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Lessons Learned from 350 Virtual-Reality Sessions with Warriors Diagnosed with Combat-Related Posttraumatic Stress Disorder

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Abstract

Virtual-reality (VR) therapy has been distinguished from other psychotherapy interventions through the use of computer-assisted interventions that rely on the concepts of "immersion," "presence," and "synchrony." In this work, these concepts are defined, and their uses, within the VR treatment architecture, are discussed. VR therapy's emphasis on the incorporation of biofeedback and meditation, as a component of the VR treatment architecture, is also reviewed. A growing body of research has documented VR therapy as a successful treatment for combat-related Posttraumatic Stress Disorder (PTSD). The VR treatment architecture, utilized to treat 30 warriors diagnosed with combat-related PTSD, is summarized. Lastly, case summaries of two warriors successfully treated with VR therapy are included to assist with the goal of better understanding a VR treatment architecture paradigm. Continued validation of the VR treatment model is encouraged.

Introduction

> We really need to do for our Soldiers and families what we do for our helicopters and Strykers … We bring those things back and we strip down every nut and bolt, we pull the power train and we go through that thing and we retest it … We ought to be doing that with every Soldier starting with the brigade and battalion commanders and sergeant majors all the way down.
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> Army Surgeon General LTGEN, Kevin C. Kiley

OUR ABILITY TO CONDUCT OVER 350 sessions of Virtual-Reality Exposure Therapy with Arousal Control (VRET-AC) for the treatment of warriors diagnosed with combat-related Posttraumatic Stress Disorder (PTSD) has evolved from the work of previous researchers and psychotherapists who have worked and are continuing to work in the field of virtual reality (VR) and exposure-based treatments for PTSD. These pioneers not only distinguished VR interventions from other psychotherapy interventions that were based on exposure treatment models, but these pioneers were also able to help us appreciate and begin to understand the variability of a warrior's responses to psychotherapy facilitated by the virtual world.[1–11] Vital to VRET-AC are the concepts of "immersion," "presence," "synchrony," the emphasis on training in biofeedback and meditation and paced abdominal breathing, and the importance of measuring and tracking both the warrior's subjective and objective arousal during VR treatment. Also vital to VR treatment are the establishment of a positive therapeutic relationship with the warrior, the emphasis on the safety of treatment, and the relationships of all of these components to the expected treatment outcome of "habituation" and the measurable reduction in clinical severity of the symptoms being treated.

In this article, we will describe VRET-AC, a state-of-the-art treatment optimized for combat-related PTSD. We will also describe our experience in treating 30 warriors, who have been diagnosed with combat-related PTSD, with VRET-AC. Case studies of two of these 30 warriors, treated with VRET-AC, are summarized as well. Lastly, we will discuss the integral components of VRET-AC, which include subjective (e.g., Subject Units of Discomfort [SUDs]) and objective (e.g., heart-rate variability, respiration rate, skin resistance, and peripheral skin temperature) measures of arousal, the treatment architecture of which is orchestrated by the VRET-AC concepts of immersion, presence, and synchrony. Whereas journals typically report a final result, this article describes a work in progress through a historical narrative. We hope this will provide the reader with an insight into the development of a therapeutic technique that is proving to be a valuable contribution to combating post-deployment PTSD.

Subjective Units of Discomfort

Prior to the first VRET-AC sessions with the warriors treated, we appreciated and understood the need to assess the

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warrior's subjective arousal by requesting that they report the level of their SUDs during their assessment. During VR treatment, we continued to appreciate and understand the need to utilize the warrior's SUDs in combination with their objective physiological arousal, such as heart-rate variability, respiration rate, skin resistance, and peripheral skin temperature, using biofeedback. Such an assessment-and-treatment strategy allows the psychotherapist to track the warrior successfully and continuously from his or her baseline arousal. We understand each patient's unique reactivity from examining how their subjective arousal corresponds to conditions of rest, stress recall, and recuperative ability.

Immersion, Presence, and Synchrony

Prior to the first VRET-AC sessions with the warriors treated, we were intriguingly aware of the research and treatment results that indicated that high levels of immersion and presence were correlated with increased responsiveness to VR therapy, as well as with more dramatic treatment success and more prolonged positive therapeutic effects.[2,4,8] Further, we began to appreciate that, in order to achieve appropriate levels of SUDs and high levels of immersion, presence, and synchrony in the VR environment, psychotherapists need to be able to modify the virtual-world scenario in order to maximize the optimal clinical protocol and treatment outcome for each warrior.[2,4,8]

Wiederhold et al.[2] have argued that immersion is characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences. Hence, when a warrior feels more immersed, they will feel more present. Presence is that quality that distinguishes VR systems from other multimedia experiences. Even though warriors engaged in VR treatment "know" they are not actually in the situation that the computer-generated world has created, warriors subjectively report that they are "there."[1] Further, a maximal level of presence is evident when the warrior feels and/or reports being immersed in the environment, feels capable of interacting with the environment, and has a greater interest in the computer-generated environment or task than the real world.

