Virtual Reality Exposure Therapy for Vietnam Veterans With Posttraumatic Stress Disorder

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Background: Virtual reality (VR) integrates real-time computer graphics, body-tracking devices, visual displays, and other sensory input devices to immerse a participant in a computer-generated virtual environment that changes in a natural way with head and body motion. VR exposure (VRE) is proposed as an alternative to typical imaginal exposure treatment for Vietnam combat veterans with posttraumatic stress disorder (PTSD).

Method: This report presents the results of an open clinical trial using VRE to treat Vietnam combat veterans who have DSM-IV PTSD. In 8 to 16 sessions, 10 male patients were exposed to 2 virtual environments: a virtual Huey helicopter flying over a virtual Vietnam and a clearing surrounded by jungle.

Results: Clinician-rated PTSD symptoms as measured by the Clinician Administered PTSD Scale, the primary outcome measure, at 6-month follow-up indicated an overall statistically significant reduction from baseline ($p = .0021$) in symptoms associated with specific reported traumatic experiences. All 8 participants interviewed at the 6-month follow-up reported reductions in PTSD symptoms ranging from 15% to 67%. Significant decreases were seen in all 3 symptom clusters ($p < .02$). Patient self-reported intrusion symptoms as measured by the Impact of Event Scale were significantly lower ($p < .05$) at 3 months than at baseline but not at 6 months, although there was a clear trend toward fewer intrusive thoughts and somewhat less avoidance.

Conclusion: Virtual reality exposure therapy holds promise for treating PTSD in Vietnam veterans.

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Posttraumatic stress disorder (PTSD) is one of the most disabling psychopathologic conditions affecting the veteran population, with estimates of 830,000 veterans suffering from chronic combat-related PTSD.[1] Exposure-based therapies for PTSD involve repeated reliving of the trauma with the aim of facilitating its processing, a mechanism presumably impaired in trauma survivors with chronic PTSD.[2] Three controlled studies[3–5] have demonstrated statistically significant yet relatively small effects utilizing imaginal exposure for reducing PTSD and related pathology in male Vietnam veterans.

One of the most common complaints of Vietnam veterans with PTSD is a strong emotional response to the sound of helicopters. The American Lake VAMC PTSD program used "helicopter ride therapy" for several years as a regular part of treatment.[6] Obviously, it is not practical to use actual Huey helicopters for the thousands of veterans with PTSD, and the benefits of standard imaginal exposure in this population are modest, at best. Therefore, virtual reality exposure (VRE) therapy is proposed as a new medium of exposure therapy for veterans with PTSD.

Virtual reality (VR) is distinguished from a mere multimedia system or an interactive computer graphics display by the sense of presence it offers the user. A sense of presence is also essential to conducting exposure therapy

aimed at facilitating emotional processing.[7] For emotional processing to occur, it has been proposed that the fear structure must be activated and modified. Exposure therapy is historically effective at activating the fear structure via confrontation with the feared stimuli, which elicits the fearful responses. The processes of habituation and extinction, in which the feared stimuli cease to elicit anxiety, aid modification of the fear structure, making its meaning less threatening. Any method capable of activating the fear structure and modifying it would be predicted to improve symptoms of anxiety. Thus, VRE has been proposed to aid the emotional processing of fears.[8]

Advantages of VRE include conducting exposure therapy without leaving the therapist's office, exactly controlling exposure stimuli, and exposing the patient to less risk of harm or embarrassment. A controlled study for the fear of flying[9] found that VRE, in which patients had repeated exposure to a virtual airplane including taxiing, takeoff, flying in smooth and turbulent weather, and landing, and standard exposure therapy, in which patients were brought to the airport and exposed to airport activities and sitting in a stationary airplane, were equally effective at reducing participants' fears and avoidance of flying, and both were significantly more effective than the wait-list control condition. By the 6-month follow-up assessment, 93% of treated patients had flown in an actual airplane. In a controlled treatment study of acrophobia,[10] VRE significantly reduced fear and avoidance of heights and improved attitudes toward heights. Repeated exposures to virtual foot bridges, outdoor balconies, and a glass elevator that ascended 50 floors produced physical symptoms of anxiety including sweating, butterflies, heart palpitations, shaking, weakness in the knees, tightness in the chest, and tension. Case studies of VRE have demonstrated reduced fears of public speaking (P. L. Anderson, Ph.D.; B.O.R.; L. Hodges, Ph.D., manuscript submitted, 2001), heights,[11] flying,[12,13] and spiders.[14]

