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Virtual Reality Exposure Therapy for World Trade Center Post-traumatic Stress Disorder: A Case Report

JOANN DIFEDE, Ph.D.,^{1,2} and HUNTER G. HOFFMAN Ph.D.^{3,4}

ABSTRACT

Done properly by experienced therapists, re-exposure to memories of traumatic events via imaginal exposure therapy can lead to a reduction of Post-traumatic Stress Disorder (PTSD) symptoms. Exposure helps the patient process and habituate to memories and strong emotions associated with the traumatic event: memories and emotions they have been carefully avoiding. But many patients are unwilling or unable to self-generate and re-experience painful emotional images. The present case study describes the treatment of a survivor of the World Trade Center (WTC) attack of 9-11-01 who had developed acute PTSD. After she failed to improve with traditional imaginal exposure therapy, we sought to increase emotional engagement and treatment success using virtual reality (VR) exposure therapy. Over the course of six 1-h VR exposure therapy sessions, we gradually and systematically exposed the PTSD patient to virtual planes flying over the World Trade Center, jets crashing into the World Trade Center with animated explosions and sound effects, virtual people jumping to their deaths from the burning buildings, towers collapsing, and dust clouds. VR graded exposure therapy was successful for reducing acute PTSD symptoms. Depression and PTSD symptoms as measured by the Beck Depression Inventory and the Clinician Administered PTSD Scale indicated a large (83%) reduction in depression, and large (90%) reduction in PTSD symptoms after completing VR exposure therapy. Although case reports are scientifically inconclusive by nature, these strong preliminary results suggest that VR exposure therapy is a promising new medium for treating acute PTSD. This study may be examined in more detail at www.vrpain.com.

INTRODUCTION

THE CURRENT STANDARD OF CARE FOR Post-traumatic Stress Disorder (PTSD) is imaginal exposure therapy. The efficacy of imaginal exposure has been established in multiple studies with diverse trauma populations.^{1,2} However, imaginal exposure presents an un-

solvable dilemma for some patients. Effective imaginal exposure requires patients to retell their trauma in the present tense to their therapist, over and over again. Avoidance of reminders of the trauma is inherent in PTSD, and is a defining symptom of the disorder. Some patients refuse to engage in the treatment, and others, though they express willingness, are

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unable to engage their emotions or senses. During imaginal therapy, such patients retell a flat emotionless tale reflecting their numbness, and fail to improve. The few studies that have addressed the question of treatment failures have concluded that failure to engage emotionally predicts a poor treatment outcome.³

The present case study describes the treatment of a survivor of the World Trade Center (WTC) attack of September 11th, 2001 who developed acute PTSD. After failing to make progress using traditional imaginal exposure therapy, this patient was offered the opportunity to try virtual reality (VR) exposure. The present study explored whether immersive VR could be used to facilitate the patient's emotional engagement and thereby improve the efficacy of exposure therapy for acute PTSD.

Until the recent introduction of VR-based therapies, imaginal exposure therapies relied solely on the imaginative and memorial capacities of individual patients. Virtual reality affords opportunities not only to capitalize on patient's imagery capacities,⁴ but also to augment them with visual, auditory, and even haptic computer-generated experiences.⁵⁻⁷ For patients who are reluctant to engage in recollections of feared memories, the sensory-rich virtual world creates an evocative therapeutic environment which may encourage the patient's emotional engagement. Because the virtual environment can be encountered at the patient's own pace, a firm distinction can be created between remembering (and staying in control) and reliving⁸ (becoming overwhelmed by the re-experience). Additionally, VR technology allows for graded exposure to increasingly feared virtual environments/objects/events that can be carefully monitored and tailored to the individual patient.⁹ As a result, VR therapy experiences may increase a patient's feelings of self-efficacy and of being an active agent of their own experience.

Research has shown that VR exposure therapy is effective for the treatment of anxiety disorders other than PTSD, such as specific phobias. VR exposure has been effective for fear of heights,^{10,11} fear of flying,¹²⁻¹⁴ claustrophobia,^{15,16} and spider phobia.^{17,18} As with PTSD, patients with specific phobias avoid the

feared stimulus, but must confront it to get well. Research suggests that those suffering from phobias may be more likely to seek and complete therapy with VR exposure than with traditional exposure.¹⁹ The VR world often does not include the same risks as returning to the feared environment and patient's can feel supported in knowing that the therapist viewing the virtual environment is sharing in their experiences.

