

# A Virtual Environment for the Treatment of Chronic Combat-Related Post-Traumatic Stress Disorder

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## ABSTRACT

Post-traumatic stress disorder (PTSD) is one of the most disabling psychopathological conditions affecting the veteran population. An estimated 830,000 U.S. veterans currently have symptoms of chronic combat-related PTSD. No therapeutic approach has proven to be consistently effective in the management of combat-related PTSD. Behavior therapies with an exposure element have proven more effective than most other types of treatment, but a significant number of patients do not seem to benefit from them, possibly because of difficulties imagining, visualizing, or describing their traumatic experiences. In this article, we describe Virtual Vietnam, a set of two virtual environments we have developed for the treatment of combat-related PTSD, and its use as one component of a comprehensive treatment program.

## INTRODUCTION

EMOTIONAL PROCESSING THEORY as applied to anxiety disorders<sup>1</sup> purports that fear memories can be construed as structures that contain information regarding stimuli, responses, and meaning. Therapy is aimed at facilitating emotional processing. For this to occur, it has been proposed that the fear structure must be activated and modified. Exposure therapy has been historically effective at activating the fear structure via confrontation with the feared stimuli, which elicits the fearful responses. Traditional mediums for exposure have been to ex-

pose the patient to the actual physical stimuli that evokes their fear response (*in vivo* exposure) or to have the patient imagine the feared stimuli (imaginal exposure). The process of habituation and extinction, in which the feared stimuli cease to elicit anxiety, aid modification of the fear structure, making its meaning less threatening.

## THERAPEUTIC USE OF VIRTUAL ENVIRONMENTS

Recently, there has been growing interest in the use of virtual environments as a medium for exposure. Although virtual environments are a relatively new modality for exposure in the treatment of anxiety disorders, several articles have reported on their usefulness. Rothbaum et al.<sup>2</sup> conducted a controlled study ap-

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plying virtual reality to the treatment of acrophobia. In that study, virtual reality exposure (VRE) was effective in significantly reducing fear and avoidance of heights and improving attitudes toward heights on all measures, whereas no change was noted in the control group. Virtual reality exposure has also been reported as effective in a number of case studies including fear of heights,<sup>3</sup> fear of flying,<sup>4,5</sup> fear of spiders,<sup>6</sup> and claustrophobia.<sup>7</sup> Virtual reality exposure allows the investigator the advantages of conducting time-consuming exposure therapy without having the patient leave the therapist's office, precise control over events and exposure stimuli, and control over the patient's exposure to possible harm or embarrassment.

To date, published studies in reviewed journals and conferences on VRE have reported on treatment of anxiety disorders with specific anxiety-producing stimuli and little comorbidity with other disorders. In this article, we present a set of virtual environments that were developed as part of an uncontrolled treatment development study to evaluate the therapeutic effectiveness of VRE with Vietnam War veterans with combat related post-traumatic stress disorder (PTSD). PTSD is a much more complex and chronic anxiety disorder than any other disorder that has been previously treated using virtual reality exposure. In fact, no therapeutic approach has proven to be consistently effective in the management of combat-related

PTSD. Behavioral therapies with an exposure element have proven more effective than most other types of treatment, but a significant number of patients do not seem to benefit from them, possibly because of difficulties imagining, visualizing, or describing their traumatic experiences. Consequently, clinical researchers have been trying to develop an intervention that does not rely on the patient's own imagining skills but rather focuses on the traumatic experience, while allowing him/her ultimate control over previously uncontrollable and terrifying stimuli. For those who are not familiar with PTSD, we first give a brief overview of diagnostic features and current therapeutic approaches.

