Virtual Reality Driven Analysis of Task Completion in Different Environments

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1 INTRODUCTION

Virtual Reality, or VR, is a growing market that has been taking consumers by storm. From entertainment like video games to use in the workforce, VR can be used for an infinite number of possibilities. Major Companies like Meta have inspired the idea of utilizing Virtual Reality technology in the office. With the recent release of the Apple Vision Pro, VR has never been more popular. In the future, virtual reality technology will continue to grow and become more accessible to the average individual. In this study, we aim to test some of VR's capabilities in terms of human productivity in different environments.

This research is motivated by the desire to better understand how VR environments affect human performance and well-being. As workplaces increasingly incorporate remote collaboration and virtual interaction, optimizing the virtual environments in which individuals operate becomes very important. By exposing participants to varied virtual settings, we aim to discern the impact of environmental factors on cognitive efficiency. Through thorough experimentation and data analysis, we seek to identify the optimal conditions for task completion and stress mitigation within VR environments.

In essence, this study adds to the rising field of VR by shedding light on the complicated relationship between environment and productivity. By defining the mechanisms by which virtual environments affect productivity, we aim to inform the development of more effective and user-centric VR applications across a wide range of fields.

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2 RELATED WORKS

There has been research done looking into the effectiveness of completing tasks in virtual reality. The first paper *Virtual Reality for Future Workforce Preparation* investigates how using virtual reality impacts academic and industry needs. This paper used 3D models to simulate specific projects for students to better understand how they work. The researchers concluded that using virtual reality in the classroom can help reduce the gaps between what companies expect and what is taught in the classroom. They also found that students who learned in virtual reality allowed them to broaden their understanding. This study was backed by: *Big Data: Astronomical or Genomical?*, *Pulling the Strands Together: MEGA Steps to Drive European Genomics and Personalised Medicine. Biomed Hub*, *A review on machine learning principles for multi-view biological data integration. Briefings in Bioinformatics*, *Visual analytics for dimension reduction and cluster analysis of high dimensional electronic health records. Informatics*, and *Visual Analytics of Genomic and Cancer Data: A Systematic Review*

The second paper, *When Does Immersion in a Virtual Environment Help Students Construct Understanding,* investigates how individuals understand concepts while immersed in virtual reality compared to using a desktop. The researchers assigned undergraduate students to an immersive environment, either in virtual reality or on a desktop. The researchers found that the students using virtual reality learned more than the other students and that they discovered new concepts. This paper was backed by: *A meta-analysis and systematic literature review of virtual reality rehabilitation programs. Computers in Human Behavior,*, *Use of virtual reality-based training in different fields of rehabilitation: A systematic review and meta-analysis. Journal of Rehabilitation Medicine*, *Presence is the key to understanding immersive learning.*, *The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. Frontiers in Psychology*, *Virtual reality applications toward medical field. Clinical Epidemiology and Global Health*, and *Effects of virtual reality training intervention on predictive motor control of children with DCD–A randomized controlled trial. Research in Developmental Disabilities,*

The third paper, *Understanding cancer patient cohorts in virtual reality environment for better clinical decisions: a usability study*, looks into using virtual reality in the medical field. The purpose was to see if using virtual reality with embedded data analytics to treat patients would assist clinicians with treatment decisions. The goal of the study was to improve efficiency, functionality and end-user satisfaction for clinicians using virtual reality. The method of the study included 20 individuals and had them complete routine clinical tasks. The virtual reality portion included interaction gestures, as well as a visual analytics tool to collect data. The data was analyzed using the statistical method Mann-Whitney U. The results showed that 65% of the participants indicated that using virtual reality is potentially helpful for daily work, but needed more flexibility like adding new patient data. Medical domain users utilized the data visual analytics parts. This paper was backed by: *Mentoring in the Technical Disciplines: Fostering a Broader View of Education, Career, and Culture In and Beyond the Workplace. New Directions for Teaching and Learning*, *Applications of computer simulation in mechanism teaching. Computer Applications in Engineering Education*, *Constructing inferences during narrative text comprehension. Psychological Review*, and *Multimedia learning: Are we asking the right questions? Educational Psychologist.*

The fourth study, *Perceived usefulness and ease of using virtual reality during physiotherapy–A cross sectional survey from physiotherapists perspective*, is similar to the last study and investigates the usefulness and ease of utilizing virtual reality during physiotherapy. The method of the study included surveying over 100 physiotherapists and asking them questions about using virtual reality in physiotherapy. The results showed that 62% of physiotherapists agreed that virtual reality would enable them to accomplish tasks more quickly, 57% think that it would increase productivity, and

