Chapter 4
Virtual Reality Applications to Treat Posttraumatic Stress Disorder

Melissa Peskin, Brittany Mello, Judith Cukor, Megan Olden, and JoAnn Difede

Introduction

Epidemiological surveys suggest that approximately 8–9% of individuals in the general population are at risk for developing PTSD at some point during their lifetimes (Breslau 2001; Hidalgo and Davidson 2000; Kessler 2000; Kessler et al. 1995). A more recent epidemiological study suggests that the lifetime prevalence rate of PTSD is 3.4% in men and 8.5% in women (McLean et al. 2011). Research suggests that certain populations are at increased risk for developing PTSD, such as sexual assault survivors (Amstadter et al. 2008), disaster relief workers (Duckworth 1986; Durham et al. 1985; Harvey-Lintz and Tidwell 1997; Marmar et al. 1999; 1996; North et al. 2002; Rosenczweig et al. 2002), and military service members (Dohrenwend et al. 2006; Prigerson et al. 2001). The deployment of approximately 2.6 million U.S. military service members to combat theaters in Iraq and Afghanistan (Institute of Medicine 2012) has lent a new urgency to efforts to expand and refine existing treatment approaches. These efforts are essential given that current estimates suggest that 5–25% of service members experience PTSD symptoms following deployment to Iraq or Afghanistan (Hoge et al. 2004; Milliken et al. 2007).

M. Peskin (✉) · J. Cukor· M. Olden · J. A. Difede (✉)
Weill Cornell Medicine/NewYork-Presbyterian, New York, NY, USA
e-mail: mep2009@med.cornell.edu; jdifede@med.cornell.edu

B. Mello
City of Monrovia, Monrovia, CA, USA

A. Rizzo, S. Bouchard (eds.), *Virtual Reality for Psychological and Neurocognitive Interventions*, Virtual Reality Technologies for Health and Clinical Applications, https://doi.org/10.1007/978-1-4939-9482-3_4

The Current State of PTSD Treatment

The following section will review the literature on current evidence-based treatments for PTSD, with particular reference to recommendations made by expert treatment guidelines regarding which treatment modalities should be offered as first-line approaches.

Medications

Although pharmacotherapy is one of the most widely utilized treatments for PTSD, expert treatment guidelines for PTSD have come to different conclusions regarding the strength of the evidence supporting the use of pharmacotherapy as a first-line PTSD treatment. The US Institute of Medicine's (2008) report assessing the evidence in support of various treatment modalities for PTSD concluded that the evidence for all classes of drugs reviewed was inadequate to determine efficacy in the treatment of PTSD. The most recent clinical practice guidelines commissioned by the UK National Institute for Clinical Excellence (2005) recommended that medications be considered a second-line treatment for PTSD, behind cognitive-based therapies, which were recommended as first-line treatments. In contrast, other organizations have concluded that the evidence supports the use of specific classes of medications as first-line treatments for PTSD (American Psychiatric Association Practice Guidelines 2004; Foa et al. 2009), and the most recent US Institute of Medicine report (2012) on the treatment of PTSD in military and veteran populations found that there is reasonably strong evidence to support the use of selective serotonin reuptake inhibitors (SSRIs) in PTSD. The largest number of randomized clinical trials have been conducted on SSRIs, and in general, most guidelines are in agreement that the evidence is strongest for this particular class of drugs. For example, joint practice guidelines for PTSD issued by the US Department of Veterans Affairs and Department of Defense concluded that good evidence was found that SSRIs improve important health outcomes and recommended that clinicians provide SSRIs to eligible patients. In addition, two SSRIs, sertraline and paroxetine, have received approval by the US Food and Drug Administration as indicated treatments for PTSD. Although fewer studies have been conducted on the use of selective norepinephrine reuptake inhibitors (SNRIs), some practice guidelines, such as those issued by the US Department of Veterans Affairs and Department of Defense, and the International Society for Traumatic Stress Studies (Foa et al. 2009), have concluded that good evidence also exists for this class of drugs and have recommended them as first-line treatments.

Evidence-Based Psychotherapies

Although expert treatment guidelines differ in their conclusions regarding the efficacy of pharmacotherapies, treatment guidelines are in unanimous agreement that exposure therapies, which are typically classified as forms of cognitive-behavioral

therapy (CBT) are effective treatments for PTSD following diverse types of trauma (Bisson et al. 2007; Bradley et al. 2005; Harvey et al. 2003; Schnurr et al. 2007). Indeed, expert treatment guidelines for PTSD published for the first time in 1999 recommended that exposure therapy should be the first-line therapy for PTSD (Foa et al. 1999b). Multiple mental health professional guilds and government agencies worldwide have since reaffirmed in various reports and updated treatment guidelines that exposure therapy is the only treatment for PTSD with substantial empirical support for its efficacy (American Psychiatric Association Practice Guidelines 2004; Australian Centre for Posttraumatic Mental Health 2007; Foa et al. 2009; Institute of Medicine (IOM) 2006; 2008; National Institute for Clinical Excellence 2005). CBT with exposure therapy has been validated across a diverse range of cultures and populations, such as those exposed to military combat (Monson et al. 2006; Nacasch et al. 2007; Rizzo et al. 2009), terrorism (Brewin et al. 2008; Difede et al. 2007a, b; Gillespie et al. 2002; Levitt et al. 2007), natural disaster (Salloum and Overstreet 2008), physical and sexual assault (Foa et al. 1999a; Resick et al. 2002), and motor vehicle accidents (Blanchard et al. 2003). In addition, the Department of Defense and Department of Veterans Affairs have recently initiated programs to disseminate two CBTs that involve exposure, Prolonged Exposure (PE) and Cognitive Processing Therapy, as part of a broader effort to expand access to evidence-based treatments for current and former US service members (Karlin et al. 2010).

Although a number of therapies involve some element of exposure, the most widely researched and well validated exposure treatment paradigm is PE (Foa et al. 1999b; 2005). PE is founded on Foa and Kozak's (1986) emotional processing theory, which proposes that phobias and PTSD are based on pathological fear structures that contain information about feared stimuli, responses, and meanings that are activated when an individual encounters information represented in the fear structure (Foa and Kozak 1986; Foa et al. 1989). Classical conditioning is believed to be a key mechanism underlying the development of pathological fear, in that the traumatic event is considered an unconditioned stimulus that has become associated with a number of harmless conditioned stimuli that then become capable of eliciting a conditioned fear response. Emotional processing theory proposes that successful treatment must accomplish two goals: first, activate the fear structure so that new learning may occur, and second incorporate new information that is incompatible with the pathological fear structure. The theory also proposes that cognitive avoidance of trauma-related thoughts, feelings, and images and behavioral avoidance of trauma-related stimuli serve to maintain PTSD symptoms by minimizing exposure to corrective information that disconfirms feared outcomes and allows for the development of a new and non-pathological competing fear structure.

