Virtual Reality in Exposure Therapy

Investigating the efficacy of VR in treating anxiety disorders and phobias through exposure therapy in a controlled and immersive virtual environment.

PRACHEE JAVIYA

University of Maryland Baltimore County

The evolution of Virtual Reality (VR) technology has ushered in a new era of therapeutic interventions, particularly in the domain of exposure therapy. Exposure therapy, a well-established treatment for anxiety disorders and phobias, traditionally involves controlled exposure to feared stimuli to reduce avoidance behaviors and conditioned fear responses. This paper presents an overview of literature that supports the application of VR in exposure therapy, exploring its potential benefits, challenges, and overall efficacy. Through the analysis of existing studies, this paper discusses the versatile nature of VR and its ability to create tailored therapeutic environments, offering a unique blend of safety and realism. The paper also delves into the comparative advantages of VR-based exposure therapy over traditional methods, highlighting patient engagement, customization, and controlled settings. Potential limitations and areas for future research are identified to provide a holistic understanding of this emerging therapeutic modality. Our findings suggest that while VR holds significant promise in enhancing exposure therapy outcomes, continued research is essential to establish standardized protocols and best practices.

CCS Concepts - Human-centered computing • Human-computer interaction • Empirical studies in HCI

Keywords - Virtual reality, Exposure Therapy, phobias, social anxiety

1. INTRODUCTION

The advent of Virtual Reality (VR) technology has revolutionized various fields, including the realm of psychological therapy (Frommel, 2021). One of the most notable applications of VR is in exposure therapy, particularly for the treatment of anxiety disorders and phobias. Traditional exposure therapy involves controlled exposure to feared stimuli to decrease avoidance behaviors and conditioned fear responses (Eustace, 2013). VR has shown immense potential in various fields, from gaming to education. However, its application in the therapeutic domain, particularly in exposure therapy, is an area of burgeoning interest and research (Dickinson, 2021).

Through a literature review on the efficacy of VR in exposure therapy, I have explored the immersive and interactive nature of VR, which allows for the creation of tailored therapeutic environments. This adaptability is crucial in addressing the unique needs of each patient, enhancing their engagement in the therapeutic process. The review also highlights the comparative advantages of VR-based exposure therapy over traditional methods, such as greater patient engagement, customization possibilities, and controlled settings. However, it also identifies potential limitations and areas for future research to offer a balanced perspective on this emerging therapeutic modality. The prevalence of anxiety disorders, exacerbated by contemporary societal and economic challenges, necessitates innovative approaches in mental health treatment. VR's ability to simulate real-world scenarios in a controlled environment presents a promising solution. This paper delves into how VR can be leveraged in exposure therapy to treat a range of phobias and anxiety disorders, from social anxiety to specific phobias like arachnophobia. Through the analysis of existing studies and clinical trials, the paper evaluates VR's role in enhancing treatment outcomes and its potential to revolutionize therapeutic approaches.

This paper presents an understanding of VR in exposure therapy, presenting it as a significant advancement in mental health interventions. It seeks to demonstrate the potential of VR in not only enhancing therapeutic outcomes but also in paving the way for innovative and effective mental health treatments in the future.

2. BACKGROUND AND MOTIVATION

Mental disorders, including anxiety disorders, have become increasingly challenging for society. This situation has been exacerbated by the economic impact of COVID-19 and changes in social interaction, as noted by Yu, A. Zhang (2023). Anxiety disorders, with a lifetime prevalence of 28.8% in America and Europe, are particularly common (Voinescu, 2023). Patients with these disorders often experience intense fear or panic attacks and feel unable to control their fear.

One specific form of anxiety disorder is Social Anxiety Disorder (SAD). Defined by Zamanifard (2023) as an intense fear of social situations and fear of negative judgment, SAD's prevalence varies across different populations and age groups. Anxiety can also stem from phobias, which may develop in children as early as ages 4 to 6. Su (2023) points out that while short-term anxiety is normal in childhood development, it can escalate into a phobia, impacting future life. Phobias can significantly affect lifestyle; for instance, individuals with vehophobia (fear of driving) may avoid driving altogether, impacting their independence and mobility (Taylor, 2011). Similarly, stage fear, affecting one-fourth to one-third of the general population, often starts in adolescence and can lead to social anxiety, depression, academic failure, and limited employment opportunities if it becomes habitual (Flobak, 2019).

