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# Virtual Reality Exposure Therapy for Military Veterans with Posttraumatic Stress Disorder: A Systematic Review

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Military personnel in a war situation appear to be especially susceptible to posttraumatic stress disorder (PTSD), given that a high number of recently deployed service members are diagnosed with the disorder. Exposure therapy is frequently used in the treatment of this population. To our knowledge, however, there are no detailed systematic reviews of a relatively new exposure therapy, virtual reality exposure (VRE), in the treatment of combat veterans with PTSD. Therefore, the present work provides a comprehensive, 15-year overview (1999 to 2013) of research on the therapeutic effectiveness of VRE in treating PTSD in military combat veterans. A considerable body of empirical evidence suggests that VRE can decrease PTSD symptoms within the veteran population and follow-up data do show promise for maintaining positive treatment outcomes. Further research is necessary to determine the long-term effects of this treatment.

*Keywords:* posttraumatic stress disorder, military veterans, virtual reality exposure therapy, exposure therapy

Posttraumatic stress disorder (PTSD) is a psychological disorder that develops during a time of increased stress following the experience of a traumatic event, in which one's life is at risk or threatened, or the person witnesses another person experience a traumatic event, involving death, injury, or a threat to that person's welfare (DSM-V; American Psychiatric Association, 2013). The prevalence rate for PTSD is about 3.5% of the United States' population, although military personnel in a war situation appear to face a higher risk level for developing PTSD (DSM-V; American Psychiatric Association, 2013; Gates et al., 2012). The actual prevalence rates for PTSD among United States (U.S.) military personnel are difficult to estimate, mainly because of secondary gain, in which veterans might benefit from the diagnosis (see Gates et al., 2012). However, epidemiological research conducted with former military personnel suggests that there is a lifetime PTSD prevalence of 31% for men and 26.9% for women in Vietnam veterans, a 10.1% prevalence in all Gulf war veterans, and a 13.8% prevalence in Afghanistan and Iraq war veterans (Department of Veterans Affairs, 2013).

This higher prevalence of PTSD for veterans likely stems from the fact that military personnel have an increased chance of experiencing a wide array of traumas ranging from rape, capture, torture, physical assault, physical injury, and witnessing a fellow soldier's death (Briere & Scott, 2006). Multiple deployments, which became increasingly common in the Afghanistan and Iraq conflicts, increase the risk for developing mental health problems, and military personnel who have deployed multiple times are more likely to show an increase in mental health issues, as are those who stayed longer in theater (Mental Health Advisory Team V, 2008). Thus, it is imperative to find effective methods of treating war veterans.

Treatments for PTSD have evolved over the years to include behavior therapy, biofeedback, eye movement desensitization reprocessing (EMDR), stress inoculation therapy (SIT), cognitive therapy, contemporary cognitive behavior therapy (CBT), and exposure therapies (e.g., systematic desensitization, flooding; Haugen, Evces, & Weiss, 2012; Wiederhold

& Wiederhold, 2005).

Exposure therapy shows some of the strongest empirical support for successfully treating PTSD (Ready, Pollack, Rothbaum, & Alarcon, 2006; Rothbaum, Hodges, Ready, Grapp, & Alarcon, 2001), and it is therefore currently considered the treatment of choice (Powers, Halpern, Ferenschak, Gillihan, & Foa, 2010). This therapy involves the repetition of the traumatic memory using imaginal or real exposure. The goal of exposure treatment is to decrease anxiety through identifying, discussing, and emotionally processing the traumatic event(s). Evoking the same emotions and feelings that occurred in the original traumatic event is key to exposure treatment's success (Bush, 2008). Emotional processing requires the activation of the fear structure during the treatment. Once the fear structure becomes activated, to decrease anxiety, the client's emotional engagement is targeted for change (Reger & Gahm, 2008). A hierarchy of fears is established, and feared stimuli are addressed beginning with the least aversive. Repeatedly approaching a feared stimulus during exposure allows the fear structure to be activated and then paired with safe outcomes (Foa & Kozak 1986). When the least aversive fear has been sufficiently reduced, the next fear is approached, and so on (Wiederhold & Wiederhold, 2005). Gradually, this leads to adequate processing of the traumatic event and extinction of fear (Foa & Kozak, 1986).

Three types of exposure therapies have traditionally been recognized as being effective treatments of PTSD: a) systematic desensitization, which involves training the client in relaxation and then introducing a series of increasingly anxiety-provoking situations to which the client practices relaxation until the most feared situation no longer causes significant anxiety (McGlynn, Mealiea, & Landau, 1981); b) imaginal exposure, where the individual repeatedly imagines his/her traumatic event with the goal of the client habituating to chronic anxiety (Foa & Chambliss, 1978; Foa, Zoellner, Feeny, Hembree, & Alvarez-Conrad, 2002); and c) in vivo exposure, which requires that the individual is placed in an environment to confront the traumatic or feared situation (Wiederhold & Wiederhold, 2005).

Although exposure therapy has been shown to be effective for treating combat-related PTSD (Ready et al., 2006; Rothbaum et al., 2001), there may be several limitations to this approach. Because one of the diagnostic criteria for PTSD is persistent avoidance of stimuli associated with the trauma (DSM-V; American Psychiatric Association, 2013), it is not surprising that many patients refuse to participate in exposure therapy. Others have difficulty approaching or staying with their traumatic memories at a level that adequately facilitates the emotional engagement necessary for habituation to occur (Rothbaum et al., 1999). It may be possible, however, to address these issues with recent technology that has allowed expansion of the in vivo experience through the use of virtual reality exposure (VRE).

## Virtual Reality Exposure Therapy

Through the fairly recent expansion of an in vivo experience into VRE, the client can be immersed into the event that triggered his or her PTSD (e.g., combat) via a multisensory computer simulation without relying on self-generated memories. In fact, virtual reality exposure attempts to offer both in vivo exposure and imaginal exposure techniques (Wiederhold & Wiederhold, 2005). Through this method, the limitations of the patient's imagination and memory are overcome (Riva & Vincelli, 2001), avoidance is reduced, and the likelihood of emotional engagement is increased. The present work critically examines recent literature on this promising type of therapy and highlights the evidence supporting the use of VRE for PTSD in veteran populations.

