

Usage of Virtual Reality in Exposure Therapy and Imagery Rescripting for Veterans Affected by PTSD: A Pre-trial Study

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ABSTRACT

This study was designed to shed light on the potential post-traumatic stress disorder (PTSD) treatment methods, particularly concerning the treatment of PTSD developed by military personnel in their line of duty. The long-term objective of this study was to determine whether the use of virtual reality (VR) technology in combination with traditional PTSD treatment methods would lead to a better success rate of treating combat-related PTSD patients. The pre-trial study focused on the use of VR technology in exposure therapy, imagery rescripting, and acoustic therapy. The study consisted of ten participants who are members of the general population that entered the Unity simulation. The simulation consisted of two VR environments meant to resemble a distressing and a calming environment. The distressing environment was designed to resemble a middle eastern area, and the calming environment was designed to display a lake-side cabin. A survey was used to record the participants' impressions of the simulation. The responses were inconclusive regarding their levels of distress, while the participants mostly agreed that the second environment was calming. The participants also all agreed that the use of audio in both environments was an effective component for an immersive experience. While VR technology still has a long way to go, this pre-trial study reinforces the idea that incorporation of audio in the VR simulation can be beneficial. This study has strong support for the integration of VR technology usage in PTSD treatments.

Keywords

Psychology, therapy, virtual reality, military, post-traumatic stress disorder, simulated environment, exposure therapy, image rescripting therapy, acoustic therapy

CSS Concepts

- **Social and professional topics** → **Computing education**;
- **Human-centered computing** → **Human computer interaction (HCI)** → *User studies Virtual reality*;

INTRODUCTION

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), a person is capable of being diagnosed with post-traumatic stress disorder (PTSD) if they were directly exposed to traumatic stimuli or witnessed a traumatic event. Symptoms seen in PTSD categorization include an intrusive symptom (nightmares, flashbacks, etc.), avoidance

of trauma-related stimuli, and negative thoughts/feelings that worsened after the traumatic event [13]. PTSD symptoms are especially difficult to alleviate when developed by combat veterans during their tour of duty [5]. Combat veterans are defined as people who served under active duty in the military. Based on a 2010 National Survey of Veterans conducted by Westat, nearly 33.9% of the veterans reported being in areas of combat or war zones, 33.9% had exposure to dead/dying/wounded people, and 23.7% were exposed to environmental hazards defined as Agent Orange, chemical warfare agents, ionizing radiation, or other potentially toxic substances [2]. The data suggests that many of these traumatic events are a common part of a combat veteran's career. With that said, these combat-related situations create a measurable risk for contributing to the development of PTSD in veteran populations. Furthermore, due to the intense nature of these combat-related stimuli, they may require a specialized form of therapy to successfully treat this form of PTSD [5].

Fortunately, as our clinical understanding of PTSD has grown, many studies have taken place with the goal of benefitting PTSD victims through new treatment methods. A common form of PTSD therapy involves the control and management of PTSD symptoms through exposure therapy (ET). ET typically includes the gradual introduction of stressful or traumatic stimuli to a patient as a means of encouraging the development of mental strength and coping mechanisms required to limit the negative effects brought on by encountering these stimuli. A *Behavior Research and Therapy* study presented over 100 participants with a full regimen of exposure therapy, with the patients reporting their subjective experiences through surveys performed after the treatment sessions. Overall, the patients reported significant reductions in avoidance of stimuli and guilt symptoms, indicating that this methodology is successful in treating general cases of PTSD [8]. In addition, there is a subset of ET which involves prolonged sessions of exposure therapy to traumatic memories via imagined scenarios and in-person exposure [7]. Another option of treatment for PTSD patients is image rescripting. Image rescripting is accomplished by letting the patient imagine an intrusive thought that is causing them distress before reshaping the imagery of their intrusive thought through therapeutic exercise. Ultimately, the intrusive thought reforms into pleasant imagery as the thought resurfaces in the future. For example, in the research done by Rusch et al., a patient

