Augmented Reality Narratives for Post-Traumatic Stress Disorder Treatment

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Figure 1: An illustration to reveal the differences between three types of narrative-based PTSD treatment by showing an example of treating patricide offender who has childhood abuse PTSD.

Abstract

Globally, it is estimated that up to 1 billion children aged 2–17 years, have experienced physical, sexual, or emotional violence in the past year [1], and 30% of the abused child is likely to develop Post-traumatic stress disorder (PTSD) [2]; 354 million adult war survivors are suffering from PTSD [3]; At where the natural disaster occurred, 70.7% of the survivor will suffer from acute PTSD [4]. PTSD has not only high prevalence but also high lethality, which is accompanied by multiple physical and mental comorbidities as well as strong suicidal tendencies [5-7]. This doctoral research aims to contribute to the development of PTSD treatment by investigating the possibility of adopting Augmented Reality (AR) narrative in treating PTSD. This four-year research project consists of three steps. In the first stage of research, we will conduct a comparative study between AR and VR narratives with healthy participants to verify whether AR narratives work better in eliciting the emotional engagement of the participants than VR narratives. In the second stage, we will create a system that integrates AR narratives with prolonged exposure (PE) treatment and experiment it with PTSD patients to verify its treatment efficacy. In the final stage, a semi-automatic and patient-authored AR system is expected to be achieved, through which the patients can design their own exposure environment via voice input. This project will provide valuable experimental samples and scientific analysis for the research of psychotherapy, narrative studies, and AR application.

Keywords: Augmented Reality, Narrative Exposure, Post-Traumatic Stress Disorder, Prolong Exposure, Patient-authored AR narrative.

Index Terms: Computing methodologies—Computer graphics—Graphics systems and interfaces—Mixed / augmented reality; Applied computing—Life and medical sciences; Applied computing—Arts and humanities—Media arts;

1 Introduction

PTSD is an anxiety disorder caused by various traumatic stressors(e.g.; life-threatening accidents, childhood abuse, sexual/physical violence, war, and torture) and is accompanied by multiple physical and mental comorbidities as well as strong suicidal tendencies [5-7].

Exposure is acknowledged as the most effective treatment method for PTSD [8-9]. Its treatment mechanism is to habituate the patients with their feared objects, activities, or situations to decrease the patient's PTSD symptoms [10].

Imaginary exposure (IE) is among the classic exposure methods for PTSD, in which the therapist will guide the patients to actively recall their traumatic events. IE is the earliest approach to explore the healing power of self-narrative. However, IE is not suitable for treating patients with memory loss and the habituation effect of IE varies, depending on the clarity of the patient's memories.

Narrative-based Virtual Reality Exposure (NVRE) is a supplement of IE that recreates the trauma-related environment, characters, and events in a virtual space to help the patients retrieve their lost memories. NVRE has been shown to be surprisingly useful in treating PTSD [11-13]. Nevertheless, the application of this method is limited, as it excludes patients who are predisposed to cybersickness or have dissociative symptoms [14].

Augmented Reality Exposure (ARE) supplements VRE by adding a real environment to the virtual images, which has potential advantages over VRE in treating PTSD.

First, not only can the participant view their entire physical body during the experience and move freely in a real environment; they can also make direct contact and interact with virtual items and characters with their physical body parts. These AR attributes

978-1-7281-7675-8/20/$31.00 ©2020 IEEE
DOI 10.1109/ISMAR-Adjunct51615.2020.00086

make the narrative experience more organic and simple, which in turn makes the participant more focused and involved in the exposure narrative.

Secondly, in AR narratives, the virtual images that created based on and closely related to a real location, person and objects could provide the patients with the most vivid reliving of their traumatic experience, which, theoretically, could contribute to a greater treatment outcome than VRE.

2 Related Work

The research related to this project are as follows: [11] created a virtual narrative to treat patients with PTSD from sexual assault encountered in a bus shelter; [12] is an NVRE, which was created based on the memories of returning Iraq War veterans in the USA; and [13] used NVRE to treat patients who were traumatized in car accidents. These three instances of NVRE treatment all reported a significant reduction in patients' PTSD symptoms.

Additionally, [15] is a study that adopted NVRE to alter participant's negative beliefs. Munhwa Broadcasting Corporation of Korea created a VR narrative for a mother who suffered from grief and guilt after the passing of her daughter. After this experience, the participant promised that she will stop guilt and grieving. However, this work only had one subject and is lacking scientific measurement of the degree of belief alteration that occurred in the subject.

