Review of exposure therapy for combat-related posttraumatic stress disorder with special focus on virtual reality exposure therapy

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Review of Exposure Therapy for Combat-Related Posttraumatic Stress Disorder

with Special Focus on Virtual Reality Exposure Therapy

Tyler Robert Sellers

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2011
Dedication

My deep thanks go to my wife Melissa for her encouragement and patience through the past two years.
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Introduction

For many an ideal exists of what a soldier looks and acts like. This ideal is often one of a service member who is highly trained, physically fit, and mentally resilient in the dangers and stresses of combat. However, this is not the reality when some service members return from combat deployments. On returning they are often marked physically and psychologically from their combat experiences. While the physical wounds may heal, the marks of the psychological trauma of combat may remain in the form of mental health disorders. One of the most notable mental health disorders is Post Traumatic Stress Disorder (PTSD). PTSD is a highly individualized and difficult to treat mental health disorder. While there are therapies available for the treatment of PTSD, they are few in number and not universally effective. Consequently, there is a significant need for effective therapies for service members who experience combat-related PTSD.

There are several therapies that have proven to be effective, whereas others show promise as future therapies. Exposure therapy is one category of therapies that has been shown to be effective. Virtual Reality Exposure therapy (VRET) is a therapy within this category that has displayed potential as a treatment option for combat-related PTSD. It is the purpose of this review to investigate VRET's existing body of research in relation to combat-related PTSD and offer some future research directions.

This is performed by searching for peer-reviewed journal articles in the following databases: Published International Literature on Traumatic Stress (PILOTS), ISI Web of Knowledge, Ohio Link, PubMed, and the National Center for PTSD. Search terms used on these databases include combat PTSD, combat-related PTSD, psychotherapy, virtual reality, virtual reality exposure therapy, VRE, VRET, exposure therapy, Rizzo, Foa, Wilks, Hoge, and
Rothbaum. Inclusion criteria for the selection of articles included those concerning VRE therapy for PTSD since its inception in 1999 (Rothbaum et al., 1999). The primary measure of efficacy of the studies involved documenting reported symptom changes in service members through the use of subjective questionnaires. These questionnaires asked the patients about the presence and severity of PTSD symptomatology. Statistically significant improvements in the questionnaires' scores were considered to indicate potential treatment efficacy.
Background

Historical Approach to PTSD

The military conflicts in Iraq and Afghanistan have brought the reality of PTSD to the forefront of the minds of both mental healthcare providers and the public. For many in the public this may be the first time they have heard of PTSD. However, PTSD-like reactions to traumatic combat events have been recognized through history. These can be seen in novels such as in Remarque's *All Quiet on the Western Front*, or more recently, O’Brien’s *The Things They Carried*. In these stories there is a clear description of some type of severe anxiety reaction to traumatic combat events. Formal investigation into post-combat anxiety disorders began following WWII (Andreasen, 2010). At that time, the recorded anxiety disorder symptoms were called “stress neuroses” (Futterman, 1951). The primary characteristics of these neuroses were anxiety, autonomic arousal, reliving the experience, and sensitivity to stimuli that patients associated with the original traumatic event. Differing points of view on the theories behind the descriptions of *stress neuroses* influenced the development of the Diagnostic and Statistical Manual, 1st edition, (DSM-I) in 1952 (Lamprecht, 2002).

The DSM-I included a new section titled *gross stress reaction*. Gross stress reaction was characterized as a, “…stress syndrome that is a response to a severe mental or physical stress such as catastrophe or battle…” (1st ed.; DSM–I; American Psychiatric Association, 1952). This diagnosis was not included in the DSM-II from 1968 to 1980 (Andreasen, 2010). PTSD was formally introduced in 1980 following the Vietnam War in the DSM-III (3rd ed.; DSM-III; American Psychiatric Association, 1980). The DSM-III described three categories of symptoms including re-experiencing, numbing of responses, and cognitive or autonomic symptoms. This diagnosis was commonly used to diagnose veterans with post-war anxiety disorders attributed to
their experiences in the Vietnam War (Andreasen, 2010). Modifications were made to the PTSD diagnosis in the DSM-IV in 1994 in that the definition of the stressor was broadened to include a threat of harm to self and others (4th ed.; DSM-IV; American Psychiatric Association, 1994). At this time a new diagnosis of acute stress disorder was also included.

The current description and diagnostic criteria of PTSD are described in the American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders, 4th edition, text revision (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000). According to this, PTSD is a severe anxiety disorder that results from exposure to an extreme stressor involving direct personal experience, witnessing, or learning of an event involving an actual or threatened death or serious injury or other threat to one’s or another’s physical integrity. It also requires that the person’s response to this event include intense fear, helplessness or horror. The likelihood of developing this mental disorder increases as the intensity of and proximity to the stressor increases. The duration of this disorder is variable. Acute PTSD is diagnosed when the symptoms last more than one month but less than three months. Symptoms lasting more than three months constitute a chronic diagnosis.

As with other aspects of PTSD, the clinical features are variable. However, there are a number of common features of this disorder. These common features include re-experiencing the event, avoidance and psychic numbing, and autonomic arousal (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000). Symptoms must be present for more than one month to establish a diagnosis of PTSD.

These symptoms are frequently debilitating to the patient. Patients with PTSD experience a number of negative outcomes concerning quality of life, social interaction, and overall functionality. PTSD carries a close association with other mental health disorders
These disorders include Major Depressive Disorder, Generalized Anxiety Disorder, Substance-Related Disorders, Panic Disorder, Agoraphobia, Obsessive-Compulsive Disorder, Social Phobia, and various specific phobias (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000).

A number of studies involving U.S. military service members supported this trend in combat PTSD. In 2010 Jackupcak et al. reported significantly increased prevalence of PTSD, depression, and alcohol misuse in 331 service members from OEF/OIF associated with combat PTSD (Jackupcak, Tull, McDermott, Kaysen, Hunt, Simpson, 2010). This study reported 28% of the participants screened positive for alcohol misuse, 37.3% for depression, and 37.3% for PTSD. In addition, 76.6% of those screening positive for PTSD also screened positive for depression. A 2009 study reported similar results in a sample of 356 military service members since September 11, 2001 (Dedert et al., 2009). 94.6% of this sample met criterion A for PTSD diagnosis. This study reported rates of 30% for PTSD, 20% for major depression, and 6% for substance abuse or dependence.