Presence can be fostered or enhanced by developing or utilizing VR experiences that are more immersive; more immersive experiences can cause increased physiological arousal.[1] Further, synchrony is fostered by the psychotherapist organizing the presentation of the VR environments. Presenting less stressful to more stressful stimuli also effects physiological arousal, as evidenced by skin-resistance levels and heart-rate variability (HRV). Specifically, increasingly stressful conditions result in suppressed HRV and high skin-resistance levels, whereas decreasingly stressful conditions result in lower skin-resistance levels and greater HRV. Of note, synchrony occurs more often in highly arousing situations, as in traumatic events, or treatment interventions that utilize simulated or in-vivo exposure. Desychrony is evident when there is no correlation between physiological and subjective measures during treatment, such as when patients suppress their feelings or thoughts, but their psychophysiology reveals their underlying stress.

As with other psychotherapeutic interventions,[12–14] it is imperative that the psychotherapist also continually monitors the warrior's verbal and non-verbal behaviors during treatment, in order to establish a successful therapeutic alliance. The establishment of such an alliance allows the psychotherapist to design VR interventions that elicit cognitive and affective schema that then allow therapy to modify the warrior's cognitive structures and dysfunctional beliefs, resulting in improved behaviors and a reduction in symptom(s). In the case of treating a warrior diagnosed with combat-related PTSD, a warrior's subjective and objective behaviors during VR treatment provide the psychotherapist with exquisite cues concerning his or her progress during the treatment session, "operational retraining," or "hop."

Other vital components that are evident for the success of VRET-AC are the ability of warriors to navigate themselves through the VR environments during "operational retraining," or "hops" while successfully employing their increasing skills with mastering the environment more predictably. To accomplish such mastery, they must first train in and then effectively utilize their biofeedback and meditation skills, as well as continue to engage cognitive reframing as they transform the VR stimuli, such as combat or combat zone that were initially "dangerous" and/or excessively arousing, into "safe" and very manageable stimuli.[15]

For instance, in describing immersion, Wiederhold et al.[16] reported that when flight-phobic and non-phobic patients were presented with a virtual environment of an airplane flight as seen on a two-dimensional computer screen and as seen from within a Head Mounted Display (HMD), significant objective differences were evident, with skin resistance being higher in the HMD compared with the computer-screen condition. An intriguing quality of synchrony, according to Wiederhold and Wiederhold,[4] is that synchrony appeared more often among patients exposed to VR-graded exposure therapy (VRGET; now VRET-AC) than patients exposed to Imaginal Exposure Therapy (IET). Wiederhold et al.[17] also investigated VR treatment with 30 adults who were diagnosed with a specific phobia: a fear of flying. These patients were randomly assigned to one of three treatment groups: VRGET with no physiological feedback (VRGETno), VRGET with physiological feedback (VRGETpm), and systematic desensitization with IET. During six weekly treatment sessions, SUDs were obtained during the treatment sessions. While all three groups were able to reduce their SUDs significantly during treatment, the VRGETpm group had the highest SUDs. When physiological responses to exposure, including skin resistance, were reviewed, both VR groups became much more physiologically aroused than the IET group, and by the end of treatment, the VRGETpm group was able to control their physiological arousal better than patients in the other two groups.[17] According to Wiederhold et al.[5] the skin-resistance outcome confirmed that the VRGETpm patients were able to desensitize themselves to their fear stimulus more successfully.

Regarding synchrony, Wiederhold et al.[17] concluded that the elevated SUDs and elevated skin resistance in the VRGETpm patients documented the existence of synchrony while they were immersed and present in the HMD VR flight-simulation environment. This synchrony enabled the VRGETpm patients to activate their fear of flying beliefs, or fear structure, during VR exposure, as evident by their elevated SUDs and elevated skin resistance. This synchrony also provided these patients with the opportunity or environment to utilize their biofeedback, relaxation, and paced abdominal breathing skills successfully, resulting in the desensitization of their flying phobia. Importantly, three months following the end of treatment, 100% of patients in the VRGETpm group were able to fly without medication; 80% of those in the VRGETno group could do so, but only 10% of the IET group could fly without medication or alcohol. One theory about why VR groups are able to desensitize is that subjects become fully aroused during exposure, such as immersed and present, remaining on task without cognitively drifting "off task," which can occur during imaginal exposure.[8,17]

Virtual-Reality Exposure Therapy with Arousal Control: Utilizing Virtual-Reality-Graded Exposure Therapy with Anxiety Disorders, including Posttraumatic Stress Disorder

VR therapy with physiological monitoring has been shown to improve treatment efficacy for PTSD in survivors of motor-vehicle accidents, war veterans, and those involved in the 9/11 World Trade Center attacks, as well as increasing the treatment efficacy for a number of anxiety disorders and phobias.[2,3,5–8,10]

Walshe et al.[7] investigated the combined use of computer-generated (GR) and VR environments in treating a driving phobia and PTSD in patients following a motor-vehicle accident. The GR/VR exposure program also utilized heart-rate monitoring as part of the screening procedure to provide physiological feedback to the patient and to the therapist during the session, and the patient's physiological feedback was also employed as a measure of change from the first to the last treatment session. Walshe et al.[7] proposed that the patients' participation in the GR/VR exposure program would result in the reduction of their driving anxiety, PTSD, and heart rate. Following completion of the GR/VR exposure program, the pre- and post-treatment comparison documented significant reductions in driving-phobia severity, PTSD, and heart rate.

