

## Case Study

# Combat-Related Post-Traumatic Stress Disorder: A Case Report Using Virtual Reality Exposure Therapy with Physiological Monitoring

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### ABSTRACT

The current report summarizes a case study from an Office of Naval Research (ONR) funded project to compare the effects of virtual reality graded exposure therapy (VRGET) with cognitive behavioral group therapy in active-duty corpsmen. Details of the collaborative program between the Virtual Reality Medical Center (VRMC) and Naval Medical Center San Diego (NMCS) will be discussed.

### INTRODUCTION

POST-TRAUMATIC STRESS DISORDER (PTSD) is one of the most serious psychological conditions affecting the active duty and veteran populations. Among active duty Army and Marine Corps personnel who participated in combat during Operation Iraqi Freedom or Operation Enduring Freedom, 11.2–17% met screening criteria for major depression, generalized anxiety disorder or PTSD.<sup>1</sup> Recently, Grieger et al.<sup>2</sup> reported that 12% of U.S. soldiers hospitalized following serious combat injury in Iraq were diagnosed with PTSD at 7 months following hospitalization. It is also expected that the rate of PTSD will be higher among troops who have been to Iraq more than once.<sup>3</sup> It has been recommended that specific screening for PTSD among

military personnel who have been deployed to combat areas and reducing barriers to care among military personnel is a priority for research and a priority for policy makers, clinicians, and leaders who are involved in providing care to those who have served in the armed forces.<sup>1</sup>

Early treatment is imperative in order to maintain personnel on active duty and to reduce the future burden the VA healthcare system. It has been estimated that 830,000 Vietnam veterans have been experiencing chronic combat-related PTSD.<sup>4</sup> The National Vietnam Veterans Readjustment Study (NVVRS) estimated that 30.9% of Vietnam veterans had developed PTSD during their lifetimes and that 15% were currently suffering from PTSD.<sup>5</sup> The Department of Veterans Affairs has reported that 31% of male Vietnam Veterans and 27% of female Vietnam

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Veterans have suffered from PTSD at some point after return from the war.<sup>6</sup> In 2001, more than 773,000 veterans were treated for PTSD by VA specialists.<sup>7</sup>

Several studies have demonstrated statistically significant effects utilizing imaginal exposure for reducing PTSD and related pathology in male Vietnam Veterans.<sup>8-10</sup> Other research has suggested that virtual reality exposure (VRE) therapy is an effective new medium of exposure therapy for treating veterans with PTSD.<sup>4,11</sup> Rothbaum et al.<sup>4</sup> reported that 10 male patients with Vietnam combat-related PTSD were exposed to 8-16 sessions of virtual reality therapy. Eight patients completed the treatment protocol. Six months following the completion of treatment, the patients demonstrated a statistically significant reduction from baseline in symptoms associated with PTSD. At the 6-month follow-up, all eight patients reported reductions in PTSD symptoms ranging from 15% to 67%. Rothbaum et al.<sup>4</sup> concluded that VRE should be considered as promising for the treatment of PTSD in Vietnam veterans.

Using computer technology, VRE therapy integrates real-time computer graphics, body-tracking devices, visual displays, psycho-physiological measures, and other sensory input devices to immerse a patient in a computer-generated virtual environment and to monitor the patient's physiological responses.<sup>12-15</sup> Typically the non-invasive physiological measures included peripheral skin temperature, heart rate, respiration, and skin conductance.<sup>12-15</sup> The advantages of VRE include conducting exposure therapy without leaving the therapist's office, exactly controlling exposure stimuli and exposing the patient to less risk of harm or embarrassment.<sup>4,12</sup>

Virtual Reality Medical Center (VRMC) has been awarded an Office of Naval Research (ONR) grant to complete a randomized study at Naval Medical Center San Diego (NMCS D) comparing the effects of virtual reality graded exposure therapy (VRGET) therapy with cognitive behavioral group therapy on active-duty personnel. The VRE system utilized by VRMC relies on both graded or gradual exposure on both visual and auditory presentations. VRMC has developed a VRE package that can run on two computers: one that displays the visual and auditory displays to the patient through VR goggles, with built-in headphones, and a second system which has the control panel and menu which the therapist can use to add arousal elements into the VRE environment (e.g., various combat events and combat background sounds, vehicle sounds, various household sounds, sounds of people conversing, music sounds). A third computer is used to run the physiological monitoring and feedback system.

