Development and Clinical Results from the Virtual Iraq Exposure Therapy Application for PTSD

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***Abstract*—Post Traumatic Stress Disorder (PTSD) is reported to be caused by exposure to an extreme traumatic stressor involving direct personal experience of (or witnessing/learning about) an event that involves actual or threatened death or serious injury, or other threat to one's physical integrity including (but not limited to) military combat, violent personal assault, being kidnapped or taken hostage and terrorist attacks. Such incidents would be distressing to almost anyone, and are usually experienced with intense fear, horror, and helplessness. Initial data suggests that at least 1 out of 5 Iraq War veterans are exhibiting symptoms of depression, anxiety and PTSD. Virtual Reality (VR) delivered exposure therapy for PTSD has been previously used with reports of positive outcomes. The current paper will present the rationale and description of a VR PTSD therapy application (*Virtual Iraq/Afghanistan*) and present initial findings from a number of early studies of its use with active duty service members. *Virtual Iraq/Afghanistan* consists of a series of customizable virtual scenarios designed to represent relevant Middle Eastern VR contexts for exposure therapy, 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 deployed in Iraq and tested by an Army Combat Stress Control Team. Results from an open clinical trial using *Virtual Iraq* with 20 treatment completers indicated that 16 no longer met PTSD diagnostic criteria at post-treatment, with only one not maintaining treatment gains at 3 month follow-up.**

Keywords: Virtual Reality, Posttraumatic Stress Disorder, PTSD, Exposure Therapy

I. INTRODUCTION

The physical, emotional, cognitive and psychological demands of a combat environment place enormous stress on even the best-prepared military personnel. Such high levels of stress exposure in combat can put a significant percentage of military service members (SMs) at risk for developing Post Traumatic Stress Disorder (PTSD) upon the return home. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) [1], the essential feature of PTSD is the development of characteristic symptoms following exposure to an extreme traumatic stressor involving direct personal experience of an event that 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; or learning about unexpected or violent death, serious harm, or threat of death or injury experienced by a family member or other close associate. Such incidents would be distressing to almost anyone, and are usually experienced with intense fear, horror, and helplessness. Characteristic PTSD symptoms include: intrusive thoughts, nightmares and flashbacks, avoidance of reminders of the traumatic event, emotional numbing, and hyper-arousal. 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/others at considerable risk.

In the early 21st century the conflicts in Iraq and Afghanistan again drew US military personnel into combat. The Iraq/Afghanistan combat theatres, with their ubiquitous battlefronts, ambiguous enemy identification, and repeated extended deployments has produced significant numbers of returning American SMs reporting symptoms that are congruent with the diagnosis of PTSD and other mental disorders. In the first systematic study of mental health problems due to these conflicts, "…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

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14. ABSTRACT

Post Traumatic Stress Disorder (PTSD) is reported to be caused by exposure to an extreme traumatic stressor involving direct personal experience of (or witnessing/learning about) an event that involves actual or threatened death or serious injury or other threat to one's physical integrity including (but not limited to) military combat, violent personal assault, being kidnapped or taken hostage and terrorist attacks. Such incidents would be distressing to almost anyone, and are usually experienced with intense fear, horror, and helplessness. Initial data suggests that at least 1 out of 5 Iraq War veterans are exhibiting symptoms of depression, anxiety and PTSD. Virtual Reality (VR) delivered exposure therapy for PTSD has been previously used with reports of positive outcomes. The current paper will present the rationale and description of a VR PTSD therapy application (Virtual Iraq/Afghanistan) and present initial findings from a number of early studies of its use with active duty service members. Virtual Iraq/Afghanistan consists of a series of customizable virtual scenarios designed to represent relevant Middle Eastern VR contexts for exposure therapy, 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 deployed in Iraq and tested by an Army Combat Stress Control Team. Results from an open clinical trial using Virtual Iraq with 20 treatment completers indicated that 16 no longer met PTSD diagnostic criteria at post-treatment, with only one not maintaining treatment gains at 3 month follow-up.