Difede and Hoffman's[6] case history of a 26-year-old female, successfully treated with six sessions of VR therapy, who was diagnosed with PTSD after witnessing the 9/11 attack near the World Trade Center, documented the effectiveness of VR therapy. The VR therapy facilitated this patient "to virtually re-experience the events of September 11th in a controllable manner that allowed for habituation . . . the patient appeared to become immersed in the virtual environment, (and) the VR therapy is thought to work by modifying the patient's memory."[6]

Several reports have demonstrated the efficacy of combined physiological (cf., heart rate, breath rate, skin conductance, and peripheral temperature) and psychological VR treatment for PTSD.[11,18] This collection of reports concluded that VR techniques with physiological monitoring provide many novel and beneficial avenues for the evaluation and treatment of psychological conditions (cf, up to a 66 to 90% effectiveness for treating various anxiety disorders), including PTSD.

Virtual-Reality Exposure Therapy with Arousal Control Therapy to Treat Sailors and Marines Diagnosed with Combat-Related Posttraumatic Stress Disorder

As has been previously described, the warriors who volunteered for and consented to VRGET (now VRET-AC), and whom we had the privilege to treat at either the Naval Medical Center San Diego or the Naval Hospital Camp Pendleton, were all diagnosed with combat-related PTSD.[19–21] These warriors were all evaluated using an approved Institutional Research Board (IRB) protocol, which included an interview with a clinical psychologist or a psychiatrist, and the warriors were administered standardized psychological and neuropsychological testing and biofeedback assessment.[19–21] The presence of PTSD was confirmed following diagnostic guidelines outlined in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV).[22]

Clinical Measurement Instruments

A number of self-report and clinician-rated measures were utilized in the assessments of the warriors treated with VRET-AC at pretreatment, after ten weeks or ten sessions of VRET-AC and after an additional three months or following ten more VR sessions. These self-report and clinician-rated measures included but were not limited to the PTSD Checklist Military Version (PCL-M).[23]

Additionally, psychophysiological measures of skin conductance and peripheral finger temperature were obtained during each assessment. The methodology employed in obtaining these psychophysiological measures have been described elsewhere, and will therefore not be reviewed here.[19–21] Note that due to the fact that the full results of the VRET-AC treatment are still pending, the outcomes of the analysis of the self-report and clinician-rated measures, as well as the clinical psychophysiological measures' assessment and the VRET-AC outcomes, cannot be presented at this time.

Equipment

The VRGET (now VRET-AC) treatment protocol relies on visual and auditory presentations.[15] VRET-AC runs on three computers. One computer displays the visual and auditory stimuli on a standard computer screen, as well as to the warrior via a HMD; the warrior also wears headphones. The second computer displays the control panel and menu, which the senior author used to introduce arousal elements into the VRGET combat environment. A third computer runs the physiological monitoring, such as skin conductance, peripheral skin temperature, respiration rate, heart rate, and heart-rate variability, and feedback system (J & J Engineering, Inc., Poulsbo, WA).

The specific details regarding the development of the custom-built Virtual Baghdad, PTSD Convoy, and PTSD Village software and environment models, the method of communicating with the warrior while they were immersed in the VR environment, the methods that the warrior employed to navigate through their combat environment, the firing of their weapon, and the head-tracking and the utilization of the HMD have been previously reported and so are not reported here.[19–21]

Virtual-Reality Exposure Therapy with Arousal Control Protocol

During the past three years, the senior author has provided 352 individual VRET-AC "hops," or "operational retraining" (i.e., one to 22 individual VRET-AC "hops" or operational retraining sessions) to 30 warriors. Each "hop" lasted approximately 90 minutes. These "hops" were conducted weekly or biweekly, and the VRET-AC individual "hop" architecture followed the recommended guidelines of the Virtual Reality Medical Center.[15] With several references to the stigma associated with PTSD diagnosis, the mental-health treatment for combat-related PTSD, and why "stigma" prevents warriors from requesting and/or receiving psychological or psychiatric care,[24–28] we choose the term "hop" or "operational retraining" to destigmatize and to describe the VRET-AC treatment method to the 30 warriors treated.