## POST-TRAUMATIC STRESS DISORDER

Persons who suffer from PTSD experience a number of characteristic symptoms (Table 1) that may include persistently re-experiencing a traumatic event; avoidance of specific thoughts, feelings, activities, or situations that are associated with the event; emotional numbness; and increased arousal. These symptoms are developed after exposure to a traumatic event that involves actual or threatened death or serious injury or other threat to one's personal integrity; witnessing an event that involves death, injury, or a threat to the personal integrity of another person; and learning about

TABLE 1. SYMPTOMS OF POST-TRAUMATIC STRESS DISORDER (DSM-IV<sup>8</sup>)

<i>Symptom</i>	<i>Comment</i>
Persistent re-experience of a traumatic event	Intrusive, recurring distressing recollections Recurring, distressing dreams Acting or feeling as if the traumatic event were recurring
Avoidance	Intense psychological or physiological distress at an event that symbolize the trauma Thoughts, feelings, or conversations associated with the trauma Activities, places or people that arouse recollections of the trauma Inability to recall important aspects of the trauma
Numbing	Markedly diminished interest or participation in significant activities Feeling of detachment or estrangement from others Restricted range of emotions Sense of a foreshortened future
Increased arousal	Difficulty sleeping Irritability and anger Difficulty with concentration Hypervigilance Exaggerated startle response

unexpected or violent death, serious harm, or threat of death or injury experienced by a family member or other close associate. The person's response to the event involves intense fear, helplessness, or horror.<sup>8</sup> Examples of traumatic events that may result in a diagnosis of PTSD include directly experiencing or witnessing military combat, violent personal assault, being taken hostage, torture, natural or man-made disasters, and severe automobile accidents.

### POST-TRAUMATIC STRESS DISORDER IN VIETNAM WAR VETERANS

War is often romanticized or described in terms of strategy, tactics, or political goals. The experience of war for the common soldier, however, is more likely to be similar to the description given by Flannery.<sup>9</sup> (1992)

[War] is cold-blooded destruction and the killing of human life in which the humanity of the enemy must be denied. It is the active and passive witnessing of death of the enemy and of one's comrades. It is atrocities of every kind imaginable. It is body parts and blood everywhere. It is personal injury and pain. It is the continuous fear of one's own death. It is a period in which testing one's self can be exhilarating as well as terrifying. War is also filth, material deprivation, and ubiquitous disease, pain, suffering and death. It may also be drugs, alcohol, and prostitution, as combatants seek to numb the horror.

It is not surprising that PTSD is one of the most disabling psychopathological conditions affecting the U.S. veteran population. Approximately 15.2% of the men and 8.5% of the women who fought in Vietnam were found to be suffering from PTSD 15 or more years after their service. An estimated 830,000 veterans currently have symptoms of chronic combat-related PTSD.<sup>10</sup> The psychological, social, occupational, and economic consequences of the disorder for patients and their families are devastating. A recent meta-analysis found that behavioral therapies (i.e., exposure) were more effective than medication or eye movement desensitization and re-

processing on observer-rated total PTSD symptoms.<sup>11</sup>

The efficacy of exposure treatment for PTSD was first demonstrated with several case reports on war veterans.<sup>12-14</sup> Exposure treatments with PTSD involved repeated reliving of the trauma with the aim of facilitating its processing, a mechanism presumably impaired in survivors with chronic PTSD.<sup>1</sup> Exposure procedures, which involve confrontation with the fear stimuli either imaginally or *in vivo*, activate the fear structure (i.e., elicit fear) and constitute an opportunity for corrective information to be integrated, thus modifying the fear structure. The result of such modification is the reduction of symptoms. Both flooding in imagination<sup>15</sup> and flooding *in vivo* to trauma-related events<sup>13</sup> appeared to be therapeutic. Most of these treatments also included additional techniques such as anger control or relaxation training.

Only three controlled studies have examined the utility of imaginal exposure (IE) for reducing PTSD and related pathology in male Vietnam veterans. In one study, all patients received the "standard" PTSD treatment, which consisted of weekly individual and group therapies in addition to exposure.<sup>16</sup> In the second study,<sup>15</sup> IE was compared to a treatment waiting-list control group. During each session, patients were initially instructed to relax. The patients subsequently received 45 minutes of imaginal flooding followed by relaxation. In the third study, all patients received a group treatment milieu program; one-half received additional IE and the remaining patients received weekly individual traditional psychotherapy.<sup>17</sup> All three studies found some benefit from the IE compared to the control groups, but the effects were small.