PE typically consists of between 8 and 15 weekly 90 min individual therapy sessions and includes both imaginal and in vivo exposure. In imaginal exposure, the patient is guided in repeatedly recounting memories of the trauma in a safe environment in order to facilitate extinction learning, whereby the cued fear response to memories of the trauma is extinguished and the patient is better able to distinguish between thinking and talking about the trauma and feeling as if it is recurring. During in vivo exposure, the therapist helps the patient begin gradually confronting

feared memories and situations that are not realistically dangerous but are avoided because they are associated with the trauma and thus trigger anxiety. Imaginal exposure typically begins in the third session and is followed by processing of the exposure, in which the therapist engages the client in a discussion of thoughts and feelings that arose during the exposure, with the goal of allowing the patient to integrate and consolidate new information about the meaning of the trauma and disconfirm distorted beliefs that may have developed in the aftermath of the event.

Limitations of Current Treatments

Despite compelling evidence for the efficacy of exposure therapy for PTSD, the nature of imaginal exposure, whereby patients are asked to repeatedly recount their most traumatic experience to a therapist, presents a challenge for some patients given that avoidance of trauma-related memories, thoughts, and cues are, by definition, part of the diagnostic criteria for the disorder. Thus, many individuals with PTSD fail to seek treatment, some who seek treatment do not engage in the treatment, and others who profess willingness struggle to engage emotionally with the trauma memory. As studies suggest that lack of emotional engagement predicts poor treatment outcome, these patients often do not improve (Jaycox et al. 1998). Finding effective ways to motivate these patients and facilitate emotional engagement in therapy is thus critical.

Virtual Reality Therapy

New developments in virtual reality (VR) technologies have expanded the range of possible treatment options for anxiety disorders, including PTSD. Researchers first applied VR to treat simple phobias, including acrophobia (Rothbaum et al. 1995a, b), arachnophobia (Carlin et al. 1997), claustrophobia (Botella et al. 1998; 2000), and fear of flying (Smith et al. 1999), with positive results. The theoretical basis for applying VR to phobias underpinned the hypothesis that VR would also help to engage an individual's trauma-related fear structure in the treatment of PTSD.

Virtual Reality Exposure Therapy (VRE) for PTSD draws upon similar principles as imaginal exposure to reach patients who are reluctant or unable to recount their traumatic experiences using traditional imaginal exposure. VR provides a sensory-rich computer-generated environment in which patients are able to encounter and gain mastery of their trauma. Patients recount the details of their experience aloud, while gradually proceeding through increasingly detailed virtual simulations of their traumatic event that are closely monitored by the therapist. By allowing the therapist to program the virtual environment to control what the patient experiences, treatment can be tailored to the needs of the individual patient, and proceed at a pace that is tolerable for that individual. Moreover, VRE therapy can promote

emotional engagement and processing of the trauma memory by offering not only visual, but auditory, olfactory, and haptic sensory cues to facilitate immersion in the virtual world.

The Framework of Virtual Reality for PTSD

VR technology integrates visual computer graphics with multiple sensory cues in order to create an evocative environment that patients may find emotionally engaging. Participants wear a specialized helmet with two miniature LCD computer screens affixed to the front. After the user dons the helmet, the screens are positioned one to two inches in front of the participant's eyes taking up the majority of their visual field. The room is kept dark in order to minimize distracting visual stimuli. Sensitive motion-tracking sensors are built-in or attached to the helmet and inform the computer of slight changes in the participant's head position. Thus, a participant looking up, down, or to either side sends immediate feedback to the computer program, which results in corresponding changes in the visual display. Users may also move their visual field forward, backward, or sideways using a hand-held controller allowing them to "interact" with the virtual environment. Participants wear headphones that deliver audio stimuli from the virtual scenario as well as any instructions that the clinician gives through a headset microphone to communicate with the patient during his session. A raised platform beneath the participant contains audio-tactile sound transducers that create customized vibrations comparable to a high-powered rumble pack on a video game controller. Participants seated or standing on the platform receive haptic cues that coincide with auditory events (e.g., an explosion). Finally, a scent machine comprised of scent cartridges relevant to the virtual environment or trauma event (e.g., body odor, diesel fuel, market spices) may be used to release an odor using a series of fans and an air compressor.

The clinician interface of a VR setup consists of two monitors: one that displays the control panel and the other that shows what the patient sees through the VR helmet. The VR software contains elementary scenarios made to resemble the setting and context that are central to a traumatic event. Before beginning the session, the clinician builds upon this basic setting to customize the virtual environment to resemble the patient's trauma as closely as possible. During the session, the clinician uses preprogrammed keys to manipulate the aforementioned multi-sensory cues. Thus, the clinician can introduce appropriate environmental stimuli that coincide with an event in real time as the patient retells his trauma.

The clinician remains connected to the patient at all times during the VRE session. Using a headset microphone linked to the user's headphones, the clinician prompts patients to recount their story and monitors their self-reported distress using the Subjective Units of Distress (SUDS) measure on a scale of 0–100 at regular intervals to ensure the exposure remains at a therapeutic level (e.g., distressing but not overwhelming to the patient).

The History of Applying Virtual Reality for PTSD

Virtual Vietnam

The first application of virtual reality to the treatment of PTSD was developed by researchers at Emory University and the Georgia Institute of Technology to treat PTSD in Vietnam Veterans. The virtual environment offered two common scenarios, the first of which consisted of riding in a virtual Huey helicopter where the patient saw the backs of the pilots' heads and the view of typical Vietnam terrain from the helicopter's side door. The second scenario involved being in a clearing surrounded by jungle landscape with the sounds of helicopters, gunfire, and explosions, as well as men shouting, "Move out!" Rothbaum et al. (1999) conducted a case study using Virtual Vietnam to treat a 50 year-old Caucasian male with severe combat-related PTSD from his military service as a helicopter pilot approximately 26 years before participating in the study. The trial consisted of fourteen 90 min sessions conducted twice weekly over the course of 7 weeks, during which the individual was immersed in both virtual environments. The study found that he improved on all measures of PTSD, including a 34% decrease on the Clinician Administered PTSD Scale (CAPS) and a 45% decrease on self-reported PTSD, and that he maintained these gains 6 months after completing treatment.

Following this case study, an open clinical trial of 16 male Vietnam Veterans with PTSD found significant reductions in PTSD and related symptoms after an average of 13 VRE sessions in the 8 participants who completed the 6 month follow-up (Rothbaum et al. 2001). At the 6 month follow-up, there was an overall statistically significant reduction in PTSD symptoms from baseline in symptoms associated with specific reported trauma experiences as measured by the CAPS. Of the 8 participants who completed the 6 month follow-up, all 8 reported reductions in PTSD symptoms ranging from 15% to 67%. Notably, none of the 16 participants decompensated due to exposure to the virtual environments, and no one was hospitalized for complications related to the treatment during the study (Rothbaum et al. 2001).