No therapeutic approach has proved to be consistently effective in the management of combat-related PTSD. Behavioral therapies with an exposure element have proved more effective than most other types of treatment,[15,16] but a significant number of patients do not seem to benefit from them, possibly due to difficulties imagining, visualizing, or describing their traumatic experiences. This report presents the results of a treatment development grant that sought to develop a treatment using VRE in the management of Vietnam combat veterans with PTSD, the first case of which was published in 1999.[17] It was planned to create a "virtual Vietnam" and have patients expose themselves by imagination to their most traumatic memories of Vietnam while immersed in these virtual Vietnam stimuli. Two virtual environments were created: a virtual Huey helicopter that flies over various Vietnam terrain (jungles, river, and rice paddies) and a virtual clearing surrounded by jungle.

METHOD

Participants

Sixteen male volunteers, all patients of the Atlanta VA Medical Center, met study criteria for participation and began treatment. All patients met DSM-IV[18] criteria for current chronic PTSD and were considered treatment refractory. Comorbid diagnoses included past major depressive disorder (MDD) (N = 3), current MDD (N = 3), past substance and alcohol abuse (N = 3), past substance dependence (N = 1), past substance abuse (N = 2), past alcohol dependence (N = 2), and dysthymia (N = 1). The mean ± SD age of the group was 51 ± 3.16 years. Fourteen of the 16 patients were taking one or more psychotropic medications for PTSD symptoms. Medications included fluoxetine (N = 4), buspirone (N = 3), trazodone (N = 2), and sertraline, doxepin, venlafaxine, methylphenidate, carbamazepine, bupropion, hydroxyzine, lorazepam, zolpidem, divalproex sodium, and simvastatin (N = 1 for each). All had served in combat operations in Vietnam, and the group averaged heavy combat exposure as measured by the Combat Exposure Scale. The majority were being compensated through the VA system for disabilities. Of the 10 participants who completed treatment, 6 were 100% service connected, 2 were 50% to 100% service connected, and 2 were not service connected. Of the dropouts, 1 was 100% service connected, 1 was 50% to 100% service connected, 1 was not service connected, and the status of 3 was unknown. Five participants terminated treatment before completing the suggested number of sessions; dropouts occurred within the first session (N = 2) and after session 5 (N = 3). Ten completed the required treatment sessions; however, 1 attended no posttreatment assessment, and thus data for 9 participants were included in subsequent analyses.

Procedure

Interested veterans were recruited via publicity efforts, and referrals were provided preliminary screening over the phone. Patients who were actively addicted or had serious heart conditions, psychosis, bipolar disorder, unstable medication regimens, planned departures from the Atlanta area, uncontrolled suicidal intention, and/or lack of approval from their treating physicians or treatment teams were excluded. A psychologist at the Atlanta VAMC (D.R.) interviewed approximately 70 veterans in person. If they were deemed potentially eligible, they were provided additional information about the study and asked to provide informed consent.

After consent was obtained, a pretreatment evaluation was conducted by an independent assessor, a clinical psychology graduate student and psychology resident (K.G.), who reviewed the inclusion (currently meeting PTSD diagnostic criteria, manageable suicidal ideation) and exclusion criteria (current substance abuse, mania, suicidal

intent, unstable medication in the past 3 months), explained the procedures of the project in detail, and scheduled the initial treatment session. Thirty-one evaluations, using the instruments listed below, were conducted. Three persons were excluded due to trauma that was deemed too dissimilar to the virtual environments available. Other patients excluded had active addictions, unstable medical conditions (heart), unstable psychotropic medication regimens, a negative recommendation from the treating professional, or a combination of these factors.