The general prevalence of PTSD is variable depending on the population studied. According to the National Comorbidity Survey Replication, the lifetime prevalence in U.S. adults 18 and older is 6.8% (Kessler, Berglund, Delmer, Jin, Merikangas, Walters, 2005). Prevalence of PTSD can range from one third to one half of at risk groups such as military combatants, rape victims, or survivors of a natural disaster (4th ed., text rev.; DSM–IV–TR; American Psychiatric Association, 2000).

The United States military involvement in Iraq and Afghanistan has spurred U.S. mental health researchers to investigate the prevalence of PTSD in returning service member populations. A 2008 study of four U.S. combat infantry units estimated the prevalence to range
from 5% to 13% among service members experiencing combat (Hoge, Castro, Messer, McGurk, Cotting, Koffman, 2008). A retrospective review of 400,000 Army service members reported PTSD prevalence to be 4.4% and 7.1% for those service members serving in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) respectively (Wojcik, Akhtar, Hassell 2009). However, a 2010 study of four Active Component and two National Guard infantry brigade combat teams showed significant variability in the study’s estimates depending on the definition of PTSD (Thomas et al., 2010). This study reported a prevalence of 5.6% to 11.3% and 20.7% to 30.5% when the most stringent and least stringent definitions of PTSD were used respectively.
Exposure Therapy

Therapies for the treatment of combat PTSD include psychotherapy and pharmacotherapy. This paper focuses on psychotherapy as it has been validated through an accumulation of scientific evidence as the first line treatment for PTSD. There are several different psychotherapy modalities. The majority of studies indicate these therapeutic modalities share a common trait in that many of them contain various elements of Cognitive Behavioral Therapy (CBT). Within Cognitive Behavioral Therapy there are four main elements: 1) Psychoeducation, 2) Anxiety Management, 3) Cognitive Restructuring, 4) Exposure.

Research suggests exposure therapy is the only therapy that has shown consistent evidence of efficacy for the treatment of PTSD. This conclusion comes from a large review that was performed by the Institute of Medicine (IOM) as commissioned by the Veterans Administration in 2008 (IOM, 2008). The exposure therapy studies reviewed included those utilizing psychoeducation, breathing retraining, and relaxation along with exposure techniques. In other words, these studies used exposure therapy as the primary therapy with addition of other elements of CBT. As such, the IOM committee stated, "Thus that the evidence supports the efficacy of exposure therapy should not be interpreted too narrowly" (IOM, 2008). This is not to say other therapeutic modalities are not effective, but that at the time of review the evidence was not supportive to warrant their recommendation.

Theory of Exposure Therapy

There are several prominent theories that serve as the basis for exposure therapy. One of those therapies is Lang’s bioinformational theory of fear structures (Lang, 1979). Fear structures are mental constructs or memories that associate certain stimuli with excessive and pathologic emotional and physiological fear. Another theory that has heavily influenced
exposure therapy called emotional processing theory, utilizes Lang’s constructs. It proposes that for a fear structure to be modified it must first be activated (Foa, Kozak, 1986). Foa and Kozak assert that activation of new information that is incongruent with the previous fear structure must be integrated in order for modification to occur.

The process of activation and modification of the fear structure is achieved through exposure therapy. The fear structure associated with the traumatic event is activated in therapy through confrontation with fear inducing stimuli. Confrontation emotionally engages the patient and has been recognized as a critical step in exposure therapy theory for successful treatment (Jaycox, Foa, Morral, 1998). Confrontation is repeated over a course of therapy sessions allowing for habituation to take place.

Habituation is a process of repeatedly subjecting a patient to an anxiety inducing stimuli in an attempt to reduce a fear response (Jaycox, Foa, Morral, 1998). This theory follows that by repeatedly eliciting a fear response through emotional engagement, one is able to correct the pathologic fear structure (Foa, Kozak, 1986). A reduction in fear response is evidenced by a decrease in autonomic arousal and subjective reports of anxiety. Habituation, along with emotional engagement, have been recognized as two critical steps for successful exposure therapy (Jaycox, Foa, Morral, 1998). However, habituation can be complicated in patients with PTSD due to the fact that these patients can have slower habituation progression (Rothbaum, Kozack, Foa, Whitaker, 2001).

The exposure to the feared stimuli in traditional exposure therapy can be either through a patient’s mind through imagination, which is called imaginal exposure, or in real life, which is called in vivo exposure. Through in vivo exposure the patient confronts the feared stimuli in real life. The intensity of the stimuli is often determined by what is referred to as a fear hierarchy. A
fear hierarchy allows the patient to be exposed gradually to stimuli that illicit more and more fearful arousal (Foa, Keane, Friedman, 2000). According to Foa and Kozack the purpose of this approach is to terminate the conditioned fear response by reducing or eliminating the overwhelming fear response over time (Foa, Kozack, 1986).

**Evidence-based Exposure Therapy Modalities**

Cognitive processing therapy (CPT) is an evidence-based therapy that involves exposure therapy theory while incorporating components of cognitive restructuring of emotional and cognitive outcomes due to a traumatic event (Beck, 1976). With CPT patients write out their trauma narrative and identify areas that emotionally disturb them. This processing of the traumatic memories is performed with the aid of a therapist. In doing so, patients are able to identify and confront negative beliefs and ideation about their traumatic events and attempt to replace them with positive thoughts (Foa, 2009).

Another form of exposure therapy is systematic desensitization (SD). This type of exposure therapy may take the form of imaginal or *in vivo* exposure therapy with the addition of relaxation techniques (Foa, Keane, Friedman, 2000). It utilizes the theory of fear structure and habituation of fear stimuli by introducing the patient to less fearful stimuli and proceeding to more fearful stimuli. When the patient begins to develop noticeable anxiety the fear stimuli is interrupted and the patient attempts to reduce the anxiety with relaxation techniques (Foa, 2009).