In treating these disorders, Exposure Therapy has been a common approach. This therapy involves exposing patients to anxiety-inducing situations in vivo (real life) or in imago

(visualization) over time, with progressively increasing levels of stimulation in controlled settings (Eustace, 2013). However, traditional Exposure Therapy has limitations, including lack of control over real-life situations and high resource costs (Brinkman, 2010). Implementing physical stimuli for therapy can be challenging; for example, it's often impractical to replicate specific situations like certain heights for treating acrophobia or to modify the size of spiders for arachnophobia (Alexandrovsky, 2020).

To address these limitations, recent studies have explored the use of Virtual Reality (VR) in Exposure Therapy. VR, known for its wide array of medical and clinical applications (Koller, 2018), offers an effective solution by simulating experiences closely resembling the real world. The use of Virtual Reality Environments (VREs) is beneficial for Exposure Therapy, which requires the repeated experience of fear-inducing situations. VR's ability to create on-demand, realistic experiences make it an appealing, cost-effective medium that replicates real-life scenarios effectively (Vona, 2023).

The subsequent sections in this paper explore how Virtual Reality (VR) is leveraged in exposure therapy to treat anxiety disorders and phobias. The limitations of traditional exposure therapy serve as a foundation to investigate how VR, with its immersive and controlled environment, can enhance treatment outcomes. By assessing the efficacy of VR in replicating real-world scenarios, this research aims to contribute to mental health interventions. This area of research holds promise for revolutionizing therapeutic approaches, offering a potentially more effective method to alleviate symptoms and improve the overall well-being of individuals with anxiety-related conditions.

3. LITERATURE REVIEW

This section presents an overview literature review in the burgeoning field of virtual reality with a particular focus on exposure therapy for anxiety disorders and phobias. This paper aims to contribute to the growing body of knowledge surrounding the potential of VR in the healthcare landscape, debating its use as a therapeutic tool for individuals with anxiety-related conditions.

3.1. Methods

3.1.1. Literature Search

This research spans across diverse research domains, each constituting substantial areas of study. To ensure a comprehensive understanding, I performed an exhaustive literature search, primarily focusing on the ACM digital library from venues such as CHI, CSCW, IEEE, and VRST (Virtual Reality Software and Technology). I utilized a combination of key terms, including "Exposure Therapy," "mental disorders," "Virtual Reality," "Phobias," and "Design of VR interfaces," to retrieve relevant literature from the sources. I skimmed through the abstracts of 22 identified papers that were appropriate for this study. Recognizing the need for a broader perspective, I extended the search to Google Scholar, leveraging its multidisciplinary scope and extensive coverage. This supplementary search gave me 10 additional papers that were potentially

includable. These sources span over a wide array of mediums, including traditional print and online journals, published articles, and conference and symposium proceedings.

3.1.2. Selection Criteria

I conducted a filtering process to ensure if the 32 papers initially selected aligned with the study's scope. I excluded 14 papers after one-pass reading of those papers that either lacked substantial content or deviated from the study's core areas. Consistent with the strict criteria set for this review, the remaining papers were directly relevant to the research topic. I prioritized recent publications, from the last 5-10 years, to reflect current trends and developments in the field. To ensure the credibility of the selected papers I selected the papers that were from well-established peer-reviewed academic journals. Papers with a high citation count were also given preference. This approach ensured that the literature review was not only comprehensive but also anchored in high-quality and relevant research.

3.2. Literature Summary

3.2.1. Introduction to Exposure Therapy and Computer-Assisted Assessments

Exposure Therapy has been implemented using computer generated assessments to draw inferences about structural and functional characteristics of the brain by assessing an individual's observable behaviors in a defined stimulus–response situations such as participant responses and subsequent performance. Results of neuropsychological assessment are used to identify the impact of the disease on various cognitive functioning domains and to make predictions regarding a person’s level of functioning in everyday life (Voinescu, 2023). During the exposure therapy the patient confronts the anxiety provoking scenario or object with the therapist's guidance in-vivo (in real-life) or in-sensu (in the imagination). The patient is encouraged to experience his/her anxiety and the therapist observes how the anxiety changes with time (Koller, 2018). According to Krijn, 2004, traditional settings of exposure therapy might not always lead to the desired generalization of fear reduction. In some cases, individuals may only experience a reduction in anxiety in the specific situations targeted during therapy, but not in related or new situations.

Voinescu, 2023 investigated the use of Virtual Reality (VR) based neuropsychological assessment tool, Nesplora Aquarium against traditional cognitive measures in predicting symptoms of depression and anxiety. 91 participants, aged from 19 to 61 years old enrolled in this study. The study examined the validity of the Nesplora Aquarium by analyzing correlations with a computerized Continuous Performance Test. They concluded that VR-based neuropsychological assessments are a valid and effective tool for predicting symptoms of depression and anxiety. These results are supported by Krijn, 2004, as they said “traditional settings of exposure therapy might not always lead to the desired generalization of fear reduction. In some cases, individuals may only experience a reduction in anxiety in the specific situations targeted during therapy, but not in related or new situations.”