Finally, [16] is research that sought to verify the significance of a patient-authored exposure narrative for PTSD treatment by creating a computer application that allowed the patient to construct their trauma memories by selecting and arranging the 3D models prepared by the researchers. The test results reported a different degree of symptom reduction amongst the four participants. However, this research had limited test subjects, and patients were required to perform a series of complex computer operations to build their memories. We plan to simplify this operation through the AR system and voice input.

3 Project Overview

This section includes the detailed description of the research question and expected contribution.

3.1 Research Question

1. Between AR and VR narratives, which one is more effective in eliciting the immersion, involvement, and emotional engagement of participants?
2. Which specific factors of VR and AR narratives contribute to a stronger immersion, involvement, and emotional engagement of the participants?
3. Is the combination of AR narrative with PE therapy effective in relieving PTSD symptoms?
4. Is a semi-automatic and patient-authored AR narrative system effective in treating PTSD?

3.2 Expected Contribution

This research project will conduct a scientific experiment to compare AR and VR narratives in the degree of the emotional engagement of the participants and identify the factors that contribute to the difference, which will be critical for the entertainment industry, education industry, and film industry to enhance the influence of their extended reality products on the audiences.

This research will expand the applicability and the beneficiaries of AR technology. Currently, AR technology is extensively studied in the filed of medical treatment, entertainment, education, and business. However, the research of AR in the area of psychotherapy is relatively scarce. Our research bridges film studies, psychology, human-computer interaction design, and extended-reality studies to form a rigorous and practical four- year plan which, upon its accomplishment, will contribute significant experimental samples and scientific analysis to promote the application of AR technology in psychotherapy.

4 Methodology

This research will be guided by the mixed method methodology in an exploratory sequential. This research began with a phenomenological analysis of PTSD and then delved into the case studies of existing VRE treatments for PTSD. Based on the knowledge gained in the qualitative research phase, We identified the shortcomings lied in the VRE treatment for PTSD including the unrealistic artificial environment, lifeless characters, limited interactive method, narrow treatment mechanism, and inefficient authoring mechanism, and determined the research questions, testing conditions and instruments needed for the following quantitative experiments.

5 Project Design

This section will unfold the experiment design and implementation plan of the this four-year doctoral research.

5.1 Stage One: The Comparison Study of AR and VR Narratives

5.1.1 Differences Between AR and VR Narratives

VR and AR narratives are different in narrative methods and interactive strategies. The narrative methods that are commonly used for VR narratives are computer-generated environments [17] and 360° real-shooting footage [18]. In AR, the blending of virtual images with a real environment produces a uniquely situated storytelling method, in which the augmented virtual images are strongly related to the attached physical medium. This physical medium could be a location[19], a person[20], or an object[21]. Volumetric-captured, real human movement could be integrated into both platforms. However, the Volumetric-captured(VC) images could be blended with the environment more naturally than the VR narrative allows.

VR and AR narratives both support voice input. VR narratives, however, still depends more on physical controllers and virtual embodiment to interact with the virtual content (e.g.; using leap-motion to track and create a virtual counterpart of the human hand in the virtual world). Besides voice input, AR narratives also support physical hand input. With the help of marker system, AR narratives can turn physical objects into a medium by which to interact with virtual content. By combining different sensors (e.g.; distance, light, temperature), AR narratives can use physical effects as input for the interaction.

5.1.2 Experiment Design

For a fair comparison, the most recent device, the most updated interactive methods, and the most optimal visual realism methods in AR and VR field will be adopted.

Table 1: Components to construct the systems for comparison.

	Move freely	Real environment	Virtual environment	Can see the physical body	Virtual embodiment	Voice input	Physical body / Object input	Physical effect input	High fidelity 3d models	VC real characters	Light and shadow
AR Narrative	✓	✓		✓		✓	✓	✓	✓	✓	✓
VR Narrative	✓		✓		✓	✓			✓	✓	✓

mechanisms (i.e.; belief change, between-session habituation, within-session habituation, extinction, emotional engagement, and trauma narrative change) were identified by these two theories. The conclusion was that belief change and between-session habituation are the strongest evidence-based indicators of PTSD symptom improvement [24].

This finding underlined my concept of combining narrative exposure-based PE (habituation) with negative cognition alternation (belief change) in treating PTSD. The most commonly used measure for negative change is the Post-Traumatic Cognitions Inventory (PTCI). This list contains 36 PTSD-related negative cognitions and can be summarized into 3 types: (1) self-blame; (2) negative beliefs about oneself; and (3) negative beliefs about the world [25]. Addressing these negative cognitions and related distressing emotions is considered to be essential to PTSD recovery [22].

