The Psychological Effects of Immersive Virtual Reality

A Technical Report submitted to the Department of Computer Science

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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CS4980 Capstone Report, 2023

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ABSTRACT

The emergence of virtual reality (VR) as an immersive digital technology has redefined what it means to be fully "present" in the technological space and has introduced questions pertaining to how similar the neural response of these virtual environments should mimic that of real ones. Working under Prof. Tian, I am investigating how fear-prone individuals react to VR environments that target their fears by developing Unity games that simulate four area of stimuli: height, sharp objects, confined spaces, and unsettling textures. The study is set to complete early Fall 2023 and currently consists of data collection from over a hundred participants for the height stimuli alone. These findings will assist us in understanding how the brain processes underpinning immersive technological experiences and what restraints should exist as the technology develops further.

1. INTRODUCTION

In the age of computers, the term "virtual" has taken on the meaning of something not physically existing, but instead made to appear by software; virtual reality recontextualizes the virtual space through a simulated experience that allows the user to view and interact with a computer-generated environment, currently through headsets and controllers. Given its high level of immersion, engineers wonder whether introducing the presence of real-life stimuli has the ability to gauge the same sensations individuals may feel from the actual event, and if so, whether these platforms should exist with safety and accessibility components that can limit those sensations.

On one hand, the beauty of VR lies in its ability to replicate visual and auditory scenarios that draw upon sensations too dangerous to experience in real life, and on the other, unconsented exposure to such scenarios can result in consequences that lie on a psychological level. For fear stimuli, specifically, the brain is not trained to differentiate the legitimacy of virtual and real environments beyond the credibility of its visual components, thus, it is worth exploring how "immersive" these experiences really have to be to elicit the same reactions.

2. RELATED WORKS

The virtual reality space has been reconfigured in the past as a treatment tool for various anxiety disorders, namely, acrophobia. Virtual reality exposure therapy (VRET) has the ability to simulate real experiences at lesser degrees, thus allowing the user to acclimate to the severity of the stimulant without hindering the credibility of the experience [1]. Though VRET has been successful as a means to understand what visual, vestibular, and postural control systems are contributive of mimicking the anxiety inducing sensations of real stimulants, there is limited research connecting these control systems to the cognitive state of the individual [2].

To differentiate the brain's activity between "high presence" and "low presence" virtual reality experiences, a study utilized functional magnetic resonance imagery (fMRI) by asking individuals to experience two variations of a roller coaster ride game that differed in levels of anticipation, dynamic, and endings. As hypothesized, the high presence version activated prefrontal areas of the brain that alluded to a level of presence. While the right dorsolateral prefrontal cortex (DLPFC) down-regulated the activation of the processing stream, the left up-regulated areas of the medial prefrontal cortex known to be involved in self-reflective and stimulus-independent thoughts [3]. Though brain activity cannot be investigated on the same scale in this study, physical response will serve as a lead in the experimental setup similarly.

3. PROJECT DESIGN

Before each session of the study, the participant is asked to fill out a consent form that gauges their level of fear for each of the four stimuli: height, sharp objects, confined spaces, and unsettling textures. Based on the participants highest ranking, they are assigned an "order." Each stimulus consists of two games, each game consists of six orders, and each order consists of three scenes. In order to promote variability in our data collection, the study cycles through the twelve orders so that each participant ends up playing a new set of three scenes.

When the session starts, the participant's heart rate data is collected using exercise mode of a Fitbit smart watch, along with the motion data from the VR headset and controllers. Once the participant is wearing both of these devices, the participant is asked to play the first scene, guided by a research assistant, and the game play is screen recorded. After playing the first scene, the participant is asked for quantitative and qualitative feedback regarding their level of fear and immersion in a self-report survey and then asked to take a break so their heart-rate can go down before starting the next scene. After two more rounds of scenes and surveys, the study is concluded with one longer survey about the study as a whole.

Using the self-report surveys, screen recordings, heart-rate and motion data, the data specific to each stimulus is analyzed in accordance to the initial consent survey for each participant and any notes regarding their behavior (light-headedness, fainting, panic attacks, etc.) are recorded in a participant tracking sheet.

4. RESULTS & FUTURE WORK

As of now, the study is still administering data collection and has yet to determine the most efficient method of data analysis respective to each of the fear stimuli. Full data collection completion and analysis is targeted for Fall 2023.

5. ACKNOWLEDGEMENTS

Because of the interdisciplinary nature of this study, I would like to acknowledge Computer Science PhD student Kunlin Cai and Psychology PhD student Kenn Dela Cruz for helping me administer this research for my engineering thesis, and most importantly, Prof. Yuan Tian for being my research advisor.

REFERENCES

[1] Merel Krijn, Paul M. G Emmelkamp, Roeline Biemond, Claudius de Wilde de Ligny, Martijn J Schuemie, and Charles

A. P. G van der Mast. 2004. Treatment of acrophobia in virtual reality: The role of immersion and presence. *Behaviour Research and Therapy* 42, 2 (February 2004), 229–239. doi: https://doi.org/10.1016/S0005-7967(03)00139-6

[2] David Giraldy and Wilson Novaldo. 2022. A Systematic Literature Review: Acrophobia Treatment with Virtual Reality. *Engineering, Mathematics and Computer Science (EMACS) Journal* 4, (February 2022), 33–38. doi: https://doi.org/10.21512/emacsjournal.v4i1.8077

[3] Thomas Baumgartner. 2008. Feeling present in arousing virtual reality worlds: prefrontal brain regions differentially orchestrate presence experience in adults and children. *Front. Hum. Neurosci.* 2, (2008). doi: https://doi.org/10.3389/neuro.09.008.2008