The cognitive behavioral therapy is being conducted by a clinical psychologist who is a staff member of the Department of Psychiatry, NMCS D. A component of the ONR-funded research project is to complete a pilot study of VRE therapy provided to eight patients diagnosed with combat PTSD secondary to a tour of duty in Iraq or Afghanistan. Each pilot study patient will receive 10 sessions of VRE treatment.

The following is a report of the VRGET therapy with the first patient who was a member of this pilot study.

## METHODS

### *Participant*

One male volunteer, a Second Class Petty Officer and Corpsman, and a patient at NMCS D, met the study criteria for participation and began VRGET treatment. This patient met the DSM-IV<sup>16</sup> criteria for chronic PTSD. This patient's co-morbid diagnoses included Adjustment Disorder with Anxiety and Depressed Mood; Major Depressive Disorder; Partner Relationship Syndrome; Post-Concussion Syndrome secondary to a Terrorist Explosion Blast; Cervical Spondylosis (C5-C6); Cervicalgia; Carpal Tunnel Syndrome; Hypertension; and Hyperlipidemia. The patient's age was 32 years, with 12 years of continuous active duty. His psychotropic medications, at the time of the study, included bupropion hydrochloride (150 mg/qd; Wellbutrin SR); Risperidone (0.25 mg/qhs); Escitalopram Oxalate (20 mg/qam); and Zolpidem Tartrate (5 mg/qhs). This patient had been stable on these psychotropic medications for 6 months prior to his starting VRGET treatment.

The patient had served in combat operations in Iraq, as a Corpsman attached to a U.S. Marine Corps battalion; he was exposed to heavy combat exposure as measured by the Combat Exposure Scale.<sup>17</sup> Additionally, during his combat tour, the patient was exposed to an Improvised Explosive Device (IED) blast that was detonated underneath the Humvee he was driving. This patient has received a Purple Heart for the injuries he received secondary to this IED blast. This patient has completed the 10 required VRGET treatment sessions.

### *Procedure*

This patient was referred to the VRGET treatment, at NMCS D, by a Navy psychiatrist (R.M.), and he was interviewed by a research assistant (J.M.). Once the patient was deemed potentially

eligible, he was provided additional information about the treatment study, and he was asked to provide informed consent.

After consent was obtained, a pre-treatment evaluation was conducted by the research assistant (J.M.), and a psychiatrist (R.M.) reviewed this evaluation as well the inclusion (currently meeting PTSD diagnostic criteria, manageable suicidal ideation, absence of homicidal ideation, absence of substance abuse, and stable psychotropic medication) and exclusion criteria (i.e., current suicidal ideation, current homicidal ideation, current substance abuse, and unstable response to psychotropic medication). The psychiatrist (R.M.) also explained to the patient the procedures of the project in detail. The research assistant (J.M.) scheduled the initial treatment session with the clinical psychologist (D.P.W.). The patient's evaluation was completed utilizing the instruments listed below.

#### *Clinical measurement instruments*

The following clinician-rated and self-report measures of PTSD were incorporated: Mini Neuropsychiatric Interview,<sup>18</sup> the PTSD Checklist Military Version (PCL-M),<sup>19</sup> the Patient Health Questionnaire-9 (PHQ-9),<sup>20</sup> the Beck Anxiety Inventory (BAI),<sup>21</sup> the Combat Exposure Scale,<sup>17</sup> and the Blast Assessment.<sup>22</sup> Additionally, psychophysical measures were obtained with skin conductance, finger temperature, respiration rate, and heart rate. These psychophysical measures were obtained during a 5 min baseline or rest period, during 5 min of a mental stressor, and during 5 min of a recovery period. During the mental stressor, the patient is asked to recall "the most disturbing memory from their recent deployment." The patient recalls the memory aloud for the first minute and then is instructed to think about the memory for the next 4 min.

Full assessments were conducted at pre-treatment, mid-treatment (i.e., following five sessions of treatment), and post-treatment (i.e., following 10 sessions of treatment).