A third major exposure therapy modality is prolonged exposure (PE) therapy. This is the most widely used exposure therapy and is the first line treatment for PTSD (Powers, Halpern, Ferenschak, Gillihan, Foa, 2010). It utilizes psychoeducation, breathing retraining, *in vivo* exposure, and imaginal exposure (National Center for PTSD, 2011). It is unique in the fact that it utilizes the major components of the aforementioned therapies. For example, it uses the
anxiety reducing behavioral strategies and theory of fear hierarchy as in SD. In addition, it also uses processing of traumatic events and imaginal exposure therapy as found in CPT.
Virtual Reality Exposure Therapy

Virtual Reality Exposure therapy has been developed in response to the need for effective treatments for PTSD. Several virtual environments have been developed to treat a variety of patients including victims of the September 11th World Trade Center attacks, survivors of Israeli bus bombings, individuals in motor-vehicle accidents, and military service members with combat-related PTSD.

VRET has been proposed as an alternative to traditional imaginal and in vivo exposure therapy. Although an alternative, it is based on the accepted theories of traditional exposure therapy. In imaginal and in vivo exposure therapy the patient narrates through the traumatic memory event with the guidance of a therapist (Rizzo et al., 2009). This allows the patient to emotionally process through the event and to reduce the intensity of the fear response.

VRET utilizes a similar method in that patients imagine the event while immersed in a virtual environment that exposes them to stimuli that activate their fear structures. In this virtual environment the patient encounters a sense of presence. A sense of presence refers to a feeling that one is actually in the virtual environment. This has been identified as a critical component to VRET fear structure activation (Alsina-Jurnet, Gutierrez-Maldonado, Rangel-Gomez, 2010). In theory, once the fear structure is activated it can be modified through habituation.

The virtual environments are equipped with a number of features to promote a sense of presence. Patients are equipped with a head-mounted display (HMD) with screens over each eye (Gerardi, Cukor, Difede, Rizzo, Rothbaum, 2010). These screens provide a three-dimensional picture of the environment along with motion sensors that track the users head position in the virtual environment. The HMD is also equipped with speakers that provide sounds to enhance
the sense of presence. Other sensory stimuli can be utilized including tactile and olfactory stimuli such as vibrations and smells (Gerardi et al., 2010).

The virtual environment experiences are highly variable. The environment can be altered on several levels to enhance the sense of presence. VRET therapists add or eliminate stimuli by adjusting the intensity of the sights, sounds, and smells encountered in the virtual environment. However, when a patient is first introduced to a virtual environment, he or she is generally introduced to stimuli of increasing intensity following a graded exposure therapy model (Cukor, Spitalnic, Difede, Rizzo, Rothbaum, 2009).

A unique feature of VRET is the fact that it is therapeutically controlled and the patients are in continuous communication with the therapist via an audio feed. This allows the therapist to discuss what the patient is thinking, feeling, and experiencing as is done in traditional exposure therapy. VRET has an advantage over traditional exposure therapy in that it provides the therapist with real time insight into what exactly what stimuli the patient is experiencing (Wood et al., 2007). These features provide a safety measure as it allows the therapist to receive immediate patient feedback. Some studies have enhanced patient monitoring by utilizing physiologic sensors during sessions (Wood et al., 2008). These physiologic sensors most commonly include blood pressure, respiratory rate, and heart rate monitors.

**Virtual Reality Exposure Therapy for Anxiety Disorders other than PTSD**

Virtual reality exposure therapy has been studied in the treatment of certain anxiety disorders with promising results. One category of anxiety disorders studied is simple phobias. The overwhelming majority of these studies revealed VRE was equivalent or superior to the standard *in vivo* exposure therapy and wait list control groups (Gerardi et al., 2010). Another study investigated patient preference when treated for arachnophobia between VRET and *in vivo*
exposure therapy. The study revealed 89.2% of patients preferred VRE to 10.8% *in vivo*, thus suggesting VRET may be more preferable to some patients (Garcia-Palacios, Hoffman, Carlin, Furness, & Botella, 2002).

**VRET for Non-Combat PTSD**

This evidence suggests VRET may be an effective treatment for other anxiety disorders. VRET has been studied as a treatment for PTSD as a result of a variety of traumatic events including motor vehicle accidents, rescue workers at the World Trade Center attack of September 11, and terrorist bus bombing survivors in Israel (Freedman et al., 2010).

One of the studies involving VRET for motor vehicle accident related PTSD reported significant reductions in symptoms of reexperiencing, avoidance, and numbing (Beck, Palyo, Winer, Schwalger, Ang, 2007). In general, studies utilizing VRET for the treatment of PTSD suggested similar benefits (Wiederhold, Wiederhold, 2010). Studies of VRET for the treatment of rescue workers from the WTC attacks have also shown promising results. One of the first studies of this population involved a case report of a woman who experienced a 90% reduction in PTSD symptoms after VRET (Difede, Hoffman, 2002). Another uncontrolled clinical trial investigated the effect of VRET on a group of thirteen patients compared to a waitlist control of eight patients (Difede et al., 2007). This study was consistent with the previous study in that it reported a significant reduction of PTSD symptoms with VRET. There is no current data regarding efficacy of treatment of victims of the Israeli bus bombings utilizing the virtual environment *BusWorld*. The literature regarding this virtual environment merely describes the virtual environment and discusses the level of distress the environment elicited from participants (Josman et al., 2006; Josman et al., 2008). The results of this study suggest the virtual environment is capable of the emotional engagement required for VRET.
VRET for Combat-related PTSD

Each of these previously mentioned studies has gained a great deal of attention, but none as much as those studying VRET for combat-related PTSD. VRET for the treatment of combat-related PTSD has been in development over the last twelve years. It was first investigated in a case study involving a Vietnam War veteran in 1999 (Rothbaum et al., 1999). Since then it has been mostly studied in two populations of service members including Vietnam War veterans and military service members from OIF/OEF. Two virtual environments have been developed for these populations called Virtual Vietnam and Virtual Iraq.