described dealing with intrusive thoughts of jumping off buildings or bridges whenever inside of a structure above the ground floor. After multiple image rescripting sessions, the intrusive thought was reshaped into imagery of the patient jumping from these areas and bouncing back like Tigger, a character in Winnie the Pooh. The humorous reshaping of the intrusive thought allowed for the patient to confront these situations with less fear and apprehension [3]. Acoustic therapy has shown promising results in treating PTSD patients, despite there not being many studies performed on the subject. Acoustic therapy is accomplished by using instruments in combination with therapy to help patients adapt to hearing what could be perceived as triggering sounds while in a safe environment. This ultimately allows patients to hear these triggering sounds in public with lessened negative effects upon the patient [4].

With changing technological improvements over time, new studies have been able to combine exposure therapy with virtual reality (VR) technology with the intent to improve the efficacy of exposure therapy in alleviating PTSD symptoms [5]. A review paper analyzed 24 studies using VR as a form of therapy, and only used studies that had control groups in order to accurately test the potential of using VR as a therapy method when compared to traditional methods of exposure therapy. The paper concluded that there is a statistically significant increase in PTSD treatment efficacy when employing VR technology as compared to the control groups [10]. In previous instances of exposure therapy, even those using modern VR technology, the inclusion of sound as an element in the treatment process has seldom been studied or used. With acknowledgement that data in this area of study is currently limited, the few studies that have been conducted thus far show very promising results regarding the addition of acoustic therapy for PTSD patients [4].

Unfortunately, there are still areas within virtual reality-based exposure therapies that fall short, such as the low number of treatment completion rates observed during these studies. Many of these studies experience high drop-out rates, particularly among recently discharged veterans and service members [3]. In addition, despite large treatment sizes, approximately one-third to one-half of patients who undergo prolonged exposure therapy do not demonstrate clinically meaningful symptom change [3]. There are limitations to accurately gauging the effects and results that therapy can provide, so psychophysiological assessments must further be conducted with each study [2]. This research will aim to provide insight into how combat-related PTSD treatments can benefit from the integration of immersive VR technology alongside traditional exposure therapy treatment sessions.

Motivation

Throughout a six-year long Department of Defense study of PTSD treatment methods, a group of military mental health providers were presented educational workshops in order to

provide new insights into treatment methods like prolonged exposure therapy for PTSD patients. Between six and eighteen months after these workshops, the military mental health providers were surveyed by the Department of Defense officials in order to provide their professional opinions on the tactics being taught during these workshops. Ultimately, it was reported that 90.3% of the therapists described these workshops as “valuable” or “extremely valuable,” while 95.1% said they would recommend these workshops to colleagues [15].

With this information in mind, there is some clear merit to the concept of exposure therapy when applied to PTSD treatment, however the current treatment options for PTSD patients lack a sense of individuality for each participant’s unique experience with their disorder. With the advent of virtual reality technology integration into exposure therapy techniques, it is possible to provide patients with highly customized and unique treatment options, including the ability to gradually expose a patient to traumatic stimuli that would otherwise be difficult or impossible to replicate and control in an office setting. For example, if a patient has a phobia of driving, the therapist would be able to introduce them to a harmless, virtual version of this phobia in a perfectly safe environment. This allows the patient to focus on the feeling they are experiencing and relay them to the therapist for further analysis [1]. PTSD is known to be a difficult psychiatric condition to treat successfully, and new VR technology has shown potential to create a breakthrough in PTSD treatment methods that have previously been underexplored.

