and navigation controls. 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.

4. Full Spectrum Warrior PTSD VR System Features

We have created a prototype virtual environment designed to resemble a middle-eastern city (see Figures 1-3). This 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 in order to refine the city scenario and to seek guidance regarding the future expansion of the system to include other relevant scenario settings. The vision for the project includes, not only the design of a series of diverse scenario settings (e.g. outlying village and desert scenes), but as well, the creation of options for providing the user with different first person perspectives. 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 needs of the patient participating in treatment. The software is being designed such that clinical users can be teleported to specific scenario settings based on a determination as to which environment most closely matches the patient's needs, relevant to their individual combat related experiences. These settings include:

1. City Scenes – In this setting, we are creating two variations. The first city setting (similar to what we have in our prototype) will have the appearance of a desolate set of low populated streets comprising of old buildings, ramshackle apartments, a mosque, factories and junkyards (see Figures 1-2). The second city setting will have 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 will be constructed to resemble a traffic checkpoint with a variety of moving vehicles arriving, stopping and then moving onward.
3. City Building Interiors – Some of the City Scenario buildings will have interiors modeled that will allow the user to navigate through them. These interiors will have the option of being vacant (see Figure 3) or have various levels of populated virtual characters inhabiting them.
4. Small Rural Village – This setting will consist 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 will be designed to appear as a desert military base of operations consisting of tents, soldiers and an array of military hardware.
6. Desert Road – This will consist of both paved and dirt roadway which will connect the City scenario with the Village scenario. The view from the road will mainly consist of desert scenery and sand dunes (see Figure 4) with occasional areas of vegetation, ramshackle structures and battle wreckage.


Figure 1. City View


Figure 2. "Flocking" Patrol


Figure 3. Interior View


Figure 4. Desert Road View


Figure 5. HUMVEE View

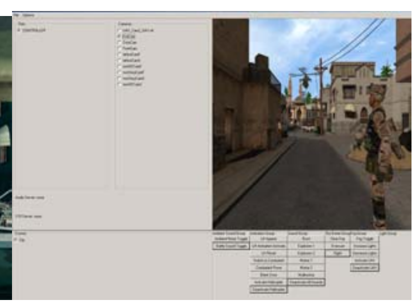
Figure 6. Clinical Interface

Once the scenario setting is selected, it will be 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 clinical user's needs. These options will include:
1. User walking alone on patrol from a first person perspective (Figure 1).
2. User walking with one soldier companion on patrol. The accompanying soldier will be animated with a "flocking" algorithm that will place them always within a 5-meter radius of the user and will adjust position based on collision detection with objects and structures to support a perception of realistic movement.
3. User walking with a patrol consisting of a number of companion soldiers using a similar "flocking" approach as in #2 above (Figure 2).

4. User view from the perspective of being in a HUMVEE or other moving vehicle as it automatically travels through the various setting scenarios (Figure 5). The interior view can have options for other occupant passengers that will have ambient movement. The view will also be adjustable to support the perception of travel within a convoy or as a lone vehicle.
5. User view from the perspective of being in a helicopter hovering above the scenarios.

In each of these user perspective options, the user may or may not possess a weapon, and in some cases 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. We have also created an initial version of a "Wizard of Oz" type clinical interface (Figure 6). This interface is a key element in the application, as it needs to provide a clinician with a usable tool for placing the user in VE locations that resemble the setting and context in which the traumatic events initially occurred. As important, the clinical interface must also allow the clinician to further customize the therapy experience to the patient'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 has a separate computer monitor that displays the clinical interface controls. While the results from planned user studies will ultimately guide the interface design process, one possible candidate setup is to provide four quadrants in which the clinician can monitor ongoing user status information, while simultaneously directing trigger stimulus delivery. The upper left quadrant will contain basic interface menu keys used for placement of the patient (and immediate removal if needed) in the appropriate scenario setting and user perspective. This quadrant will also contain 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' heartrate and GSR readings for monitoring of physiological status. The upper right quadrant will contain 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 specification and creation of such trigger stimuli is an evolving process that has begun with our intuitive efforts to include options that have been reported to be relevant by returning soldiers and combat environment experts. For example, Hoge et al., [1], present a useful listing of combat related events that were commonly experienced in their sample of returning Iraq War military personnel. These events provide a useful starting point for conceptualizing how relevant trigger stimuli could be presented in a VE, including: "*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…"* (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 our current clinical interface.

5. Conclusion

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. One of the more foreboding findings in the recent Hoge et al., [1] report, was the observation that among Iraq 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 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. In this regard, 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 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 [11-12], an initial procedure that integrates our VR PTSD application with physiological recording could be of value. If indicators of such physiological reactivity are present during an initial VR exposure, a referral for continued care could be negotiated and/or prescribed. 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.

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