VRE has advantages over other exposure therapies and other treatment modalities for veterans with PTSD. Virtual reality occurs in real time and offers a sense of presence while encouraging the veteran to return to those prior memories and thoughts in a safe environment. Paradoxically, virtual reality is not reality; nothing can truly harm the individual in this treatment. Successful uses for virtual reality have included the treatment of eating disorders (Wiederhold & Wiederhold, 2005), sexual disorders (Riva et al., 2004), phobias (Hodges et al., 1999; Rothbaum et al., 1995), and during neuropsychological evaluations and medical procedures (Wiederhold & Wiederhold, 2005). In relation to PTSD treatment, researchers have noted that if other exposure treatments such as prolonged exposure are not effective,

virtual reality may be the most effective exposure therapy in assisting individuals with decreasing PTSD symptoms (Reger & Gahm, 2008).

Virtual reality uses computer-based technology in a three-dimensional world, whereby the individual navigates a computer simulation of the triggering traumatic environment in real time (Wiederhold & Wiederhold, 2005). During VRE sessions, the client wears a head-mounted display (HMD), which includes headphones, a display screen for each eye, and a head-tracking device (Rothbaum et al., 2001; Rothbaum, Ruef, Litz, Han, & Hodges, 2003; Wiederhold & Wiederhold, 2005). In some virtual environments the veteran has her or his own chamber with a computer and other measurement devices, which keeps attention focused on the simulation. Researchers contend that head-mounted displays are immersive; they allow the client to explore and experiment with cognitions and emotions while perhaps decreasing a sense of threat (Riva, Bacchetta, Cesa, Conti, & Molinari, 2001; Rizzo, Schultheis, Kerns, & Mateer, 2004).

Virtual reality exposure treatment simultaneously stimulates the senses—the visual, auditory, and olfactory systems—which immerse the veteran in virtual environments during exposure sessions (Cukor, Spitalnick, Difede, Rizzo, & Rothbaum, 2009). Visual stimuli include night vision images, soldiers, civilians, buildings, and vehicles. Specific sounds include weapon fire, explosions, mortar fire, helicopter and vehicle noises, wind blowing, human voices, and radio communications. Olfactory stimuli can be released through a scent palette contained in the chamber; an example of sensory stimuli would be a burning smell. Other stimuli provided can be tactile and kinesthetic; an example would be feeling vibrations on the floor or on the seat, such as in a helicopter VRE session (Gerardi, Rothbaum, Ressler, Heekin, & Rizzo, 2008).

Sensory exposure can be tailored to each veteran's needs. For instance, Virtual Vietnam and Virtual Iraq are simulation environments developed specifically to match what these veterans encountered sensory-wise while deployed. Within the Virtual Vietnam environment there are two subtypes of environments, the Huey Helicopter and an open field (Hodges et al., 1999). The Virtual Iraq environment, again, has two subtype environments, the Middle Eastern City and desert road (Rizzo et al., 2009).

## The Present Work: Review of Studies Using VRE with Combat Veterans

The purpose of the present research project is to provide a comprehensive, systematic review of the scientific literature regarding virtual reality exposure's therapeutic success of treating PTSD in military combat veterans and to promote awareness about virtual reality exposure as a viable, contemporary treatment for military personnel with PTSD. As VRE is a fairly new treatment that has not been widely used or recognized, the aim of this work is to provide an organized compilation and analysis of the extant literature on VRE that may serve as a valuable tool for determining its viability as a treatment option.

Although the literature features valuable meta-analyses by other pioneers in the field (see Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008), they have focused on VRE therapy for treating anxiety and specific phobias. Other systematic reviews on virtual reality exposure have also provided excellent narratives on the effectiveness of VRE in treating anxiety disorders (see Meyerbroker & Emmelkamp, 2010) and clinical treatments in general (see Riva, 2005). In addition, Paul, Hassija, and Clapp (2012) provided a review of promising technological advances in treating posttraumatic stress disorder, including VRE. However, their review was brief and included other groups such as the survivors of the World Trade Center attacks. The present work aims to contribute to the body of knowledge by reporting on recent research on VRE therapy directed at improving the lives of combat-exposed veterans with posttraumatic stress disorder.

## Method

We conducted a systematic review of the scientific literature from 1999 to 2013, as the first virtual reality exposure session to treat a Vietnam veteran took place in 1999 (Rothbaum et al., 1999). Databases used were PsychINFO, PubMed (Medline), Published International Literature on Traumatic Stress (PILOTS), and the Staff College Automated Military Periodicals Index (SCAMPI), allowing for the careful

consideration of peer-reviewed journal articles and books that detailed studies of VRE therapy in military veterans. Selected key-words for searches were as follows: Posttraumatic Stress Disorder, military veterans, virtual reality exposure, VRE, combat experience, and military psychology. Military veterans, for the purpose of this systematic review, included any military personnel who were diagnosed with combat-related PTSD. This included retired military personnel and active duty personnel. To be included, the article had to address each factor; that is, PTSD, military veterans, and VRE. The resources that the search yielded were carefully examined by reading the abstracts to determine whether or not they met the inclusion criteria. Below we describe the empirical research studies that meet the aforementioned criteria.