15. SUBJECT TERMS

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in Afghanistan (11.2 percent) or before deployment to Iraq (9.3 percent)" [2]. These estimates were made before the violence escalated even further and other reports since the original Hoge et al. [2] publication, have indicated equivalent or higher numbers of returning military SMs and veterans reporting positive for PTSD and symptoms of other forms of mental disorders [3-5].

Among the many approaches that have been used to treat PTSD, cognitive-behavioral treatment (CBT) with Prolonged Exposure (PE) appears to have the best-documented therapeutic efficacy [6-10]. PE is a form of individual psychotherapy based on Foa and Kozak's [11] emotional processing theory, which posits that PTSD involves pathological fear structures that are activated when information represented in the structures is encountered. These fear structures are composed of harmless stimuli that have been associated with danger and are reflected in the belief that the world is a dangerous place. This belief then manifests itself in cognitive and behavioral avoidance strategies that limit exposure to potentially corrective information that could be incorporated into and alter the fear structure. Successful treatment requires emotional processing of the fear structures in order to modify their pathological elements so that the stimuli no longer invoke fear. Emotional processing first requires accessing and activating the fear structure associated with the traumatic event and then incorporating information that is not compatible with it. Imaginal exposure entails engaging mentally with the fear structure through repeatedly revisiting the traumatic event in a safe environment. In practice, a person with PTSD typically is guided and encouraged by the clinician gradually to *imagine, narrate and emotionally process* the traumatic event within the safe and supportive environment of the clinician's office. 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. Expert treatment guidelines for PTSD published for the first time in 1999 recommended that CBT with PE should be the first-line therapy for PTSD [12]. The comparative empirical support for exposure therapy was also recently documented in a review by the Institute of Medicine at the National Academies of Science (sponsored by the U.S. Department of Veterans Affairs) of 53 studies of pharmaceuticals and 37 studies of psychotherapies used in PTSD treatment [13]. The report concluded that while there is not enough reliable evidence to draw conclusions about the effectiveness of most PTSD treatments, there is sufficient evidence to conclude that exposure therapies are effective in treating people with PTSD.

While the efficacy of imaginal PE has been established in multiple studies with diverse trauma populations, many patients are unwilling or unable to effectively visualize the traumatic event. This is a crucial concern since avoidance of cues and reminders of the trauma is one of the cardinal symptoms of the DSM diagnosis of PTSD. In fact, research on this aspect of PTSD treatment suggests that the inability to emotionally engage (*in imagination*) is a predictor for negative treatment outcomes [14]. To address this problem, researchers have recently turned to the use of Virtual Reality (VR) to deliver exposure therapy (VRET) by immersing clients in simulations of trauma-relevant environments in which the emotional intensity of the scenes can be precisely controlled by the clinician. In this fashion, VRET offers a way to circumvent the natural avoidance tendency by directly delivering multi-sensory and context-relevant cues that evoke the trauma without demanding that the patient actively try to access his/her experience through effortful memory retrieval.

Equally challenging is the fact that stigma and concerns about peer and leadership perceptions of treatment may have a significant impact on whether a SM or veteran will seek care. Hoge et al. [2] reported significant fear of treatment stigma among deployed SMs that was greatest among those most in need of help. Those who screened positive for a mental disorder were twice as likely to report concerns about treatment stigma. In another study, Britt [15] examined the perceived stigma of psychological versus medical problems in SMs returning from a peacekeeping mission to Bosnia, and found that SMs felt more stigmatized when admitting a psychological than a medical problem. This was magnified for SMs returning with their units rather than alone, suggesting that subjective norms influence stigma perceptions. The challenges associated with emotionally engaging with the fear structures as required in PE and the stigma associated with traditional "talk therapies", are significant barriers to optimizing access to care that could be addressed via a VR approach. Within a VR environment, the hidden world of the patient's imagination is not exclusively relied upon and VRET may also offer an appealing, non-traditional treatment approach that is perceived with less stigma by "digital generation" SMs and veterans who may be reluctant to seek out what they perceive as traditional talk therapies.

