User-centered design driven development of a virtual reality therapy application for Iraq war combat-related post traumatic stress disorder

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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 experience including (but not limited to) military combat, violent personal assault, being kidnapped or taken hostage and terrorist attacks. Initial data suggests that at least 1 out of 6 Iraq War veterans are exhibiting symptoms of depression, anxiety and PTSD. Virtual Reality (VR) delivered exposure therapy for PTSD has been used with reports of positive outcomes. The aim of the current paper is to present the rationale, technical specifications, application features and user-centered design process for the development of a Virtual Iraq PTSD VR therapy application. The VR treatment environment is being created via the recycling of virtual graphic assets that were initially built for the U.S. Army-funded combat tactical simulation scenario and commercially successful X-Box game, *Full Spectrum Warrior,* in addition to other available and newly created assets. Thus far we have created a series of customizable virtual scenarios designed to represent relevant contexts for exposure therapy to be conducted in VR, including a city and desert road convoy environment. User-centered design feedback needed to iteratively evolve the system was gathered from returning Iraq War veterans in the USA and from a system in Iraq tested by an Army Combat Stress Control Team. Clinical trials are currently underway at Camp Pendleton and at the San Diego Naval Medical Center. Other sites are preparing to use the application for a variety of PTSD and VR research purposes.

1. INTRODUCTION

In 1997, Virtually Better, Inc. released the first version of the Virtual Vietnam VR scenario for use as an exposure therapy tool for treating Post Traumatic Stress Disorder (PTSD) in Vietnam veterans. This occurred over 20 years following the end of the Vietnam 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 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. Hoge et al., (2004), in the first systematic study of mental health problems due to these conflicts 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) initiated a project to create an immersive virtual environment system for the exposure therapy treatment of Iraq and Afghanistan War veterans diagnosed with combat-related PTSD. This PTSD VR therapy environment is being created via the recycling of graphic assets that were initially built for the U.S. Army-funded combat tactical simulation scenario and commercially successful X-Box game, *Full Spectrum Warrior*. As well, other existing and newly created assets available to ICT are being integrated into this rapidly evolving application. The presence of ICT expertise in designing combat simulations and an interdisciplinary collaboration with leading experts in the field of combat related PTSD has led to the opportunity to apply VR for this relevant clinical challenge, albeit within a tighter timeframe than the technology allowed for Vietnam era veterans with PTSD.

According to the DSM-IV (1994), 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, rape, 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 the witnessing or awareness of an event that involves death, injury, or a threat to the physical integrity of another person. The essential feature of PTSD is the development of characteristic symptoms that may include: intrusive thoughts and flashbacks, avoidance of reminders of the traumatic event, emotional numbing, hyper-alertness, anger, isolation, anxiety, depression, substance abuse, survivor guilt, suicidal feelings and thoughts, negative self-image, memory impairment, problems with intimate relationships, emotional distance from family and others and denial of social problems. 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 and narrative recounting 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 (Rothbaum et al., 2000; 2002), many patients are unwilling or unable to effectively visualize the traumatic event. In fact, *avoidance* of reminders of the trauma is one of the cardinal symptoms of PTSD. 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). Research on this aspect of PTSD treatment suggests that the inability to emotionally engage (*in imagination*) is a predictor for negative treatment outcomes (Jaycox et al., 1998). In contrast to imaginal therapy, VR is seen to provide a controlled stimulus environment that can more effectively deliver the controlled exposure to trauma cues needed for therapeutic gain. Such use and value of VR for the treatment of cognitive, emotional, psychological and motor disorders has been well specified (Glantz, Rizzo & Graap, 2003; Rizzo et al., 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. This case study was followed by an open clinical trial of VR for Vietnam veterans (Rothbaum et al., 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.

The early positive findings from the Vietnam studies led other groups to propose VR environments to facilitate PTSD treatment in both civilians and military personnel. For example, subsequent to the September 11, 2001 terrorist attacks on the World Trade Center in New York, Difede and Hoffman (2002) constructed a scenario in which civilians, firefighters and police officers with PTSD could be exposed in VR to relevant trauma-related events. 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 imaginal 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, June 17, 2006). These initial positive findings have also encouraged others to begin development and initial user-centered testing of VR scenarios to treat

PTSD in survivors of war and terrorist attacks. In Portugal, where there is an estimated 25,000 survivors with PTSD from the 1961-1974 colonial wars in Mozambique, Angola and Guiné, Gamito et al. (2005) has constructed a VR "ambush" scenario using the Halo 2 game engine as a starting point. They report having recently conducted an initial user-centered test with one PTSD patient 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 patient is positioned in an urban cafe across the street from the site where a civilian bus may explode. The system controls allow the patient 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 efficacy data are currently available. However, based on the data that is available across the field since the advent of Virtual Vietnam, the initial results indicate that VR exposure therapy is a vital component to be included within a comprehensive treatment approach for persons with combat-related PTSD.