## Results

### VRE Treatment of U.S. Veterans of the Vietnam War

Rothbaum et al. (1999) conducted the first study of virtual reality exposure treatment effectiveness with a veteran. This was a case study of a 50-year-old male Vietnam veteran diagnosed with PTSD and major depressive disorder. The veteran completed the Clinician-Administered PTSD Scale (CAPS; Blake et al., 1995), Combat Exposure Scale (CES; Keane et al., 1989), Beck Depression Index (BDI; Beck, Epstein, Brown, & Steer, 1988), and Impact of Events Scale (IES; Horowitz, Wilner, & Alvarez, 1979) prior to and after treatment. During VRE treatment, the veteran was immersed in the two environments of Virtual Vietnam—the jungle and Huey helicopter environments. Subjective Units of Distress (SUDS) ratings were gathered every 5 minutes during treatment. Treatment took place over seven weeks, with 14 sessions lasting 90 minutes each. Results suggested that the veteran had benefited from the treatment as evidenced by his decrease in overall symptom scores related to PTSD (34% decrease on clinician-rated scores and 45% decrease on self-rated scores), intrusion and avoidance symptoms, and depression (Rothbaum et al., 1999). Although this veteran still met the criteria for depression, his overall symptoms had improved from posttreatment to the six-month follow-up (Rothbaum et al., 1999). This study provided evidence that virtual reality exposure can effectively decrease PTSD symptoms and even comorbid diagnoses.

In another study, Rothbaum et al. (2001) explored the effectiveness of the virtual reality exposure therapy in the treatment of nine male veterans from the Vietnam War. Assessments were conducted at pretreatment, posttreatment, and three- and six-month follow-ups. Treatment consisted of ten 90-minute sessions conducted two times a week for an average of five to seven weeks. The approach required a discussion of the traumatic event in the present tense and also prompted the veteran to keep his eyes open during this discussion and during the VR simulation so the therapist could attempt to match the virtual environment to what the veteran was describing (e.g., helicopters). The therapist assessed SUDS ratings every 5 minutes during exposure sessions.

Of the nine veterans in the study, eight veterans at the six-month follow-up showed reductions in PTSD symptoms as evidenced by CAPS, which showed a range of 15-67% decrease in overall PTSD symptomatology. IES total scores also showed decreases in intrusion and avoidance symptoms from baseline to the three- month follow-up, but there was an increase in symptoms at the six-month follow-up. BDI results also showed a decrease following treatment, and again, an increase which tapered off at the six-month follow-up. Taken together, Rothbaum et al.'s series of studies conducted in 1999 and 2001 provide evidence of the effectiveness of VRE; however, the results from such a small number of participants may not be generalizable. In addition, Rothbaum et al.'s (2001) study was an open clinical trial whereby both researchers and participants were aware of the treatment. Thus, expectancy effects and demand characteristics may have affected the results.

Rothbaum et al. (2003) continued their examination of the effectiveness of VRE in another case study of a 52-year-old male Vietnam veteran who exhibited PTSD, depression, and other anxiety symptoms. Data collected on the veteran included detailed accounts of five traumatic events he encountered during the Vietnam War. The veteran participated in twice-weekly sessions of VRE using a Huey helicopter environment or a Vietnam jungle environment. The study's goal was to assess anxiety symptoms

by measuring physiological responses during virtual reality exposure therapy. Heart rate and skin conductance ratings were measured every minute for 25 minutes followed by a posttreatment measurement. Physiological assessments showed that this veteran's overall heart rate was high when he was asked to recall and discuss his traumatic memories; however, as the treatment progressed, his heart rate decreased when recalling and discussing the same memories.

Interestingly, the client's physiological reactivity and self-reported distress were not always correlated (Rothbaum et al., 2003). Nonetheless, his SUDS ratings decreased as well. The participant's BDI scores indicated a marked posttreatment decrease in depression compared to pretreatment. CAPS scores decreased significantly from 40 (pretreatment) to 30 (posttreatment) at the six-month follow-up. However, there was an increase in symptoms at the three-month follow-up with a CAPS score of 49 from the baseline of 40. The researchers hypothesized that this increase could be due to a lack of coping skills and adjustment prior to terminating therapy and treatment. More research is needed to determine causes and possible explanations for such increases in PTSD symptoms after posttreatment.

In another study, Ready and colleagues (2006) examined 14 male Vietnam veterans who participated in two 90-minute therapy sessions per week in an outpatient setting. Veterans received eight to 20 total sessions of virtual reality exposure. The first session was an orientation session, with veterans experiencing a neutral virtual reality environment session (i.e., mock trial). Session two focused on the traumatic memory and the virtual reality treatment (Virtual Vietnam), and became progressively intense as treatment continued. Maintaining a discussion with the veteran about the traumatic memory was important in order to create a setting for habituation in combination with the virtual environment component. As previously mentioned, a key objective in this treatment is to not overwhelm the veteran, so SUDS ratings were obtained every 5 minutes to determine the level of anxiety. If the ratings were too high, a neutral stimulus was presented in the virtual module in order to lower anxiety.

For these veterans, the treatment ended when he was able to successfully discuss the traumatic memory in detail without obtaining a high level of negative emotion (i.e., fear) or anxiety, again measured by the SUDS ratings (Ready et al., 2006). The study concluded with a posttreatment assessment at the three- and six-month follow-up. The researchers found lowered posttreatment symptom scores compared to pretreatment scores, showing support for the effectiveness of virtual reality exposure treatment. Posttreatment scores lowered from the three-month follow-up to the six-month follow-up, showing evidence that after the treatment had been completed, the veterans learned the proper coping skills to successfully manage posttraumatic stress symptoms. The researchers also found reductions in specific criterion variables in avoidance and arousal symptoms of PTSD from the CAPS. Further, veterans' self-reports of intrusion symptoms from the IES and depression level, measured by the BDI were significantly lower at posttreatment. This study demonstrated significant overall reductions in PTSD symptoms and depressive symptoms as a result of using virtual reality exposure treatment, but it should be noted that limitations in this study include a small sample size and lack of a control group.

During a more recent study with 11 male Vietnam veterans, Ready, Gerardi, Backscheider, Mascaro, and Rothbaum (2010) investigated whether virtual reality exposure therapy ($n$ = 6) or present-centered therapy (PCT; $n$ = 5) would have more impact in decreasing PTSD symptoms. While virtual reality exposure therapy focuses on a corrective experience of the "there and then" by including the details of the trauma, processing the trauma, and incorporating reprocessed information, present-centered therapy emphasizes the "here and now" by maintaining a focus away from the traumatic stimuli through the use of psychoeducation and problem-solving techniques (Ready et al., 2010).