One of the most common complaints of Vietnam veterans with PTSD is that they have a strong emotional response to the sound of a helicopter going overhead. Even Vietnam veterans without PTSD report that one of the most terrifying experiences they had in the war was riding Huey helicopters into combat. It was in these aircraft that many veterans reported having their greatest anticipatory anxiety. The American Lake VAMC PTSD program in Washington State used "helicopter ride therapy" for several years as a regular part of their

treatment.<sup>18</sup> All of their Vietnam veteran patients (more than 400) had the opportunity to ride in real Huey helicopters. Although they did not present hard data, the authors report that this type of exposure treatment was very helpful to their patients.

## VIRTUAL VIETNAM

The Virtual Vietnam software consists of two distinct virtual environments: a helicopter environment and an open field environment. Visual models, audio, and virtual reality software were designed and implemented by the GVV Center's Virtual Environments Group at Georgia Tech and are licensed to other organizations through Virtually Better, Inc. ([www.virtuallybetter.com](http://www.virtuallybetter.com)).

### *Apparatus*

Users experience Virtual Vietnam by wearing a Virtual Research V6 head-mounted display that is equipped with high-quality stereo earphones and a Polhemus InsideTrak position tracker. Computer graphics images and spatial audio consistent with the orientation and position of the patient's head are computed in real time as the patient experiences and explores each Vietnam environment. In all the environ-

ments the patient experiences only computer-generated audio and visual stimuli while "real-world" stimuli are shut out. The therapist communicates with the patient with a microphone connected through the computer to the headphones. For the helicopter ride environment, the patient sits in a special chair ("Thunder Seat") that provides tactile stimuli via a bass speaker integrated in the chair. For the open field environment, the patient stands on a raised (8 inches) platform (3.5 feet by 3.5 feet) surrounded by handrails on all sides. The patient "walks" in the environment by pushing a button on a hand-held joystick. Audio, head-tracking, and real-time graphics are computed on a PC with a 233 MHz Intel Pentium II Processor, 64 MB of RAM, and an Evans & Sutherland 3D graphics card.

### *Helicopter environment*

In the helicopter environment a participant is seated in the gunner's seat of a Huey helicopter with the side door open (Fig. 1). The helicopter is initially on the ground in an open field surrounded by jungle. The helicopter subsequently may take off, land, or fly over different types of terrain including rice paddies, forest, mountainous terrain, and a river cutting through the jungle. The sequence of terrain and duration of each leg of the flight is under the

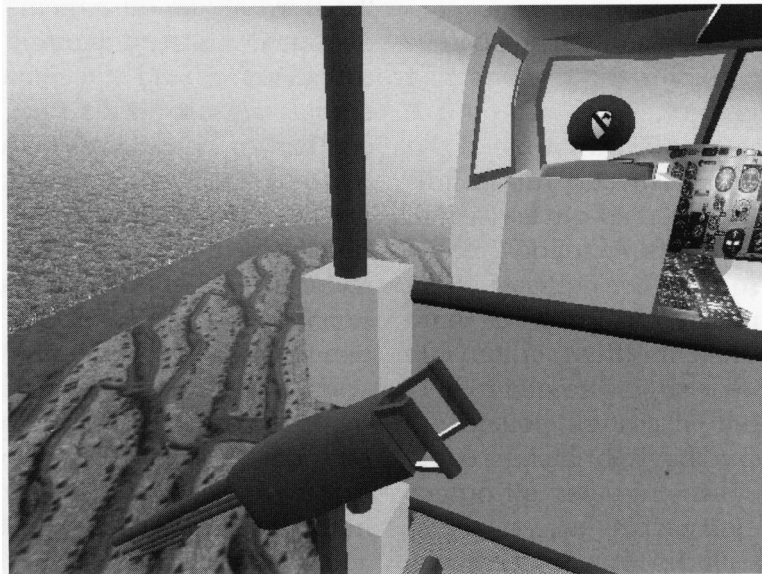


FIG. 1. Helicopter environment.