Virtual World Trade Center

Following the terrorist attacks on the World Trade Center (WTC) on September 11, 2001, Difede and Hoffman (2002) published a case study of WTC-related PTSD. The virtual WTC environment used in the study consists of 11 scenes, which the clinician proceeds through at an optimal pace for emotional processing after receiving the patient's verbal assent. The protocol was designed to evoke a level of response that created tolerable discomfort, but not to overwhelm patients with affect. The early stages of the scenario begin with a view of the Twin Towers and a jet that flies past safely; then a jet collides with the first tower but does not create an explosion; an explosion is added; and then sound effects are introduced to create a

more realistic collision and explosion. The next stages gradually incorporate fire and smoke escaping from where the jet collided into the first tower; sound effects of people in the area screaming; and individuals jumping from the first tower. In the final stages, the second jet collides into the second tower with sound effects for the explosion and people screaming; the second tower collapses and creates a large dust cloud; followed by the first tower collapsing into the dust cloud. The patient concludes the scenario when they are able to view the full sequence of events in its entirety. Throughout the process, the clinician controls the environment and introduces relevant feared stimuli to gradually and systematically expose patients to a virtual representation of their specific traumatic experience. In the first case study with Virtual WTC, the participant was a 26 year-old African-American woman who had worked in the WTC and had previously failed to improve with imaginal exposure therapy. After six, 60 min weekly sessions, the patient's PTSD symptoms were reduced by 90% as measured by the CAPS (Difede and Hoffman 2002), offering initial support for Virtual WTC as a treatment tool.

Subsequent to these promising results, Difede and colleagues (2007a) compared the use of VRE therapy in 13 participants with direct exposure to the WTC attacks, including firefighters, disaster workers, and civilians, with 8 participants in a matched waitlist control group. Due to two non-completers and one dropout, there were 10 participants in the VR group who completed the treatment protocol. Participants in the treatment condition showed a significant decrease in PTSD symptoms on the CAPS as compared to pretreatment and to the control group, who showed no improvement; participants maintained treatment gains at 6 month follow-up. It is important to note that five of the VRE participants had previously undergone imaginal exposure therapy and not shown improvement. Notably, no participant reported becoming overwhelmed by the evocative scenario. Furthermore, these promising results lent support to the use of a standardized virtual environment for a wide range of traumatic experiences, benefiting both disaster workers and civilians.

BusWorld

After the September 2000 Palestinian uprising, frequent acts of terrorism targeting Israeli civilians led to more than 1100 fatalities and 6700 wounded (Freedman 2009). In response to numerous attacks on civilians using public transportation, Josman et al. (2006), in collaboration with Hoffman and his team at the University of Washington, developed a virtual reality terrorist bus bombing scenario dubbed "BusWorld." In the scenario, participants begin by standing on the sidewalk in an urban street scene across the street from a bus stop resembling those in Haifa, Israel. A bus appears in the next stage and pulls up to the stop, but does not explode. In the final stages, explosions are added with visual and auditory effects, and the bus is set on fire with sound effects of people screaming in Hebrew and police sirens in the background, signaling that help has arrived. They then conducted an analog pilot test with 30 non-symptomatic individuals to test the validity of the virtual

environment and its ability to evoke increasing levels of anxiety as the virtual scenario escalated (Josman et al. 2008). These individuals reported significantly more distress with each stage of the VR scenario, as measured by SUDS ratings, corroborating the scenario's ability to provide graded exposure.

Freedman et al. (2010) conducted a case study of a 29 year-old male patient who developed PTSD after becoming trapped on a crowded public bus when an attacker used a bulldozer to flip his and a second bus on their sides and crushed multiple cars, leaving three dead and dozens injured. The BusWorld virtual scenario was adapted in order to meet the needs of the patient, so that only the early levels (a street scene and bus stop with a bus approaching) were utilized. The patient entered treatment approximately 1 month after the traumatic event. He was treated with 10 sessions of therapy, 3 of which involved imaginal exposure while immersed in the BusWorld environment, and one of which involved imaginal exposure without VR. As measured by the CAPS, the patient's PTSD symptoms showed a significant decrease from a pretreatment score of 79 to zero posttreatment (Freedman et al. 2010). These treatment gains were maintained 6 months later. Interestingly, the patient was able to improve using the early levels of the BusWorld environment despite having experienced an attack for which the scenario was not specifically designed. Thus, this study provided initial evidence that a PE protocol using imaginal exposure augmented by VR was effective in treating PTSD following a terrorist attack in Israel. Furthermore, it demonstrated how a virtual environment could be used in conjunction with imaginal exposure therapy to facilitate the care of individual patients.

Virtual Motor Vehicle Accident

The high frequency of motor vehicle accidents in which individuals are injured or killed often results in psychological consequences as well, so much so that these collisions have been identified as a leading cause of PTSD (Norris 1992). For patients trying to confront their fears, real world "in vivo" exposure may entail potentially unsafe driving or traffic conditions. Using VR to treat MVA-related PTSD reduces safety risks associated with in vivo uncontrolled driving situations and provides a safe way for patients to process memories associated with the trauma (Beck et al. 2007). Following promising evidence in which VR scenarios were used to treat driving phobias (Wald and Taylor 2003), Beck and colleagues published the first report on the use of VR in the treatment of post-collision PTSD.

Beck et al. (2007) designed several virtual, customizable driving scenarios to help treat individuals with acute PTSD following a motor vehicle accident in the first effort to assess the efficacy and acceptability of VRE in this population. The virtual apparatus includes a steering wheel, gas and brake pedals, and stereoscopic glasses that both the patient and therapist wear to view a large 10 foot × 8 foot projection of the simulation in 3D. The virtual environment itself was designed to simulate a real-world driving experience – not a motor vehicle accident – so that the driver chose their own route to take in a rural, suburban, urban, or highway setting and

feared driving events (e.g., tailgating) occurred in real time. In an uncontrolled case series, the authors examined the use of a weekly, 10-session VRE protocol for 6 individuals with full or subsyndromal PTSD who had been involved in a serious road accident in the last 6 months (3.5 months on average). Clinically significant reductions between pretreatment and posttreatment were found on the CAPS total score, the CAPS Reexperiencing cluster, and the CAPS Avoidance/Numbing cluster, with effect sizes ranging from $d = .79$ to $d = 1.49$. No difference was found on the CAPS Hyperarousal cluster score. Participants scored high in overall satisfaction scores on the Client Satisfaction Questionnaire (CSQ; Larsen et al. 1979) and achieved high levels of presence in the virtual environment. However, participants also reported higher levels of disorientation relative to published norms, which the authors speculate may be due to the use of stereoscopic glasses to view the VR simulation on a screen 5 feet away, and which the authors suggest may be reduced by switching to a head-mounted display, as simulation sickness is less likely with this type of system. These preliminary results suggest that VRE may be effective for survivors of traumatic motor vehicle accidents.