Traditional exposure therapy, while effective for treating phobias and anxiety, faces notable challenges. One significant limitation is the lack of control in real-life situations (exposure in vivo), making it difficult to tailor the intensity of stimuli to individual needs (Eustace, 2013). This is particularly problematic in treating social anxieties, where individual-specific scenarios are required and there's a higher dropout rate, especially among adolescents, due to lack of engagement or interest (Mandryk, 2021). Practical issues such as high costs and logistical challenges, like organizing real-world social interactions or compromising client confidentiality, further impede traditional methods (Vona 2023). These limitations underscore the necessity for innovative approaches, possibly leveraging digital and virtual reality technologies, to enhance the effectiveness and accessibility of exposure therapy for anxiety and phobias. Various studies have shown that virtual exposure can be as effective as real exposure and that VRET (Virtual Reality Exposure Therapy) can successively be applied in treatment. VRET overcomes a range of challenges that traditional therapy faces.

3.2.2. Emergence of Virtual Reality in Exposure Therapy

VR is a human-computer interaction paradigm in which users are active participants within a computer generated three-dimensional virtual world. To become part of the virtual world, the user wears an immersive head-mounted display (HMD) that consists of a display screen for each eye, earphones, and a head-tracking device, while sitting standing on a low platform atop bass speaker, thus placing the user within a multisensory, 360-degree environment that can provide visual, auditory, and kinesthetic cues(i.e., vibrations). Natural body and head motion by the user correspond to change within the virtual world. The image seen by the patient in the HMD is displayed on a computer monitor for the therapist's view who analyses their responses. (Rothbaum, 2006)

Koller (2018) studied the current practices in exposure therapy by studying 58 responses from an online questionnaire from psychotherapists and observing therapy sessions, literature review, and interviews with psychotherapists. The questionnaire focused on the therapeutic effects of VR in exposure therapy, emphasizing the importance of patient engagement, realistic simulation of phobic situations, and the potential for VR to enable exercises not otherwise possible. They derived design implications to develop adaptable therapeutic VR scenarios to cater to each patient's individual needs. For example, in treating arachnophobia, the specific appearance of spiders (such as spiders with hairy legs versus small restless spiders) is crucial for triggering the appropriate emotional response in different patients. This study is referenced by Koller (2019) which introduces a VR system that generates virtual audiences, controllable by a therapist, to create a more flexible and individualized therapeutic environment for people with fear of public speaking.

A recent study by Bonnail (2023) discusses how memory can be manipulated during retrieval, using VR reconstructions of past events. This approach can be used in VRET to change a patient's perception of past traumatic events, leveraging tools like positivity bias and misattribution to aid in recovery. It is noted that behaviors in virtual environments mimic real behaviors, making VR an ideal tool for studying and influencing cognition under controlled

conditions. This aspect is critical in VRET, where realistic simulation of experiences can enhance the effectiveness of the therapy.

Along with the VRET, the possibility of using Augmented Reality (AR) to create phobic stimuli is being researched, called Augmented Reality Exposure Therapy (ARET). These systems use the real world and overlay it with phobic objects, e.g. spiders Flobak (2019).

3.2.3. Current works supporting VR in Exposure Therapy

Current works in VR for exposure therapy demonstrates VR's potential in creating immersive, interactive environments tailored to individual psychological needs. Alexandrovsky (2020) introduced a unique approach where participants design their own VRET experiences. It split the VRET experience into a design phase and an actual exposure phase, allowing participants to create their exposure scenarios in VR before experiencing them. This method was tested in a user study, showing positive effects on player experience and height perception. Another participatory design approach was implemented by Flobak (2019) which involved prototyping VR scenarios using 360° video, as opposed to the traditional use of computer-generated imagery (CGI) in VR applications for exposure therapy. In this study, adolescents aged 15-17 participated in the workshop (involved in various stages like ideation, storyboarding, live-action plays (recorded by a 360° camera), and group evaluations). The resulting VR scenarios were evaluated by clinical psychologists. Their findings align with Takac (2023), which highlights the importance of presence and the realism of the content, for the efficacy of exposure therapy.