VRET-AC "hops" 1 and 2 focused on orienting and introducing the warrior to meditation and paced abdominal breathing as interventions that could facilitate emotional, cognitive, and physical relaxation. To ensure consistent meditation training and practice, a two-computer-disc meditation training program (Jon Cabot Zinn & Andrew Weil, Meditation for Optimum Health, Sounds True, Boulder, CO) was utilized during the "hops." Additionally, the warrior was provided with a copy of the meditation CD, and encouraged to practice meditation daily at home and/or work.

During the first two "hops," the warrior was asked to discuss their PTSD symptoms. They were also asked to "tell their stories about their sentinel (i.e., most traumatic) events during their combat tour or tours." The PTSD diagnosis and symptoms were conceptualized as a normal response to an abnormal situation, and the senior author also discussed that the goal of VRET-AC was to help the warrior gain control over his or her intrusive thoughts and feelings and for them to learn to tolerate events or stimuli that were currently intrusive and bothersome. The "safety" of VRET-AC was emphasized, as was the recommendation that the warrior could easily terminate a "hop" by removing their HMD and headphones. During the first two "hops," the warriors were taught the principles of attentional retraining, such that whatever they paid attention to would be enhanced in relationship to the concept of immersion and presence. If they paid attention to thoughts and feelings that were uncomfortable and/or intrusive, these thoughts and feelings would initially be enhanced; if they paid attention to comfortable sensations at that moment, or to the immersive and presence of the combat environment in front of them (cf, in the HMD and headphones), they would enhance those thoughts and feelings.

During the 20 minutes of the VRET-AC combat "hops" (i.e., "hops" 3–20), the warrior's subjective (i.e., SUDs) and objective (physiological) status was continuously monitored in order to discover what type of combat exposure or positive mental images helped to increase or decrease their subjective and objective arousal. For instance, heart rate, skin conductance, respiration rate, and peripheral skin temperature were evaluated during different VR combat scenarios with the expectation that three of their physiological measures (heart rate, skin conductance, and respiration rate) would increase and peripheral temperature would decrease in synchrony with their increased arousal. Conversely, when the warrior reached maximum arousal (i.e., SUDs = 60–70), they were instructed to "hold fire" and switch from the combat environment to a non-combat environment using their skills with meditation, progressive relaxation, and paced abdominal breathing. By doing so, it was expected that their physiological arousal would decrease to levels indicating increased control and relaxation, again employing the concept of immersion, presence, and synchrony.[2,4,5,15]

During combat "hops" 3 to 20, the warriors continued to exercise their increasing skills with meditation, physiological control, paced abdominal breathing, and attentional refocusing within the VR environment. Employing the principles of immersion, presence, and synchrony, the 90-minute "hops" were divided as follows: 20 to 25 minutes to review progress made during the previous week, successes with meditation, and attentional refocusing; 15 minutes of meditation training and attentional refocusing; a 20-minute "hop" in the VR combat environment; and a debrief of 20 to 25 minutes to conclude the "hop." Typically, following the principles of immersion, presence, and synchrony, the 20-minute combat "hop" included time to allow the warrior to establish a "baseline" of low subjective (i.e., SUDs) and low-arousal objective (i.e., physiological responses) in the combat environment. The warriors then moved to the various combat environments during which arousal or combat intensity elements were increased, with the warrior being instructed to utilize their skills of meditation, physiological control, paced abdominal breathing, and attentional refocusing to calm their mind and body. When "hold fire" was called, the warriors were encouraged to employ their skills of meditation, physiological control, paced abdominal breathing, and attentional refocusing to reduce subjective (i.e., SUDs) and objective (i.e., physiological responses) arousal, with the expectation that they would reacquire their baseline subjective and objective arousal. The warrior would typically be able to complete two to four combat/hold-fire cycles during a 20-minute combat "hop."

After the combat "hop," a debriefing period was utilized to ask the warrior about their experiences during the "hop," what they learned and/or discovered, and feedback was given to the warrior regarding levels of presence, immersion, and synchrony. The warrior was encouraged to practice their VR skills and their skills with meditation, physiological control, paced abdominal breathing, and attentional refocusing daily in the context of their everyday life, and in relationship to the presence of arousing or intrusive stimuli, including thoughts, feelings, and/or activities. Finally, during the debriefing, plans for the subsequent VRET-AC "hop" were discussed.

As VRET-AC architecture matured through combat "hops" 6, 10, and even to 22, and the VR combat intensity was increased (see Figures 1–4) to foster immersion, presence, and synchrony, the warriors were encouraged to continue to employ their skills of meditation, physiological control, paced

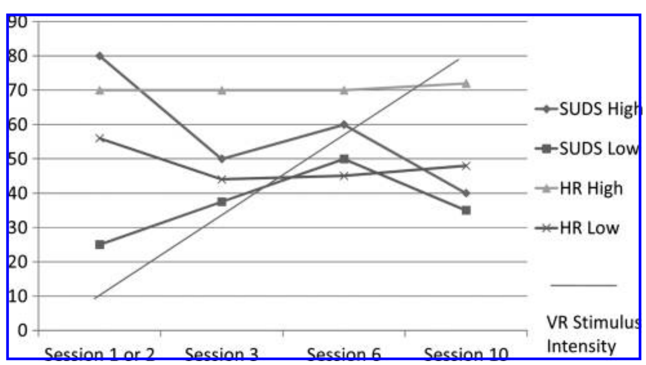

FIG. 1. High/low SUDs and HR for case #1's VRET-AC sessions 1 or 2, 3, 6, and 10.