FIG. 2. Open field environment.

control of the therapist. Accompanying the visual stimuli are a number of audio effects that include the sounds of the helicopter, machine guns, background rumble of B52s, explosions, and radio chatter, all of which are also controlled by the therapist.

#### *Open field environment*

In the open field environment the user is initially standing in an open field surrounded by jungle (Fig. 2) and hears only background jungle sounds. Using a hand-held joystick, the patient is free to “walk” around the field, which includes individual trees, a swampy area, and a hilly area that can be used for cover. The therapist can initiate, terminate, and control the mix and duration of a wide number of visual and auditory effects such as helicopters flying over and landing, fog and night conditions, different types of gunfire, mine explosions, mortar bombardment, and soldiers yelling and screaming.

### ROLE OF VIRTUAL VIETNAM ENVIRONMENTS

The Virtual Vietnam environments were designed in consultation with experienced PTSD therapists and interviews with Vietnam War

veterans to represent experiences common to most veterans of the Vietnam War. The helicopter and open field environments were chosen for implementation because they represented two experiences that elicit strong emotional responses from Vietnam veterans with PTSD. Huey helicopters are associated with many terrifying and anxiety producing events in Vietnam, including the commencement of combat, evacuation of the wounded, and vulnerability to enemy fire, especially on landing and takeoff. An open field also meant exposure and vulnerability to becoming a casualty from gunfire from invisible enemies in the surrounding jungle. The emotional effect of being exposed was so strong, in fact, that the research team eventually had to modify the open field environment to add a bunker of hills that a patient could use as cover from enemy fire.

The initial expectation was that general exposure to the Virtual Vietnam environments would help overcome difficulties that many PTSD patients experience in imagining, visualizing, or describing their traumatic experiences. As a measure of the degree of reaction that participants were experiencing in Virtual Vietnam, subjective units of discomfort (SUDs) were elicited approximately every 5 minutes during exposure. The patient was asked to rate

his anxiety on a scale of 0 (no discomfort) to 100 (panic-level anxiety). In traditional exposure therapy using physical situations, the pattern is for subjects' anxiety to increase as they are exposed to more threatening situations, then for habituation to occur (anxiety decreases) as they spend time in the situation. Occurrence of this same pattern for virtual situations would be evidence that exposure to virtual environments is effective.

Table 2 provides an overview of the first patient's subjective reaction to his initial virtual helicopter ride. The participant's anxiety clearly increased as the helicopter left the ground, tended to level off or decrease the longer he continued flying over the same terrain, and tended to increase when the terrain changed or new stimuli such as radio chatter were added. Note that during this first flight, the more anxiety-producing stimuli such as machine gun fire or explosions were not included. These stimuli were added to the experience after the participant had habituated to the "calm" helicopter.

Patients who have been treated using Virtual Vietnam eventually become immersed in their virtual experience. Comments and reactions from the first patient to the experience of the open field environment include:

- Cursing and "running" away the first time he unexpectedly stepped into a swampy area in the clearing environment.
- Ducking as he approached a landed aircraft whose blades were still spinning.
- Commenting, "I feel good for that guy for getting out of here" as a helicopter took off, and "I'm worried they're not going to clear the trees" as he watched a helicopter leave the clearing.

Once the therapy sessions began to explore the participants' traumatic and triggered memories, the therapists began using the system in such a way as to produce a more explicit form of exposure. As the patient recounts his memories, the therapist attempts to match the events in the virtual environment to what the patient is describing as closely as possible. Because the design of the software allows the therapist explicit control over a large menu of possible events, it was often possible for the therapist to actively support the patient's verbal account with appropriate imagery and audio. This sensory support of a patient's own recounting of triggered and traumatic experiences was very successful in encouraging veterans to virtually re-experience aspects of Vietnam.