59% believe it would enhance the effectiveness of their job. Most physiotherapists believe virtual reality is slightly useful and would improve efficiency and performance, but some remain neutral. The fifth and final study investigated learning in virtual reality. As virtual reality gains popularity, research should be done to explore how it can be used for learning. This study was backed by: *Is dental auto transplantation underestimated and underused by Syrian dentists? Journal of Educational Evaluation for Health Professions*, *What are the learning affordances of 3-D virtual environments? British Journal of Educational Technology*, *Is Metaverse in education a blessing or a curse: a combined content and bibliometric analysis. Smart Learning Environments*, *What are the learning affordances of 3-D virtual environments? British Journal of Educational Technology*, and *Constructivist Approaches in Educational Research. Review of Educational Research*

A paper, *Learning in the Metaverse: Are University Students willing to Learn in Immersive Reality?*, looked into this. They surveyed a few hundred undergraduate students to see the impact on using virtual reality in the classroom. They found that there are many new possibilities provided by virtual reality for learning and it is crucial to fully understand how it can be incorporated into the classroom. This paper was backed by: *Water on Tap: The Use of Virtual Reality as an Educational Tool*, *The Evolution of Constructivist Learning Environments: Immersion in Distributed, Virtual Worlds. Educational Technology*, *Using Virtual Reality Technology to Convey Abstract Scientific Concepts*, *Learning the Sciences of the 21st Century: Research, Design and Implementing Advanced Technology Learning Environments*, *A Guided Exploration Model of Problem-Solving Discovery Learning*, and *Use of Virtual Reality for Adjunctive Treatment of Adolescent Burn Pain during Wound Care: A Case Report.*

3 METHODOLOGY

Our experiment aimed to explore the effects of various virtual environments on human productivity and stress levels, employing a between-subject design. We selected twelve college students from Colorado State University aged 19-23. All participants had minimal prior experience with virtual reality to ensure a uniform baseline familiarity with the technology.

Utilizing an Oculus Quest 2 headset, we immersed participants in three different virtual environments: calming, neutral, and hectic. These environments were designed using Unity to specifically provide a cognitive challenge for our participants. The calming environment simulated a relaxing beach scene with gentle waves and ambient nature sounds. The neutral environment presented participants with a plain white room devoid of any visual and auditory distractions. The hectic environment simulated a closed-off brick room with uneasy lighting and threatening sounds, intended to induce stress.

Each participant was randomly assigned to one of these environments and underwent five separate trials. This repeated exposure was intended to ensure consistency across sessions and to observe adaptation effects. Upon arrival at the lab, participants were briefed about the study's purpose and procedure. They were then equipped with the VR headset and controllers and underwent a short practice session to familiarize themselves with the VR interface and the tasks involved.

During the experiment, participants were tasked with completing a puzzle involving 3D shapes reminiscent of a simple children's puzzle, like the one depicted in Figure 1. Utilizing the Quest 2's controllers to move blocks, the participants manipulated each of the virtual shapes to correctly match each shape with its desired location. Each of the five runs was limited to five minutes, ensuring that all participants reached a measurable output within each environment. This consistent time constraint was crucial for comparing performances across different environments. In each of the trials where the participants had to move the shape, we randomized the location of each block to minimize any learning bias for the participants.

Fig. 1. Children's 3D Geometric Shape Building Puzzle. [Public domain], via peachandpumkins. (https://peachandpumpkins.com/products/3d-geometric-shape-building-blocks).

This methodological approach enabled a thorough analysis of how different virtual environments influence cognitive performance and stress. By limiting each participant to a single environment but allowing multiple trials, we were able to minimize the variability between subjects and enhance the reliability of our findings. This setup offers valuable insights that could inform the design of virtual workspaces and therapeutic environments, while also advancing our understanding of human interaction with immersive virtual realities.

4 RESULTS

Participant	Scene	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Tom Hansen	Neutral	117.47	60.37	62.10	66.52	65.51
Charlie Hanlon	Neutral	148.73	64.78	78.78	61.18	56.54
Ashley Schuler	Neutral	67.87	69.14	62.73	60.73	57.99
Katie WIllard	Neutral	114.45	63.52	62.73	66.47	57.95
Abeeb Abdullahi	Beach	152.42	72.69	177.89	126.86	132.47
Omar Soliman	Beach	149.66	76.87	104.88	66.75	73.37
Bridget Kearney	Beach	79.91	71.96	66.59	72.39	66.57
Sagar Kothari	Beach	55.86	42.89	71.63	40.77	51.77
Bruen Johnson	Dark	83.24	60.52	46.21	47.21	61.51
Aaron Masih	Dark	110.87	71.09	60.01	68.17	55.86
Andrew Biron	Dark	73.00	58.33	40.05	52.13	40.12
Ben Ibarra	Dark	76.51	60.95	95.77	55.63	69.06

Fig. 2. Trial Times From Experiment

The analysis of our experiment involved comparing the time taken to complete the puzzle in each of the three environments: calming, natural, and dark. Our results indicated a distinct difference in performance across these environments. Notably, participants in the hectic dark scene recorded the fastest average completion times, while those in the calming beach scene had the slowest times. The results indicate that a neutral setting gives an average time to complete the experiment among the participants. Figure 3 illustrates the average trial time of all trials. The results show that the average time to complete the experiment decreases as the participant completes more trials. There is an outlier in trial 3 with a high time for the beach setting due to skewed data from one participant.