Though VR and acoustic therapy share the same goal of treating PTSD afflicted military personnel, there are few instances in which these two therapies have been combined to increase their efficiency. With these two useful therapies being used simultaneously, it becomes possible for therapists to create a cohesive virtual environment that optimizes PTSD treatment and exposure therapy through the stimulation of both auditory and visual senses. This idea is important to consider as a *Journal of Anxiety Disorders* study has shown that when patients become more emotionally involved in their own treatment, there is a direct connection to more positive PTSD treatment results [12]. The simultaneous use of VR and acoustic therapy can support the development of further emotional involvement in the treatment process, hopefully increasing positive results along with it. It is worth noting, however, that the aforementioned study did not find VR exposure therapy to have better treatment results than the prolonged exposure group.

Beyond the realm of exposure therapy, which typically makes use of negative or distressing imagery to elicit a response from the participant, this pre-trial study aims to use VR with a combination of both distressing and calming imagery as a means of reducing PTSD symptoms. The distressing imagery

is primarily used in the sector of exposure therapy, whereas calming imagery is used to enact image rescripting. This study will determine if there is any merit in using VR as a means to undergo both exposure therapy and imagery rescripting for the treatment of PTSD.

Related Work

Multiple related works from global scientific publications informed the creation of this study and the content it contains. For example, a 2019 publication from *Journal of Affective Disorders* highlights a study on analyzing the efficacy of VR exposure therapy in PTSD by reviewing over 46 other studies. The findings show that VR exposure therapy is effective in treating PTSD and performing at around the same efficacy rate as traditional therapies for treating PTSD [9]. Another study from *Journal of Anxiety Disorders*, tested the use of VR exposure therapy to specifically manage combat-related PTSD [5]. With the results of these studies and others, there is ample evidence supporting the claim that there are clear benefits in the use of VR for exposure therapy when treating PTSD patients. In a study performed by Rizzo et al., an Iraq War VR simulation game was followed through development as it went from a design for military training to an Xbox video game, before finally becoming a viable treatment method for PTSD. This indicates that the field of VR is constantly evolving, with many profound innovations releasing nearly every day [14].

As VR technology advances and become more realistic, the potential for further medical benefit increases. For example, the addition of acoustic stimuli to be used in conjunction with the already effective methods of VR exposure therapy has potential to compound on the effectiveness of the treatment. This hypothesis was derived from a study that tested the acoustic sensitivity of trauma patients, using the possibility of music therapy as a means of treating their trauma [4].

Alongside the integration of audio queues in PTSD therapy, there is promising data backing the notion of imagery rescripting therapy as a means of transforming distressing intrusive thoughts and imagery into pleasant or manageable imagery. This therapy is accomplished by a therapist working to encourage their patient to switch details of their intrusive thoughts into positive, calming imagery. After these changes are continually reinforced, the patient can then make these changes to their intrusive thoughts in real time, lessening the negative effect these thoughts have on their psyche [3]. This notion of imagery rescripting has potential to be used in conjunction with the VR exposure therapy and acoustic therapy, in order to maximize positive results for patients.

Contribution

This experiment contains various ideas that will hopefully be tested by qualified psychologists in order to assist former or current military personnel in the future. The findings may lead to furthered research in the field that can ultimately contribute to a more developed and precise method of treatment for

military personnel and other PTSD patients. Virtual reality technology is undoubtedly the next frontier of treatment research concerning PTSD, and as the technology and understanding of VR increases, hopefully the quality of life for PTSD patients is able to grow as well.

In a study conducted by Norr et al., the effects of virtual prolonged exposure therapy on active-duty U.S. army soldiers were studied, particularly regarding suicidal ideation among combat-related PTSD patients. The study found a greater reduction in suicidal ideation from the virtual prolonged exposure therapy group when compared to the results of the control groups [6]. This successful example of exposure therapy treatment for PTSD patients is a very encouraging advancement for improving the quality of life for PTSD patients. The combination of these forms of therapy (acoustic, VR ET, and imagery rescripting) can serve complimentary to one another, possibly compounding many benefits for PTSD patients.