Clinical Measurement Instruments

The following clinician-rated and self-report measures of PTSD were incorporated: the Clinician Administered PTSD Scale (CAPS),[19] the Combat Exposure Scale (CES),[20] the Structured Clinical Interview for DSM-IV (SCID),[21] the Impact of Event Scale (IES),[22] the Beck Depression Inventory (BDI),[23] and the clinician-administered Clinical Global Impressions-Improvement scale (CGI-I) and the patient rated version of the CGI-I (PGI-I).[24]

Full assessments were conducted at pretreatment, posttreatment, and 3- and 6-month follow-ups. Patients were informed that to try to avoid the confound of improvement in symptoms and loss of compensation, the results of the assessments would not become part of their VA hospital files. Participants were reimbursed for their time and travel expenses: $10, $20, and $30 for completed posttreatment and 3- and 6-month follow-up assessments, respectively. Statistical tests compared scores at pretreatment with scores at posttreatment and 3- and 6-month follow-ups.

Equipment

During VRE, patients wore a Virtual Research V6 head-mounted display (Virtual Research Systems, Aptos, Calif.) equipped with a Polhemus InsideTrak position tracker (Polhemus Inc., Colchester, Vt.) and high-quality headphones. This head-mounted display contains 2 mini-television screens, 1 in front of each eye, and earphones over each ear. The head-mounted display is worn with T-straps holding it on the head and is connected by a cable to the computer. Computer graphics images and spatial audio consistent with the orientation and position of the patient's head were computed in real time as the patient experienced and explored each environment. All environments were immersive, i.e., the patient experienced only the computer-generated audio and visual stimuli while "real-world" stimuli were shut out. Therapist communications were via a microphone connected to the headphones. During the virtual helicopter stimulus, the patient sat in a special chair with a woofer under the seat that allowed the vibrations from the helicopter to be felt. For the clearing environment, the patient stood on a raised (8 inches) platform (3.5 feet × 3.5 feet) surrounded by handrails on all sides. The patient "walked" in the environment by pushing a button on a hand-held joystick. Audio, headtracking, and real-time graphics were computed on a PC with a 233 MHz Intel Pentium II Processor (Dell, Round Rock, Tex.), 64 MB of RAM, and an Evans & Sutherland 3D graphics card (Evans & Sutherland, Salt Lake City, Utah). The Virtual Vietnam software and environment models were custom-built (to run on a PC) at Georgia Tech University and Virtually Better, Inc., (both in Atlanta, Ga.) using the Simple Virtual Environment (SVE) tools and incorporating regular feedback and suggestions from veterans and staff of the Atlanta VA Medical Center's Mental Health Service Line.

Treatment

Treatment was typically delivered in ten 90-minute individual sessions conducted twice weekly by one of the authors (D.R.) over 5 to 7 weeks, although the range was 8 to 16 sessions depending on the participants' progress. Session 1 was devoted to information gathering, explaining the therapy from an emotional processing viewpoint, teaching a brief breathing relaxation method, and familiarizing the patient with the virtual reality equipment using a neutral environment.

During sessions 2 and 3, the participant was exposed to the 2 virtual environments. In the virtual jungle clearing, the audio effects included recordings of jungle sounds (i.e., crickets), gunfire, helicopters, mine explosions, and men yelling "Move out! Move out!" that could be increased in intensity. Visual effects included muzzle flashes from the jungle; helicopters flying overhead, landing, and taking off; and fog. In the virtual helicopter, audio effects included the sound of the rotors, gunfire, bombs, B52s, engine sounds, radio chatter, and men yelling "Move out! Move out!" Visual effects included the interior of a Huey helicopter in which the backs of the pilot's and copilot's heads with patches, instruments, and controls were visible, as was the field out of the helicopter side door. This view included aerial shots of other helicopters flying past, clouds, and the terrain below, which included rice paddies, jungle, and a river.