VR-based therapy for PTSD was introduced by Rothbaum and colleagues.^{20,21} Based on theories of Foa and colleagues,^{8,22} Rothbaum and colleagues proposed that the illusion of presence in the virtual world facilitates emotional processing of memories associated with the traumatic event. Additionally, they have shown that virtual reality exposure therapy can reduce symptoms of chronic PTSD in Vietnam Veterans.^{20,21} The present study is the first to explore whether VR exposure therapy is effective for treating acute PTSD (within a few months after the traumatic event).

MATERIALS AND METHODS

Assessment method

Our patient was assessed with standardized clinical and self-report instruments. PTSD was assessed with the Clinician Administered PTSD scale (CAPS), psychiatric history was assessed with the Structured Clinical Interview for the DSM-IV,²³ and trauma history was assessed with a structured trauma history checklist. Standardized self-report measures included the Beck Depression Inventory and the Post-traumatic Diagnostic Scale. A baseline clinical assessment was conducted one week prior to the initiation of VR treatment, and included the standardized clinical and self-report measures. The self-report measures were also administered prior to each VR treatment session. Assessments were conducted before the patient began VR therapy, and after completing the final VR treatment session, by an independent assessor blind to the treatment condition. During treatment, the patient rated her distress several times a session, using the Subjective Units of Distress Scales.²⁴

Three months post-trauma

Our patient was a 26-year-old single African American female presented for evaluation approximately four months after the attack on the WTC. At the time of the attack, she was an executive for a large financial institution located near the WTC. Prior to September 11th, she had functioned well in a very competitive industry and was on the "fast track." She described herself as having bright prospects and the ambition to match.

The patient was across the street from the North tower when the first plane hit. During her evaluation she described with little emotion the sequence of events that she experienced September 11th. She spoke in a monotone voice, and denied feeling any terror when giving her description.

The patient was diagnosed with PTSD and a co-morbid major depression according to DSM-IV criteria. She did not meet criteria for any other Axis I or II disorder. She had no trauma history. She reported moderate to severe symptoms in each of the three DSM-IV cluster areas for PTSD. Her re-experiencing symptoms included frequent unbidden intrusive imagery of the plane striking the tower, and the building collapsing, being distressed when confronted with reminders, and occasional flashbacks. The patient's avoidant symptoms were extensive, and included avoiding thoughts of the attack, avoiding reminders of the attack (e.g., refusal to watch TV news or read newspapers) and avoiding situations where she perceived herself to be especially vulnerable (e.g., she would not stay in her boyfriend's apartment because it was on a

high floor of a tall tower). Although she was raised in a close extended family, she described feeling distant, and cut-off from her family and friends after September 11th. Her symptoms of hyperarousal included difficulty falling asleep and staying asleep, difficulty concentrating, an exaggerated startle response and intense anger. Her hypervigilance extended to sleeping with the lights on and keeping a pair of eyeglasses near the door. She reported being very irritable and angry with those closest to her. She repeatedly lost her temper and yelled at her mother and others in her family. She had "no patience" for them. She noted that this was unlike her. Indeed it was her mother who initially called the first author to ask for help, noting that she was very worried about her daughter who "was not herself, and was unusually irritable."

Treatment

Before beginning VR therapy, the patient had been treated with imaginal exposure therapy without success. Attempts to engage her in imaginal exposure therapy were made in four successive unsuccessful sessions before VR treatment was initiated. There was no change in the patient's symptoms of PTSD or Major Depression between the time of the initial evaluation and initiation of the VR exposure therapy (Table 1, baseline vs. VR session 1). Though she appreciated the rationale for the treatment, repeated attempts continued to yield a flat emotionless tale. The patient gave Subjective Units of Distress ratings of zero, reflecting her inability to engage emotionally. In a rather irritable voice, she would

TABLE 1. SELF-REPORT SCORES OF PTSD AND DEPRESSION

	<i>Depression (BDI)</i>	<i>PTSD (PDS) total score</i>	<i>Reexperience symptoms</i>	<i>Avoidance symptoms</i>	<i>Arousal symptoms</i>
Baseline	37.00	37.00	9.00	16.00	12.00
VR Session 1 (week 5)	30.00	40.00	13.00	14.00	13.00
Completion of Treatment (week 14)	5.00	4.00	1.00	0.00	3.00

Note that re-experiencing symptoms + avoidance symptoms + arousal symptoms = PTSD total score.

give the therapist a vexed look and say, "I don't understand why I should do this. I am fine." Though saying that she was fine, in follow-up discussion with her therapist (J.D.), she would acknowledge that there was something wrong because she was aware of, and distressed by, her irritability. Thus, she agreed to try the VR therapy.