Research Questions

- 1) Can auditory and visual imagery exposure in virtual reality improve results in PTSD therapy?
- 2) Did including an audio component aid in creating a more realistic VR experience?
- 3) How can this new proposed form of therapy be assessed and employed with psychophysiological measurements in the future?

Hypotheses

- 1) Using the calming VR experience directly after the distressing VR experience will aid in suppressing the negative reaction following the PTSD triggering environment, acting as a faster and more effective image rescripting therapy.
- 2) Including the audio component in VR will aid in making the VR experience more realistic, and ultimately increase patient success rates.

METHODS

Software and Materials

The simulated environment used throughout this study was developed in Unity. Unity is a real-time development platform that can be used to create landscapes and settings, particularly for use in video games. The coding language that Unity uses for its user interface scripts is C#.

The audio files were found through various royalty-free, public domain websites such as SoundBible (<https://soundbible.com>) and Free Sound (<https://freesounds.org>). The sounds were then manipulated and edited through Garage Band, a digital audio studio developed by Apple. The videos recorded in Unity were filmed with the asset extension, “Unity Recorder”. These clips

were then arranged using iMovie, a video editing software developed by Apple.

The post-simulation survey was created using Google Forms, a Google application developed to create online forms and surveys. The survey contained four questions that took the participants approximately a minute to complete. Using the Google Forms automated Google Sheets feature, the responses were immediately converted into a spreadsheet. This feature easily combined all of the response data, making several visual representations for analytical purposes.

Simulated Environments

The distressing virtual environment was modeled to specifically treat combat veteran PTSD patients that developed their disorders through modern wartime scenarios. The study is designed to display an area reminiscent of a middle eastern warzone. This includes a virtual landscape of a sandy area, including heavy vehicles and weaponry, all meant to resemble a middle eastern region such as Afghanistan or Iraq. The participant is able to wander areas that may be quite familiar to their previous wartime experience, such as a tent containing machine guns. The scene incorporates background audio of Arabic speech and the sound of distant gunfire. The gunfire audio increases as the participant approaches the tent that holds the weaponry and decreases as they walk away.

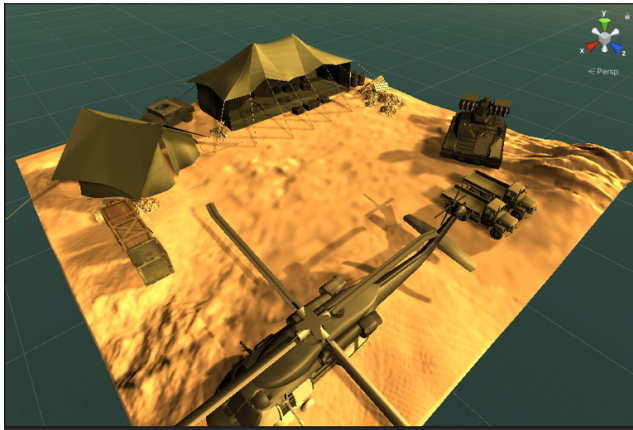


Figure 1. Distressing Environment

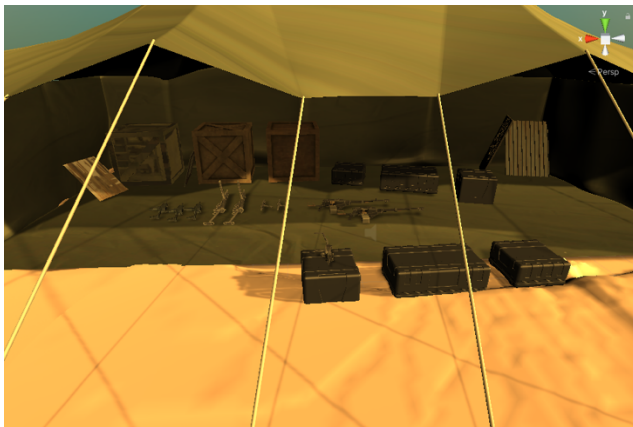


Figure 2. Weaponry and source of gunfire audio

For the calming VR environment, the study is designed to display a lake-side view of a cabin with a dock. Beside the dock is a rowing boat, meant to signify what might be a participant's hobby. This cabin is surrounded by green, grassy landscape. There are trees and a fountain area that the participant can look at as well. The audio includes peaceful, slow paced violin and piano sounds, alongside chirping birds and sounds of waves. This is a prototypically calm setting that many patients would feel at peace within, but this setting may need to be personalized on a patient-to-patient basis in order to maximize efficacy.