Sessions 4 and 5 exposed the patient to these virtual environments plus triggered memories. The patient was asked to describe in detail memories triggered by the virtual environments and to repeat them several times to allow habituation. The content of these triggered memories was controlled by the patient through the continuous communication with and feedback to the therapist. The remaining sessions were spent exposing the patient to the virtual environments plus imaginal exposure to his most traumatic memories, which had been determined prior to treatment and were prompted by the therapist during the sessions. As in standard imaginal exposure for PTSD,[25] the patient was asked to recount these memories in the present tense repeatedly until his anxiety decreased. In contrast to standard imaginal exposure, the patient was

Table 1. Summary of Outcome Measures at Pretreatment (Baseline), Posttreatment, and 3- and 6-Month Follow-Up[a]

Measure	Baseline[b] (N = 9)	Posttreatment (N = 9) Value[b]	p[c]	3-Month Follow-Up (N = 5) Value[b]	p[c]	6-Month Follow-Up (N = 8) Value[b]	p[c]
CAPS							
Total	68.00 ± 15.26	57.78 ± 20.61	.0727	54.6 ± 17.5	.0256	47.12 ± 17.04	.0021
% Change from baseline, mean (range)	...	–15 (+41 to –38)		–27 (–31 to –48)		–31 (–15 to –67)	
Cluster B (reexperiencing)	16.33 ± 6.06	13.89 ± 6.33	.2812	9.40 ± 6.99	.0231	11.12 ± 4.45	.0103
Cluster C (avoidance)	28.22 ± 8.18	24.78 ± 10.74	.2814	23.20 ± 7.33	.0507	17.25 ± 9.35	.0116
Cluster D (arousal)	23.44 ± 4.47	19.11 ± 8.91	.1163	22.00 ± 4.69	.0777	18.75 ± 5.31	.0021
Impact of Event Scale							
Total	42.89 ± 10.20	36.11 ± 21.64	.3988	19.4 ± 14.7	.0327	29.88 ± 19.39	.0912
Intrusion	20.33 ± 6.10	16.11 ± 8.56	.2126	8.00 ± 9.07	.0135	13.88 ± 10.48	.0949
Avoidance	22.55 ± 7.88	20.00 ± 15.43	.6259	11.40 ± 5.86	.1585	16.00 ± 10.61	.1412
Beck Depression Inventory	26.11 ± 11.36	21.77 ± 10.12	.09	25.6 ± 12.3	.38	17.85 ± 11.01	.01

[a]Abbreviation: CAPS = Clinician Administered PTSD Scale.
[b]Values shown as mean ± SD unless noted otherwise.
[c]p Values vs. baseline; differences significant at $p < .05$.

Figure 1. Mean Scores on the Clinician Administered PTSD Scale (CAPS) at Pretreatment, Posttreatment, and 3- and 6-Month Follow-Up

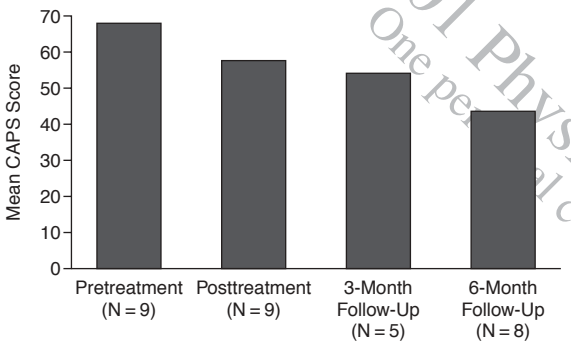
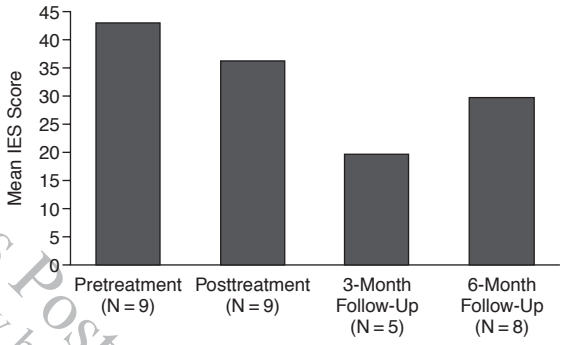


Figure 2. Mean Scores on the Impact of Event Scale (IES) at Pretreatment, Posttreatment, and 3- and 6-Month Follow-Up



asked to keep his eyes open, and the therapist attempted to match in virtual reality what the patient was describing as closely as possible. For example, the therapist would land and take off the helicopter or introduce gunfire or men yelling at appropriate times when the patient described these activities in his imaginal exposure.