This realism is achieved through a user interface (UI) which is crucial for VR's effectiveness and its integration into therapeutic practices. A user-friendly UI is essential for therapists with varying levels of technical expertise, enabling them to easily navigate and utilize the VR system. Eustace (2013) discusses the development and evaluation of 4 iterations of user interfaces for the PhobiAR application. They proposed the following guidelines to design UI interface for therapists - [1] Provide therapists with automated exposure scenario(s), [2] Provide therapists with an integrated timeline representation of the different phases in the scenario, the recorded anxiety scores, comment flags, the events to come and those already taken place, and the current position on the timeline, [3] Design for error prevention by not allowing therapists to trigger inappropriate simulation events. This ease of use is vital for the efficient administration of therapy sessions. The UI design provides therapists with control over the session, allowing them to tailor the environment and stimuli intensity to meet individual patient needs. This contributes to patient engagement and compliance, as smooth operation of the VR system minimizes disruptions. Additionally, a good UI supports interdisciplinary collaboration among psychologists, psychiatrists, and VR technicians, enhancing treatment planning and execution.

These papers collectively illustrate the multifaceted nature of VRET. They show its adaptability to different psychological conditions, its effectiveness in diverse populations (including children and military personnel), and the importance of customized VR content tailored to individual needs. They also demonstrate the evolution of VRET, from traditional clinical settings to more interactive and participatory formats, including game design and streaming. This

body of research underscores the growing potential and applicability of VRET in modern psychotherapy.

4. DISCUSSION

The studies discussed above utilized VRET systems developed controlled and immersive virtual environments that created a realistic and safe space for individuals to confront their fears and traumas. The observed reduction in anxiety symptoms post-VR exposure therapy sessions suggests that VR can be a valuable tool in the treatment of these mental health conditions. The study's findings align with previous research on the use of VR in exposure therapy, further emphasizing the potential of this technology as a therapeutic intervention. Virtual reality (VR) stands as a beacon of innovation in the psychological treatment landscape, especially in the realm of exposure therapy. This narrative explores its applications, challenges, and future possibilities, painting a comprehensive picture of VR's role in revolutionizing mental health care.

From the literature review it is apparent that the primary advantage of VR in Exposure Therapy lies in its controlled and customizable nature. Therapists can tailor virtual scenarios to individual patient needs, adjusting the intensity and complexity of the exposure. This personalized approach not only makes the therapy more relevant but also enhances its effectiveness. For example, a person with a fear of heights can start with low heights in VR and gradually progress, building tolerance and coping strategies in a stepwise fashion.

However, using VR as a tool poses some technical challenges. Technological constraints, such as less realistic simulations, can diminish the effectiveness of the therapy. The cost and accessibility of high-quality VR equipment remain barriers, limiting its widespread use. Physical side effects like motion sickness and emotional risks, including increased anxiety or re-traumatization, particularly in severe PTSD cases, are also concerns. The field also has a lack of standardization in treatment protocols and limited research on long-term effectiveness. As such, there’s a pressing need for more extensive studies and standardized guidelines to ensure consistent and safe therapeutic practices.

5. CONCLUSION AND FUTURE WORKS

The future of VR in exposure therapy brims with possibilities. Technological advancements promise enhanced realism and interactivity, potentially making the therapy more effective. As VR becomes more affordable and widespread, its accessibility is poised to increase, reaching a broader spectrum of patients and clinics.

Integrating VR with other therapeutic techniques like cognitive-behavioral therapy could yield even more effective treatment outcomes. The prospect of incorporating machine learning and AI to adapt scenarios in real-time offers a glimpse into a future where therapy is highly individualized and can be put to broader use to treat, for example, obsessive compulsive disorder (OCD). Developing standardized treatment protocols and conducting long-term studies are

essential steps towards understanding VR's optimal application in therapy. Training for therapists in using VR effectively and guidelines for ensuring emotional safety during sessions are also critical.

In conclusion, VR in exposure therapy represents a transformative fusion of technology and psychology. Its journey from a novel approach to a potentially mainstream treatment option reflects the dynamic evolution of mental health care. As VR technology advances and becomes more integrated into therapeutic practices, it holds the promise of offering more effective, personalized, and accessible treatment for individuals grappling with anxiety disorders. The road ahead is filled with challenges, but the potential rewards for patients and therapists alike make it a path worth exploring.

6. ACKNOWLEDGEMENTS

I extend my heartfelt gratitude to Dr. Foad Hamidi who contributed to the success of this research. His valuable feedback throughout allowed me to put forth my best work. I would like to thank my peers for helping me overcome technical shortcomings. Lastly, I would like to mention the assistance received from OpenAI's ChatGPT which helped me paraphrase some of my writing and checking my grammar, which was instrumental in shaping the final manuscript.