Virtual Iraq/Afghanistan

In a landmark 2008 study, RAND estimated that 14% of Iraq and Afghanistan Veterans suffer from PTSD (Tanielian and Jaycox 2008), and subsequent studies have suggested that this figure may be as high as 25% (Kok et al. 2012; Ramchand et al. 2010; Thomas et al. 2010). Along with Traumatic Brain Injury, these "invisible wounds of war" are having a devastating impact on military personnel, many of whom have had multiple deployments, putting them at greater risk for subsequent mental health problems. Researchers at the USC Institute for Creative Technologies, led by Albert "Skip" Rizzo and Jarrell Pair, developed Virtual Iraq between 2005–2007 to aid in the treatment of combat-related PTSD (Rizzo et al. 2005). The virtual environment and clinician interface of Virtual Iraq evolved to reflect feedback from Iraq and Afghanistan service members and clinicians (Reger et al. 2009; 2010). The 2007 version of Virtual Iraq consisted of 4 customizable environments, including 3 Humvee scenarios, and a Middle-Eastern city scene that included a marketplace, crowded or desolate streets, a checkpoint, building interiors, and rooftops (Rizzo et al. 2010). In order to increase the number of scenarios and degree of user customizability, a revised and expanded version of Virtual Iraq/Afghanistan, termed BRAVEMIND, was developed in 2011. This redesigned system increased the number of scenarios from 4 to 14 and added a number of new features to increase customizability and usability. This highly complex environment was designed to give clinicians the flexibility to place patients in a virtual setting and context that resembles their traumatic event and provide relevant stimuli.

Research has supported the acceptability of technology-based mental health approaches among service members. For instance, in a study of soldier attitudes toward receiving technology-based behavioral health care, 58% of the 352 service

members surveyed reported some willingness to use VR treatment (Wilson et al. 2008). Additionally, one third of those surveyed who stated they were unwilling to use traditional psychotherapy were willing to use at least one kind of technology-based mental health treatment (e.g., video teleconferencing, Internet-based treatment, or VR), suggesting that technology and VR may help overcome barriers to accessing care in this population.

Wood and colleagues published a case report on the first active-duty service member with combat related PTSD to complete treatment with VR graded exposure therapy with physiological monitoring within a randomized study comparing this treatment with cognitive behavioral group therapy for active duty military personnel (Wood et al. 2007). Following 10 sessions of VR treatment, the patient's scores on the PCL-Military Version (PCL-M) decreased to below the threshold for PTSD diagnosis. Subsequent case reports on VR graded exposure therapy with physiological monitoring for combat-related PTSD in male (Wood et al. 2008) and female (Wood et al. 2009) US Navy personnel have yielded similar findings.

Gerardi, Rothbaum, and colleagues (2008) published results of the first Iraq veteran to complete treatment within an ongoing controlled study of VRE using Virtual Iraq. The 29 year-old Caucasian male patient had served in the National Guard and was deployed for a year in support of Operation Iraqi Freedom. Approximately 6 months post-deployment, the individual entered treatment. After four, 90 min sessions of VRE over 4 weeks, the patient's PTSD score on the CAPS decreased by 56% compared to pretreatment scores (Gerardi et al. 2008). The patient stated he felt comfortable with the VR technology, and no adverse effects were reported. This brief therapy resulted in both clinically and statistically significant change, providing early support for VRE with Iraq veterans suffering from PTSD.

Reger and Gahm (2008) conducted a case study using Virtual Iraq with an active duty soldier in the Army who had been diagnosed with combat-related PTSD. The trial consisted of 6 90 min sessions of VRE with the virtual military convoy scenario over the course of 4 weeks. As measured by the PCL-M, the participant's pretreatment score of 58 decreased to 29. Additionally, self-report data on the Behavior and Symptom Identification Scale-24 (BASIS; McLean Hospital 2006), which assesses treatment outcome according to five symptom and functioning domains, corroborated a positive treatment outcome.

McLay et al. (2010) were the first to use VRE with active duty soldiers while deployed in a combat theater using a parallel case series design. Individuals seeking treatment for deployment-related PTSD at the Combat Stress Clinic in Camp Fallujah, Iraq, from February to November 2008 were offered either traditional exposure therapy or VRE. The study reported the results of a retrospective record review; therefore, therapeutic procedures were not standardized. Exposure therapy was administered based on the methods outlined in Foa et al. (2007). Both traditional VRE and VRE with arousal control were administered, wherein participants are taught how to monitor their physiological responses to help them tolerate trauma-related stress. Due to the realities of being deployed, participants were treated anywhere between 10 days and 13 weeks, and were surrounded by trauma-related cues. Of the six participants who received VRE, all showed improvement on

their PCL-M scores, with an average decrease in symptoms of 67%, and five no longer met criteria for PTSD by the end of treatment. None of the individuals who received VR experienced adverse effects while in treatment. The four participants who received imaginal exposure therapy also showed improvement and none met criteria for PTSD upon treatment completion. This was the first study of active duty military personnel deployed to a combat theater undergoing exposure therapy with and without virtual reality. Despite the additional stressors of serving in military operations, no patients decompensated or dropped out of the study, and all patients showed symptom improvement. Overall, the authors founds that both types of therapy could be delivered safely and effectively during a combat deployment.

Multiple studies have now examined the use of VRE with active duty service members following deployment to Iraq or Afghanistan. Reger et al. (2011) conducted a retrospective study of a mixed, clinical sample of 18 active duty soldiers with PTSD and 6 soldiers diagnosed with anxiety disorder not otherwise specified who did not meet full criteria for PTSD. Thirteen participants had failed to report significant clinical benefit from other forms of psychotherapy, including four patients who had undergone exposure therapy. The treatment provided was based on a manualized prolonged exposure treatment (Foa et al. 2007), adapted for use with VR, with an introduction to the virtual environment in Session 2. Participants received an average of 7 sessions (range 3–12) lasting approximately 90 min each. There was a significant decrease in PCL-M-based estimates of PTSD with 62% (n = 15) of the sample reporting a reliable change of 11 points or more (Reger et al. 2011). In another study of active duty service members, McLay et al. (2011) compared VR-graded exposure therapy to treatment as usual in 20 active duty military personnel with combat–related PTSD. The authors found that 7 out of 10 participants in the VR condition showed 30% or greater improvement on the CAPS while only 1 out of 9 participants in the treatment as usual condition showed similar improvement.

Additionally, McLay et al. (2012), with funding from the Office of Naval Research, conducted the first open clinical trial to develop Virtual Iraq/Afghanistan and a treatment protocol. Forty-two active duty service members were enrolled in intent-to-treat analysis, and 20 completed treatment. Participants received treatment twice weekly in sessions ranging from 90 to 120 min each. Since an aim of the study was to develop a treatment protocol, the number of sessions varied with early participants (n = 26, including 14 who completed the protocol) and was later fixed to 12–15 sessions over a maximum of 10 weeks. Of the 20 participants who completed treatment, 75% (n = 15) no longer met criteria for PTSD based on PCL-M at the post-assessment. Furthermore, these fifteen participants showed improvement by at least 50% on the PCL-M. No patient experienced an adverse event related to participation in the study. This study helped to determine the optimal protocol for VRE using Virtual Iraq/Afghanistan resulting in a published treatment manual (Rothbaum and Ressler 2009).