Self-ratings of Subjective Units of Discomfort (SUDS) from 0 to 100 were elicited from the patient every 5 minutes during exposure. The therapist simultaneously viewed on a video monitor all of the virtual environments with which the patient was interacting and, therefore, was able to comment appropriately and to encourage continued exposure until the patient's anxiety habituated. At the end of the session's exposure, practice with breathing exercises was completed. The patient and therapist discussed the session and the patient's reactions. The 1 patient given 16 sessions had several non-VR sessions in between VRE sessions to aid in his processing of the memories and to titrate the intensity of the VR exposures.

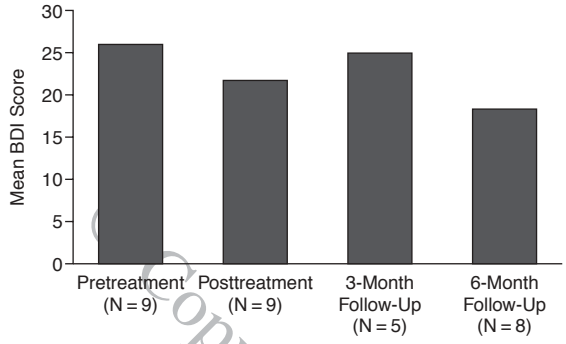
Patients were exposed only to the virtual reality environments that matched their experiences; thus, several patients were exposed only to the jungle clearing stimulus, since that environment more closely matched their traumatic memories. All treatment sessions were videotaped for supervision by the first author.

RESULTS

Table 1 contains the mean ± SD values for outcome measures at pretreatment, posttreatment, and 3- and 6-month follow-up. Clinician-rated PTSD symptoms as measured by the CAPS, the primary outcome measure, at 6-month follow-up indicated an overall statistically significant reduction from baseline (Figure 1). All 8 participants interviewed at the 6-month follow-up reported reductions in PTSD symptoms ranging from 15% to 67%. Significant decreases were seen in all 3 symptom clusters.

Patient self-reported intrusion symptoms as measured by the IES were significantly lower at 3 months than at baseline but not at 6 months (see Table 1), although there was a clear trend toward fewer intrusive thoughts and

Figure 3. Mean Scores on the Beck Depression Inventory (BDI) at Pretreatment, Posttreatment, and 3- and 6-Month Follow-Up



somewhat less avoidance (Figure 2). After treatment, the majority of patients' ratings of their global improvement as measured on the PGI-I indicated improvement. At 6 months, 6 of 8 reported improvement. Clinicians' ratings of patients' global improvement as measured by the CGI-I indicated that 5 of 6 showed improvement immediately after the study, whereas 1 appeared unchanged. At 6 months, 7 of 8 were rated as demonstrating some improvement.

Since this was an open clinical trial and no comparisons can be made except pretreatment and posttreatment, the results of each measure are presented in terms of clinical significance and references are made, where data exist, to studies with information on these measures in similar populations. In this context, the mean pretreatment CAPS total score of 68 falls into the "severe" range (60–79) (CAPS Clinical Cutoffs, Frank Weathers, Ph.D., unpublished data, 1998), whereas the 6-month follow-up CAPS total score of 47 falls into the "moderate/threshold" range (40–59), indicating a decrease in clinical severity, although the patients were obviously still suffering from some PTSD symptoms. The mean pretreatment IES total score in the current sample was 43. The mean IES total score for participants who specifically had a Vietnam incident was 25, more than 1 standard deviation higher than scores in 2 samples of Vietnam veterans with PTSD,[26,27] and the 3-month follow-up total score of 19 is greater than 1 standard deviation lower, indicating a meaningful change in IES total score of over 2 standard deviations following therapy; there was, however, a rise to 30 in IES total score at 6-month follow-up, indicating a worsening from the 3-month follow-up. The mean pretreatment BDI score of 26 indicates moderate depression according to the cutoffs recommended by Steer and Beck.[28] The mean BDI score of 18 at 6-month follow-up falls into the mildly depressed range, indicating a decrease in severity of depression over time, although some depressive symptoms were still present (Figure 3).