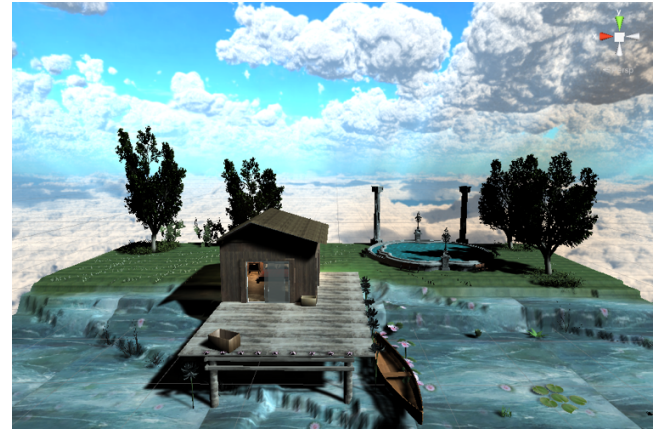


Figure 3. Calm Environment

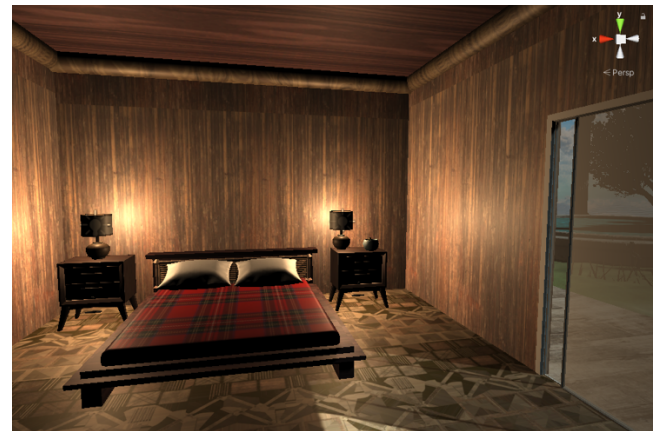


Figure 4. Calm Environment's exit

Participants

As a preface, this pre-trial study was unable to host live participants from the intended group of military PTSD patients. Because of this, the participants of the pre-trial consist of general population individuals.

In total, there were ten participants. The majority were in their twenties, working in various fields outside of anything technical. Five of the participants were Colorado State University graduates while another two participants were still undergraduate students in Computer Science. One participant

was an undergraduate student in the bio-medical sciences field. Two participants were in their fifties with very limited technical experience. The majority of the participants were unfamiliar with virtual reality. None of the participants had a family background in or a personal connection with the military.

When commencing with a fully prepared trial, participants for the study would be selected from a pool of military veteran PTSD patients, particularly those who have developed their symptoms as a result of middle eastern wartime experience. Despite the large number of patients that could potentially benefit from this area of therapy, there are some essential exclusion criteria that need to be implemented. Unfortunately, patients exhibiting the following characteristics should not be permitted to participate in the study in order to ensure that accurate and useful data is gathered:

- 1) Those who are at a risk level for self-harm that requires immediate, focused intervention.
- 2) Those with unmanaged psychosis or bipolar disorder.
- 3) Those with alcohol or substance dependence in the immediate past.
- 4) Those who are currently involved in abusive relationships or confronted with overwhelming stress.
- 5) Those who present evidence of acute psychosis or severe dissociation.
- 6) Those with hearing problems must be excluded, in order to ensure that the auditory component of the therapy study is properly implemented.