These promising results provide additional support for the efficacy of virtual reality-enhanced exposure therapy. This is particularly important in the context of treating combat-related PTSD, since prolonged exposure therapy may not be as effective with this population (e.g., Bradley et al. 2005).

Future Horizons in Clinical Work and Research

The past decade has witnessed a burgeoning of research on VRE for PTSD. Studies focused on PTSD stemming from diverse types of trauma, including combat exposure in Vietnam, Iraq, and Afghanistan, motor vehicle accidents, and terrorist attacks in the US and Israel, have demonstrated that VRE is an effective exposure therapy treatment. Moreover, VRE may offer several unique advantages over imaginal exposure therapy that make it particularly well-suited to the challenges faced by veterans of the conflicts in Iraq and Afghanistan. Foremost among these is the perceived stigma associated with seeking treatment for mental health problems. Studies among Iraq and Afghanistan veterans have found that treatment seeking for psychological problems may be inhibited by fears of negative perceptions, being considered weak, or damaging one's career (Stecker et al. 2007; Warner et al. 2008). Unfortunately, fear of stigma and other treatment barriers may be particularly relevant to those most in need of treatment, as one study found that Iraq and Afghanistan veterans who met screening criteria for a psychiatric disorder were more likely than those who did not to report such fears (Pietrzak et al. 2009). It has been proposed that VR may offer one avenue for addressing these concerns as part of a redesigned post-deployment treatment approach. In such an approach, VRE could be offered to veterans with PTSD as one component of a standard post-deployment training that all veterans completed, possibly decreasing perceived stigma since such training would be one of many routine post-deployment duties (Rizzo and Shilling 2018). In addition, younger service members, who are likely more familiar with digital gaming and training simulation technology, may be more attracted to and comfortable with participating in VRE than traditional talk therapy (Reger and Gahm 2008), which may promote treatment seeking among this population (Leaman et al. 2013; Rizzo and Shilling 2018). Given the pressing mental health needs of the current generation of veterans and concurrent low rates of treatment engagement (Hoge et al. 2004), finding acceptable forms of mental health treatment for returning service members is critical (Leaman et al. 2013). As part of a broader array of novel and innovative approaches, VRE may offer one such tool to facilitate treatment and emotional engagement, particularly in difficult-to-reach populations.

There are several remaining avenues for the next generation of research on VRE to explore. A substantial evidence base has demonstrated that VRE is an effective exposure therapy for PTSD resulting from various traumas. An important question is whether VRE offers benefits above those of established treatments. It will be valuable for future studies to examine not only whether VRE is associated with a greater decrease in PTSD symptoms than established treatments, but also whether individuals who fail to respond to established treatments show improvement with VRE. Randomized controlled trials comparing VRE with imaginal exposure for combat-related PTSD are now being conducted, which should offer insight into the first of these questions, but additional studies should examine whether individuals who have completed established treatments with little improvement may benefit from VRE. If differences emerge between imaginal exposure and VRE in direct comparisons,

or if research reveals that VRE reduces symptoms in those who have not responded to established treatments, this will pave the way for studies to examine specific patient or trauma characteristics associated with treatment response, which may offer the opportunity to better match patients with treatment modalities. Another question for future research is whether the addition of a pharmacologic agent can enhance the efficacy of VRE. Although studies examining the use of pharmacologic agents to enhance exposure rather than palliate PTSD symptoms have been mixed (de Kleine et al. 2012; Difede et al. 2014; Litz et al. 2012), an outstanding question is whether such cognitive enhancers are differentially effective when used with imaginal exposure versus VRE. Studies exploring this issue may offer greater understanding into the extinction of conditioned fear responses and are ongoing. As new developments in VR technologies have flourished over the past 15 years, a growing literature has established that VRE is an effective treatment for PTSD. Future research that expands upon this strong foundation to address the next generation of questions facing VRE represents a promising area for further investigation with the potential to yield valuable treatment advances.

References

American Psychiatric Association Practice Guidelines. (2004). *Practice guideline for the treatment of patients with acute stress disorder and posttraumatic stress disorder*. Arlington: American Psychiatric Association.

Amstadter, A. B., McCauley, J. L., Ruggiero, K. J., Resnick, H. S., & Kilpatrick, D. G. (2008). Service utilization and help seeking in a national sample of female rape victims. *Psychiatric Services, 59*, 1450–1457.

Australian Centre for Posttraumatic Mental Health. (2007). *Australian guidelines for the treatment of adults with acute stress disorder and posttraumatic stress disorder*. Melbourne: Australian Centre for Posttraumatic Mental Health.

Beck, J. G., Palyo, S. A., Winer, E. H., Schwagler, B. E., & Ang, E. J. (2007). Virtual reality exposure therapy for PTSD symptoms after a road accident: An uncontrolled case series. *Behavior Therapy, 38*, 39–48.

Bisson, J. I., Ehlers, A., Matthews, R., Pilling, S., Richards, D., & Turner, S. (2007). Psychological treatments for chronic post-traumatic stress disorder. Systematic review and meta-analysis. *British Journal of Psychiatry, 190*, 97–104.

Blanchard, E. B., Hickling, E. J., Devineni, T., Veazey, C. H., Galovski, T. E., Mundy, E., Malta, L. S., & Buckley, T. C. (2003). A controlled evaluation of cognitive behavioural therapy for posttraumatic stress in motor vehicle accident survivors. *Behaviour Research and Therapy, 41*, 79–96.

Botella, C., Banos, R. M., Perpina, C., Villa, H., Alcaniz, M., & Rey, A. (1998). Virtual reality treatment of claustrophobia: A case report. *Behaviour Research and Therapy, 36*, 239–246.

Botella, C., Banos, R. M., Villa, H., Perpina, C., & Garcia-Palacios, A. (2000). Virtual reality in the treatment of claustrophobic fear: A controlled multiple-baseline design. *Behavior Therapy, 31*, 583–595.

Bradley, R., Greene, J., Russ, E., Dutra, L., & Westen, D. (2005). A multidimensional meta-analysis of psychotherapy for PTSD [erratum appears in *American Journal of Psychiatry*, *162*(4):832]. *American Journal of Psychiatry, 162*, 214–227.

Breslau, N. (2001). The epidemiology of posttraumatic stress disorder: What is the extent of the problem? *Journal of Clinical Psychiatry, 62*, 16–22.