Virtual Vietnam

Three studies have been performed involving Virtual Vietnam. Each of these studies used the same virtual environment and basic equipment setup. The Virtual Vietnam system offered the participants the choice of two virtual environments. One of the virtual environments was a simulation of riding in a Huey helicopter over the jungles of Vietnam (Rothbaum et al., 1999). For this environment the patient was seated in a Huey helicopter "Thunder seat" with a sub woofer underneath to simulate vibrations from the helicopter. In this scenario patients experienced a number of visual stimuli including flying through clouds, landing and taking off in a landing zone under attack, and flying over variable terrain (Ready et al., 2010). Participants also experienced auditory stimuli with sounds of radio chatter, helicopter rotors, bombs exploding, gunfire, and men shouting (Rothbaum, Hodges, Ready, Graap, Alarcon, 2001). These auditory and visual stimuli were provided via the use of a Virtual Research V6 head-mounted display with motion sensors (Rothbaum et al., 2001).

The second environment placed the participant in an open clearing that simulated a landing zone (Ready et al., 2010). The landing zone was approximately two acres in size with
rolling hills, a rice paddy, and the edge of a jungle. Patients moved through this environment with a joystick while standing on a platform with rails. Patients were exposed to auditory and visual stimuli as controlled by the therapist. The auditory stimuli included jungle sounds, gunfire, mine explosions, and men yelling (Rothbaum et al., 2001). Muzzle flashes, helicopters flying and landing, and fog were provided as visual stimuli.

The sequence of treatment was fairly similar among the three studies. In the first session information was gathered about the patient concerning his most traumatic war memories. The patient was then oriented about the virtual reality exposure therapeutic process and introduced to a neutral virtual environment. The three studies reported the standard treatment was ten ninety minute sessions, but the exact number of sessions per participant ranged from eight to sixteen among the participants (Rothbaum et al., 2001).

Through the therapy sessions participants began to describe their traumatic war experiences while in the virtual environments. Participants were exposed to varying levels of intensity and combinations of auditory, visual, and tactile stimuli. The stimuli were manipulated for each patient in an attempt to provide a virtual environment that was emotionally engaging enough to activate the fear structure (Ready et al., 2010). During these sessions the patient was asked to report their Subjective Units of Distress Score (SUDS) every five minutes. In the 2010 study the participants were also asked to report any areas of body tension noticed during therapy (Ready et al., 2010). These self reports were used as markers of emotional engagement for the therapists.

**Virtual Vietnam Results**

The results from these three studies focused on three primary measures of outcome. These included the Clinician Administered PTSD scale (CAPS) score, Impact of Event Scale
(IES) score, and Beck Depression Inventory (BDI) score. Some of the studies did not use all of these measures.

The 1999 case study reported an overall decrease in the individual symptom clusters and total CAPS, IES, and BDI scores (Rothbaum et al., 1999). The pretreatment and six month follow-up total CAPS were 64 and 47 respectively, thus indicating a clinically significant improvement in symptomatology. However, this still indicated the patient was experiencing PTSD symptomatology despite decreases in his pre-treatment baseline. Similar results were reported in the BDI score as it decreased from 37 to 21 at six months post-treatment. According to these findings, this moved the patient from a severe depression range to a moderate depression range. The total IES score was reduced from thirty-three pre-treatment to 0 at six months post-treatment. While the CAPS and BDI score indicated the patient was still experiencing symptoms of PTSD and depression, there was still evident improvement at follow-up.

The 2001 open clinical trial report also showed decreases in its primary measures of outcome (Rothbaum et al., 2001). This was an expanded study from the 1999 study. The primary measure of outcome was the CAPS score, which reported a statistically significant decrease from pretreatment CAPS scores. Patients reported a decrease in PTSD symptoms in all three clusters over a range of 15% to 67% at six months. There was also a decrease in IES scores at six months, but these were not deemed statistically significant. From three to six months there was actually a rise in IES scores from 19.4 to 29.88. Lastly, the mean BDI scores decreased from 26 pretreatment to 18 post-treatment, indicating an improvement from moderate depression to mild depression.

The investigation from 2010 attempted to compare the efficacy of VRET to Present Centered therapy (PCT) (Ready et al., 2010). The primary measures of outcome in this study
were CAPS and BDI scores. Findings from this study indicated improvement in the CAPS and BDI scores' means in both arms of the study. However, there was a great deal of variability between the arms in these measures at post-treatment and follow-up. It should also be noted there were only six participants in the VRE arm of the study, and of those, only five remained in the study for follow-up measures of CAPS and BDI. This made generalizability of results difficult. Nonetheless, $t$ tests were performed to determine if the changes in the CAPS and BDI scores were significant. These tests reported neither arms' outcome measure changes were statistically significant.

**Virtual Iraq**

The overwhelming majority of recent research on VRET for PTSD has been directed towards treating service members from OEF/OIF. The studies have included case reports, uncontrolled case series, and uncontrolled clinical trials. The populations the studies have examined have largely been returning service members, but one did include active duty service members while deployed (McLay, McBrien, Wiederhold, Wiederhold, 2010). A large portion of these studies utilized the virtual environment called *Virtual Iraq*.

*Virtual Iraq* is a virtual environment that was developed in 2004 by the University of Southern California’s Institute for Creative Technologies and a number of VRET researchers (Rizzo et al., 2009). *Virtual Iraq* was funded by the Office of Naval Research, and it was built from the virtual environment used in the X-Box game and U.S. army funded combat simulation trainer *Full Spectrum Warrior* (Rizzo et al., 2009). The electronic hardware for *Virtual Iraq* is similar to that used in *Virtual Vietnam*. A slight variation is noted in the fact that with *Virtual Iraq* the patient navigates through the virtual environment with a gamepad controller as opposed to a joystick (Rizzo et al., 2010). A model non-firing M4 assault rifle is also an option for
navigation of the environment (Rizzo et al., 2010). Navigation with the M4 is operated with a “thumb-mouse” on the rifle.

The main difference in the two systems is the virtual environment settings and sensory stimuli options. In *Virtual Iraq* there are two primary virtual environments that are highly adjustable. This allows for a more individualized experience and the potential for enhanced therapeutic relevance to a broader spectrum of patients (Rizzo et al., 2010). One of the virtual environments is a twenty-four square block Middle Eastern urban center (Rizzo et al., 2010). This environment is nearly fully navigable by the participant. He or she is able to go inside of buildings, onto roofs, or walk the streets (Rizzo et al., 2009). In addition, the environment can include moving vehicles, pedestrians, and military personnel. The second virtual environment is set within a high-mobility multipurpose wheeled vehicle (HUMVEE) on a desert highway (Rizzo et al., 2010). Within the HUMVEE the patient can be positioned as the driver, the passenger, or the turret gunner. The number of people and whether or not they are wounded can also be adjusted within the HUMVEE (Rizzo et al., 2010).