Virtual reality exposure therapy was completed following the guidelines with SUDS ratings assessed every five minutes and all veterans recounted their traumatic memories during treatment. Both treatment groups completed ten 90 minute sessions. A clinician blind to the treatment group conducted the CAPS and BDI for all veterans at pretreatment, posttreatment, and at the six-month follow-up. There were no statistically significant differences between CAPS scores pre and posttreatment or between BDI

scores pretreatment and posttreatment. The virtual reality exposure group showed CAPS improvement from pretreatment to posttreatment, and from pretreatment to the six-month follow-up. The present-centered therapy group also showed improvement from pretreatment to posttreatment, and from pretreatment to the six-month follow-up. Upon further analyses, after combining both treatment groups, there was significant improvement in CAPS scores from pretreatment to posttreatment and pretreatment to the 6-month follow-up (Ready et al., 2010). Thus, VRE was shown to be effective, but in their study, it was not more effective than PCT at reducing PTSD symptoms. Ready et al. (2010) acknowledged their low sample size and the issues with generalizing from such. The authors noted they encountered difficulty in recruiting Vietnam veterans, as these veterans show significant treatment resistance, especially with technology. Nonetheless, this study is the most current known to have success in using VRE therapy with Vietnam veterans, thus demonstrating promise; further research should endeavor to compare VRE treatment with more established treatments to determine its effectiveness.

**VRE Treatment of U.S. Veterans of the Iraq and Afghanistan War**

Besides the veterans of the Vietnam War, VRE has also been used in the treatment of the veterans of the Iraq and Afghanistan wars. Wood et al. (2007) examined a 32-year-old Iraq male veteran with 12 years of current active duty service who had been diagnosed with PTSD. To assess his symptoms, The Posttraumatic Stress Checklist-Military (PCL-M), Beck Anxiety Inventory (BAI) and CES were used, along with psychophysiological measures of skin conductance, respiration rate, and heart rate. All assessments were acquired pretreatment, midway through the treatment at the five session mark, and posttreatment. Also, SUDS ratings were assessed every 5 minutes during exposure. The veteran participated in ten, 90 minute virtual reality graded exposure therapy (VRGET) sessions, one time a week. During the first two sessions, the individual became acclimated to the equipment and process of the therapy, and learned about meditation training techniques. In these initial sessions, the veteran also described, in detail, his traumatic event account and physiological measurements were obtained. During the subsequent sessions, each therapy session was divided into four, 20 minute increments (a review of the previous session, meditation training, virtual reality graded exposure therapy, followed by a debriefing and discussion of current symptoms and issues).

The client's scores on the BAI indicated that his anxiety remained consistently "moderate" throughout the sessions. On the PCL-M the veteran met a formal PTSD diagnosis on both the pre- and mid-treatment assessments; however, the posttreatment score was significantly lower and the veteran no longer met the criteria for PTSD. With respect to physiological measurements, skin conductance ratings decreased following treatment and the participants reported no arousal symptoms. Lastly, the veteran's heart rate was lowest at posttreatment following the recovery phase of treatment, meaning he was able to also decrease his arousal and allow for habituation to occur. Whereas this veteran exhibited desired improvement, it is important to note that outcome of a case study cannot necessarily be generalized to all veterans.

Similar to the studies mentioned above, Gerardi et al. (2008) reported successful VRE treatment of a 29 year-old male Iraq veteran with over 10 years of military experience who was diagnosed with PTSD. The veteran spent 4 weeks, with one session a week lasting 90 minutes, in virtual reality exposure therapy with an average of 50 minutes a session in the virtual environment. SUDS ratings were collected every 5 minutes during the treatment. The veteran's posttreatment PTSD Symptom Scale Self-Report (PSS-SR) score reflected a decrease from pretreatment. Similarly, depressive symptoms decreased as evidenced by BDI scores. However, although posttreatment scores on CAPS exhibited a 56% decrease in PTSD symptoms, he still met an official diagnosis of PTSD according to the CAPS. Nonetheless, the majority of these results, along with the veteran's self-reported data, showed an increase in quality of life, including less intense PTSD symptoms following the VRE treatment. This case study offers additional support for the need of nomothetic research into VRE effectiveness.

Along the same lines, Reger and Gahm (2008) conducted a case study with a 30-year-old man with

active duty Army status. The veteran client had completed nine years of military service with one prior deployment to Iraq. He had experienced several traumatic events while deployed (e.g., witnessing a friend's death and enemy death) and was diagnosed with PTSD. This Army veteran completed six 90-minute sessions of VRE for a total of four weeks. Treatment also consisted of psychoeducation, relaxation training, and in vivo exposure. Following the treatment, the veteran's posttreatment score on the PCL-M was 29. The veteran self-reported a higher quality of life including fewer PTSD symptoms and an increase in overall functioning. At the seven week follow-up, the veteran reported improved functioning compared to the level of functioning he reported prior to the treatment. When researchers asked his opinion on VRE, he stated "I don't think I would be where I am today without it," (p. 944). His family also noted his improvement. We should add, however, that there were no objective scores provided at this point, so these anecdotal accounts, although encouraging, must be interpreted with caution.

More recently, Rizzo, Difede, and colleagues (2009) conducted a study of VRE effectiveness with Iraq and Afghanistan veterans which included female ($n$ = 1) and male ($n$ = 19) participants. All veterans had met a formal diagnosis for PTSD and had not benefited from other treatment modalities. Virtual reality sessions occurred twice a week for 90-120 minutes on average over a five-week time period. Self-report measures on the PCL-M and BAI were collected at pretreatment, posttreatment, and at a three month follow-up. The PCL-M results showed 16 participants no longer met an official PTSD diagnosis and 17 of the 20 participants reported decreases of at least 50% in PTSD symptoms following treatment. The BAI showed significant decreases in anxiety levels following treatment, with a 33% decrease in anxiety symptoms (Rizzo, Difede, et al., 2009). These results are again encouraging, as 80% of participants no longer met a formal PTSD diagnosis. The evidence from this study further points toward virtual reality exposure's effectiveness in decreasing PTSD symptoms with small samples of participants.