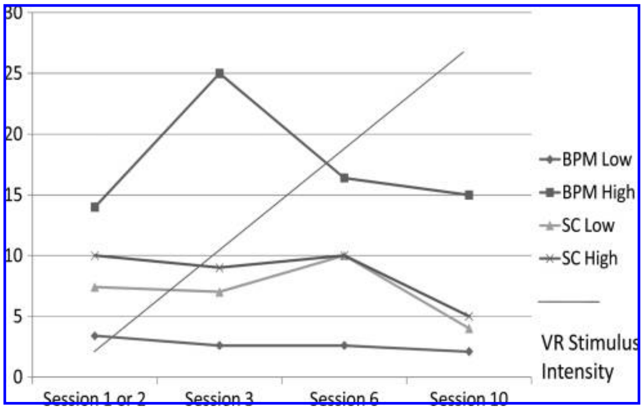

FIG. 2. Sessions 1 or 2 through session 10 for case #1's low and high BPM and SC.

abdominal breathing, attentional refocusing, and cognitive reframing to reduce subjective (i.e., SUDs) and objective (i.e., physiological) arousal. Again, the synchrony between subjective (i.e., SUDs) and objective (i.e., physiological) measures determined the timing of the initiation of a more intense combat VR environment or calling "hold fire." To drive immersion, presence, and synchrony, combat elements in the VR environment would be added or reduced while continuing to focus on the concept of the warrior's moderate arousal (SUDs equal to 60 to 70; HR not greater than 80 to 90, and BPM not greater than 36). Of note, an activated fear structure and a corresponding opportunity for maximal learning are evident in the moderately aroused VR environment. Interestingly, breaths per minute (BPM) above 14 represent a clear indication of sympathetic drives. Correspondingly, BPM below eight provide a good indication of parasympathetic dominance or low arousal in the VR environment that drives or turns on the parasympathetic system and fosters relaxation, decompression, and habituation.[15]

Case Report #1—Combat-Related Posttraumatic Stress Disorder

The warrior was a Navy First Class Petty Officer in his mid 30s who had made multiple combat deployments to Iraq,

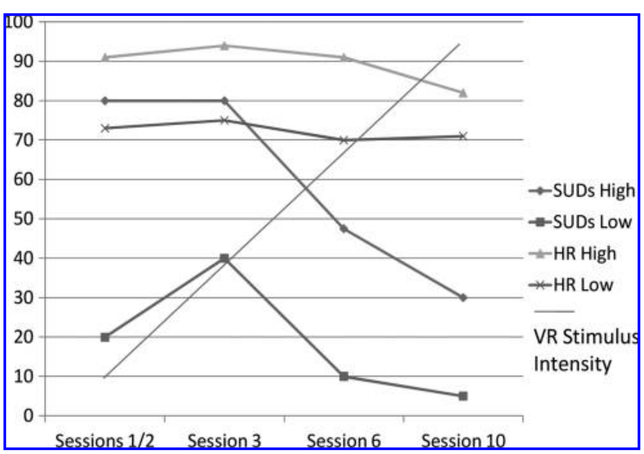

FIG. 3. High/low SUDs and HR for case #2 during 10 VRET-AC sessions; due to no high SUDs being available for session 6, this value was extrapolated.

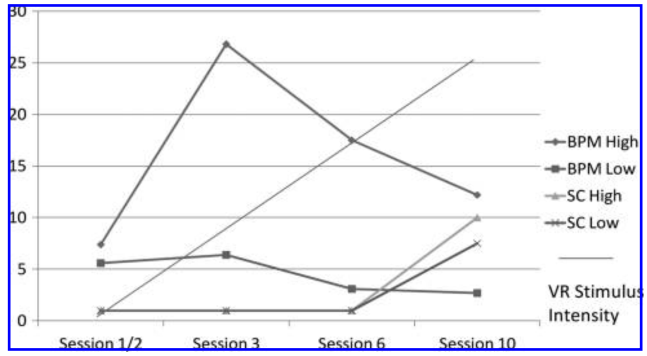

FIG. 4. High/low BPM and SC for case #2 during 10 VRET-AC sessions; of note, the results obtained for the SC readings for sessions 1/2, 3, and 6 were due to computer error.

including his first combat deployment during the months following the initiation of Operation Iraqi Freedom (OIF). During these combat deployments, this warrior had experienced a high level of combat, and he had been exposed to exploding Improvised Explosive Devices (IEDs). During one combat deployment, he witnessed the combat death of a US Marine, and during another combat deployment, one of his "combat buddies" was severely wounded. Following his return home at the completion of his combat deployment during which he witnessed the Marine's death, the warrior reported that he began to experience symptoms that were later diagnosed as PTSD. During a subsequent combat deployment, the warrior was wounded, and the event exacerbated his PTSD symptoms. The warrior consulted with a Navy doctor in Iraq, and was prescribed paroxetine hcl and zolpidem tartrate. Following the warrior's return to the United States, his Command referred him for VRET-AC.