#### *Equipment*

The VRGET system, utilized by this patient, relied on visual and auditory presentation. The VRGET package ran on two computers: one that displayed the visual and auditory displays to the patient through VR goggles with built-in headphones, and a second system which had the control panel and menu which the therapist (D.P.W.) used to add arousal elements into the VRGET environment

(e.g., various combat events and combat background sounds, vehicle sounds, various household sounds, sounds of people conversing, music sounds, etc.). A third computer was used to run the J&J Engineering physiological monitoring (i.e., skin conductance, finger temperature, respiration rate, heart rate) and feedback system (J&J Engineering, Inc., Poulsbo, WA). Importantly, computer graphics images and spatial audio, consistent with the orientation and position of the patient's head, were computed in real time as the patient experienced and explored each environment. All environments were immersive (i.e., the patient experienced only the computer-generated audio and visual stimuli while "real-world" stimuli were shut out). Therapist communications with the patient were via hand pre-arranged signals/hand pressure on the patient's left shoulder.

The patient sat in a chair that could rotate 360 degrees in order for him to be able to move where he chose to go. The patient "walked" in the environment or "drove" a Humvee in the environment by pushing a button on the hand-held joy-stick. The patient "fired" the M-16 rifle by depressing another button on the hand-held joy-stick. Audio, head-tracking, and real-time graphics were computed on two PCs with a 2.0-MHz Intel Pentium Core Duo Processor (Dell, Round Rock, TX), 1-G RAM, and an nVidia 7900 GTX 512-MB graphics card (nVidia, Santa Clara, CA). The Physiological measures were computed on a portable PC with a 1.7-MHz Intel Centrino Processor (Dell), 256 RAM, and the J&J Engineering I-330-C2 Hardware and software (J&J Engineering, Inc.). All of the physiological assessments (i.e., skin conductance, finger temperature, respiration rate, and heart rate) were recorded and stored on the portable PC utilizing the J & J Engineering Hardware and software. The Virtual Baghdad software and environment models were custom-built (to run on a PC) by VRMC (San Diego, CA) using 3D game technology and incorporating information from focus groups and suggestions from Navy and Marine Corps combat veterans who were deployed to Iraq or Afghanistan.

#### *Treatment*

Treatment was typically delivered in ten 90-min individual sessions conducted one time each week by one of the authors (D.P.W.). Sessions 1 and 2 were focused on orienting and introducing the patient to the process and method of meditation as an intervention that could facilitate emotional, cognitive, and physical relaxation. To maintain consistency with meditation training and practice, a two

computer disc meditation training program was played for and given to the patient (Jon Cabot Zinn & Andrew Weil, *Meditation for Optimum Health*, Sounds True, Boulder, CO). Additionally, during the first two sessions, the patient was asked to discuss his PTSD symptoms, he was asked to "tell his story about his sentinel event during his combat tour," the therapist discussed PTSD as a normal response to an abnormal situation. The therapist also discussed the goal of VRGET treatment was to help the patient gain control over his intrusive thoughts and feelings and to learn to tolerate events or stimuli that currently bothered him. Lastly, during the first two sessions, the patient was taught the principles of attentional re-training (i.e., whatever the patient pays attention to, they will enhance; if the patient pays attention to thoughts and feelings that are uncomfortable, they will enhance those uncomfortable thoughts and feelings; if they focus on comfortable sensations in the moment or to the work in front of them, and/or while in the VRGET environment, he will enhance those activities). During 20 min of the treatment session, the patient's physiological status was monitored in order to discover what type of activity or positive mental images worked best for him.

During sessions 2–10, the patient applied their skill with meditation, increased physiological control and attentional refocusing within the VR environment. The 90-min treatment sessions were divided as follows: 20-min review of treatment progress during the previous week, success with meditation, and attentional refocusing; 20-min additional training with meditation and attentional refocusing; and 20-min of VRGET and 20-min of debriefing following formal VRGET. The 20 min of VRGET included time to allow the patient to get used to a safe area in the VR; movement to the various areas in the VR environment during which arousal elements were increased with the patient being instructed to utilize his meditation skills and attentional refocusing to calm his mind and body. The debriefing period was utilized to ask the patient about their experience in the VR, feedback was given to the patient about what was observed on the physiological monitoring, and the patient was encouraged to use his skills in the context of his life every day. Lastly, plans for the subsequent VRGET session were discussed with the patient. The patient was encouraged to practice his meditation and attentional refocusing daily, and to apply these skills whenever arousing stimuli intruded into their thoughts, feelings, and activities.