2. TECHNICAL BACKGROUND AND DEVELOPMENT HISTORY

In the pragmatic design of this application, minimizing costs was achieved in two ways. Whenever possible, assets from previous applications were "recycled" for use in the current project. This can be most poignantly seen in the use of Full Spectrum Warrior X-Box game art assets as a start point for developing the initial prototypes. However, as user-centered feedback guided iterative design cycles, it became apparent that we also needed to create specialized art for the scenario development. As well, an attempt was made whenever possible to use low cost commodity off the shelf equipment in order to maximize the access and availability of the finished system. The current application is designed to run on two Pentium 4 notebook computers each with 1 GB RAM, and 128 MB DirectX 9-compatible NVIDIA 3D 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). We evaluated HMDs from three different manufacturers for use in this application with the aim of finding an affordable display with acceptable resolution and field of view (5DT, Cyvisor, eMagin). The HMD that was chosen was the eMagin z800, which contains OLED displays capable of 800x600 (SVGA) resolution with a 40 degree diagonal field of view (http://www.emagin.com/). The major selling point for using this HMD was the presence of a built-in 3DOF head tracker. At under $600 per unit, this integrated display/tracking solution was viewed as the best option to minimize costs and maximize the access to this system by those in need. It should also be noted that while we believe that a HMD will provide the optimal level of immersion and interaction for this application, the system is 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) (Treskunov, Pair & Swartout, 2004). 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 controller can introduce scripted elements to the VR environment at runtime. These scripted elements allow the controller to provide real-time client-side interaction despite potential network delays. FCSA scripting is based on the Lua programming language and provides facilities for real-time triggered events, animation and path planning. The client's real-time 3D scenes are presented using Numerical Design Limited's (NDL) Gamebryo rendering library. Pre-existing art assets were integrated using Alias' Maya 6 and Autodesk 3D Studio Max 7 with new art created primarily in Maya.

We have also added olfactory and tactile stimuli to the experience of the environment. Recently, Virtually Better, Inc. in collaboration with Envirodine, Inc. introduced the *Scent Palette* for use in conjunction with VR environments. The *Scent Palette* is a USB device that uses up to 8 smell cartridges, a series of fans, and a small air compressor to deliver scents to participants. The scents can be activated by placing location-aware triggers into the VR application. For example, a user walks by a fire and smells smoke. The smells can also be controlled by operator key presses or mouseclicks. Scents may be employed as direct stimuli (e.g., scent of burning rubber) or as cues to help immerse users in the world (e.g., ethnic food cooking). The amount of scent to be released is specified in seconds. The scents selected for this application include burning rubber, cordite, garbage, body odor, smoke, diesel fuel, Iraqi food spices, and gunpowder. Vibration is also used as an additional user sensory input. Vibration is be generated through the use of a Logitech force-feedback game control pad and through audio-tactile sound transducers from Aura Sound Inc. located beneath the patient's floor platform and seat. Audio files are customized to provide vibration consistent with relevant visual and audio stimuli in the scenario. For example, explosions are accompanied by a shaking floor. In the HUMVEE scenarios, the user's seat vibrates as the vehicle moves across uneven ground.

3. CLINICAL APPLICATION CONTROL OPTIONS: SCENARIO SETTINGS, USER PERSPECTIVES, TRIGGER STIMULI & THE CLINICAL INTERFACE

3.1 Early Prototype and Evolving Vision

Prior to acquiring the Office of Naval Research (ONR) 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 small middle-eastern city (see Figures 1-2). This virtual environment 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. The resulting feedback has been used to refine the city scenario and to drive development of other relevant virtual contexts. Current ONR funding has now allowed us to evolve this existing prototype into a various versions that have undergone user-centered design feedback trials at sites throughout the USA with non-PTSD soldiers who have returned from an Iraq tour of duty. User centered feedback was also collected within an Army Combat Stress Control Team in Iraq (see Figure 3). The vision for the project includes both the design of a series of diverse *scenario settings* (i.e. city, outlying village and desert convoy scenes), and the creation of methods for providing users with different *user perspective options*. These choice options when combined with real time clinician input via a "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 patients who participate in treatment. This is an essential component for giving the therapist the capacity to modulate patient anxiety as is required for an exposure therapy approach. Such options for user experience customization and real time stimulus delivery flexibility are key elements for these types of VR exposure applications.