The first effort to apply VRET began in 1997 when researchers at Georgia Tech and Emory University began testing the *Virtual Vietnam* VR scenario with Vietnam veterans diagnosed with PTSD. This occurred over 20 years after the end of the Vietnam War. During those intervening years, in spite of valiant efforts to develop and apply traditional psychotherapeutic and pharmacological treatment 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 families and friends. This initial effort yielded encouraging results in a case study of a 50-year-old, male Vietnam veteran meeting *DSM* criteria for PTSD [16]. Results indicated post-treatment improvement on all measures of PTSD and maintenance of these gains at a 6-month follow-up; with a 34% decrease in clinician-rated symptoms of PTSD and a 45% decrease on self-reported symptoms of PTSD. This case study was followed by an open clinical trial with Vietnam veterans

[8]. In this study, 16 male veterans with PTSD were exposed to two head-mounted display-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, shouting). 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 were reported by Difede et al. [17] for PTSD that resulted from the attack on the World Trade Center in a case study using VRET with a patient who had failed to improve with traditional exposure therapy. This group has recently reported positive results from a wait-list controlled study using the same World Trade Center VR application [18]. The VR group demonstrated statistically and clinically significant decreases on the "gold standard" Clinician Administered PTSD Scale (CAPS) relative to both pre-treatment and to the wait-list control group with a between-groups post treatment effect size of 1.54. Seven of 10 people in the VR group no longer carried the diagnosis of PTSD, while all of the wait-list controls retained the diagnosis following the waiting period and treatment gains were maintained at 6-month follow-up. Also noteworthy was the finding that five of the 10 VR patients had previously participated in imaginal exposure treatment with no clinical benefit. Such initial results are encouraging and suggest that VR may be a useful component within a comprehensive treatment approach for persons with combat/terrorist attack-related PTSD.

There are also other research groups currently in the early stages of applying VR to treat PTSD in survivors of war and terrorist attacks [19-21]. One research group has reported "partial remission" of PTSD symptoms in four of six Iraq war SMs using VR combined with meditation and attentional refocusing [19]. However, it is difficult to draw any conclusions from this work as the authors did not provide a clear specification or statistical analysis of the pre/post PTSD Checklist-Military version (PCL-M) scores other than to report a baseline PCL-M mean of 47.3, which is actually below the PTSD cutoff of fifty. Another research group in Portugal, where there are an estimated 25,000 survivors with PTSD from their 1961-1974 colonial wars in Mozambique, Angola and Guiné, has constructed a VR exposure scenario by modifying a common PC-based combat game [20]. This group has reported an initial case study where the patient did not complete treatment due to experiencing a distressing flashback following the seventh session. While this is rarely reported in the exposure literature, this report highlights the need for well-trained clinicians with expertise in the delivery of exposure therapy at a rate that the patient can effectively handle and process and in the sensitive monitoring of patient status. Finally, in Israel, Josman et al. [21] are implementing a VR terrorist "bus bombing" PTSD treatment scenario in which participants are positioned in an urban cafe across the street from a site where a civilian bus may explode. This research program has only recently commenced and no clinical data are currently available. However, analog pilot research by this group with non-PTSD participants is underway to examine emotional reactivity across VR exposure levels in order to characterize the evocative nature of the stimulus environment to inform future clinical use (Naomi Josman, personal communication, Dec. 4, 2007).

II. Design of the Virtual Iraq Exposure Therapy System

The University of Southern California's Institute for Creative Technologies (ICT), in collaboration with the authors of this paper, have partnered on a project funded by the Office of Naval Research (ONR), the U.S. Army Research, Development and Engineering Command (RDECOM) and the Telemedicine and Advanced Technology Research Center (TATRC) to develop a series of VR exposure environments known as *Virtual Iraq*. This VR treatment system was originally constructed by recycling virtual art assets that were initially designed for the commercially successful X-Box game and U.S. Army-funded combat tactical simulation trainer, *Full Spectrum Warrior*. Other existing and newly created ICT art and technology assets have been integrated into this continually evolving application and now support the current development of the *Virtual Afghanistan* scenario.