Vygotsky believed that speech exists in three forms: (1) external; (2) egocentric; and (3) inner. Through a process of internalization, external speech is transformed from a directly interpersonal and communicative means of regulating and directing human behavior, to what Vygotsky describes as "inner speech", or the capacity to evoke self-consciousness and introspection, which can then serve as a guide for cognitive and behavioral changes [26].

5.2.2 Intervention Design

In classic PE treatment, after imaginary exposure, the therapist will attempt to alter the patient's negative cognitions through discussion. However, this cognition intervention is direct, obvious, and purposeful. Rooted faiths are hard to change, and, in the case that the therapist is not engaged with the patient, this external speech intervention is highly likely to devolve into an ideological dispute.

Instead of exposing the intentions of cognition intervention directly, this project proposes to cover the intention with the AR narrative. This inclined narrative will affect the patient's cognition quietly, and the patient will believe that their motivation for cognition change has been generated from their own will.

Below is an examples of inserting the cognition intervention in AR narratives, which was created based on the self-narrative treatment theory presented in [27] (see Tables 2).

Table 2: An example to treat patients with childhood–abuse PTSD

Depth of Experience	Content of the Exposure in AR	Aims
1 level(Aware of the emotions)	Place the patient at the real location where she was abused before and augment the location with the high fidelity 3d model of his/her father	Acknowledge the feeling of angry, shame and hopeless
2 level(Emotion release)	Add positive aspects to the traumatic event, such as the undisclosed facts of the father(e.g.; mental illnesses, financial crisis) and his guilt after the abuse.	Talk with the father about his undisclosed facts and try to accept his apologies
3 level(Further release)	Add narratives to show the obscure love of the father(e.g.; The father sold the house to support his daughter studying abroad and learned to cook until late.)	Father talks more about how he loves his daughter

5.3 Stage Three: Semi–Automatic and Patient–Authored AR System for PTSD Treatment

5.3.1 Background

Although the exposure environment in NVRE is derived from a patient's trauma memories, the visual content is generated and arranged by researchers before the treatment begins [11-13]. This researcher-authored method demands huge efforts from the patient before the treatment to convey the images in their head to the researcher in multiple ways. Additionally, the visualization of the traumatic experience requires tremendous time and effort within the computer simulation, thereby elevating the treatment costs and prolonging the treatment timetable.

I plan to create a semi-automated patient-authored treatment system, which renders patients capable of designing their exposure environment quickly and easily. Specifically speaking, when the patient verbally narrates their traumatic experience, the event-related characters, objects, events, and emotions they describe will be visualized in real-time and displayed in the patient's surroundings.

5.3.2 Narrative Creation Process

At the beginning of the treatment, the patient is required to describe the situation before the disaster was occured in detail. This includes the environment, any sounds they heard, and the people at the location where the event happened. Their verbal dictation will be captured by a HoloLens device and sent to Unity in the form of text. A system in Unity will then request to retrieve 3D models from the database that correspond to keywords from the dictation. Subsequently, Unity will livestream the updated scene to the HoloLens device. Finally, the patient can view the scenes they have just described in real-time and resize and rearrange the objects displayed to match with their inner images using a hand-tracking function.

In the next step, the patient will describe how the traumatic event took place. Similarly, their dictation will be recognized and transformed into text before being sent to Unity. Unity will then attempt to match keywords from the dictation to 3D animations and sound materials in the local library, then update the scene and stream the results back to the patient.

In the final stage, the patient will be required to narrate the emotions and physical sensations they felt after the traumatic event occurred. Corresponding abstract 3D animations will be retrieved and displayed to the patient, thereby facilitating the full release of negative emotions (see Fig. 2).

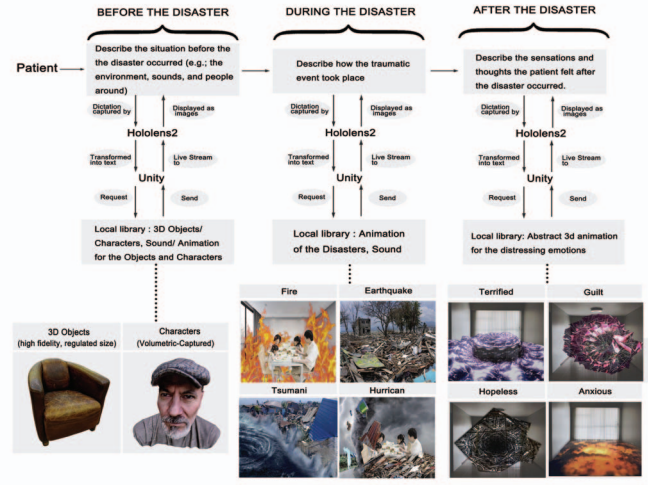

Figure 2: The system design of the semi–automatic and patient– authored AR narrative system.