3.2 Scenario Settings

The software has been designed such that patients can be teleported to specific scenario settings based on a determination as to which environments most closely match the patient'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:

City Scenarios – In this setting, we are creating two variations. The first city setting 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 1-2). The second city setting has similar street characteristics and buildings, but is more highly populated and has more traffic activity, a marketplace, monuments and alleys with insurgents (see Figures 3-4, 16, 17).

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.

Desert Road – This scenario consists of paved and dirt roadways that will eventually connect the City and Village scenarios. The view from the road currently consists of desert scenery and sand dunes (see Figures 5-6) with occasional areas of vegetation, ramshackle structures, battle wreckage, debris and virtual human figures (see Figures 7-8). The scenario supports the perception of travel within a convoy or as a lone vehicle.

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

Checkpoints – 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.

3.3 User Perspectives

The VR system is designed such that 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 patient's needs. User perspective options in the final system will include:

1. User walking alone on patrol from a first person perspective (see Figures 1–4, 9).
2. User 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 patient and will adjust position based on collision detection with objects and structures to support a perception of realistic movement. (see Figure 10).

3. User walking with a patrol consisting of a number of companion soldiers using a similar "flocking" approach as in #2 above (see Figure 11). These flocking options are under development and will be integrated during year two of this project.
4. An adjustable user view from the perspective of being either inside of the cab of a HUMVEE or other moving vehicles or from a more exposed position in a gun turret above the roof of the vehicle (see Figures 5, 7, 8, 12). Options are provided for automated travel as a passenger through the various setting scenarios 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.
5. User view from the perspective of being in a helicopter hovering above or moving over any of the scenario settings (see Figure 13). Night vision is also an option (see Figure 14).

In each of these user perspective options, we are considering the wisdom of having the patient 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 clinical test application.

3.4 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 patient 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, in the Hoge et al., (2004), study of self-reported anxiety, depression and PTSD-related symptomatology in Iraq War veterans, they present a 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. Thus far, 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 the 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 patient 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.

3.5 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. 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 patient 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 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 uses a separate computer monitor/mouse or tablet laptop to display and actuate the clinical interface controls. The results from our initial user feedback trials guided the interface design whereby our setup provides four quadrants in which the clinician can monitor ongoing user status information, while simultaneously directing trigger stimulus delivery (see Figure 15) 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 patient can experience this customized environment setting while the clinician focuses 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 patient. Although cost factors limit the creation of custom VEs specific to the unique experiences of every person, it is possible to construct flexible archetypic VR worlds for PTSD patients that lend themselves to abstraction and some degree of commonality.

4. USER CENTERED EVALUATION

User-Centered tests with the application were conducted at the Naval Medical Center–San Diego, Weill Cornell Medical College-NYC and within an Army Combat Stress Control Team in Iraq (see Figures 18-20). This feedback with non-diagnosed personnel provided feedback on the content and usability of our application to feed an iterative design process. A clinical trial version of the application built from this process is currently being tested with PTSD-diagnosed personnel at various USA sites and any available data from these clinical tests will be presented at IEEE VR2006. We have also conducted brief exposure with two volunteer PTSD patients using an early prototype. One of these patients has reported a reduction in nightmares and the other has reported that the scenario has helped him to cognitively reframe his experience with positive results. These anecdotal and informal self-report commentaries are encouraging for our continued efforts in this clinical direction.

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. 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 number 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.

One of the more foreboding findings in the 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 (Wiederhold & Wiederhold, 2004). These authors 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 healthcare system also provide incentives for investigating novel approaches in this area. As of Sept. 2004, there were 13,524 Gulf War Veterans receiving compensation for PTSD from the Dept. of Veterans Affairs (VA Fact Sheet, 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 et al., 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 who 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 inoculation training 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.

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Figures 1, 2. *Small City Scenarios*.


Figures 3, 4. *Large City Scenarios.*

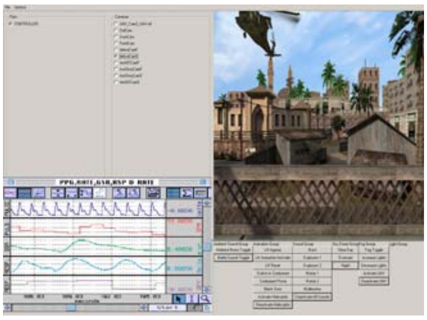

Figures 5, 6. *Desert Outskirts.*


Figures 7, 8. *Desert Roads.*


Figures 9, 10. *Building Interior ~ "Flocking" Soldier.*


Figures 11, 12. *"Flocking" Patrol ~ Turret View.*


Figures 13, 14. *Helicopter View ~ Night Vision View.*




Figures 15, 16. *Clinical Interface ~ Insurgent "Attack".*


Figures 17, 18. *Insurgent "Attack" ~ USA User Tests.*


Figures 19, 20. *User Tests – Iraq Combat Stress Control Team.*