Virtual Iraq consists of Middle Eastern themed city and desert road environments (See Fig. 1) and was designed to resemble the general contexts that most SMs experience during deployment to Iraq. The 18 square block "City" setting has a variety of elements including a marketplace, desolate streets, old buildings, ramshackle apartments, warehouses, mosques, shops and dirt lots strewn with junk. Access to building interiors and rooftops is available and the backdrop surrounding the navigable exposure zone creates the illusion of being embedded within a section of a sprawling densely populated desert city. Vehicles are active in streets and animated virtual pedestrians (civilian and military) can be added or eliminated from the scenes. The "Desert Road" scenarios consist of a roadway through an expansive desert area with sand dunes, occasional areas of vegetation, intact and broken down structures, bridges, battle wreckage, a checkpoint, debris and virtual human figures. The user is positioned inside of a HUMVEE that supports the perception of travel within a convoy or as a lone vehicle with selectable positions as a driver, passenger or from the more exposed turret position above the roof of the vehicle. The number of soldiers in the cab of the HUMVEE can also be varied as well as their capacity to become wounded during certain attack scenarios. Both the city and HUMVEE scenarios are adjustable for time of day or night, weather conditions, night vision, illumination and ambient sound (wind, motors, city noise, prayer call, etc.). The software has been designed such that users can be teleported to specific locations within the virtual scenarios, based on a determination as to which elements most closely match the patient's needs, relevant to their individual trauma-related experiences. As well, we now have created visual elements that can be selected to resemble both USA and Afghanistan scenery/architecture to broaden the relevance of the application for a wider range of SMs.

Users can navigate in both scenarios via the use of a standard game pad controller, although we have recently added the option for a replica M4 weapon with a "thumb-mouse" controller that supports movement during the city foot patrol. This was based on repeated requests from Iraq experienced SMs who provided frank feedback indicating that to walk within such a setting without a weapon in-hand was completely unnatural and distracting! However, there is no option for firing a weapon within the VR scenarios. It is our firm belief that the principles of exposure therapy are incompatible with the cathartic acting out of a revenge fantasy that a responsive weapon might encourage. In addition to the visual stimuli presented in the VR Head-Mounted Display (HMD), directional 3D audio, vibrotactile and olfactory can be delivered into the VR scenarios in real-time by the clinician.

Figure 1. Scenes from Virtual Iraq and Virtual Afghanistan

The presentation of additive, combat-relevant stimuli in the VR scenarios can be controlled via a separate "Wizard of Oz" control panel, while the clinician is in full audio contact with the patient. This clinical "interface" is a key feature that provides a clinician with the capacity to customize the therapy experience to the individual needs of the patient. The patient can be placed by the clinician in VR scenario locations that resemble the setting in which the trauma-relevant events occurred and modify ambient light and sound conditions to match the patients description of their experience. The clinician can then gradually introduce and control real time trigger stimuli (visual, auditory, olfactory and tactile), via the clinician's interface, as required to foster the anxiety modulation needed for therapeutic habituation and emotional processing in a customized fashion according to the patient's past experience and treatment progress. Equipment specifications for the *Virtual Iraq* system have been detailed previously [22,23].

III. Virtual Iraq Research Results

The *Virtual Iraq* scenario is currently being implemented as an exposure therapy tool with active duty SMs and Veterans at the National Center for Telehealth and Technology at Madigan Army Medical Center (T2-MAMC) at Ft. Lewis, WA., the Naval Medical Center-San Diego (NMCSD), Camp Pendleton, Emory University, Walter Reed Army Medical Center (WRAMC), the Weill Medical College of Cornell University and at 24 other VA, Military and University Laboratory sites for VRET clinical research and a variety of other PTSD-related investigations. However, the user-centered design process for optimizing Virtual Iraq for clinical use is noteworthy and will be described before summarizing the results of the initial VRET open clinical trial.