Self-ratings of subjective units of discomfort (SUDS) from 0 to 100 were elicited from the patient

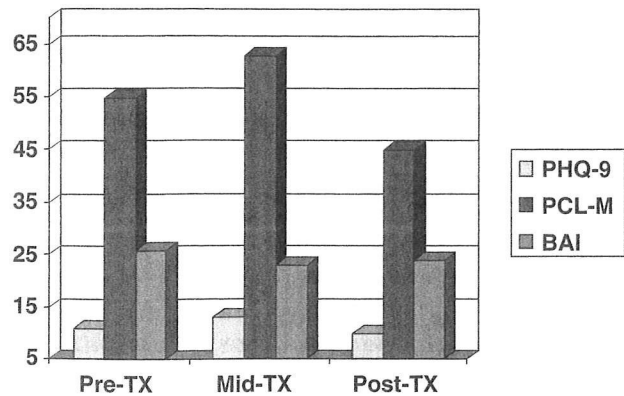


FIG. 1. Results of PHQ -9, PCL-M and BAI at Pre-treatment, Mid-treatment and Post-treatment Assessments (N = 1)

every 5 min during VRGET exposure. The therapist simultaneously viewed on the two video monitors all of the VEs with which the patient was interacting as well as the video monitor summarizing his physiological responses and, therefore, was able to comment appropriately and to encourage continued exposure until the patient's arousal habituated.

## RESULTS

Figure 1 contains the pre-treatment, mid-treatment and post-treatment scores for the three self-administered psychological questionnaires (i.e., PHQ-9, PCL-M, and BAI) completed by the patient. On both the PHQ-9, which measured the presence of depression, and the BAI, which measured the presence of anxiety, the patient consistently scored in the "moderate" range during all three assessments. However, on the self-report of intrusive PTSD symptoms, as measured by the PCL-M, the patient's scores indicated the presence of a formal PTSD (i.e., score equal to/greater than 50) diagnosis at both the pre-treatment and mid-treatment assessment periods. However, his PCL-M score reduced during the last 5 sessions of VRGET treatment and following 10 VRGET sessions, the patient's score was below the PCL-M "strict" criteria for a PTSD diagnosis.

Figures 2–4 contain the pre-treatment, mid-treatment and post-treatment scores on three of the physiological measures (i.e., skin conductance, peripheral temperature, and heart rate). The general trend, as evidenced by the patient's skin conductance (Fig. 2), showed decreased arousal during the recall stressor at the end of the treatment. In addition, at the end of treatment the patient no longer

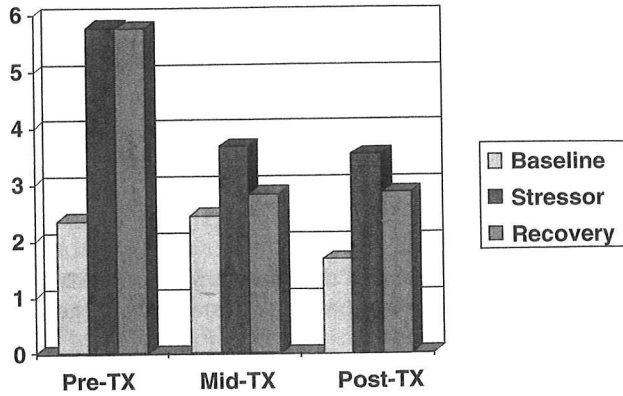


FIG. 2. Physiological Assessment of Skin Conductance (MicroMhos per second) at Pre-Treatment, Mid-Treatment and Post-Treatment (N = 1)

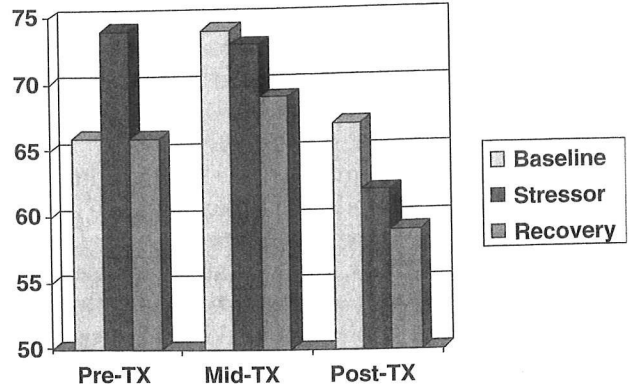


FIG. 4. Physiological Assessment of Heart Rate (Beats per Minute) at Pre-Treatment, Mid-Treatment and Post-Treatment (N = 1)

sustained arousal during the recovery period following a recall stressor. At the end of treatment the patient's peripheral temperature (Fig. 3) was highest during the recovery period following the mental stressor. This trend of increased temperature following the mental stressor suggested that the patient is less aroused after the mental stressor by the end of the treatment protocol. The patient's heart rate (Fig. 4) also showed a trend of decreased arousal during the recall stressor at the end of the treatment due to the finding that the patient was not as aroused during the recall stress condition. Furthermore, at the end of the treatment, the patient's heart rate was lowest during the recovery phase after the recall stressor. This finding suggested that the patient was now better able to reduce his arousal after the recall stress condition. These physiological findings suggested that the

patient had been able to achieve increased habituation by the termination of VRGET treatment.