Within each of these environments there are a number of variables that can be adjusted to individualize and intensify the experience. These include time of day, weather conditions, illumination, night vision, explosions, gunfire, vibrations, and sounds (Rizzo et al., 2009). *Virtual Iraq* is also unique in the fact that it can be enhanced with olfactory stimuli such as the smell of burning rubber, cordite, garbage, body odor, smoke, diesel fuel, Iraqi spices and gunpowder (Rothbaum, Rizzo, Difede, 2010). These stimuli are integrated into the environment via a fan. Vibrations are generated with a subwoofer underneath the chair are also synched with the audio and visual stimuli to enhance the environment's sense of presence (Rizzo et al., 2009).

**Virtual Iraq Results**
One of the first studies utilizing *Virtual Iraq* was reported in 2008 by Gerardi, Rothbaum, Ressler, and Heekin (Gerardi, Rothbaum, Ressler, Heekin, 2008). This was a case study of a twenty-nine year old male Georgia Army National Guard service member. This participant did not meet criteria for PTSD diagnosis but did have some symptoms of PTSD. The treatment regimen in this study was significantly shorter than in other studies. In this study the participant received four ninety minute sessions over four weeks. VRET was not used in all of the sessions. Instead, it was only used in sessions two through four. The average time spent in the virtual environment was fifty minutes. After the final treatment the study reported a decrease in PTSD symptomatology of 56%. This was calculated from a decrease in the CAPS pretreatment score of 106 (severe range) to 47 (moderate range). In addition, the patient subjectively reported improvement in his focus at work, social interactions, and that he felt like he didn’t have to “keep thinking about” his traumatic combat experience.

Another case study was performed the same year by another research group (Reger, Gahm, 2009). This study involved a male Army infantry service member who met criteria for PTSD. In this study the patient received six ninety minute sessions of therapy with an average of thirty-five minutes of virtual environment exposure. The rest of the therapy sessions were divided between psychoeducation, relaxation training, and *in vivo* exposure between sessions.

This study utilized two primary measures of outcome including the PCL-M and Behavior and Symptom Identification Scale-24 (BASIS-24). The study reported the PCL-M score decreased from 58 pretreatment to 29 post-treatment. This left the patient with a PCL-M score well below the cutoff of 50 for PTSD diagnosis and a loss of his PTSD diagnosis. The study also reported a noticeable downward trend in the patient’s BASIS-24 score. Lastly, the participant
self reported improved social interactions, increased enjoyment of previously enjoyed hobbies, and a decrease in what the authors referred to as “problematic symptoms”.

One of the more extensively reported studies utilizing the *Virtual Iraq* system was reported in 2009 by Rizzo et al. (Rizzo et al., 2009). This study was an open clinical trial of twenty active duty U.S. service members diagnosed with PTSD or PTSD-like symptoms (Rizzo et al., 2010). These participants had all undergone previous unsuccessful treatment for their PTSD. Treatment protocol for this study involved biweekly ninety to one hundred and twenty minute sessions over five weeks. This study was unique in that it recorded physiological measures of heart rate (HR), galvanic skin response (GSR), and respiration rate. This study was also unique in that the treatment protocol followed a graded prolonged exposure model. With this model patients were exposed to increasingly intense and emotionally arousing exposure therapy sessions over the course of the total therapy. This type of virtual reality exposure therapy is called virtual reality graded exposure therapy (VRGET).

The primary measures of outcomes for this study included PCL-M, BAI, and Patient Health Questionnaire-Depression (PHQ-9) scores. PCL-M mean scores decreased in both clinically and statistically significant manners according to clinician observations and paired pre and post t-tests. The t-tests revealed a decrease from 54.4 pretreatment to 35.6 post-treatment. This decrease resulted in a reported 50% decrease in the symptoms. In addition, eleven of the patients that met criteria for PTSD no longer met criteria at post-treatment. Of the five participants who did not meet PTSD criteria at pretreatment, they also had decreases in their scores at post-treatment. Likewise, the mean BAI scores of the participants decreased noticeably from 18.6 to 11.9. This resulted in an average decrease of 33% in BAI. The PHQ-9 scores decreased as well from 13.3 to 7.1, resulting in a 49% overall decrease. However, despite these
remarkable results, the study experienced a high number of dropouts. Seven participants failed to come to the first session, six dropped out after the first session, and seven more at different times thereafter.

The most recent study utilizing *Virtual Iraq* was published in February of 2011 by Reger et al. (Reger et al., 2011). This study consisted of twenty-four participants of which twenty met PTSD criteria for diagnosis, and the other four diagnosed with anxiety disorder not otherwise specified. All patients received VRET with an average of 7.4 sessions. The treatment regimen was adapted from a protocol designed for prolonged exposure therapy by Foa, Hembree, and Rothbaum (Foa, Hembree, Rothbaum, 2007). The primary measure of outcome for this study was the PCL-M.

Results from this study reported a statistically significant post-treatment decrease in PTSD symptoms. The mean PCL-M score at pretreatment was 60.92 and decreased to 47.08 post-treatment. There was no statistically significant difference between participants who had or had not received prior treatment at pretreatment and post-treatment. Further, at post-treatment there was no longer any statistical difference in the PCL-M scores between those participants diagnosed with PTSD or anxiety disorder not otherwise specified. Most notably, 45% of the twenty who initially met criteria for PTSD no longer met criteria at post-treatment.

**Miscellaneous VRET Studies involving OEF/OIF Service Members**

Several other studies independent of the above studies involving VRET for combat-related PTSD have been conducted. Two of these studies were published in 2007 and 2008 (Wood et al., 2007; Wood et al., 2008). These studies consisted of a case study in 2007 and a multiple case report in 2008. The studies investigated the effects of VRGET on OIF/OEF active
duty Corpsmen diagnosed with PTSD. The same virtual environment and treatment protocol were used for both of the studies.