TABLE 2. THE FIRST VIRTUAL HELICOPTER RIDE

<i>Time in minutes</i>	<i>SUDS (1-100)</i>	<i>Situation</i>
0	5	Before putting on head-mounted device
2.5	20	Helicopter on ground
3.4	30	
5	40	
7.3	30	
7.6	50	Helicopter takes off
8.4		Over rice paddies
9.5	60	Into clouds
10.2		Radio chatter
10.7	60	Over mountains and jungle, hears radio chatter
11.5	50	Into clouds
12		Following river through jungle, hears B52s
12.6	40	
13.3	60	Radio chatter
14.9	40	
15.6		Into clouds
16.5	40	Over jungle
17.3	60	Landing
18.2	20	Helicopter on ground

As one would expect to be the case, there were often instances in which patients recounted traumatic events that could not be fully supported by the menu of visual and audio effects. In many instances, the result was a combination of exposure modalities in which the patient added imaginal components to the virtual environment they were experiencing. For example, one of our patients was a bulldozer operator in Vietnam. His traumatic memories included digging and burying bodies in a mass grave. Using the mouse buttons we had intended for virtual "walking" as the bulldozer controls he methodically dug the grave and covered the bodies while he recounted his experience.

In another case, a patient who had been a tank commander was reliving the experience of having his tank overrun by North Vietnamese soldiers. He gave a vivid description of the other tanks in the area and of the enemy soldiers who were attacking his tank, none of which was supported by virtual imagery. But, when the therapist let the machine gun fire lapse, his immediate comment was, "Why have they stopped shooting?" The implication seems to be that enough virtual stimuli must be provided to support at least some aspects of the patient's recounting of his experiences. These details can be approximations to the real events, but they must not be clearly incorrect. Our patients had little trouble accepting the cartoon nature of the Virtual Vietnam visuals, but they were sensitive to details such as the way the helicopters landed or whether gunfire or artillery sounded as if it was incoming or outgoing. If they were given accurate caricatures of Vietnam to support their memories, adding imaginal details to the simulated events was not uncommon. Their virtual experience was affected just as much, if not more, by the mental and emotional Gestalt that they brought with them into the virtual environment as it was by the imagery and audio that we had contributed.

In addition to initial subjective indications of the usefulness of virtual reality exposure for PTSD, more analytic results have been described in a case study of the first Vietnam combat veteran with PTSD to have been treated with virtual reality therapy.<sup>19</sup> This patient ex-

perienced a 34% decrease on clinician-rated PTSD and a 45% decrease on self-rated PTSD. These treatment gains were maintained at 6-month follow-up.

## SUMMARY AND CONCLUSIONS

It is generally accepted that Vietnam war veterans with PTSD require a comprehensive treatment program rather than just treatment focused on PTSD.<sup>20</sup> Our use of Virtual Vietnam has been in the context of an ongoing treatment development study in which virtual reality exposure is just one component of treatment. Our experience with the initial patients in the treatment development study and the specific results of the case study, however, suggests that being immersed in Virtual Vietnam can be an effective aid to assist PTSD sufferers in imagining, visualizing, and describing their traumatic experiences. This study is ongoing and continues to be used in the treatment of more patients, which will lend more information in the future.

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## DISCLOSURE STATEMENT

Drs. Rothbaum and Hodges receive research funding and are entitled to sales royalties from *Virtually Better, Inc*, which is developing products related to the research described in this article. In addition, the investigators serve as consultants to and own equity in *Virtually Better, Inc*. The terms of this arrangement have been reviewed and approved by Emory University in accordance with its conflict of interest policies and by the Dean of the College of Com-

puting at Georgia Tech. Information on Virtually Better, Inc. is located at their web site: [www.virtuallybetter.com](http://www.virtuallybetter.com)