The warrior's combat-related PTSD was confirmed by a Navy psychiatrist in accordance with DSM-IV,[22] and he received a full psychological and psychophysiological evaluation that has been previously described.[19–21] During his evaluation, he described his primary "sentinel event" as being the wounding of his combat buddy. He was experiencing moderate difficulties with depression and anxiety. He did not meet the criterion for substance abuse or dependency, and he denied the presence of suicidal and homicidal ideation/intent.

As previously described in this paper and elsewhere,[15,19,20] a VRET-AC "hop" began with education concerning PTSD, VRET-AC, and the skills of meditation, physiological control, paced abdominal breathing, attentional refocusing, and cognitive behavioral theory. It was emphasized to this warrior that breathing six to eight breaths a minute automatically "turns on" his parasympathetic autonomic system, and would result in a "breaking" of his hyperaroused or hypervigilant coping mechanisms associated with his PTSD. The warrior's sentinel events were discussed, and the method of integrating these sentinel events into his VRGET-AC was reviewed. During the warrior's first two VRET-AC sessions, while thinking about one of his sentinel events, the warrior's SUDs were 75 to 80; when he focused on relaxation, his SUDs were 25. Similarly, his low BPM were 3.4, and his high BPM were 14. His low SC was 7.4; and his high SC was 10 (see Figures 1–2).

During his third VRET-AC session, the warrior's low BPM and SC were 2.6 and 7.0 respectively, with no active combat stimuli, but immersed and present in a combat environment. His high BPM and SC were 25 and 9.0 during the high active combat stimuli. During VRET-AC session 10, this warrior mentioned that his low SUDs and high SUDs were 35 and 40 respectively. His low BPM and SC were 2.1 and 4.0 respectively, with no active combat stimuli, but immersed and present in a combat environment. His high BPM and SC were 15 and 5.0 during the high active combat stimuli.

During this warrior's three-month follow-up VRET-AC evaluation, there was no clinical evidence of PTSD, depression, or anxiety. He was able to achieve a 24% reduction in his PCL-M pretreatment score compared with the three-month follow-up (see Figure 5). With the knowledge of his psychiatrist, he had discontinued paroxetine hcl and zolpidem tartrate. He was returned to an unrestricted active duty status.

Case Report # 2—Combat-Related Posttraumatic Stress Disorder

A female Navy Second Class Petty Officer Seabee met the study criteria for participation. She was 26 years old, and had served 6 years of continuous active duty. She had completed three tours of combat duty in Iraq. Following her first combat deployment, she was diagnosed with PTSD, and prescribed paroxetine hcl by a Navy psychiatrist. The warrior then took paroxetine hcl intermittently during the next 3 years. Prior to starting VRET-AC, she had no previous mental-health treatment other than her psychotropic medication. Following a reevaluation with a Navy psychiatrist, following completion of her third combat tour to Iraq, the warrior had been stable on paroxetine hcl for 6 months prior to starting VRET-AC.

The warrior served in combat operations in Iraq as a Humvee 50-caliber gunner protecting convoys. She was exposed to heavy combat, and she was exposed to a total of five blasts, including IEDs, a rocket-propelled grenade (RPG), and a land mine. As a result of these blasts, the warrior reported that she never lost consciousness but was dazed and confused and experienced brief amnesia from several of the blasts. Additionally, she was injured in July 2006 when a Humvee hatch was jarred loose, causing the Humvee hatch to strike her in her upper back/neck area. During the warrior's early VRET-AC, she was referred to the NMCSD Traumatic Brain Injury (TBI) Clinic for evaluation of her blast exposure and her report of continued difficulties with upper back/neck area pain and restricted range of motion. She received concurrent care in the TBI Clinic for TBI and chronic pain, and she was continued in a full active duty status. The warrior's sentinel events included "being shot at, multiple times, during convoys during my 2003 deployment," "one of my 'Bees' died from a mortar round," and "standing security duty near a Humvee that blew up, wounding two of my fellow Seabees." Additional information concerning the warrior's medical history and combat deployment history has been previously documented.[21]

The warrior's first two VRET-AC "hops" began with education concerning PTSD, VRET-AC, and the skills of cognitive behavioral theory, meditation, physiological control, paced abdominal breathing, and attentional refocusing. Her sentinel events were discussed, and the method of integrating these sentinel events into her VRGET-AC was reviewed. The senior author emphasized to this warrior that breathing six to eight breaths a minute would automatically "turn on" her parasympathetic autonomic system, and would result in "breaking" her hyperaroused or hypervigilant coping mechanisms associated with her PTSD. During this warrior's first two VRET-AC sessions, while thinking about one of her sentinel events, her SUDs were 80; when she focused on relaxation, her SUDs were 20. Her high HR was 90, and her low HR was 73 (see Figure 3). Similarly, her high BPM were 7.4, and her low BPM were 5.6 (see Figure 4). Her high SC was 1, and her low SC was 1. Of note, there were difficulties with the computer monitoring the warrior's SC during her first six sessions, resulting in uniform readings of SC = 1.