For VR exposure therapy, the patient wore a virtual reality helmet that positioned two goggle-sized miniature computer monitor screens close to the patient's eyes. Position tracking devices kept the computer informed of changes in the patient's head location. The scenery in VR changed as the patient moved her head orientation (e.g., virtual objects in front of the patient in VR got closer as the patient, wearing the VR helmet, leaned forward in the real world). The essence of immersive virtual reality is the illusion it gives patients that they are inside the computer-generated environment—as if they are "there" in the virtual world. In the present study, the place the patient visited was lower Manhattan, and the event she re-experienced was the September 11th attack on the WTC.

Equipment

A Dell (www.dell.com) 530 workstation with dual 2-gig CPUs, 2 gigs of RAM, a Wildcat 5110 video card, Windows 2000 operating system, and MultiGen-Paradigm Inc Vega VR software (www.multigen.com) was coupled with a 1,024 × 768 resolution VR helmet, with 40 degrees horizontal field of view (www.keo.com/proviewxl3550.htm). A Polhemus™ Fastrak position tracking system was used to measure the position of the user's head (www.polhemus.com).

The virtual World Trade Center world

After putting on the head gear, initially the patient saw the twin WTC towers from a distance, with no sound effects, with a sunny blue sky, as it appeared the morning of September 11, 2001. The virtual world was programmed such that the therapist was able to control what the patient experienced in VR by touching pre-programmed keys on the keyboard.

The therapist was able to view what the patient was experiencing simultaneously on the computer screen. The following is a list of the sequences that the patient viewed:

- a. A jet flies over the WTC towers, but doesn't crash, normal New York city street sounds.
- b. Then a jet flies over, hits building, but no explosion
- c. Then a jet flies over, crashes with explosion, but no sound effects
- d. Then a jet flies over, crashes with explosion, and explosion sound effects
- e. Burning and smoking building (with hole where jet crashed), no screaming
- f. Burning and smoking building (with hole where jet crashed) and screaming
- g. Burning and smoking building (with hole where jet crashed), screaming, and people jumping
- h. Second jet crashes into second tower with explosion and sound effects
- i. Second tower collapses with dust cloud
- j. First tower collapses with dust cloud
- k. The full sequence

Procedure

Time in VR ranged from 45 to 60 min per session. The pace was patient-driven. Each sequence in the VR menu was repeated until the Subjective Units of Distress level decreased by at least 50%. Each sequence was repeated a number of times before habituation occurred. The next sequence was not approached without the patient's verbal assent. This procedure was designed to evoke a level of response that created discomfort, but was tolerable. Gradually, as the patient habituated to her experience, she was able to approach sequences that more nearly approximated the traumatic event (Fig. 1). After two VR exposure therapy sessions, the patient was able to experience the most realistic version of the WTC virtual world, sequence K (the full sequence).

Course of treatment

While it had not been possible to engage the patient in imaginal exposure, it was apparent from the very first moments of VR exposure