Brewin, C. R., Scragg, P., Robertson, M., Thompson, M., d'Ardenne, P., Ehlers, A., & Psychosocial Steering Group, & London Bombings Trauma Response Programme. (2008). Promoting mental health following the London bombings: A screen and treat approach. *Journal of Traumatic Stress, 21*, 3–8.

Carlin, A. S., Hoffman, H. G., & Weghorst, S. (1997). Virtual reality and tactile augmentation in the treatment of spider phobia: A case report. *Behaviour Research and Therapy, 35*, 153–158.

de Kleine, R. A., Hendriks, G.-J., Kusters, W. J. C., Broekman, T. G., & van Minnen, A. (2012). A randomized placebo-controlled trial of D-cycloserine to enhance exposure therapy for posttraumatic stress disorder. *Biological Psychiatry, 71*(11), 962–968.

Difede, J., & Hoffman, H. G. (2002). Virtual reality exposure therapy for world trade Center post-traumatic stress disorder: A case report. *Cyberpsychology & Behavior, 5*, 529–535.

Difede, J., Cukor, J., Jayasinghe, N., Patt, I., Jedel, S., Spielman, L., Giosan, C., & Hoffman, H. G. (2007a). Virtual reality exposure therapy for the treatment of posttraumatic stress disorder following September 11, 2001. *Journal of Clinical Psychiatry, 68*, 1639–1647.

Difede, J., Malta, L. S., Best, S., Henn-Haase, C., Metzler, T., Bryant, R., & Marmar, C. (2007b). A randomized controlled clinical treatment trial for world trade Center attack-related PTSD in disaster workers. *The Journal of Nervous and Mental Disease, 195*, 861–865.

Difede, J., Olden, M., & Cukor, J. (2014). Evidence-based treatment of post-traumatic stress disorder. *Annual Review of Medicine, 65*, 319–332. https://doi.org/10.1146/annurev-med-051812-145438.

Dohrenwend, B. P., Turner, J. B., Turse, N. A., Adams, B. G., Koenen, K. C., & Marshall, R. (2006). The psychological risks of Vietnam for U.S. Veterans: A revisit with new data and methods. *Science, 313*, 979–982.

Duckworth, D. (1986). Psychological problems arising from disaster work. *Stress Medicine, 2*, 315–323.

Durham, T. W., McCammon, S. L., & Allison, E. J., Jr. (1985). The psychological impact of disaster on rescue personnel. *Annals of Emergency Medicine, 14*, 664–668.

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99*, 20–35.

Foa, E. B., Steketee, G., & Rothbaum, B. O. (1989). Behavioral/cognitive conceptualizations of posttraumatic stress disorder. *Behavior Therapy, 20*, 155–176.

Foa, E. B., Dancu, C. V., Hembree, E. A., Jaycox, L. H., Meadows, E. A., & Street, G. P. (1999a). A comparison of exposure therapy, stress inoculation training, and their combination for reducing posttraumatic stress disorder in female assault victims. *Journal of Consulting & Clinical Psychology, 67*, 194–200.

Foa, E. B., Davidson, R. T., & Frances, A. (1999b). Expert consensus guideline series: Treatment of posttraumatic stress disorder. *American Journal of Clinical Psychiatry, 60*, 5–76.

Foa, E. B., Hembree, E. A., Cahill, S. P., Rauch, S. A. M., Riggs, D. S., Feeny, N. C., & Yadin, E. (2005). Randomized trial of prolonged exposure for posttraumatic stress disorder with and without cognitive restructuring: Outcome at academic and community clinics. *Journal of Consulting and Clinical Psychology, 73*, 953–964.

Foa, E. B., Hembree, E., & Rothbaum, B. (2007). *Prolonged exposure therapy for PTSD: Emotional processing of traumatic experiences, therapist guide*. New York: Oxford University Press.

Foa, E. B., Keane, T. M., Friedman, M. J., & Cohen, J. A. (2009). *Effective treatments for PTSD: Practice guidelines from the international society for traumatic stress studies* (2nd ed.). New York: Guilford Press.

Freedman, S. A. (2009). Psychological effects of exposure to terrorist attacks. In S. Shapira, J. Hammond, & L. Cole (Eds.), *Essentials of terror medicine*. New York: Springer.

Freedman, S. A., Hoffman, H. G., Garcia-Palacios, A., Tamar Weiss, P. L., Avitzour, S., & Josman, N. (2010). Prolonged exposure and virtual reality-enhanced imaginal exposure for PTSD following a terrorist bulldozer attack: A case study. *Cyberpsychology, Behavior and Social Networking, 13*, 95–101.

Gerardi, M., Rothbaum, B. O., Ressler, K., Heekin, M., & Rizzo, A. (2008). Virtual reality exposure therapy using a virtual Iraq: Case report. *Journal of Traumatic Stress, 21*, 209–213.

Gillespie, K., Duffy, M., Hackmann, A., & Clark, D. M. (2002). Community based cognitive therapy in the treatment of posttraumatic stress disorder following the Omagh bomb. *Behaviour Research and Therapy, 40*, 345–357.

Harvey, A. G., Bryant, R. A., & Tarrier, N. (2003). Cognitive behaviour therapy for posttraumatic stress disorder. *Clinical Psychology Review, 23*, 501–522.

Harvey-Lintz, T., & Tidwell, R. (1997). Effects of the 1992 Los Angeles civil unrest: Post traumatic stress disorder symptomatology among law enforcement officers. *Social Science Journal, 34*, 171–183.

Hidalgo, R. B., & Davidson, J. R. (2000). Posttraumatic stress disorder: Epidemiology and health-related considerations. *Journal of Clinical Psychiatry, 61*, 5–13.

Hoge, C. W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., & Koffman, R. L. (2004). Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care.. [see comment]. *New England Journal of Medicine, 351*, 13–22.

Institute of Medicine (IOM). (2006). *Posttraumatic stress disorder: Diagnosis and assessment*. Washington, DC: The National Academies Press.

Institute of Medicine (IOM). (2008). *Treatment of posttraumatic stress disorder: An assessment of the evidence*. Washington, DC: The National Academies Press.

Institute of Medicine (IOM). (2012). Treatment for posttraumatic stress disorder in military and veteran populations: Initial assessment. Retrieved from Washington, DC.

Jaycox, L. H., Foa, E. B., & Morral, A. R. (1998). Influence of emotional engagement and habituation on exposure therapy for PTSD. *Journal of Consulting and Clinical Psychology, 66*, 185–192.

Josman, N., Somer, E., Reisberg, A., Weiss, P. L. T., Garcia-Palacios, A., & Hoffman, H. (2006). BusWorld: Designing a virtual environment for post-traumatic stress disorder in Israel: A protocol. *Cyberpsychology & Behavior, 9*, 241–244.

Josman, N., Reisberg, A., Weiss, P. L., Garcia-Palacios, A., & Hoffman, H. (2008). BusWorld: An analog pilot test of a virtual environment designed to treat post-traumatic stress disorder originating from a terrorist suicide bomb attack. *CyberPsychology & Behaviour, 11*, 775–777.