A. User-Centered Feedback from Non-PTSD Service Members

User-Centered tests with early prototypes of the *Virtual Iraq* application were conducted at the NMCSD and within an Army Combat Stress Control Team in Iraq. This formative feedback from non-diagnosed Iraq-experienced military personnel provided essential information that fed an iterative design process on the content, realism and usability of the initial "intuitively designed" system. More formal evaluation of the system took place at T2-MAMC from late 2006 to early 2007 [24]. Ninety-three screened SMs (all non-PSTD) evaluated the *Virtual Iraq* scenarios shortly after returning from deployment in Iraq. SMs experienced the city and HUMVEE environments while exposed to scripted researcher-initiated VR trigger stimuli to simulate an actual treatment session. SMs then completed standardized questionnaires to evaluate the realism, sense of "presence" (the feeling of being in Iraq), sensory stimuli, and overall technical capabilities of *Virtual Iraq*. Items were rated on a scale from 0 (Poor) to 10 (Excellent). Qualitative feedback was also collected to determine additional required software improvements. The results suggested that the *Virtual Iraq* environment in its form at the time was realistic and provided a good sense of "being back in Iraq". Average ratings across environments were between adequate and excellent for all evaluated aspects of the virtual environments. Auditory stimuli realism (M=7.9; SD=1.7) and quality (M=7.9; SD=1.8) were rated higher than visual realism (M=6.7; SD=2.1) and quality (M=7.0; SD=2.0). Soldiers had high ratings of the computer's ability to update visual graphics during movement (M=8.4; SD=1.7). The eMagin HMD was reportedly very comfortable (M=8.2; SD=1.7), and the average ratings for the ability to move within

the virtual environment was generally adequate or above (M=6.1; SD=2.5). This data, along with the collected qualitative feedback, was used to inform upgrades to the current version of *Virtual Iraq/Afghanistan* that is now in clinical use and this "design-collect feedback-redesign" cycle will continue throughout the lifecycle of this project.

B. Service Member Acceptance of VR in Treatment

The user-centered results indicated that *Virtual Iraq* was capable of producing the level of "presence" in Iraq-experienced SMs that was believed to be required for exposure therapy. However, successful clinical implementation also requires patients to accept the approach as a useful and credible behavioral health treatment. To address this issue, a survey study with 325 Army SMs from the T2-MAMC deployment-screening clinic was conducted to assess knowledge of current technologies and attitudes towards the use of technology in behavioral healthcare [25]. One section of the survey asked these active duty SMs to rate on a 5-point scale how willing they would be to receive mental health treatment ("Not Willing at All" to "Very Willing") via traditional approaches (e.g. face-to-face counseling) and a variety of technology-oriented delivery methods (e.g. website, video teleconferencing, use of VR). Eighty-three percent of participants reported that they were neutral-to-very willing to use some form of technology as part of their behavioral healthcare, with 58% reporting some willingness to use a VR treatment program. Seventy-one percent of SMs were equally or more willing to use some form of technological treatment than solely talking to a therapist in a traditional setting. Most interesting is that 20% of SMs who stated they were not willing to seek traditional psychotherapy rated their willingness to use a VR-based treatment as neutral to very willing. One possible interpretation of this finding is that a subgroup of this sample of SMs with a significant disinterest in traditional mental health treatment would be willing to pursue treatment with a VR-based approach. It is also possible that these findings generalize to SMs who have disengaged from or terminated traditional treatment.