Peak Response Over Time

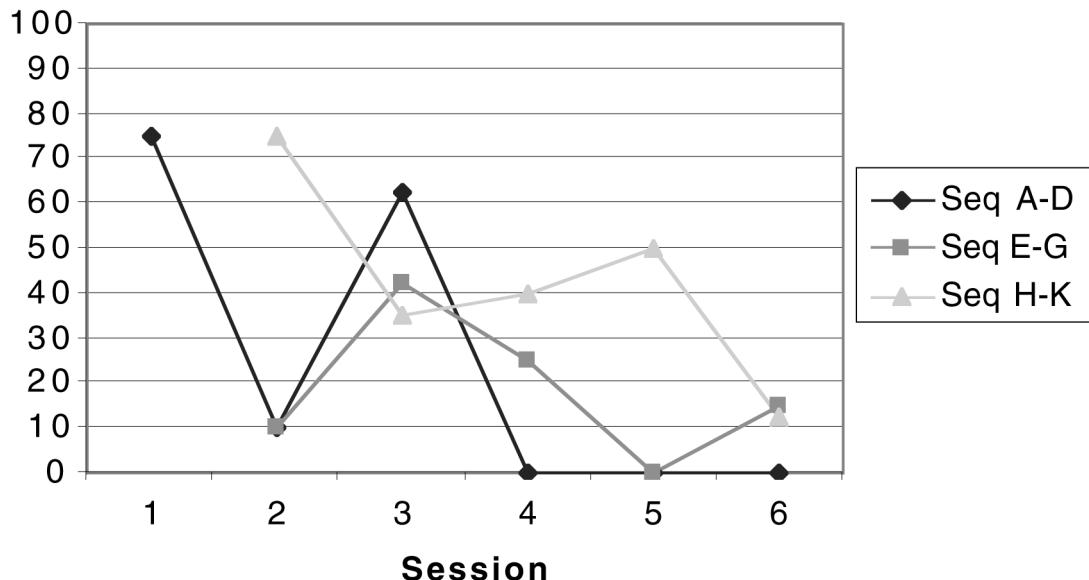


FIG. 1. Event 1: (a) A jet flies over the WTC towers, but doesn't crash, normal NY city street sounds, (b) Then a jet flies over, hits building, but no explosion, (c) Then a jet flies over, crashes with explosion but no sound effects, and (d) Then a jet flies over, crashes with explosion and explosion sound effects. Event 2: (e) Burning smoking building (with hole where jet crashed), no screaming, (f) Burning smoking building (with hole where jet crashed) and screaming, and (g) Burning smoking building (with hole where jet crashed), screaming and people jumping. Event 3: (h) Second jet crashes into second tower with explosion and sound effects, (i) Second tower collapses with dust cloud, (j) First tower collapses with dust cloud, and (k) The full sequence.

therapy that she was able to engage emotionally in the virtual WTC world. This was evident in her verbal report, her behavior, notable physical signs of emotional arousal, and in her Subjective Units of Distress scores. She approached the first sequence with nervous, but determined, anticipation. As she viewed the first image of the twin towers through the VR helmet, she began to cry for the first time, saying that she "never thought she'd be able to look at them again". She then began to recount an emotional tale of the harrowing events of that day, spontaneously recalling memories that had been previously inaccessible. The ordeal began September 11th when she stopped at a drug store across from her office, on the way to work that morning. She witnessed the second plane hit the South Tower while she was in a crowd of people all of whom were staring in disbelief. Then it seemed that everyone around her was trying to escape, which was terrifying. For the first time since the ordeal began she remembered believing that she would die. She noted that as she tried to run,

there was a crush of bodies trying to escape, people began to fall on one another, and she struggled to free herself from beneath several other people. As she fled, a woman cried out for help. Our patient recalled meeting the woman's eyes, and thinking that if she stopped to help, that she herself would die, too. She looked down to see that the women's legs had been severed, and she was bleeding to death. Our patient recalled looking in the woman's eyes and telling the woman that she couldn't stop. Debris was falling all around them bringing along with it the possibility of a fatal collision. She recalled running and running through the hazy smoke. Eventually, when she was a few miles away, clear of the smoke and falling debris, she recalled noting that people were looking at her oddly. She stopped in a deli, where people looked calm and were going about their daily routine, and she screamed "don't you know what's happening?" A woman came over to her to help her. Our patient had no shoes on, no money, and her feet were bleeding. The woman took

her to buy a pair of shoes, and gave her carfare home. Our patient described the relief that she felt when her boyfriend met her in midtown Manhattan to escort her home.

RESULTS

Six VR exposure sessions were conducted. Figure 1 shows the decrease in the patients Subjective Units of Distress rating over time for each VR event. After completion of VR treatment, our patient no longer met criteria for PTSD, Major Depression, or any other psychiatric disorder upon examination by an independent assessor. This finding was consistent with her verbal report and with the improvement documented on the standardized self-report measures of PTSD and Major Depression (Table 1).

DISCUSSION

VR graded exposure therapy was successful for reducing acute PTSD symptoms, providing converging evidence for a growing literature showing the effectiveness of VR as a new medium for exposure therapy. While in the virtual WTC world, the patient relived September 11th, retrieving and modifying memories she had already stored. VR exposure therapy is thought to work by modifying the patient's memory²⁰. After treatment, the patient could remember what happened to her on September 11th with much greater detail, without the same degree of associated terror. And doing so no longer elicited PTSD symptoms anymore. VR exposure therapy has the advantage of allowing PTSD patients to virtually re-experience the events of September 11th in a controllable manner that allows for habituation. The patient appeared to become immersed in the virtual environment, and she claimed that going into VR helped her improve.

In the treatment of PTSD, VR technologies can offer patients who are unable to otherwise recount their experiences an external setting in which to encounter and master their trauma. The multiplicity of sensory cues that VR affords also may provide a greater possibility of

generating patient involvement and a sense of presence that can facilitate processing of the traumatic experience. VR environments can be manipulated above and beyond the constraints of the everyday world, thus creating new possibilities for therapeutic action.²⁵

The substantial limitations of case studies are well known.²⁶ Although case studies are a good vehicle for presenting innovative techniques, more convincing evidence for effectiveness will require larger, more generalizable, controlled studies. Because of VR's potential, and the need for new techniques for treating acute and chronic PTSD, additional research on the potential value of VR exposure therapy for treating PTSD is warranted.

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