Miyahira, Folen, Hoffman, Garcia-Palacois, and Schaper (2010) presented the case of a male Iraq veteran diagnosed with chronic PTSD. This veteran had two prior deployments and a total of six years of military service. He completed six sessions of virtual reality exposure therapy, in combination with cognitive behavioral therapy sessions, for a total of 10 treatment sessions. Clinical assessments utilized were the CAPS, BDI, Quality of Life Inventory (QOLI), and the Posttraumatic Stress Diagnostic Scale, which evaluates PTSD symptoms. Assessments were completed pretreatment, posttreatment, and at the three-month follow-up. All assessments showed a decrease in PTSD symptoms, avoidance symptoms, and depression symptoms from pretreatment to posttreatment and three-month follow up. One unfortunate exception to this pattern of success was that scores on the QOLI, a self-report of quality of life, did not improve. One possible explanation for a low quality of life score, according to the researchers, may be the veteran's impending re-deployment to Iraq and report of having a newborn child from whom he would be separated when deployed.

Among research on virtual reality exposure therapy to treat military veterans with PTSD, we could locate only one study which described and discussed the treatment of a female veteran with combat-related PTSD. Wood et al. (2009) presented the case study of a 26-year-old female Seabee (a Naval Construction Battalion solider) who completed three deployments in Iraq with six total years of active duty service. This client was diagnosed with PTSD and a mild traumatic brain injury. Her prior mental health treatment consisted of the antidepressant paroxetine, which did not decrease her symptoms. During the treatment with VRE, the client was administered the PCL-M, the BAI, and the CAPS at pretreatment, posttreatment, and three-month follow up. Additional assessments included psychophysiological measures of skin conductance and peripheral finger temperature ratings (Wood et al., 2009).

The female veteran completed 20 virtual reality exposure sessions over 20 weeks and each session lasted 90 minutes. According to her BAI scores, there was a significant decrease in anxiety from pretreatment (28) to posttreatment (3), with a three-month follow-up score of 6 (indicating minimal anxiety). On the PCL-M this veteran scored 65 at pretreatment, 27 at posttreatment, and 24 at the three-month follow-up. Finally, the CAPS also showed a downward

trend of decreasing PTSD symptoms (83 at pretreatment; 11 at posttreatment; and 12 at three month follow-up). Of further note, skin conductance ratings lowered throughout treatment. Skin temperature did increase throughout treatment, which was expected, but showed no evidence of increase at the three-month follow-up (Wood et al., 2009). According to Wood et al. (2009), this female veteran's results showed improved PTSD scores compared with those of male veterans with PTSD. The client also reported improvements in her quality of life and more control over her symptoms following treatment (Wood et al., 2009). The results of this study showing the effectiveness of VRE in treating combat-related PTSD is consistent with the results of other VRE research using the case study methodology or research using small samples. Limitations include a lack of directly comparing gender effects, and the inclusion of a single female, as her results might not generalize to all females diagnosed with this disorder.

Reger and colleagues (2011) recently examined VRE therapy's effectiveness in treating active duty Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) veterans. The sample included 24 veterans with at least one combat deployment, 75% of whom had a PTSD diagnosis and 25% of whom were diagnosed with anxiety disorder, not otherwise specified (NOS). Thirteen participants had not responded to other treatments. These veterans had experienced significant traumas such as improvised explosive device attacks involving body recovery or death, killing, or witnessing a fatal suicide attack.

Veterans received VRE therapy following the standard protocol (cf. Foa, Hembree, & Rothbaum, 2007) with the exception of session two. Here, Reger et al. (2011) introduced VR using an initially pleasant virtual environment. Following this, they introduced the Virtual Iraq environment. Researchers assessed symptoms using the PCL-M at pretreatment, throughout treatment, and posttreatment. Results showed a statistically significant drop in participants PCL-M scores from pretreatment ($M$ = 60.92, $SD$ = 11.03) to posttreatment ($M$ = 47.08, $SD$ = 12.70). Participants who averaged seven sessions of VRE reported PTSD symptom reductions with statistical and clinical significance.

Moreover, in this study, prior treatment did not have a significant effect on PCL-M scores (Reger et al., 2011). At pretreatment, PCL-M scores were significantly higher among participants with PTSD than those with anxiety disorder NOS. However, at posttreatment, differences in PCL-M scores were no longer significant between the groups (Reger et al., 2011). Twenty of the participants met the criteria for PTSD diagnosis at pretreatment, but at posttreatment, nine participants no longer met the criteria for PTSD and 15 participants had improved at least 11 points on the PCL-M.

Limitations of Reger et al.'s (2011) study include the lack of a comparison group, and that the outcome measures did not include clinician administered measures or blind assessments. Nonetheless, they took a rare nomothetic approach to the study of VRE effectiveness, and their results do underscore the promise of VRE in treating PTSD in veterans. One important feature of their study was the timing of the treatment. Often, veterans do not receive treatment for PTSD until decades after their trauma. Here, the average time from trauma until treatment was 2.33 years. Further research should account for time lags from trauma until VRET to assess its effect on outcomes.