C. Results from an Open Clinical Trial using Virtual Iraq at the NMCSD

The *Virtual Iraq* system built from this user-centered design process has been tested in an open clinical trial with PTSD-diagnosed active duty SMs at NMCSD and Camp Pendleton. The Office of Naval Research funded the initial system development of *Virtual Iraq* along with this initial trial to evaluate the feasibility of using VRET with active duty participants. The participants were SMs who recently redeployed from Iraq and who had engaged in previous PTSD treatments (e.g., group counseling, pharmacological approaches, etc.) without benefit. The standard treatment protocol consisted of 2X weekly, 90-120 minute sessions over five weeks that also included physiological monitoring (heart rate, Galvanic skin response and respiration) as part of the data collection. However, in this open clinical trial, elements of the protocol were occasionally modified (i.e., adjusting the number and timing of sessions) to meet patients' needs and thus these data represent an uncontrolled feasibility trial. The VRET exposure exercises followed the principles of graded prolonged behavioral exposure and the pace was individualized and patient-driven. The first VRET session consisted of a clinical interview that identified the index trauma, provided psychoeducation on trauma and PTSD, and instruction on a deep breathing technique for general stress management purposes. The second session provided instruction on the use of Subjective Units of Distress (SUDS), the rationale for prolonged exposure (PE), including imaginal exposure and in-vivo exposure. The participants also engaged in their first experience of imaginal exposure of the index trauma and an in-vivo hierarchical exposure list was constructed, with the first item assigned as homework. Session three introduced the rationale for VRET and the participant experienced the VR environment without recounting the index trauma narrative for approximately 25 minutes with no provocative trigger stimuli introduced. The purpose of not recounting the index trauma was to allow the participant to navigate Virtual Iraq in an exploratory manner and to function as a "bridge session" from imaginal alone to imaginal exposure combined with virtual reality. Sessions four through ten focused on the participant engaging in the VR while recounting the trauma narrative. Generally, when participants were putting on the HMD, they were instructed that they would be asked to recount their trauma in the first person, as if it were happening again with as much attention to sensory detail as they could provide. Using clinical judgment, the therapist might prompt the patient with questions about their experience or provide encouraging remarks as deemed necessary to facilitate the recounting of the trauma narrative. The treatment included homework, such as requesting the participant to listen to the audiotape of their exposure narrative from the most recent session. Listening to the audiotape several times over a week functioned as continual exposure for processing the index trauma to further enhance the probability for habituation to occur. In-vivo hierarchy exposure items were assigned in a sequential fashion, starting with the lowest rated SUD item. A new item was assigned once the participant demonstrated approximately a 50% reduction of SUDs ratings on the previous item. Self-report measures were obtained at baseline and prior to sessions 3,5,7,9,10 and one week and three months post treatment to assess in-treatment and follow-up symptom status. The measures used were the PTSD Checklist-Military Version (PCL-M) (Blanchard et al., 1996), Beck Anxiety Inventory (BAI) (Beck et al., 1988) and Patient Health Questionnaire-Depression (PHQ-9) (Kroenke & Spitzer, 2002).

Initial analyses of results from the first 20 *Virtual Iraq* treatment completers (19 male, 1 female, Mean Age=28, Age Range: 21-51) have indicated positive clinical outcomes. For this sample, mean pre/post PCL-M scores decreased in a statistical and clinically meaningful fashion; Mean (standard deviation) values went from 54.4 (9.7) to 35.6 (17.4). Paired pre/post t-test analysis showed these differences to be significant ($t=5.99$, $df=19$, $p < 0.001$). Correcting for the PCL-

M no-symptom baseline of 17 indicated a greater than 50% decrease in symptoms and 16 of the 20 completers no longer met DSM criteria for PTSD at post treatment. Five participants in this group with PTSD diagnoses had pretreatment baseline scores below the conservative cutoff value of 50 (prescores= 49, 46, 42, 36, 38) and reported decreased values at post treatment (postscores= 23, 19, 22, 22, 24, respectively). Individual participant PCL-M scores at baseline, post treatment and 3-month follow-up are in Fig. 2. For this same group, mean Beck Anxiety Inventory scores significantly decreased 33% from 18.6 (9.5) to 11.9 (13.6), ($t=3.37$, $df=19$, $p < 0.003$) and mean PHQ-9 (depression) scores decreased 49% from 13.3 (5.4) to 7.1 (6.7), ($t=3.68$, $df=19$, $p < 0.002$). The average number of sessions for this sample was just under 11. Also, two of the successful treatment completers had documented mild and moderate traumatic brain injuries, which suggest that this form of exposure can be usefully applied with this population. In spite of these initial positive results for treatment completers, challenges existed with dropouts from this active duty sample. Seven participants who were assessed and approved for the study failed to appear at the first session, six attended the first session and dropped out prior to formal commencement of VRET at session four, and seven dropped out at various points following session four. While some of these active duty participants left due to transfers and other reasons beyond their control, these dropout numbers are concerning and we intend to examine all data gathered from this subset of the total sample to search for discriminating factors.