## REFERENCES

- Foa, E.B., Steketee, G., and Rothbaum, B. (1989). Behavioral/cognitive conceptualizations of post-traumatic stress disorder. *Behavior Therapy*, 20:155-176.
- Rothbaum, B.O., Hodges, L.F., Kooper, R., Opdyke, D., Williford, J., and North, M.M. (1995). Effectiveness of virtual reality graded exposure in the treatment of acrophobia. *American Journal of Psychiatry*, 152:626-628.
- Rothbaum, B.O., Hodges, L.F., Kooper, R., Opdyke, D., and Williford, J. (1995). Virtual reality graded exposure in the treatment of acrophobia: A case study. *Behavior Therapy*, 26:547-554.
- Rothbaum, B.O., Hodges, L., Watson, B.A., Kessler, G.D., and Opdyke, D. (1996). Virtual reality exposure therapy in the treatment of fear of flying: A case report. *Behaviour Research and Therapy*, 34:477-481.
- Wiederhold, B.K., Gevirtz, R., and Wiederhold, M.D. (1998). Fear of flying: A case report using virtual reality therapy with physiological monitoring. *CyberPsychology and Behavior*, 1:97-103.
- Carlin, A.S., Hoffman, H.G., and Weghorst, S. (1997). Virtual reality and tactile augmentation in the treatment of spider phobia: A case report. *Behaviour Research and Therapy*, 35:153-158.
- Botella, C., Banos, R.M., Perpina, C., Villa, H., Alcaniz, M., and Rey, A. (1998). Virtual reality treatment of claustrophobia: A case report. *Behaviour Research and Therapy*, 36:239-246.
- American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.
- Flannery, R.B. (1992). *Post-traumatic Stress Disorder: The victim's guide to healing and recovery*. New York: The Crossroad Publishing Company.
- Weiss, D.S., Marmar, C.R., Schlenger, W.E., Fairbank, J.A., Jordan, B.K., Hough, R.L., and Kulka, R.A. (1992). The prevalence of lifetime and partial post-traumatic stress disorder in Vietnam theater veterans. *Journal of Traumatic Stress*, 5:365-376.
- Van Etten, M.L., and Taylor, S. (in press). Comparative efficacy of treatments for posttraumatic stress disorder: A meta-analysis. *Clinical Psychology and Psychotherapy*.
- Fairbank, J.A., Gross, R.T., and Keane, T.M. (1983). Treatment of posttraumatic stress disorder: Evaluation of outcome with a behavioral code. *Behavior Modification*, 7:557-568.
- Johnson, C.H., Gilmore, J.D., and Shenoy, R.Z. (1982). Use of a feeding procedure in the treatment of a stress-related anxiety disorder. *Journal of Behavior Therapy and Experimental Psychiatry*, 13:235-237.
- Keane, T.M., and Kaloupek, D.G. (1982). Imaginal flooding in the treatment of post-traumatic stress disorder. *Journal of Consulting and Clinical Psychology*, 50:138-140.
- Keane, T.M., Fairbank, J.A., Caddell, J.M., and Zimmerman, R.T. (1989). Implosive (flooding) therapy reduces symptoms of PTSD in Vietnam combat veterans. *Behavior Therapy*, 20:245-260.
- Cooper, N.A., and Clum, G.A. (1989). Imaginal flooding as a supplementary treatment for PTSD in combat veterans: A controlled study. *Behavior Therapy*, 20:381-391.
- Boudewyns, P.A., and Hyer, L. (1990). Physiological response to combat memories and preliminary treatment outcome in Vietnam veteran PTSD patients treated with direct therapeutic exposure. *Behavior Therapy*, 20:381-391.
- Fontana A., Rosenheck, R., and Spencer, H. (1993). *The long journey home III: The third progress report on the department of veterans affairs specialized PTSD programs*. West Haven, CT: Northeast Program Evaluation Center, Evaluation Division of the National Center for PTSD, Department of Veterans Affairs Medical Center.
- Rothbaum, B.O., Hodges, L.F., Alarcon, R., Ready, D., Shahar, F., Graap, K., Pair, J., Hebert, P., Goetz, D., Wills, B., and Baltzell, D. Virtual reality exposure therapy for PTSD Vietnam veterans: A case study. *Journal of Traumatic Stress* (in press).
- Foy, D.W., Glynn, S.M., Friedman, M.J., Schnurr, P.P., Neilson, N., Howard, A., Schapiro, J.A., Knight, C.P., Morland, L.A., and Gusman, F.D. (1988, March). *Trauma focus group treatment for combat-related PTSD: Implementation data from a 10-site pilot study*. Paper presented at the Lake George Research conference on posttraumatic stress disorder, Lake George, NY.

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