Also fairly recently, Mclay et al. (2011) conducted a randomized, controlled trial to compare virtual reality graded exposure therapy (VR-GET) to treatment-as-usual (e.g., group therapy) for active duty service members with PTSD. Their subjects were 20 veterans of Iraq or Afghanistan campaigns who had a minimum CAPS score of 40. Ten participants were randomly assigned to the VR-GET group and ten were assigned to the treatment-as-usual (TAU) group. VR-GET combines graded VRE with physiological monitoring and skills training. The skills training component helps the patient become aware of cognitive reactivity levels and autonomic arousal cues and then employs techniques to facilitate a sense of control in high anxiety situations. This may allow clients to confront their trauma in a more present way. The VR-GET group participated in 1–2 sessions per week for ten weeks. The first two sessions were devoted to completing an intake interview, obtaining a complete trauma history including the participants' symptoms, disclosure of their most traumatic event, psychoeducation with respect to meditation skills and attention control skills, and practicing these skills while

recalling their most significant trauma. In the following sessions, participants began the Virtual Iraq or Afghanistan while a therapist controlled the intensity and provided a graded exposure experience. SUDS scores and physiological monitoring guided the therapist in selecting the appropriate intensity. The TAU group could use prolonged exposure, cognitive processing therapy, EMDR, pharmacotherapy, group therapy, or other common treatment for PTSD.

Results showed that 70% of the VR-GET group had at least a 30% CAPS score improvement. The TAU group did not demonstrate the same improvement (Mclay et al., 2011). These results offer more data supporting VR-GET effectiveness for combat-related PTSD in veteran populations. Study limitations included small sample size and variability in the control group.

McClay and colleagues (2011) conducted another study of VRET effectiveness. In an open-label, single group study, 20 active duty soldiers who served in Iraq and Afghanistan participated in VRET as part of a treatment development project. All participants had a diagnosis of combat related chronic PTSD. VRET was provided using the Virtual Iraq environment. Sessions took place twice per week for 90 to 120 minutes. VRE sessions were 45 minutes long and the remainder of the session consisted of processing the exposure. The number of sessions ranged from 10-15. The PCL-M, Patient Health Questionnaire-9 (PHQ-9), and BAI were administered two weeks before treatment, one week after completing treatment, and at three months posttreatment.

Results show that of the 42 patients who entered treatment, 20 completed treatment and posttreatment measures (Mclay et al., 2011). Of those, 15 (75%) no longer met diagnostic criteria for PTSD and demonstrated an improvement of at least 50% on PCL-M scores (Mclay et al., 2011). At the three month assessment, 13 participants (76%) continued to show at least a 50% improvement from baseline on PCL-M scores. A significant difference was reported between pretreatment scores and posttreatment scores on the PCL-M, as well as between pretreatment and 3-month follow up scores. Scores between posttreatment and three month follow-up were not statistically significant. Results of PHQ-9 scores indicated a significant difference between pretreatment and posttreatment and between pretreatment and three month follow-up, indicating a reduction in depression was maintained. Moreover, BAI mean scores dropped significantly from 19.9 (moderate anxiety) pretreatment to 14.7 (mild anxiety) posttreatment. This study offers additional evidence of VRET effectiveness for active duty PTSD sufferers, as well as for treatment resistant PTSD patients. However, the lack of a control group and a non-randomized design may limit the internal validity of this study.

**VRE Treatment of Non-U.S. Veterans**

VRE treatment studies have not been limited to veterans of the U.S. military. The conflicts in Iraq and Afghanistan have forced new populations to deal with the issue of PTSD in veterans.

Tworus, Szymanska, and Ilnicki (2010) noted that Poland has not been involved with military conflict since the time PTSD was officially recognized by the medical literature. Thus, when Polish soldiers became involved in Iraq and then Afghanistan, cases of PTSD presented a problem for Polish military psychiatrists and psychologists who had no experience with treating the disorder. The clinicians turned to the United States for assistance with treatment alternatives and in so doing, collaborated to implement VRE in the treatment of Polish veterans diagnosed with PTSD.

Tworus and colleagues (2010) presented the case of a 30-year-old soldier from the Polish military who experienced three traumatic incidents over the short period of about one month. The soldier was diagnosed with severe PTSD and hospitalized for approximately four months. He received group and individual psychotherapy, as well as pharmacotherapy. The soldier was stabilized and released from the hospital. Three months later the patient was re-hospitalized due to PTSD symptoms and an intense fear of weapons that rendered him unfit for military service. The veteran was evaluated with the Minnesota Multiphasic Personality Inventory-2 (MMPI-2), Mississippi scale, Watson's PTSD Interview, CES, Stress Events Questionnaire, and the Psychopathology Checklist-Military: Stress Event Impact Questionnaire. The soldier received VRE therapy. The first three sessions focused on concentration training to allow the soldier to manage severe intrusive thoughts associated with

PTSD. The soldier then completed 22 VRE sessions scheduled twice per week for 30–45 minutes. Autonomic arousal was measured while he experienced the virtual Iraq environment. Notably, during VR sessions the veteran was able to experience the environment and then extrapolate the scene in his mind to include images that were not displayed. Though initially distressing, eventually the soldier had no difficulty being in the virtual Iraq environment. At this point, the soldier began three sessions of in vivo exposure by participating in an actual shooting exercise. Initially the exposure caused intense anxiety that included fear, trembling, and muscle pain. At the conclusion of the third session the soldier no longer experienced these symptoms.

The soldier was able to return to duty without symptoms of PTSD. At three month follow up, the soldier remained symptom free. To verify that the soldier was not covering up symptoms or engaging in the emotional numbing common to PTSD sufferers, the soldier was asked to complete an additional VR session. Autonomic arousal was monitored and confirmed that the soldier maintained improvement (Tworus et al., 2010).

Although case studies do not necessarily allow for generalization, this case shows that VRE therapy can be effective for treating PTSD in veterans who have not responded to psychotherapy and pharmacotherapy. It also offers evidence that VRE therapy can be effective for treating PTSD in veteran populations cross-culturally. That being said, there are limitations in this case report. For example, the authors did not provide the pretreatment and posttreatment assessment test results. Rather, the authors simply indicated that the patient showed improvement. Even more important to note, the patient was coerced into VRE therapy. That is, he was told that his participation was a condition for release from the hospital (Tworus et al., 2010). Still, this case is an example of a positive outcome, and this case study adds to the mounting evidence of success of VRE therapy for the treatment of PTSD using primarily case studies (e.g., Miyahira et al., 2010), or small sample sizes (e.g., Mclay, 2011).