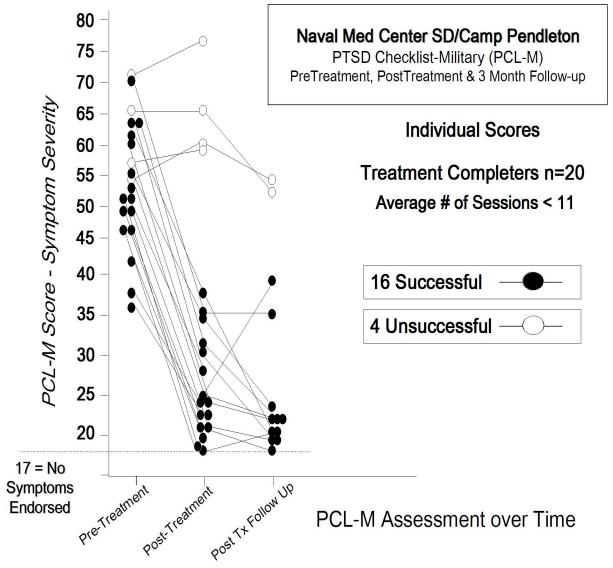

Figure 2. PTSD Checklist scores across treatment

D. *Results from a Non-randomized Standard of Care Clinical Comparison using Virtual Iraq at T2-MAMC*

As a precursor to conducting a randomized controlled trial to compare VRET with imaginal exposure and a wait-list control sample, the data from a preliminary open clinical trial conducted at T2-MAMC using *Virtual Iraq* was compared with results from a Group Cognitive Behavioral Therapy (CBT) program of similar length. This quasi-experimental design comparison did not include random assignment to groups and was conducted as part of an ongoing TATRC funded project to assess VRET in reference to an existing standard of care approach. The same VRET protocol was used as in the NMCSD study (see *Section III.C*), with some notable exceptions. This VRET group consisted of patients who were either imaginal PE non-responders or those who specifically sought VR treatment, the sessions were weekly (compared to twice weekly), and the total number of sessions could vary depending on progress (ranging from 5-11). By contrast, the CBT group employed a psychoeducational and skills based approach and consisted of patients who were unwilling to participate in individual trauma-focused treatment (e.g., PE, CPT, EMDR). CBT group treatment generally consisted of 11 weekly 90-minute sessions, but the total number could vary depending on progress (ranging from 7-14).

Initial analyses indicated that the VRET group (n=13) reported significant post-treatment reductions in PTSD symptoms with mean pre/post PCL-M values going from 59.8 to 43.0; $p < 0.0005$). Sixty-two percent reported a clinically meaningful reduction in symptoms, as characterized by a 10-point or greater reduction on the PCL-M [29], and the number of treatment sessions averaged 8.3. The CBT group (n=7) showed a lesser, but still significant improvement, with mean pre/post PCL-M values going from 63.7 to 56.8; $p < 0.05$). However, only 28% of patients demonstrated a clinically meaningful reduction in symptoms, in contrast to the 62% found in the VRET sample (see Fig. 3).

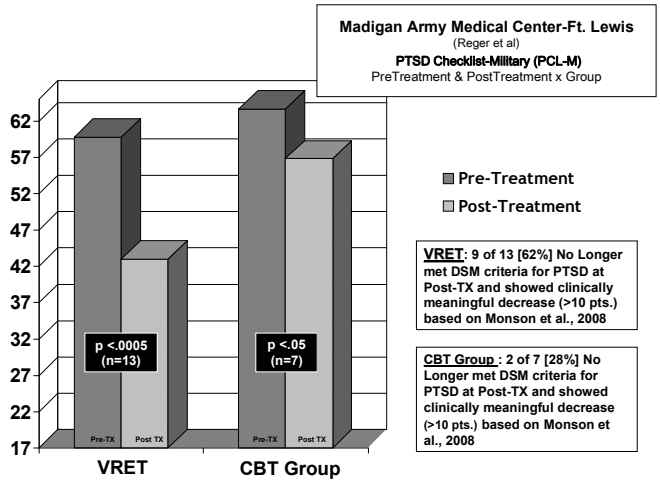

Figure 3. T2-MAMC PTSD Checklist scores across treatment

IV. Conclusions

Results from uncontrolled trials and case reports are difficult to generalize from and we are cautious not to make excessive claims based on these early results. However, using accepted diagnostic measures, 80% of the treatment completers in the NMCSD VRET sample showed both statistically and clinically meaningful reductions in PTSD, anxiety and depression symptoms, and anecdotal evidence

from patient reports suggested that they saw improvements in their everyday life situations. These improvements were also maintained at three-month post-treatment follow-up. Based on this initial open clinical trial and the quasi-experimental standard of care comparison at T2-MAMC, we are encouraged by these early successes and continue to gather feedback from patients regarding the therapy and the *Virtual Iraq* environment. The system is currently being updated with added functionality that has its design "roots" from feedback acquired from these initial patients and the clinicians who have used the system thus far. These findings will be used to develop, explore and test hypotheses as to how we can improve treatment and also determine what patient characteristics may predict who will complete and benefit from VRET and who may be best served by other approaches.