6 Conclusion

VRE for PTSD treatment has been widely studied, and its treatment efficacy is supported by scientific evidence. However, there is still a lot of room for improvements in several undesirable aspects, such as the unrealistic virtual environment, unresponsive 3D characters, monotonous interactive methods (e.g.; VR controllers), and limited-treatment mechanisms (e.g.; habituation). This doctoral project proposes to adopt AR into PTSD treatment. It will place AR images inside a real environment to enhance

immersion within the exposure. It will provide volumetric-captured, real human movement as a substitution for unresponsive 3D models, thereby increasing the virtual realism of the narrative. It can also be combined with hand tracking, voice input, marker tracking, and physical sensors to unlock more natural and organic interaction methods within the narrative. Most importantly, it can be combined with prolonged exposure to not only habituate the patients with their fears but also to completely alter their negative beliefs and emotions related to the event.

There are still many imperfections and a lack of consideration in this research plan. We will conduct more research on psychological research design, intervention design and medical humanities to keep enhancing it.

REFERENCES

[1] S. Hillis, J. Mercy, A. Amobi, and H. Kress, "Global Prevalence of Past-year Violence Against Children: A Systematic Review and Minimum Estimates," Pediatrics, vol. 137, no. 3, Mar. 2016, doi: 10.1542/peds.2015-4079.

[2] P. T. Ackerman, J. E. O. Newton, W. B. McPherson, J. G. Jones, and R. A. Dykman, "Prevalence of post traumatic stress disorder and other psychiatric diagnoses in three groups of abused children (sexual, physical, and both)," Child Abuse & Neglect, vol. 22, no. 8, pp. 759–774, Aug. 1998, doi: 10.1016/S0145-2134(98)00062-3.

[3] T. H. Hoppen and N. Morina, "The prevalence of PTSD and major depression in the global population of adult war survivors: a meta-analytically informed estimate in absolute numbers," European Journal of Psychotraumatology, vol. 10, no. 1, p. 1578637, Dec. 2019, doi: 10.1080/20008198.2019.1578637.

[4] P. Baddam John, S. Russell, and P. S. S. Russell, "The Prevalence of Posttraumatic Stress Disorder Among Children and Adolescents Affected by Tsunami Disaster in Tamil Nadu," Disaster Management & Response, vol. 5, no. 1, pp. 3–7, Jan. 2007, doi: 10.1016/j.dmr.2006.11.001.

[5] American Psychiatric Association. Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub, 2013.

[6] R. D. Marshall, M. Olfson, F. Hellman, C. Blanco, M. Guardino, and E. L. Struening, "Comorbidity, Impairment, and Suicidality in Subthreshold PTSD," AJP, vol. 158, no. 9, pp. 1467–1473, Sep. 2001, doi: 10.1176/appi.ajp.158.9.1467.

[7] M. Panagioti, P. A. Gooding, and N. Tarrier, "A meta-analysis of the association between posttraumatic stress disorder and suicidality: the role of comorbid depression," Comprehensive Psychiatry, vol. 53, no. 7, pp. 915–930, Oct. 2012, doi: 10.1016/j.comppsych.2012.02.009.

[8] C. P. McLean and E. B. Foa, "Prolonged exposure therapy for post-traumatic stress disorder: a review of evidence and dissemination," Expert Review of Neurotherapeutics, vol. 11, no. 8, pp. 1151–1163, Aug. 2011, doi: 10.1586/ern.11.94.

[9] Institute of Medicine, Board on Population Health and Public Health Practice, and Committee on Treatment of Posttraumatic Stress Disorder, Treatment of Posttraumatic Stress Disorder: An Assessment of the Evidence. Washington, D.C., UNITED STATES: National Academies Press, 2008.

[10] X. Zhu et al., "Exposure-based therapy changes amygdala and hippocampus resting-state functional connectivity in patients with posttraumatic stress disorder," Depression and Anxiety, vol. 35, no. 10, pp. 974–984, 2018, doi: 10.1002/da.22816.

[11] C. Loranger and S. Bouchard, "Validating a Virtual Environment for Sexual Assault Victims," Journal of Traumatic Stress, vol. 30, no. 2, pp. 157–165, 2017, doi: 10.1002/jts.22170.

[12] Rizzo et al., "Development and Clinical Results from the Virtual Iraq Exposure Therapy Application for PTSD," in 2009 Virtual Rehabilitation International Conference, Jun. 2009, pp. 8–15, doi: 10.1109/ICVR.2009.5174198.