Measures

To begin, it is important to emphasize that this is a pre-trial study, meaning that there are materials and methods that need to be further developed in order to produce a professional study with scientifically meaningful results.

It is also essential to mention that these methods of patient treatment are by no means intended or capable of completely alleviating a patient's symptoms. In fact, a study performed in the Netherlands found that patients with more severe introductory PTSD scores regrettably still showed significant PTSD symptom expression, though these symptoms had noticeably lessened after treatment [16].

Several studies have found that an effective way to measure a participant's level of distress is via Subject Units of Distress (SUDS), meaning that the baseline and within-session/between-session habituation levels are measured entirely on subjective responses through a 1-10 scale [3,4,7]. These measurements would be recorded by researchers alongside the symptoms self-reported by the patients involved in the study.

It is important that psychophysiological measurements are taken throughout any PTSD study, such as heart rate and skin conductance. PTSD symptom expression is associated with elevated heart rate and elevated galvanic skin response. Although this means that more variables would be introduced in the research, it is perhaps the most important measurement to be recorded as it is directly associated with the stress response of a test subject. In a study by Gramlich et al., 61 military veterans that were deployed to the middle east during wartime were subjected to either prolonged exposure therapy or VR exposure therapy. The group being treated through the VR exposure method showed an overall increase in heart rate (beats per minute) when compared to the prolonged exposure therapy group. Additionally, the VR exposure therapy group saw an overall decrease in galvanic skin responses as the sessions progressed, whereas the prolonged exposure group showed no such decrease [11].

In order to gauge the patient response of the treatment methods, all participants in this study were presented with a questionnaire after the completion of treatment. All questionnaire responses were measured through multiple-choice options: (yes, no, or maybe) and through a 1-5 intensity scale: (1=rarely; 2=sometimes; 3=usually; 4=mostly; 5=always). The questionnaire was presented as follows:

- 1) On a scale from 1-5, how often did you experience feelings of distress throughout the first half of the testing?
- 2) On a scale from 1-5, how often did you experience feelings of calmness throughout the second half of the testing?
- 3) Do you feel that switching from the first environment to the second environment caused you to feel calm, or at ease?
- 4) Do you feel that the audio components used in both environments helped you to become more immersed within the virtual environment?

Procedure

Before the experiment began, all participants were briefed on how to begin the study. They were told the experiment was expected to take from two to ten minutes and how to enter the simulation in Unity. There were instructions available on the menu of the simulation before entering the VR environment. The participants were directed to follow said instructions and, upon finishing the simulation, were directed to complete a Google Forms survey. This survey was made available to the participants through an iPad immediately after the simulation.



Figure 5. Main Menu

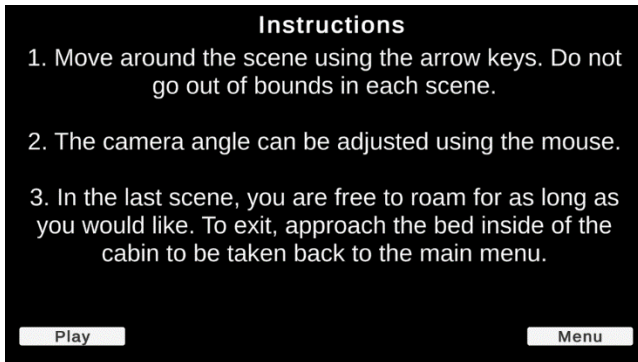


Figure 6. Instruction screen

All participants were sat down at a desk in a room alone. This was to minimize distractions and help with the overall immersion experience. Every participant had the same experience of entering a distressing environment before being transported into a calm environment. The participants were allowed to freely wander the distressing environment but were not able to leave the scene until the allotted time of sixty seconds had passed. The minute-long time parameter was included to enforce the methods behind exposure therapy by creating a scenario that simulates stressful stimuli for a forced period of time. After the sixty seconds had passed, participants were automatically transported to the calm environment. They are allowed to wander the grounds for as long as they liked.