The virtual environment described by the report was similar to that described in the *Virtual Iraq* studies. There were two modes of travel available to the participants. One mode included riding in a HUMVEE and the other walking through a virtual Baghdad (Wood et al., 2007). This study was unique because the participant was seated in a chair that rotated 360 degrees depending on the direction of movement in the virtual environment. The general treatment regimen consisted of ten ninety minute sessions using a protocol as described by Spira et al. (Spira, Wiederhold, Pyne, Wiederhold, 2007). The primary measures of outcome were the PHQ-9, PCL-M, and BAI scores measured at pretreatment, mid-treatment, and post-treatment. The physiological measures monitored were skin conductance, finger temperature, respiration rate, and heart rate.

In the 2007 case study the participant did not show significant improvement in his PHQ-9 or BAI scores at post-treatment (Wood et al., 2007). Initially, the patient’s PCL-M score did not improve significantly either. However, after the last five sessions of treatment his PCL-M score decreased below what the authors referred to as the “strict” criteria for PTSD diagnosis. The physiological markers appeared to indicate the participant was less aroused over time by mental stressors. This was evidenced by decreases in heart rate and skin conductance and an increase in finger temperature during the recovery period following the mental stressor. According to the investigators, this trend in decreased arousal was a marker of the patient’s habituation and extinction of his traumatic memories.

The results of the multi-case report of six Navy personnel participants appeared to reveal a greater positive effect as measured by the primary outcome measures than in the first study.
(Wood et al., 2008). This study reported a notable decrease in all of the primary measures of outcome. The PHQ-9 scores were reduced from a moderate to a mild depression level. The BAI scores decreased from a severe anxiety level to a moderate anxiety level. The PCL-M scores decreased from baseline; however, the exact decrease was not reported. Lastly, four out of the six participants no longer met criteria for PTSD based on their PCL-M scores.

The physiological measures of arousal reported mixed results. The heart rate and skin conductance indicated a decrease in arousal after sessions five through ten in the stress recall and recovery phases of treatment. On the other hand, finger temperature decreased below baseline after the ten sessions of VRGET during the stress recall and recovery phases. This decrease was in opposition to nearly all other findings in the study as it suggested increased arousal. This was an area of admitted uncertainty on the part of the investigators.

Another study following these studies was reported in 2010 (McLay et al., 2010). This study was connected to the former two in that it utilized the same virtual reality equipment and software (Wood et al., 2007; Wood et al., 2008). However, it was unique in that it was an uncontrolled case series that compared VRET to traditional exposure therapy. The virtual reality therapy was a combination of virtual reality exposure therapy with arousal control. The arousal control component of this study monitored physiological markers of arousal such as heart rate. Participants were then taught relaxation techniques in an attempt to modify or control their arousal. The number of sessions and length of treatment was variable depending on the duty requirements of each service member. The primary measures of outcome included the PCL-M, PHQ-9, and BAI. The delivery of the treatments was also unique in the fact that it was performed in a combat zone on a marine base in Fallujah, Iraq. In this setting, participants experienced triggers related to their traumatic experiences daily.
This study enrolled ten participants, six of which were treated with VRET, and four who were treated with traditional imaginal exposure therapy. Five of the six participants receiving VRET no longer met criteria for PTSD at post-treatment. The mean decrease in symptoms according to the PCL-M was 67% for this group. Similar results were reported for those treated with exposure therapy. Of this group, no participant met criteria for PTSD at post-treatment according to the PCL-M. In addition, the mean decrease in PTSD symptoms was 74%. However, while the drops in the PTSD symptoms were clinically and statistically significant, there was no statistically significant difference reported between the treatment groups. Lastly, the BAI and PHQ-9 scores showed a statistically significant decrease for the VRET group. These measures were not performed in the imaginal exposure therapy group, therefore, a comparison could not be performed.

A final study regarding the use of VRET for the treatment of combat-related PTSD in U.S. service members was reported in 2010 (Miyahira, Folen, Hoffman, Garcia-Palacios, Schaper, 2010). This was a case study of an OIF soldier with chronic PTSD. This participant's treatment consisted of ten sessions with the last six being VRET sessions. The virtual environment utilized was a simulation of riding in a HUMVEE in a town in the Middle East. While in a VRET session the participant’s physiologic arousal markers of heart rate, skin conductance, temperature, and respiration were monitored. The primary measure of outcome was the CAPS score. Ancillary measures included the BDI, trauma-related guilt inventory (TRGI), quality of life inventory (QOLI), and the posttraumatic stress diagnostic scale (PDS). These measures were performed at pre-, post- and three months follow-up.

The results were encouraging for VRET in that there were improvements sustained at the three month follow-up in all of the outcome measurements except the QOLI score. Interestingly,
the QOLI increased from pretreatment to post-treatment, but then decreased from post-treatment to three months. This left the patient with a QOLI score in the “very low” quality of life range. Nevertheless, the primary outcome measure of the CAPS score reported a decrease from 90 at pretreatment to 16 at the three month follow-up. Most notably, of the PTSD symptom clusters of the CAPS scores, the avoidance symptoms decreased from 39 pretreatment to 0 at the three month follow-up.

**VRET Portuguese Veterans Studies**

A final study regarding VRET for the treatment of combat-related PTSD was a study that did not involve U.S. service members (Gamito et al., 2010). The treatment protocol was similar and highly applicable to other VRET studies reported in those involving U.S. service members. This study enrolled ten elderly Portuguese veterans, and each of the participants was randomly assigned to VRET (N=5), imaginal exposure therapy (N=2), or a wait list control group (N=3). All of these participants were diagnosed with chronic PTSD.

The virtual environment for this study was made up of a footpath on which the participant followed in a column of soldiers surrounded by thick grasses. Auditory and visual stimuli included enemy ambush, sounds of gun fire, tracer bullets, mortar blasts, smoke, and waiting for evacuation by a helicopter. All patients experienced a total of twelve treatment sessions. Patients within the VRET arm experienced increasingly intense scenarios within the virtual environment in an attempt to activate and habituate the fear structures. The primary measures of outcome included the CAPS, Impact of Events Scale Revised (IES-R), Symptoms Checklist Revised (SCL-90-R), and BDI.