[13] J. G. Beck, S. A. Palyo, E. H. Winer, B. E. Schwagler, and E. J. Ang, "Virtual Reality Exposure Therapy for PTSD Symptoms After a Road Accident: An Uncontrolled Case Series," Behavior Therapy, vol. 38, no. 1, pp. 39–48, Mar. 2007, doi: 10.1016/j.beth.2006.04.001.

[14] Mazloumi Gavgani, F. R. Walker, D. M. Hodgson, and E. Nalivaiko, "A comparative study of cybersickness during exposure to virtual reality and 'classic' motion sickness: are they different?," Journal of Applied Physiology, vol. 125, no. 6, pp. 1670–1680, Oct. 2018, doi: 10.1152/japplphysiol.00338.2018.

[15] "South Korean mom has tearful VR 'reunion' with dead daughter - National |Globalnews.ca."https://globalnews.ca/news/6550977/mom-dead-daughter-virtual-reality/ (accessed Aug. 25, 2020).

[16] M. L. Tielman, M. A. Neerincx, R. Bidarra, B. Kybartas, and W.-P. Brinkman, "A Therapy System for Post-Traumatic Stress Disorder Using a Virtual Agent and Virtual Storytelling to Reconstruct Traumatic Memories," J Med Syst, vol. 41, no. 8, 2017, doi: 10.1007/s10916-017-0771-y.

[17] T. Tuvia and S. Rego, "Five sessions of in vivo exposure therapy for post-traumatic stress disorder: A case report," European Psychiatry, vol. 41, p. S727, Apr. 2017, doi: 10.1016/j.eurpsy.2017.01.1325.

[18] B. Nabil, M. Margot, E. Marine, F. A. D. S. João, P. Antoine, and M. Luc, "Personalised 360° video exposure therapy for the treatment of obsessive-compulsive disorder : a proof-of-concept study," PsyArXiv, preprint, Jun. 2019. doi: 10.31234/osf.io/kqw3u.

[19] R. Ballagas, A. Kuntze, and S. P. Walz, "Gaming Tourism: Lessons from Evaluating REXplorer, a Pervasive Game for Tourists," in Pervasive Computing, vol. 5013, J. Indulska, D. J. Patterson, T. Rodden, and M. Ott, Eds. Berlin, Heidelberg: Springer Berlin Heidelberg, 2008, pp. 244–261.

[20] C. Zheng et al., "Toon-chat: a cartoon-masked chat system for children with autism," in ACM SIGGRAPH 2017 Posters on - SIGGRAPH '17, Los Angeles, California, 2017, pp. 1–2, doi: 10.1145/3102163.3102249.

[21] C. Xiao and Z. Lifeng, "Implementation of mobile augmented reality based on Vuforia and Rawajali," in 2014 IEEE 5th International Conference on Software Engineering and Service Science, Jun. 2014, pp. 912–915, doi: 10.1109/ICSESS.2014.6933713.

[22] E. B. Foa and M. J. Kozak, "Emotional processing of fear: Exposure to corrective information.," Psychological Bulletin, vol. 99, no. 1, pp. 20–35, Jan. 1986, doi: 10.1037/0033-2909.99.1.20.

[23] M. G. Craske, M. Treanor, C. C. Conway, T. Zbozinek, and B. Vervliet, "Maximizing exposure therapy: An inhibitory learning approach," Behaviour Research and Therapy, vol. 58, pp. 10–23, Jul. 2014, doi: 10.1016/j.brat.2014.04.006.

[24] A. Cooper, E. G. Clifton, and N. C. Feeny, "An empirical review of potential mediators and mechanisms of prolonged exposure therapy," Clinical Psychology Review, vol. 56, pp. 106–121, Aug. 2017, doi: 10.1016/j.cpr.2017.07.003.

[25] B. Kleim, "Investigating cognitive pathways to psychopathology: Predicting depression and posttraumatic stress disorder from early responses after assault.," Psychological Trauma: Theory, Research, Practice, and Policy, 20120123.

[26] P. E. Jones, "From 'external speech' to 'inner speech' in Vygotsky: A critical appraisal and fresh perspectives," Language & Communication, vol. 29, no. 2, pp. 166–181, Apr. 2009, doi: 10.1016/j.langcom.2008.12.003.

[27] I. Georgieva and G. V. Georgiev, "Reconstructing Personal Stories in Virtual Reality as a Mechanism to Recover the Self," IJERPH, vol. 17, no. 1, p. 26, Dec. 2019, doi: 10.3390/ijerph17010026.