After each participant finished both the experiment and survey, they were debriefed on the purpose of the study and the role that they played in place of actual veterans.

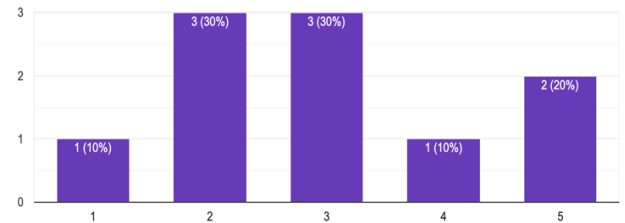
RESULTS

The results were inconclusive for determining how successful the middle east environment was at making the participants feel distressed. The majority, accounting for 60% of the participants, had feelings of calmness during the lake-side environment simulation. The third question in the survey had a positive response with 70% of the participants agreeing that switching from the first environment to the second environment produced a calm feeling. All ten of the participants agreed that the audio component of the environments aided in the feeling of immersion during the simulation.

Using an ANOVA one-way repeated measures calculator, the p -value was calculated being <0.00001 . With the value of statistical significance being p -values less than or equal to 0.05, the results in this study were significant. It is important to note that there were no corrections done to account for the small sample size. The statistical significance would likely change once adjustments for a small sample size are done, such as a Bonferroni correction.

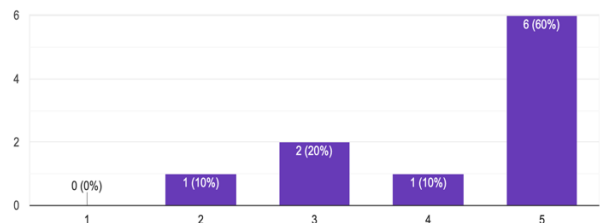
On a scale from 1-5, how often did you experience feelings of distress throughout the first half of the testing?

10 responses



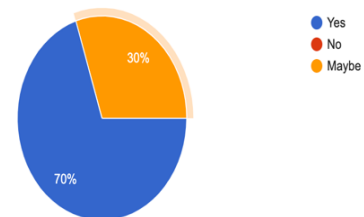
On a scale from 1-5, how often did you experience feelings of calmness throughout the second half of the testing?

10 responses



Do you feel that switching from the first environment to the second environment caused you to feel calm, or at ease?

10 responses



Do you feel that the audio components used in both environments helped you to become more immersed within the virtual environment?

10 responses

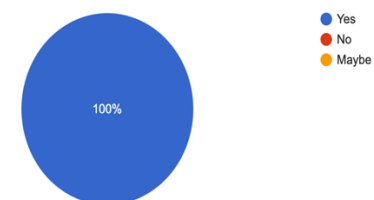


Figure 7. Participant survey data

Discussion

While conducting the simulation, great effort was done to limit the outside variables during each trial. The outside variables were prevented by having the participants be in a room alone for the duration of the simulation. A random variable that may have influenced the results was prior familiarity with video games. There were three participants who regularly play video games. While the types of video games the participants may have played were never recorded, the usage alone is worth noting. Prior experience with video games could have created a desensitization to the graphics used in the simulation as well as the warfare audio. This could have resulted in slightly skewed data concerning the amount of distress felt in the first VR environment.

Another factor that could have influenced the participant response was the idea that the environments could have been more immersive. Greater immersion could derive from the addition of more interactive elements. The VR simulation could have had included animation besides player movement and more objects to interact with.

Testing the length of time for each session was not thought of before the experiments were conducted, but due to a possible pattern, it is worth considering. The duration of time that all of the participants each took to complete the VR simulation was approximately under five minutes.