DISCUSSION

Virtual reality exposure therapy led to significant reductions in PTSD and related symptoms and was well tolerated in this small sample of male Vietnam veterans. Patients appeared to become emotionally engaged in the exposures and seemed to think they had helped. No patient decompensated due to exposure to the virtual environments. Although we began the study on outpatients but were physically located on the inpatient unit to be prepared in case of emergency, no participant was hospitalized during the study for complications related to the treatment. One person reported headaches and neck pain that he attributed to participation in this study approximately 6 months after the study had taken place. Subsequently, he was diagnosed with a "pinched nerve" that was deemed unrelated to his participation. All of those who dropped out of the study were provided opportunities for other treatment within the PCT (PTSD Clinical Team) clinic or the Mental Health Clinic at the Atlanta VA Medical Center and appeared to suffer no long-term problems attributable to their participation.

Initially, we experienced a noteworthy dropout rate that led to reevaluation of the entrance criteria and an examination of the information participants were receiving prior to treatment. Communication with a study consultant indicated that we should expect at least a 50% dropout rate in this population. Since the research team was gaining experience, we were able to better communicate the demands of the study and to more clearly identify challenges potentially faced by participants. Communication improvements included describing in detail the course of treatment, including the expectation that patients would experience more symptoms (that would later subside) during the initial treatment sessions. We also developed informational packages for wives and family members of participants and met with them as necessary to help alleviate their fears about having their loved one undertake this novel type of treatment. As a result, there were no dropouts among the last 5 patients entered into the study. As in many exposure-based studies, patients continued to improve even after treatment terminated such that continued improvement was seen at follow-up assessments.[9,25]

Obvious limitations to the generalizability of these results center on the fact that this was an open clinical trial testing just one component of treatment with a small sample. It is clear that VRE therapy is proposed as a component of a comprehensive treatment program, an approach generally accepted in the overall management of this patient population.[29]

VRE has the advantages of allowing veterans to virtually reexperience aspects of Vietnam in a controllable manner that allows for habituation. The patients certainly appeared to become immersed in the virtual environment.

The sample included very "typical" Vietnam combat veterans with PTSD participating in the VA system: all met criteria for current PTSD, and many met criteria for major depression and past substance abuse. Almost all were currently taking several medications. Many were receiving VA disability assistance for their PTSD. Many of the veterans were quick to anger and slow to trust, yet were unhappy with their current life and verbally expressed motivation to change and to try almost anything that might help. Many of the marriages were in distress, and there were many problems in most other areas of life such as work and social relationships. Most were very weary of this treatment and admitted to not wanting to attend sessions at times. Yet, the treatment appears to have helped, even if modestly. This report is quite limited in its scope due to its small sample size and open clinical trial design, but it is suggestive that imaginal exposure while immersed in Vietnam audio and visual stimuli may be an effective component of a comprehensive treatment package for Vietnam veterans with PTSD and is worthy of further study.

In summary, this treatment development grant was successful in creating a new virtual reality exposure therapy for Vietnam combat veterans with PTSD. Two effective, immersive virtual environments were successfully constructed to be run on a turnkey PC by a therapist who does not have to be computer-sophisticated. A treatment manual was developed describing the treatment, and patients were successfully treated in an open clinical trial, leading to clinically and statistically significant reductions in PTSD and related symptoms. A controlled study with a similar patient population is currently underway at the VA National Center for PTSD in Boston, Mass.

Drug names: bupropion (Wellbutrin), carbamazepine (Tegretol), divalproex sodium (Depakote), doxepin (Sinequan and others), fluoxetine (Prozac), hydroxyzine (Vistaril and others), lorazepam (Ativan), methylphenidate (Ritalin and others), sertraline (Zoloft), trazodone (Desyrel and others), venlafaxine (Effexor), zolpidem (Ambien).

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