Karlin, B. E., Ruzek, J. I., Chard, K. M., Eftekhari, A., Monson, C. M., Hembree, E. A., Resick, P. A., & Foa, E. B. (2010). Dissemination of evidence-based psychological treatment for post-traumatic stress disorder in the veterans health administration. *Journal of Traumatic Stress, 23*, 663–673.

Kessler, R. C. (2000). Posttraumatic stress disorder: The burden to the individual and to society. *Journal of Clinical Psychiatry, 61*, 4–12; discussion 13–14.

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & Nelson, C. B. (1995). Posttraumatic stress disorder in the National Comorbidity Survey. *Archives of General Psychiatry, 52*, 1048–1060.

Kok, B. C., Herrell, R. K., Thomas, J. L., & Hoge, C. W. (2012). Posttraumatic stress disorder associated with combat service in Iraq or Afghanistan: Reconciling prevalence differences between studies. *Journal of Nervous and Mental Disease, 200*(5), 444–450.

Larsen, D. L., Attkisson, C. C., Hargreaves, W. A., & Hguyen, T. D. (1979). Assessment of client/patient satisfaction: Development of a general scale. *Evaluation and Programming Planning, 2*, 197–207.

Leaman, S., Rothbaum, B. O., Difede, J., Cukor, J., Gerardi, M., & Rizzo, A. (2013). Virtual reality exposure therapy: A treatment manual for combat related PTSD. In J. Coll, A. Rubin, & E. Weiss (Eds.), *Handbook of military social work*. Hoboken: John Wiley & Sons, Inc.

Levitt, J. T., Malta, L. S., Martin, A., Davis, L., & Cloitre, M. (2007). The flexible application of a manualized treatment for PTSD symptoms and functional impairment related to the 9/11 world trade Center attack. *Behaviour Research and Therapy, 45*, 1419–1433.

Litz, B. T., Salters-Pedneault, K., Steenkamp, M. M., Hermos, J. A., Bryant, R. A., Otto, M. W., & Hofmann, S. G. (2012). A randomized placebo-controlled trial of D-cycloserine and exposure therapy for posttraumatic stress disorder. *Journal of Psychiatric Research, 46*(9), 1184–1190.

Marmar, C. R., Weiss, D. S., Metzler, T. J., Ronfeldt, H. M., & Foreman, C. (1996). Stress responses of emergency services personnel to the Loma Prieta earthquake interstate 880 freeway collapse and control traumatic incidents. *Journal of Traumatic Stress, 9*, 63–85.

Marmar, C. R., Weiss, D. S., Metzler, T. J., Delucchi, K. L., Best, S. R., & Wentworth, K. A. (1999). Longitudinal course and predictors of continuing distress following critical incident exposure in emergency services personnel. *Journal of Nervous & Mental Disease, 187*, 15–22.

McLay, R. N., McBrien, C., Wiederhold, M. D., & Wiederhold, B. K. (2010). Exposure therapy with and without virtual reality to treat PTSD while in the combat theater: A parallel case series. *Cyberspsychology, Behavior, & Social Networking, 13*, 37–42.

McLay, R. N., Wood, D. P., Webb-Murphy, J. A., Spira, J. L., Wiederhold, M. D., Pyne, J. M., & Wiederhold, B. K. (2011). A randomized, controlled trial of virtual reality-graded exposure therapy for post-traumatic stress disorder in active duty service members with combat-related post-traumatic stress disorder. *Cyberpsychology, Behavior and Social Networking, 14*, 223–229.

Mclay, R. N., Graap, K., Spira, J., Perlman, K., Johnston, S., Rothbaum, B. O., Difede, J., Deal, W., Oliver, D., Baird, A., Bordnick, P. S., Spitalnick, J., Pyne, J. M., & Rizzo, A. (2012). Development and testing of virtual reality exposure therapy for post-traumatic stress disorder in active duty service members who served in Iraq and Afghanistan. *Military Medicine, 177*, 635–642.

McLean Hospital. (2006). *BASIS-24 instruction guide*. Belmont, MA: Author.

McLean, C. P., Asnaani, A., Litz, B. T., & Hofmann, S. G. (2011). Gender differences in anxiety disorders: Prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research, 45*, 1027–1035.

Milliken, C. S., Auchterlonie, J. L., & Hoge, C. W. (2007). Longitudinal assessment of mental health problems among active and reserve component soldiers returning from the Iraq war. *Journal of the American Medical Association, 298*, 2141–2148.

Monson, C. M., Schnurr, P. P., Resick, P. A., Friedman, M. J., Young-Xu, Y., & Stevens, S. P. (2006). Cognitive processing therapy for veterans with military-related posttraumatic stress disorder. *Journal of Consulting & Clinical Psychology, 74*, 898–907.

Nacasch, N., Foa, E. B., Fostick, L., Polliack, M., Dinstein, Y., Tzur, D., Levy, P., & Zohar, J. (2007). Prolonged exposure therapy for chronic combat-related PTSD: A case report of five veterans. *CNS Spectrum, 12*, 690–695.

National Institute for Clinical Excellence. (2005). *Post-traumatic stress disorder (PTSD): The management of PTSD in adults and children in primary and secondary care*. London: National Institute for Clinical Excellence.

Norris, F. H. (1992). Epidemiology of trauma: Frequency and impact of different potentially traumatic events on different demographic groups. *Journal of Consulting and Clinical Psychology, 60*(3), 409–418.

North, C. S., Tivis, L., McMillen, J. C., Pfefferbaum, B., Spitznagel, E. L., Cox, J., Nixon, S., Bunch, K. P., Smith, E. M., North, C. S., Tivis, L., McMillen, J. C., Pfefferbaum, B., Spitznagel, E. L., Cox, J., Nixon, S., Bunch, K. P., & Smith, E. M. (2002). Psychiatric disorders in rescue workers after the Oklahoma City bombing. *American Journal of Psychiatry, 159*, 857–859.

Pietrzak, R. H., Johnson, D. C., Goldstein, M. B., Malley, J. C., & Southwick, S. M. (2009). Perceived stigma and barriers to mental health care utilization among OEF-OIF veterans. *Psychiatric Services, 60*(8), 1118–1122. https://doi.org/10.1176/appi.ps.60.8.1118.

Prigerson, H. G., Maciejewski, P. K., & Rosenheck, R. A. (2001). Combat trauma: Trauma with highest risk of delayed onset and unresolved posttraumatic stress disorder symptoms, unemployment, and abuse among men. *Journal of Nervous and Mental Disease, 189*, 99–108.

Ramchand, R., Schell, T. L., Karney, B. R., Osilla, K. C., Burns, R. M., & Caldarone, L. B. (2010). Disparate prevalence estimates of PTSD among service members who served in Iraq and Afghanistan: Possible explanations. *Journal of Traumatic Stress, 23*, 59–68.