Implications

The survey results support the first hypothesis regarding the calming VR experience aiding in suppressing the negative reaction following the PTSD triggering environment. 70% of the participants answered “yes” to the survey question asking if switching from the first environment to the second environment cause the participant to feel calm. Still, there was not enough data to support the second claim of the hypothesis. Without a larger sample size, the use of the calming VR environment was not able to be properly analyzed as a faster and more effective form of image rescripting therapy.

The first claim in the second hypotheses was also supported. The hypothesis speculated that using an audio component in VR will aid in making the VR experience more realistic, and ultimately increase patient success rates. There were no real patients in this pre-trial study, so there was no way to measure the success rates of the patients. However, the use of audio in making the VR experience more immersive could be highly supported with the survey question that asked if the use of audio helped the participant become more immersed in the environment. There was an 100% agreement response from all of the participants.

Limitations and Challenges

This research experienced a minor challenge from the start, simply due to the fact that it is a pre-trial as opposed to a

professionally developed study. This meant that the studied patients were neither veterans nor PTSD patients, but rather members of the general population. Furthermore, all results were obtained from a small sample size, as there was not sufficient access to the number of participants needed to collect meaningful data.

Being that this study is lacking in professional equipment and necessary materials, patient experiences had to be collected via surveys as opposed to numerical data such as heart rate changes or perspiration increases. This survey data is useful, but not as objective and definitive as quantitative data.

Finally, there is the limitation of achieving distressing or calming imagery as both are entirely subjective to the perspective of the viewer. A scenario that is calming for one may be disturbing for another, and vice versa. This makes the process of creating a properly designed VR environment difficult.

Regarding technical limitations, the coding in Unity was not written by an extremely experienced professional, limiting what was capable in terms of the aesthetic development of the VR scene for patients. Beyond that, the current era of VR technology has some existing issues regarding a lack of realism in the visual graphics processing, making it difficult for patients to fully immerse themselves in the virtual scenario they have been placed within. An example of a study lacking a more immersive experience was a driving and aggression study done on veterans. One participant described the virtual reality therapy experience as “irritating” due to the severe lack of realism within the VR headset [1].

CONCLUSION

As this study was only a pre-trial study, there was not enough viable information gathered that could conclusively indicate whether VR technology in combination with various forms of PTSD therapy significantly aided patient success rates. With the few data the study collected, there was enough support indicating acoustic therapy in VR could be worth researching more in depth. The use of VR for the practice of imagery rescripting is a fairly new idea that has only just begun to be researched in the past decade. To my knowledge, there are no other studies that focus specifically on the idea of merging all mentioned therapies for a higher success rate in treatment. If this is the case, an effort to customize every individual PTSD patient’s VR simulation experience should be done, as the results may be significant for future research. As VR technology develops, there will likely be more ideas that arise with the potential to significantly advance both the technical and medical field.

Future Work

In future experiments, a 360-degree VR video can be used to increase the feeling of immersion for the patient in treatment.

Although the environment would feel significantly more immersive, being taken back to a traumatic scene may be overwhelming for those starting ET. Therefore, a 360-degree VR video could be used as the ET treatment progresses. Allowing for patient treatment using very realistic VR technology could make the transition from VR to the real world much smoother for the patient once treatment is completed.

Furthermore, the audio component of the VR exposure therapy sessions can be more sophisticated, and thus more effective for treatment. For example, in future work the volume and intensity of the sound could progress as the patient moves further through the treatment session. Different types of sounds could be explored as well, such as explosions. Moving from manageable, quieter audio stimuli to louder, more realistic sounds would be extremely helpful for getting the patient to a point in recovery where they are able to cope with these stimuli when out in public post-treatment.

Finally, there is potential for these treatment sessions to be even further customized to be able to assist in the treatment of patients with other severe disorders and illnesses. This study was presented with a very narrow focus of treating solely combat-related PTSD patients with VR technology, but this approach certainly has many other possible applications in the area of mental health treatment and development.

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