Gamito et al. (2009) investigated Portuguese veterans with PTSD in a controlled virtual reality exposure study. Five Portuguese veterans received virtual reality exposure therapy and completed either traditional psychotherapy or were in a waiting list group. From pretreatment (before session one) to midtreatment (after session five), the VRE group showed a statistical reduction in obsession-compulsion scores on the Symptoms Check List-Revised (SCL-90R). In addition, even though not statistically significant, avoidance, intrusion, and hyperarousal symptoms showed descriptive reductions (Gamito et al., 2009). Ostensibly, statistical significance may not have been reached in this study due to the low sample size. In addition, the researchers reported that these assessments were conducted during treatment, and not thereafter. Regardless, since symptoms were reduced in clients, this treatment should be further tested cross-culturally.

Gamito et al. (2010) completed another study to investigate whether VRE therapy or imaginal exposure were more effective. Portuguese veterans with PTSD were assigned to receive VRE ($n = 4$), imaginal exposure ($n = 2$), or a control group ($n = 3$), consisting of a waitlist. All participants were provided with 12 sessions of treatment with the exception of the waiting list group, who did not receive any treatment. Measurements used to assess symptoms were the Impact of Events Scale (IES-R), SCL-90-R, and the BDI, which were conducted at pretreatment and posttreatment. Following the 12 sessions of treatment, the virtual reality exposure group showed an 8% decrease in overall PTSD symptoms found by the CAPS, while the imaginal exposure group showed a 1% decrease, followed with the waiting list group with a 6% decrease in PTSD symptoms (Gamito et al., 2010). While these results did not meet statistical significance, they followed the predicted pattern, and the lack of significance may be due to the low sample size. There were, however, some statistical differences between the groups. According to scores on the SCL-90-R, a significant decrease was found along the depression dimension for the virtual reality exposure therapy group from pretreatment to posttreatment, while there was an increase in depression with the imaginal exposure group. The BDI was assessed with the virtual reality exposure therapy group only and resulting in a 40% statistically significant decrease from pretreatment to posttreatment in depression symptoms. In addition, veterans who

experienced VRE reported less anxiety and depression than the veterans in the other groups (Gamito et al., 2010).

Taken together, Gamito and colleagues' (2009; 2010) findings suggest cross-cultural evidence of the promise for VRE in treating PTSD. Future studies should test VRE with non-U.S. participants. Future studies should also utilize larger number of participants to increase the likelihood that typical outcomes are representative of the target population.

## Discussion

The goal of this study was to critically examine the literature related to the use of virtual reality exposure therapy in the treatment of PTSD in veterans. We found 13 pertinent empirical studies, all of which used the case study methodology or utilized small sample sizes, but provided evidence of the success of VRE treatment. The main purpose of VRE is to decrease PTSD symptoms, thus augmenting quality of life. All studies documented decreases in PTSD symptom clusters (avoidance, hyperarousal, and intrusion), and in almost all studies the veterans reported increases in quality of life. In addition, evidence indicated that VRE treatment may work better than other treatment models (e.g., imaginal exposure therapy). Thus, VRE therapy appears to hold promise in treating military veterans with combat-related PTSD.

### Advantages of Virtual Reality Exposure

Based on the evidence presented in the studies above, as underscored by many experts in the area, virtual reality exposure therapy has many strengths and poses numerous advantages over other treatment modalities for PTSD.

One of the biggest advantages of VRE is that the veteran is able to control the level of stimulation with regard to the amount of anxiety and the virtual environment. For instance, if the session becomes too overwhelming, the therapist can discuss this event with the veteran and the veteran may slow the pace during virtual reality or change the presented VR stimuli. Patient-directed VR navigation instills a feeling of control, which allows PTSD patients to develop a new sense of accomplishment (Bush, 2008). This is critical in PTSD recovery, as sufferers often feel like they are not in control of their own actions, thoughts, or feelings.

An additional advantage of VRE is allowing full engagement. Unlike imaginal exposure, whereby the individual imagines the traumatic event, virtual reality exposure allows the individual to remain immersed and engaged during the entire session through discussions of the event and the virtual environment (Ready et al., 2006; Rothbaum et al., 2001). With the triggering environment created by technology, the client can focus mental resources on anxiety and coping, allowing for more emotional engagement compared to imaginal exposure (Riva, 2009).

Another benefit of VRE in treating combat-related PTSD, for both therapist and veteran, is easier access to the triggering environment because it is conducted in an office setting and not in the field (Cukor et al., 2009). In addition to "case of access," there is little risk of physical harm during virtual reality exposure sessions compared to other exposure treatments and it is therefore safer and more private, making it easier to bring the traumatic memory to practice (Riva, 2009; Rothbaum et al., 1995). Taking a client into combat or onto a battlefield would be necessary to elicit emotional processing during in vivo exposure. With VRE, however, the triggering situation is realistically simulated in a comfortable setting (Rothbaum, Rizzo, & Difede, 2010), and therapists can repeat exposure experiences with ease compared to other exposure treatments, e.g., in vivo (Rothbaum et al., 2010).

The use of technology in VRE is yet another advantage to this treatment approach. Technology in work or at play has become second nature to the younger generation, and with younger military personnel returning from combat, learning how to navigate a new piece of technology should not be difficult (Rizzo, Newman, et al., 2009). Virtual Iraq appears to be an attractive treatment that may allow more Iraq and Afghanistan veterans the ability to utilize technology and treatment to decrease their symptoms (Reger, Gahm, Rizzo, Swanson, & Duma, 2009; Rizzo, Newman, et al., 2009). Further, stigma reduction occurs as less one-on-one time is spent with the psychologist and more time is devoted to the use of a computer. The veteran may initially feel safer in the virtual environment than in the traditional therapeutic context (e.g., individual talk-therapy), given that he

or she does not have to engage in constant person-to-person contact.