Reger, G. M., & Gahm, G. A. (2008). Virtual reality exposure therapy for active duty soldiers. *Journal of Clinical Psychology, 64*, 940–946.

Reger, G. M., Gahm, G. A., Rizzo, A. A., Swanson, R., & Duma, S. (2009). Soldier evaluation of the virtual reality Iraq. *Telemedicine and e-Health, 15*, 101–104.

Reger, G. M., Holloway, K. M., Candy, C., Rothbaum, B. O., Difede, J., Rizzo, A. A., & Gahm, G. A. (2011). Effectiveness of virtual reality exposure therapy for active duty soldiers in a military mental health clinic. *Journal of Traumatic Stress, 24*, 93–96.

Resick, P. A., Nishith, P., Weaver, T. L., Astin, M. C., & Feuer, C. A. (2002). A comparison of cognitive-processing therapy with prolonged exposure and a waiting condition for the treatment of chronic posttraumatic stress disorder in female rape victims. *Journal of Consulting & Clinical Psychology, 70*, 867–879.

Rizzo, A. A., & Shilling, R. (2018). Clinical virtual reality tools to advance the prevention, assessment, and treatment of PTSD. *European Journal of Psychotraumatology, 8*(sup5), 1414560. https://doi.org/10.1080/20008198.2017.1414560.

Rizzo, A. A., Pair, J., McNerney, P. J., Eastlund, E., Manson, B., Gratch, J., Hill, R., Roy, M., & Swartout, B. (2005). Design and development of a VR therapy application for Iraq war veterans with PTSD. In J. D. Westwood et al. (Eds.), *Technology and informatics* (Vol. 111, pp. 407–413). Amsterdam: IOS Press.

Rizzo, A., Difede, J., Rothbaum, B. O., Johnston, S., McLay, R. N., Reger, G., Gahm, G., Parsons, T., Graap, K., & Pair, J. (2009). VR PTSD exposure therapy results with active duty OIF/OEF combatants. *Studies in Health Technology & Informatics, 142*, 227–282.

Rizzo, A., Difede, J., Rothbaum, B. O., Reger, G., Spitalnick, J., Cukor, J., & Mclay, R. (2010). Development and early evaluation of the virtual Iraq/Afghanistan exposure therapy system for combat-related PTSD. *Annals of the New York Academy of Science, 1208*, 114–125.

Rosenczweig, C. C., Kravitz, J., & Devlin, E. (2002). The psychological impact of helping in a disaster - the new York City experience, September 11th, 2001. *Academic Emergency Medicine, 9*, 502.

Rothbaum, B. O., Hodges, L. F., Kooper, R., Obdyke, D., Williford, J. S., & North, M. (1995a). Virtual reality graded exposure in the treatment of acrophobia: A case report. *Behavior Therapy, 26*, 547–554.

Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., & North, M. (1995b). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *American Journal of Psychiatry, 152*, 626–628.

Rothbaum, B. O., Hodges, L., Alarcon, R., Ready, D., Shahar, F., Graap, K., Pair, J., Hebert, P., Gotz, D., Wills, B., & Baltzell, D. (1999). Virtual reality exposure therapy for PTSD Vietnam veterans: A case study. *Journal of Traumatic Stress, 12*, 263–271.

Rothbaum, B. O., Hodges, L. F., Ready, D., Graap, K., & Alarcon, R. D. (2001). Virtual reality exposure therapy for Vietnam veterans with posttraumatic stress disorder. *Journal of Clinical Psychiatry, 62*, 617–622.

Rothbaum, B. O., & Ressler, K. J. (2009). Psychosocial treatments of posttraumatic stress disorder. In *Post traumatic stress disorder* (pp. 108–124). CRC Press.

Salloum, A., & Overstreet, S. (2008). Evaluation of individual and group grief and trauma interventions for children post disaster. *Journal of Clinical Child and Adolescent Psychology, 37*(3), 495–507. https://doi.org/10.1080/15374410802148194.

Schnurr, P. P., Friedman, M. J., Engel, C. C., Foa, E. B., Shea, M. T., Chow, B. K., Resick, P. A., Thurston, V., Orsillo, S. M., Haug, R., Turner, C., & Bernardy, N. (2007). Cognitive behavioral therapy for posttraumatic stress disorder in women: A randomized controlled trial. *Journal of the American Medical Association, 297*, 820–830.

Smith, S. G., Rothbaum, B. O., & Hodges, L. (1999). Treatment of fear of flying using virtual reality exposure therapy: A single case study. *The Behavior Therapist, 22*, 154–158.

Stecker, T., Fortney, J. C., Hamilton, F., & Ajzen, I. (2007). An assessment of beliefs about mental health care among veterans who served in Iraq. *Psychiatric Services, 58*, 1358–1361.

Tanielian, T., & Jaycox, L. H. (Eds.). (2008). *Invisible wounds of war: Psychological and cognitive injuries, their consequences, and services to assist recovery*. Santa Monica: RAND.

Thomas, J. T., Wilk, J. E., Riviere, L. A., McGurk, D., Castro, C. A., & Hoge, C. W. (2010). The prevalence of mental health problems and functional impairment among active component and national guard soldiers 3 and 12 months following combat in Iraq. *Archives of General Psychiatry, 67*, 614–623.

Wald, J., & Taylor, S. (2003). Preliminary research on the efficacy of virtual reality exposure therapy to treat driving phobia. *CyberPsychology and Behavior, 6*(5), 459–465.

Warner, C. H., Appenzeller, G. N., Mullen, K., Warner, C. M., & Grieger, T. (2008). Soldier attitudes toward mental health screening and seeking care upon return from combat. *Military Medicine, 173*(6), 563–569.

Wilson, J. A. B., Onorati, K., Mishkind, M., Reger, M. A., & Gahm, G. A. (2008). Soldier attitudes about technology-based approaches to mental health care. *Cyberpsychology & Behavior, 11*, 767–769.

Wood, D. P., Murphy, J., Center, K., McLay, R., Reeves, D., Pyne, J., & Wiederhold, B. K. (2007). Combat-related post-traumatic stress disorder: A case report using virtual reality exposure therapy with physiological monitoring. *Cyberpsychology & Behavior, 10*, 309–315.

Wood, D. P., Murphy, J. A., Center, K. B., Russ, C., McLay, R. N., Reeves, D., & Wiederhold, B. K. (2008). Combat related post traumatic stress disorder: A multiple case report using virtual reality graded exposure therapy with physiological monitoring. *Studies in Health Technology and Informatics, 132*, 556–561.

Wood, D. P., Webb-Murphy, J., Center, K., McLay, R., Koffman, R., Johnston, S., & Wiederhold, B. K. (2009). Combat-related post-traumatic stress disorder: A case report using virtual reality graded exposure therapy with physiological monitoring with a female Seabee. *Military Medicine, 174*, 1215–1222.