DISCUSSION

VRGET led to measurable reductions in reported difficulties with PTSD and was well tolerated by our patient. Our patient, as has been previously reported with VRGET therapy, reported having become emotionally engaged in the graded exposures of the VR simulations.<sup>12-15</sup> He also reported that the VRGET combat simulations, which spanned safe simulations to combat simulations, assisted his skills with "attentional refocusing" and also assisted the development of his meditation skills. Of note, during the early phase of VRGET, the patient would require 1-2 h of personal decompressing following his treatment (i.e., took a 1-2-hour walk in the park), while during the second half of VRGET the patient was no longer "having" to take this 1-2-h decompressing period, but was sometimes taking a walk, following a VRGET session, in order to enjoy his time outside.

Based upon previous research which documented that combat veterans diagnosed with PTSD continued to reduce their difficulties with PTSD following the termination of treatment,<sup>11</sup> we expect that our patient would continue to improve his ability to more effectively manage his PTSD symptoms following the termination of treatment (i.e., following treatment session 10). Hence, our patient has been continued in VRGET and will soon be completing session 20 of VRGET. We look forward to presenting the results from the patient's post VRGET session 20 psychological questionnaires and physiological assessment in the not too distant

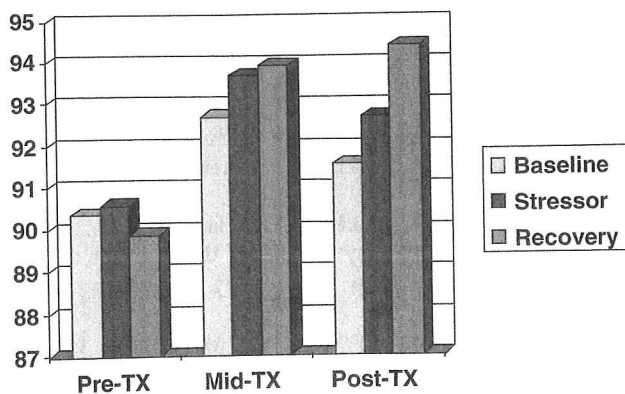


FIG. 3. Physiological Assessment of Peripheral Temperature (Degrees Fahrenheit) at Pre-Treatment, Mid-Treatment and Post-Treatment (N = 1)

future. More importantly, we look forward to the patient's report that his subjective quality of life has improved and he has attained increased skills with habituation and being able to engage in active and positive attentional refocusing.

We must caution that there are obvious limitations to the generalizability of these results to other PTSD treatment populations at other medical centers, military or civilian. Our case study focused on selective psychological questionnaires and physiological assessment, utilized one VRGET program and also utilized a single meditation training stimulus. Additionally, the positive effect of the therapeutic zeal, as demonstrated by the team of therapists who enjoyed the privilege of working with the patient who was the focus of this case study, on the treatment outcomes cannot be measured. However, we hope that such positive therapeutic zeal remains a constant not only in our treatment program at NMCSD but among staff of other programs providing treatment and consultation to Sailors, Marines and Soldiers who have been diagnosed with combat-related PTSD. Further we believe, as has been previously reported,<sup>4,11</sup> that VRE therapy or VRGET should be a component of a comprehensive treatment program for individuals diagnosed with combat-related PTSD.

In summary, the ONR treatment development grant was successful in fostering the creation of a new virtual reality exposure therapy for veterans of the War on Terror who have been diagnosed with combat-related PTSD. A compelling, therapeutic effective and immersive virtual environment was successfully developed to be run on a turnkey PC by a therapist who does not have to be knowledgeable or skilled with computer/video games. A treatment manual has been developed describing the VRGET, and one patient has been successfully treated in a pilot study trial, leading to clinically measurable habituation of physiological responses and reductions in PTSD symptoms. Four additional patients, enrolled in the pilot study, have initialized VRGET and a controlled study, with a randomized design of assigning patients to VRGET and to traditional cognitive behavioral group therapy, is planned at Naval Medical Center San Diego.

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