During her third VRET-AC session, the warrior's high SUDs and high HR were 80 and 94 respectively. Her low SUDs and low HR were 20 and 74 respectively. Her high BPM and high SC were 26.8 and 1.0 respectively. Her low BPM and SC were 6.4 and 1 during high active combat stimuli. Of note, the warrior's third session was terminated early at her request due to her becoming tearful due to increased irritability. By VRET-AC session 10, the warrior's high SUDs and high HR were 10 and 82; her low SUDs and low HR were 5 and 71 respectively. Her high BPM and high SC were 12.2 and 10; her low BPM and low SC were 2.7 and 7.5 during high active combat stimuli.

During the warrior's post VRET-AC 10-week reevaluation, there was no clinical evidence of PTSD, depression, or anxiety. She was able to achieve a 63% reduction in her PCL-M pretreatment score compared with 10 weeks post-treatment (see Figure 5). Intriguingly, at the end of her first 10 sessions of VRGET, the warrior mentioned that "I wished I had this training (i.e., meditation and exposure components) prior to my first combat deployment or between my combat deployments!" Moreover, she elaborated, "I don't think that my PTSD difficulties would have been as bad if I would have had this treatment before or between my combat deployments."[21] Following the completion of VRET-AC (after 13 VRET-AC sessions), she had discontinued the paroxetine hcl and she was returned to an unrestricted active duty status.

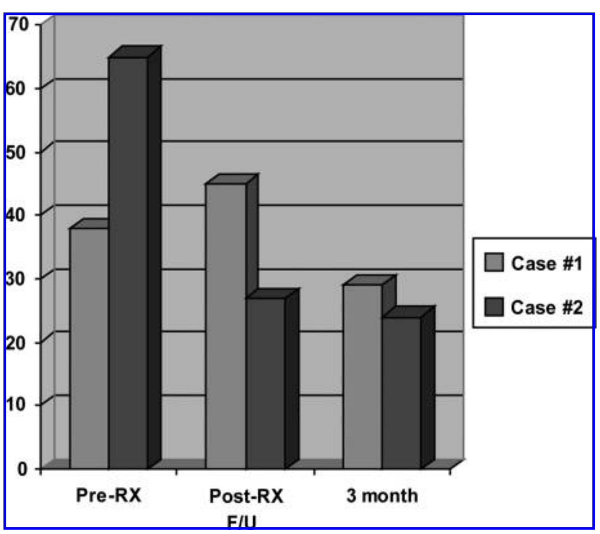

FIG. 5. PCL-M scores, pretreatment, post-treatment, and at the 3-month follow-up for cases #1 and #2. (PCL-M scoring guidelines: PCL-M <30 = optimal for the absence of a combat-related PTSD diagnosis; ≥ 50 = optimal for making a combat-related PTSD diagnosis.)

Conclusions

VRET-AC is an effective and safe treatment for combat-related PTSD. The case studies of the two warriors documented that their difficulties with combat-related PTSD measurably reduced after or during VRET-AC. This measurable reduction in PTSD severity was due to the application of the VRET-AC model, which utilized SUDs (subjective measure) and ongoing physiological measurements (objective measures) to assist with the arousal and decompression phases of the "architecture" of each combat "hop" or treatment session. Additionally, the VRET-AC combat environments were designed to simulate or re-create various missions that sailors and marines would have executed while deployed to Iraq or Afghanistan, and these virtual environments, combined with the use of a HMD and headphones, facilitated and maintained our warriors' immersion, presence, and synchrony. The concept of each VRET-AC session being a "hop" or "retraining evolution" assisted in reducing the stigma associated with the sailor or marine having a PTSD diagnosis, and receiving consultations in a military mental-health clinic.

As evident in our two VRET-AC case studies, distributed training over a period of time at the appropriate intervals with appropriate levels of arousal is the best method for learning and creating new memories.[29] Memory consolidation occurs best with an optimal level of stress; when stress levels exceed this optimal range, there is a dramatic impairment in memory.[29] The reason why exposure therapy should work is that fear is associated with safety, and the brain learns this new association. There is no safety associated with "flooding," so "flooding" should be ineffective for associated learning.