The results of this study were not as remarkable as those previously discussed. While the descriptive statistics of the CAPS score of the VRET group showed an 8% decrease, the
ANOVA reported no statistical significance between the VRET CAPS score and the other two groups’ scores. Likewise, the IES-R scores for the VRET group did decrease but not in a statistically significant manner. On the other hand, the IES-R scores for the waitlist and imaginal exposure groups reported increases in their means. Nevertheless, statistically significant decreases were reported when comparing the pretreatment and post-treatment scores for the BDI and SCL-90-R scores. The BDI score decreased from a range of moderate depression to mild depression. Similarly, the SCL-90-R showed decreases for somatization and anxiety symptoms.
Discussion

Over the past twelve years Virtual Reality Exposure Therapy research has consistently reported results that suggest VRET may be an effective treatment for combat PTSD. The studies in the last three to four years have been especially encouraging. Research has consistently reported both subjective and objective measures of improvement in participants’ PTSD symptomatology. The studies have also reported a marked reduction in the severity of anxiety and depression symptomatology. These encouraging findings are further reinforced by the fact that VRET is based on the accepted principles of exposure therapy. Further, the reviewed studies appear to mirror the successes reported in studies utilizing VRET to treat other anxiety disorders such as phobias. Overall, VRET research for the treatment of combat PTSD appears to be positive and warrants further investigation.

The encouraging findings of the reviewed studies seem to be due to a variety of attributes unique to VRET. One of those attributes is the fact that VRET offers the PTSD patient a multisensory therapeutic experience. This multisensory approach appears to facilitate emotional arousal, which is necessary for successful activation of fear structures, and ultimately attenuation of unnatural fear responses (Foa, Kozack, 1986). This approach is potentially beneficial for those with PTSD who have strong avoidance symptoms and are unable or unwilling to recall their traumatic experiences as required in imaginal exposure therapy (Gerardi et al., 2010). As a matter of fact, several reports recorded gains in PTSD symptomatology in patients who reported failed previous treatments with traditional exposure therapies (Rizzo et al., 2009; Rizzo et al. 2010; Gamito et al., 2010).

Another beneficial attribute of VRET is the fact the fearful stimuli that activate the fear structures can be accessed repeatedly in serial therapy sessions. This is especially helpful when
treating service members who may have experienced a traumatic event that is not possible or feasible to experience through *in vivo* exposure (Rothbaum, Rizzo, Difede, 2010). Several examples of this would be with Vietnam veterans who experienced traumatic events while flying in a helicopter or deployed throughout Vietnam. *In vivo* exposure therapy would be difficult to institute as well for service members from OIF/OEF who experienced a traumatic event while in a HUMVEE or in a foreign urban combat zone. In these cases, VRET has the ability to facilitate the repeatable virtual generation of environs and experiences relevant and emotionally engaging to each patient.

Another unique asset of VRET for combat-related PTSD is the virtual environment is fully controlled by the clinician. This allows the clinician to increase or decrease the intensity of the fear stimuli to a therapeutic level for each patient. It also provides the clinician with firsthand insight as to exactly what stimuli the patient is experiencing. This level of control and insight is not possible with imaginal or *in vivo* exposure therapy. Furthermore, the clinician's control provides researchers with the ability to accurately manipulate stimuli variables in future VRET research (Rothbaum, Rizzo, Difede, 2010).

A unique characteristic of VRET is that research suggests it may be a more appealing PTSD therapy to younger service members (Rizzo et al., 2008). This finding was attributed to the fact that the majority of younger soldiers are more familiar with computer technology since they grew up with computers and digital gaming systems. This type of research offers insight into a potential demographic group that may benefit more from VRET than other forms of PTSD therapies.

A final unique attribute of VRET is it has the potential to offer an additional treatment for combat PTSD. This is important because PTSD is a challenging mental disorder to treat with
frequent treatment failure. It requires a highly individualized and dedicated approach due to the unique traumatic experiences that cause PTSD. Another option in the list of treatments for combat PTSD offers more PTSD survivors an additional opportunity for treatment success (Reger, Gahm, 2008).

**Challenges to VRET**

Despite all of the potential benefits of VRET, there are a number of challenges facing it. One of the foremost challenges is VRET systems are rather costly (Rothbaum, Rizzo, Difede, 2010). In a time of economic challenge there will likely be significant financial concern regarding VRET development and dissemination. However, while the development and maintenance costs are steep, so are the costs of the psychological, occupational, social, and health concerns of inadequately treated service members with combat-related PTSD (Miyahira et al., 2010).

Another challenge that must be considered is that of the possibility of equipment malfunction during therapy sessions. Equipment failure has the potential to significantly impede the efficacy of the therapy. The slightest defect in the virtual environment may severely undermine the required sense of presence. The sense of presence is critical for emotionally engaging PTSD survivors and effective exposure therapy (Alsina-Jurnet, Gutierrez-Maldonado, Rangel-Gomez, 2010). Many combat PTSD survivors have already developed dissociative symptoms that make fear structure activation difficult.

Another prominent challenge is that of promoting clinician awareness of VRET. However, increased awareness is not the end point. From there, clinicians must be willing to participate in VRET training. The logistical challenges of achieving widespread awareness and accessible training would likely be costly. Nevertheless, a clinician who chooses to utilize
VRET must have thorough training in order to efficiently, innovatively, and therapeutically adjust the virtual environment in a way that facilitates a sense of presence and emotionally engages each patient.

The theory underlying VRET may be familiar with many clinicians, but the application of that theory in conjunction with the use of the new technology poses a challenge. Efficient use of VRET implies two types of familiarity. The first is a baseline familiarity of how the overall VRET system operates and its capabilities. The second, and arguably more difficult level of familiarity, is a working familiarity of how to accurately adjust the virtual environment in a way that is emotionally engaging to each patient. Even with extensive standardized training there will remain much room for operator variance and error.