It should be noted that in spite of these initial positive results for treatment completers, challenges existed with treatment attrition in the NMCSD active duty population. Seven participants who were assessed and approved for the study failed to appear at the first session, six attended the first session and dropped out prior to formal commencement of VRET, and seven dropped out at various points following the start of VRET proper in session four. While some of these active duty participants left due to transfers and other reasons beyond their control, these dropout numbers are concerning and we are in the process of examining all data from this subset of the total sample to search for discriminating factors.

Such treatment attrition rates need to be viewed in the context of research that suggests there is an urgent need to reduce the stigma of seeking mental health treatment in military populations. For example, one of the more foreboding findings in the Hoge et al., [2] 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, a VR system for PTSD treatment could serve as a component within a reconceptualized approach to how treatment is accessed by SMs and veterans returning from combat. Perhaps VR exposure could be embedded within the context of "post-deployment *reset* training" whereby the perceived stigma of seeking treatment could be lessened as the soldier would simply be involved in this "training" in similar fashion to other designated duties upon redeployment stateside. VRET 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 VRET as an alternative to what is perceived as traditional "talk therapy".

The current clinical research and development program with the *Virtual Iraq* application is also providing important knowledge for determining the feasibility of expanding the range of applications that can be created from this system to address other scientific questions. For example, following a similar design process, we have now created a *Virtual Afghanistan* themed scenario that has more mountainous terrain and relevant building architecture. During the course of the ongoing R&D evolution of this application, our design approach has always focused on the creation of a flexible VR system/tool that could address *both* clinical and scientific PTSD research questions in a more comprehensive fashion. In this regard, we aim to repurpose the *Virtual Iraq* and *Virtual Afghanistan* applications as tools to investigate other clinical and scientific questions including:

- the feasibility of assessing soldiers prior to deployment to predict potential risk for developing PTSD or other mental health problems based on physiological reactivity to a series of virtual combat engagements.
- stress inoculation training to psychologically prepare military personnel for what might occur in real combat.
- the effectiveness of using VR as an assessment tool immediately upon redeployment to determine who may be "at risk" for developing full-blown PTSD after an incubation period. Physiological reactivity could figure well as a marker variable for this project and a prospective longitudinal study is needed in this area. This is particularly important for maximizing the probability that a soldier at risk would be directed into a "reset" program before being sent on a 2nd or 3rd deployment.
- differences among National Guard, reservist personnel, Army/Navy/Marine/Air Force standing military SMs and veterans in terms of their susceptibility for developing PTSD and if variations in the course of treatment would be required. This is also relevant for the study of PTSD treatment response differences due to multiple deployments, age, gender, education, family support, and previous civilian exposure to trauma.
- the neuroscience of PTSD via the use of brain imaging, traditional physiological measurement (e.g., electroencephalography, heart rate) and other responses (e.g., eye blink, startle response) by leveraging the high controllability of stimulus presentation that is available within the *Virtual Iraq/Afghanistan* applications.
- the interaction effects of the use of VR exposure in combination with pharmacological treatments (e.g., D-

cycloserine). Randomized controlled trials comparing VRET alone and VRET+D-cycloserine are in progress at Emory University and at the Weill Cornell Medical College after successful results were reported with VRET+D-cycloserine for treating fear of heights [30].

- expansion of the functionality of our existing system based on the results of ongoing and future research. This will involve refining the system in terms of the breadth of scenarios/trigger events, the stimulus content and the level of Artificial Intelligence of virtual human characters that "inhabit" the system.

Finally, a guiding principle in the development of *Virtual Iraq* concerns how novel VR systems can extend the skills of a well-trained clinician. VR exposure therapy is not intended to be an automated treatment or 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 with a professional appreciation of the complexity and impact of this disorder.

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