7. REFERENCES

1. Alexandrovsky, D., Volkmar, G., Spliethöver, M., Finke, S., Herrlich, M., Döring, T., Smeddinck, J. & Malaka, R. (2020, November). Playful user-generated treatment: A novel game design approach for VR exposure therapy. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (pp. 32-45).
2. Bonnail, E., Tseng, W. J., McGill, M., Lecolinet, E., Huron, S., & Gugenheimer, J. (2023, April). Memory Manipulations in Extended Reality. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-20).
3. Brinkman, W.-P., van der Mast, C., Sandino, G., Gunawan, L. T., and Emmelkamp, P. M. The therapist user interface of a virtual reality exposure therapy system in the treatment of fear of flying. Interacting with Computers 22, 4 (2010), 299–310.
4. Dickinson, P., Jones, A., Christian, W., Westerside, A., Mulloy, F., Gerling, K., ... & Parke, A. (2021, May). Experiencing simulated confrontations in virtual reality. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (pp. 1-10).
5. Eustace, N., Head-Mears, J., & Dünser, A. (2013, November). Exploratory development and evaluation of user interfaces for exposure therapy treatment. In *Proceedings of the 25th Australian Computer-Human Interaction Conference: Augmentation, Application, Innovation, Collaboration* (pp. 527-530).

6. Flobak, E., Wake, J. D., Vindenes, J., Kahlon, S., Nordgreen, T., & Guribye, F. (2019, May). Participatory design of VR scenarios for exposure therapy. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (pp. 1-12).
7. Frommel, J., Dechant, M. J., & Mandryk, R. L. (2021). The Potential of Video Game Streaming as Exposure Therapy for Social Anxiety. *Proceedings of the ACM on Human-Computer Interaction*, *5*(CHI PLAY), 1-25.
8. J. E. Taylor, F. Alpass, C. Stephens, and A. Towers, "Driving anxiety and fear in young older adults in New Zealand," Age and Ageing, vol. 40, no. 1, pp. 62–66, 1 2011.
9. Koller, M., Schäfer, P., Lochner, D., & Meixner, G. (2019, June). Rich interactions in virtual reality exposure therapy: a pilot-study evaluating a system for presentation training. In *2019 IEEE International Conference on Healthcare Informatics (ICHI)* (pp. 1-11). IEEE.
10. Koller, M., Schäfer, P., Sich, M., Diemer, J., Müller, M., & Meixner, G. (2018, September). Next Generation Virtual Reality Exposure Therapy Systems - A Study Exploring Design Implications. In *2018 International Conference on Intelligent Systems (IS)* (pp. 528-535). IEEE.
11. Krijn, M., Emmelkamp, P. M., Olafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. Clinical psychology review, 24(3), 259-281.
12. Rothbaum, B. O., Anderson, P., Zimand, E., Hodges, L., Lang, D., & Wilson, J. (2006). Virtual reality exposure therapy and standard (in vivo) exposure therapy in the treatment of fear of flying. *Behavior therapy*, *37*(1), 80-90.
13. Su, X., & Yan, S. (2023, April). NoPhobiar: Designing A VR Game to Prevent Childhood Dark Phobia with Children and Stakeholders. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-6).
14. Takac, M., Collett, J., Conduit, R., & De Foe, A. (2023). A cognitive model for emotional regulation in virtual reality exposure. *Virtual Reality*, *27*(1), 159-172.
15. Voinescu, A., Petrini, K., Stanton Fraser, D., Lazarovicz, R. A., Papavă, I., Fodor, L. A., & David, D. (2023). The effectiveness of a virtual reality attention task to predict depression and anxiety in comparison with current clinical measures. *Virtual reality*, *27*(1), 119-140.
16. Vona, F., Pentimalli, F., Catania, F., Patti, A., & Garzotto, F. (2023, April). Speak in Public: an Innovative Tool for the Treatment of Stuttering through Virtual Reality, Biosensors, and Speech Emotion Recognition. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-7).
17. Yu, A., Zhang, C., Huang, J., & Yi, Y. (2023, May). VR-Assisted Healing: VR CONTENT Creation Cuts through the Psychological Healing Process. In *2023 9th International Conference on Virtual Reality (ICVR)* (pp. 353-360). IEEE.
18. Zamanifard, S., & Robb, A. (2023, April). Social Virtual Reality Is My Therapist: Overcoming Social Anxiety Disorder Through Using Social Virtual Reality. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (pp. 1-6).