A challenge all of the studies faced was a difficulty enrolling and maintaining participants. Studies with small cohort groups lacked generalizability due to low statistical power. The reasons attributed to the low enrollments and high attrition rates were varied. One reason given was the lack of participant familiarity with computers as seen in the Virtual Vietnam studies (Ready, Gerardi, Backscheider, Mascaro, Rothbaum, 2010). An additional reason was attributed to poor communication between the research team and the participants (Rothbaum et al., 2001). Other reasons included job conflicts, service transfers, and stigma towards accessing mental health services (Rizzo et al., 2010). The research designs of the studies further undermined the generalizability in that they were case studies or open non-randomized clinical trials.

VRET is also challenged because individuals with PTSD experience symptoms of avoidance behaviors. Avoidance behaviors have been identified as symptoms that are associated with increased severity and duration of PTSD (Pietrzak, Harpaz-Rotem, Southwick, 2011).
Avoidance behaviors are caused when individuals inaccurately develop a negative perception to certain stimuli or situations they associate with their traumatic event (Hayes, Wilson, Gifford, Follette, 1996). They seek to control their anxiety by avoiding these stimuli and situations altogether. According to Kashdan and Breen, “When a person avoids exposure to unwanted experiences they limit opportunities to disconfirm or change belief systems about potential threat and danger” (Kashdan, Breen, 2010). As a result, these individuals often avoid exposure therapy because it forces them to confront anxiety causing thoughts, situations, and stimuli.

A final challenge to VRET is that of service member stigma towards accessing mental healthcare. A 2008 study reported 23% to 40% of the soldiers who screened positive for a mental health disorder did not access mental health services (Hoge et al., 2008). In addition, those who reported a mental health disorder were twice as likely to report concerns about stigma regarding accessing mental health services. Another study identified a number of factors contributing to decreased acceptance of mental health services in a survey of 2,684 U.S. veterans (Lindley, Cacciapaglia, Noronha, Carlson, Schatzberg, 2010). These factors included preference for a different mode of therapy than available, difficulty contacting patients, location of the mental health clinic, and decreased overall acceptance with increased age. This reluctance by some service members to access mental health services could likely hold true for VRET as well.

**Future Research Directions**

There is a significant need for further research of VRET for the treatment of combat-related PTSD. Firstly, VRET research must make a movement away from case studies and open clinical trials. Instead, studies should be structured as randomized control trials with larger population sizes whenever possible. By ensuring randomized control trial research designs and
expanding participant populations, the findings from these studies will be more easily
generalized and reliable.

Researchers should also begin to systematically examine how effective VRET is
compared to the traditional forms of in vivo and imaginal exposure therapies. In an age of
rapidly advancing technology there is an admitted technological fascination for some with virtual
reality. However, caution should be advised while pursuing the development of VRET because
it is rather costly (Rothbaum, Rizzo, Difede, 2010). The decision to utilize and expand VRET
must be based on research supporting its efficacy. If proven effective, research should focus on
how to develop and maintain VRET in a fiscally conscious manner. In addition, research should
be performed to establish the optimal duration for therapy to ensure both adequate treatment and
prevention of therapy overutilization (Miyahira et al., 2010).

The use of VRET in specific demographic populations should be examined as well.
Several studies have observed some resistance to VRET in certain service member demographic
groups. The most notable group is Vietnam veterans (Rothbaum, Hodges, Ready, Graap,
Alarcon, 2010). Likewise, it would be wise to investigate the efficacy of VRET in newly
diagnosed compared to chronic PTSD patient groups. Determination of efficacy in various
demographic groups is important because it can help guide therapy selection. In a mental
healthcare setting with limited resources, it is in the patient’s best interest and fiscally
responsible to treat with a therapy that has the highest chance of success.

Another area of further research is investigating the efficacy of combination
pharmacotherapy and VRET for combat-related PTSD. It is important to identify whether the
efficacy of VRET can be enhanced with pharmacologic agents. While there is evidence to
suggest the combination of pharmacotherapy and VRET may have advantages, no studies were found specifically treating combat-related PTSD (Lorenzo et al., 2011).

If future research of VRET for combat-related PTSD supports the findings of these early studies, then one of the next critical steps will be to establish standardized clinician VRET training. A complex therapy such as VRET will require extensive training in both the use of the technology of the virtual environment system, as well as education on the theories and techniques of exposure therapy. This training will likely need to be updated over time as new research is reported and VRET technology is improved.
Conclusion

Combat-related PTSD is a devastating mental disorder which carries a high incidence of mental health comorbidities. It is also a rather difficult condition to treat. With more service members returning from Iraq and Afghanistan there will be continued need for screening and treatment of combat-related PTSD. Based on the reviewed studies VRET appears to warrant further study as a treatment for this form of PTSD. These studies show consistent improvement in PTSD symptomatology through self-reports and PTSD clinical assessment scales. They also indicate improvement in subjective measurements of anxiety and depression. However, VRET is not without its challenges including high development and maintenance costs, training of clinicians, software malfunction, military stigma towards accessing mental health services, and avoidance behaviors inherent to PTSD.

Future studies need to be more rigorously controlled and designed with larger populations. Head-to-head comparison trials with VRET and other accepted therapies need to be conducted. Further, VRET needs to be assessed in various demographic groups to maximize the cost and treatment effectiveness in different populations. Lastly, it is imperative to keep in mind VRET must not be pursued for its technologic appeal. It must be developed in an evidenced based and cost conscious manner. While research continues in VRET, research should continue investigating other innovative therapies for PTSD. Nevertheless, VRET for the treatment of combat-related PTSD does appear to be a promising therapy modality that warrants further study.
References


Abstract

Objective: It is the objective of this review to investigate the existing body of research of VRET for the treatment of combat-related PTSD and offer some future research directions.

Method: This study was performed by searching for peer-reviewed journal articles regarding VRET for the treatment of combat-related PTSD in the following databases: Published International Literature on Traumatic Stress (PILOTS), ISI Web of Knowledge, PubMed, and the National Center for PTSD.

Results: Twelve studies concerning VRET for the treatment of combat-related PTSD were reviewed. These consisted of case, multi-case report, open clinical trial, non-randomized control trial, and randomized control trial studies. The majority of the studies reviewed reported results that show clinical and statistical improvement in PTSD symptomatology after VRET.

Conclusion: VRET appears to be a promising therapy modality for the treatment of combat-related PTSD that warrants further study.