Indeed, one of the difficulties therapists encounter in the treatment of PTSD is the avoidance and escape behavior clients exhibit (Bush, 2008; Cukor et al, 2009). These clients often consider travel time and distance to the treatment center as time consuming and may use this as an excuse to avoid treatment. However, VRE therapy helps to eliminate the use of this excuse and the avoidance behavior. Some virtual environments are mobile, and depending on the circumstances, the therapist can meet the veteran in a more comfortable setting (Bush, 2008; Cukor et al., 2009). For veterans who live far from treatment centers or have other psychiatric symptoms, such as social phobias, they can complete treatment in the comfort of their home.

**Disadvantages of Virtual Reality Exposure**

Virtual reality exposure (VRE) therapy is not without its disadvantages. Avoidance and escape tendencies may interfere with the initial use of the virtual reality system. That is, veterans may use their discomfort with technology as an escape. This may be particularly true for older veterans who are not comfortable with the use of technology (Ready et al., 2010). As mentioned above, avoidance and escape are prevalent in those suffering from PTSD (Bush, 2008).

Along these lines, another limitation of VRE might be that the simulation can serve to perpetuate avoidance of human contact that is already present in PTSD symptomatology. In other words, more time spent in the virtual environment is less time spent directly engaged with the therapist. Because the aim is to decrease PTSD symptomatology, therapists may want to decrease virtual environment exposure and increase the actual time spent in human-to-human interaction with the veterans as their PTSD symptoms improve.

Moreover, whereas the use of technology may be a draw, particularly to younger veterans, Riva (2005) emphasized the lack of complete personalization of the virtual environments. As underscored by Hodges et al. (1999), not every memory or event can be perfectly created in the virtual environment. Each individual in treatment will have experienced different trauma in combat. For example, a virtual explosion may not replicate the precise memory for a veteran who suffered a trauma in this manner.

Also, with respect to the technology employed in VRE therapy, as mentioned earlier, cost is a major barrier to implementing its widespread use. Virtual reality exposure's expenditure requires money and time in order to begin initial treatment, both for the therapist and the veteran. A virtual reality system ranges in price from $5,000 to $200,000, with some estimates for an entire system reaching as high as $1 million (Riva, 2005; Wiederhold & Wiederhold, 2005). Further related to funding issues is the lack of trained professionals certified to conduct this type of therapy. This treatment tends to be unfamiliar, which can cause anxiety in clinicians and therapists (Bush, 2008). In addition, it is costly to train clinicians and technical support individuals to create, maintain, and operate virtual environments (Riva, 2005; Rothbaum et al., 2010). Thus, there appears to be large hurdles in terms of providing this treatment for the people who need it.

Among the drawbacks of VRE, one must consider the minor side effects that can occur from use of the virtual environment and device—motion sickness, cybersickness (motion sickness caused by a virtual environment), dizziness, and nausea have been reported in clients (Riva & Vincelli, 2001). While these symptoms are minor compared to the presenting symptoms of PTSD, proper care should be taken to prevent any side effects which could deter the veteran from further progress and even cause him or her to terminate therapy.

**Future Directions**

Whereas evidence suggests there are many benefits to using VRE to help combat-exposed veterans conquer PTSD symptoms, as this review has found, and as Ready et al. (2006) discussed, the need exists for future research with respect to its effectiveness and limitations.

There has been little research on VRE effectiveness conducted with larger sample sizes. Most of the studies discussed herein included either a single case or a very few participants (e.g., case studies by Reger & Gahm, 2008; Wood et al., 2009). Although case studies and low sample-size research provide valuable sources of hypotheses, virtual reality exposure is

a non-traditional and fairly new treatment for reducing PTSD symptoms, and further studies would benefit from larger participant sample sizes and further replication studies within the military population, as the diagnoses of combat-related PTSD continue to increase (Rothbaum et al., 2003).

In addition, most research involving military veterans treated for combat-related PTSD has been conducted with Vietnam veterans (Creamer & Forbes, 2004). Future research should examine other veteran populations beyond the Vietnam War and include recent veterans such as the Gulf War, and more recently Iraq and Afghanistan, to allow for generalizability across the veteran population. Moreover, additional research needs to be conducted with veterans in other countries to test the cross-cultural effectiveness of the VRE therapy. With respect to study design, creating treatment plans using randomized controlled clinical trials might provide stronger empirical evidence about how this therapy fairs against the other types of treatments.

Another limitation to the generalizability of studies of VRE treatment for PTSD is the limited number of female participants and the overall limited data on female veterans with PTSD (Creamer & Forbes, 2004). According to the Department of Veterans Affairs, as of September 2009, there were approximately 23 million United States veterans, and 1.8 million are female. That is, roughly 8% of the veteran population is comprised of women (Department of Veterans Affairs, 2010). In addition, female military veterans are twice as likely as men to develop PTSD (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Not emphasizing the treatment needs of female veterans is a grave oversight on researchers' and therapists' part (Breslau, 2002), and it is clear that future research should focus on this vulnerable population so that gender differences in the experience and treatment of PTSD and the effectiveness of VRE therapy in the treatment of female veterans can be determined.

Moreover, the current published research includes follow-up information on the veterans at three- and six-month posttreatment. Future studies should examine longer effects of this treatment by following these veterans perhaps at nine- or twelve-month posttreatment.

**Summary: The Promise of VRE Treatment**

Based on the evidence presented in this work, we contend that virtual reality exposure therapy is a promising technological treatment for use with military veterans, and we concur with other researchers who have suggested that this treatment become a standardized treatment for veterans with PTSD (Cukor et al., 2009). In addition, in the wake of evidence of its effectiveness, further research is needed to discover methods of creating a virtual reality module at a less expensive price; this would have obvious benefits to the therapist, the organizations purchasing the device, and insurance companies.

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