Some additional advantages of VR therapy, besides a defined and/or shortened treatment duration, as compared to Imaginal Exposure Therapy (IET), include increased safety, control, and flexibility. Since the VR treatment takes place in the office and can be terminated at any moment, it should be "safer" than being trapped in an elevator, on a plane, or in another in-vivo situation, and beginning to experience a severe anxiety, excessive arousal, intrusive thoughts (i.e., about combat), and/or a possible panic attack. Since there is more control of the VR scenario, the warrior is able to, at any time, remove their HMD and headphones or direct the psychotherapist to stop the VR scenario. Such a "safety" emphasis may encourage more warriors to be willing to seek and continue in VRET-AC. Also, the VR therapy may be just "unreal" enough that many warriors who have resisted therapy due to in-vivo approaches are willing to try it. If the warrior's main fear centers on airplane landing, one can practice "graded" landings over and over in the virtual world. If the warrior's fear centers on entering and engaging in a combat zone, he or she can practice transiting into a combat zone in a "graded" fashion" until the required tasks associated with entering and engaging a combat zone are mastered. VR's treatment flexibility allows for more effective and successful treatment that may require less treatment time, thereby reducing the costs of treatment for combat-related PTSD.[2,21] Of note, one warrior completed his VRET-AC in 10 sessions, and the second warrior completed her VRET-AC in 13 sessions.

Additional considerations when engaging a warrior in VRET-AC include but are not limited to the following. First, as a traditionally trained clinical psychologist, the senior author had to switch conceptually to endorsing a treatment intervention that was warrior-led and non-verbal for the most part. Second, in the process of pursuing increased immersion, presence, and synchrony, it was paramount to ask the warrior what they needed or wanted, and what their SUDs were; also paramount was engaging the warrior during the VRET-AC process in discussing their sentinel event(s), and integrating their SUDs and physiological responses into the VRET-AC architecture in order to achieve habituation. Third, the SUDs and physiological data become indispensable in directing the VRET-AC; specifically, the senior author engaged in a continuous process of evaluating and redirecting the warrior in addition to an ever-active response to his or her verbal communications, such as "where is the wounded Marine," "steer clear of the trash," "watch out for that victor," "where is that a** h*** firing the RPGs,", and so on, and non-verbal, such as SUDs and physiology levels. Fourth, the senior author found that it was vital to ask warriors frequently during the VR sessions to explain aspects of combat or terms they and their combat buddies used to identify threats, to issue orders, and/or to engage in VR combat. Fifth, managing the administrative aspects of VRET-AC (e.g., logging SUDS, physiological readings, specific comments of the warrior being treated, and aspects of their sentinel event, combat, or "hold-fire" status, etc.) was very daunting, and temporarily distracted the senior author from the process of the VRET-AC architecture. At this point in time, in order to provide a warrior with clinical information that can be reviewed during the debrief period, "traditional note taking" will remain a treatment requirement, but perhaps some other electronic record keeping for VRET-AC sessions can be developed. Sixth, the senior author not only found VRET-AC to be an extremely engaging and effective therapy, but also personally stressful. The senior author learned that to be as effective as possible with the warriors, he had to limit the treatment time to not more than three warriors a day, two or three days a week. Kraft[30] has discussed the concept of compassion fatigue that she and other medical providers experienced during their 2007 combat deployment to Iraq, providing medical and psychological services to US Marines. While not involved in direct combat with our warriors being treated with VRET-AC, the senior author was directly and personally involved in the warriors' VRET-AC by assisting them with reliving and reexperiencing their combat experiences within the safety of VRET-AC, as they were actively engaged in immersion, presence, synchrony, decompression, and habituation. Finally, frequently employing resources, such as newspaper articles, books, movies, video games, and other media sources, can facilitate the architecture and success of VRET-AC.

Of note, the sentinel events of one of the warrior's treated with VRET-AC were documented in a book describing Operation Iraqi Freedom, entitled *The March Up*.[31] Being able to understand aspects of this warrior's sentinel events better by discussing these events with him, augmented by the references contained in West and Smith's book,[31] facilitated the positive therapeutic relationship between the warrior and the senior author, and facilitated this warrior's ability to be immersed and present while engaged in VRET-AC. Several of our warriors were able to obtain and read *From Baghdad, with Love*[32] and *From Baghdad, to America*;[33] both of these books conceptualize the combat-related PTSD diagnosis and symptoms as a normal response to an abnormal situation, and those warriors who read these books mentioned that the message in these books assisted their "decompression and habituation."

VRET-AC is a compelling, therapeutically effective, and immersive virtual environment that has been successfully developed for a PC platform. This PC-based system is both clinician and warrior friendly, and can be implemented by skilled clinicians with appropriate training in exposure therapy and VRET-AC.[15] VRET-AC should be a component of a comprehensive treatment program for individuals diagnosed with combat-related PTSD. As previously recommended, continued validation of VRET-AC for the treatment of combat-related PTSD is necessary for sustained growth and acceptance of this promising technologically oriented psychotherapy. Perhaps our lessons learned and the clinical and technical information we have obtained from those warriors we were privileged to treat with VRET-AC can also aid in the expected and hoped-for growth and acceptance of VRET-AC.

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