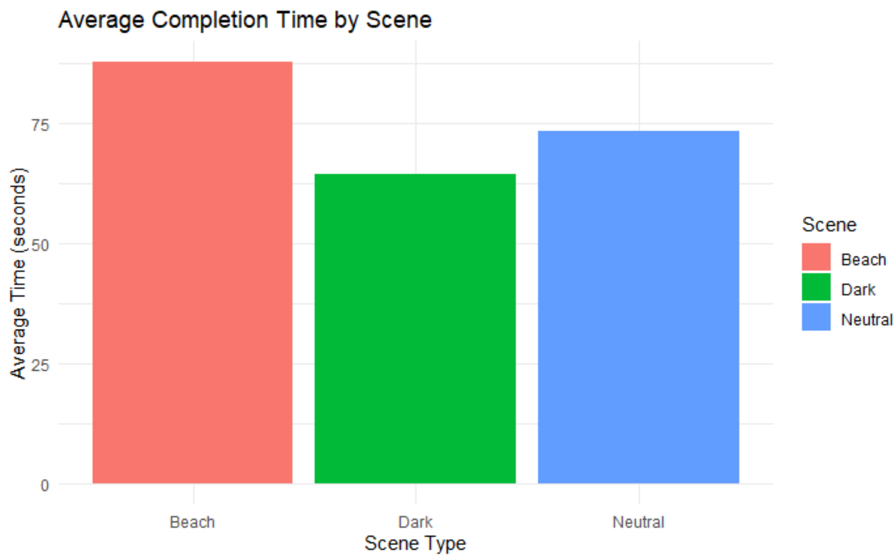

Fig. 3. Average Completion Time by Scene Bar Graph

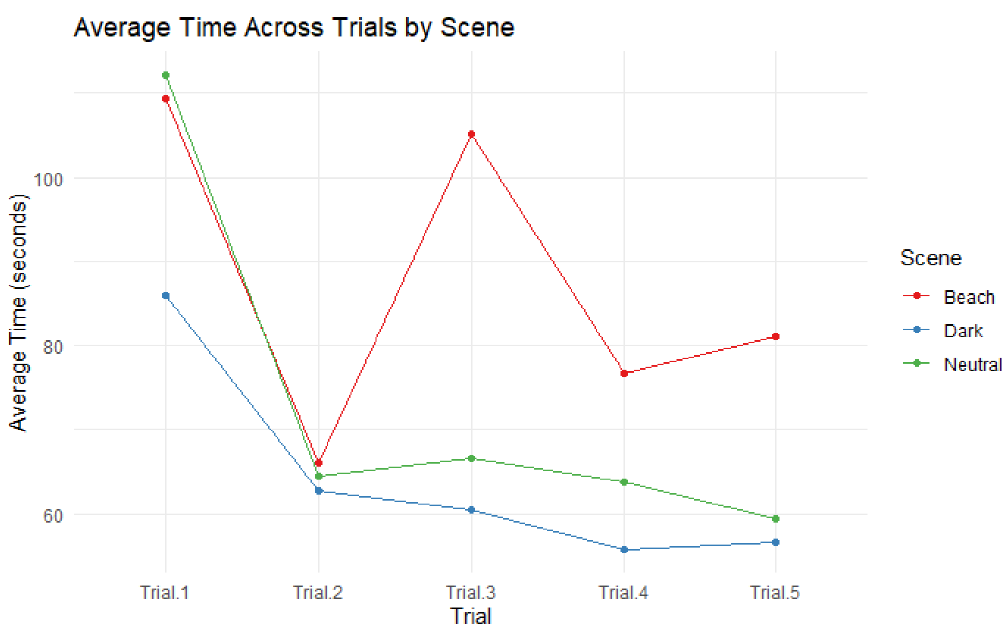

Fig. 4. Average Trial Times by Scene

5 DISCUSSIONS

The experimental results indicate that the type of virtual environment can significantly influence cognitive performance. Participants in the calming beach environment exhibited slower puzzle-solving times. This outcome might be attributed to the environment's relaxing nature, which may have reduced the participant's alertness and energy levels, leading to slower times. On the other hand, the dark room seemed to have created a sense of urgency or slight distress among participants. This might have triggered a more alert state, pushing them to complete the puzzle more rapidly. The quickened response times in this stressful environment suggest that some level of sensory stimulation or environmental challenge can prompt individuals to focus their cognitive resources better.

It's crucial to note that individual reactions to these environments vary. We believe this is because some individuals may prefer a less stressful environment, while others feel the opposite. This variation highlights the importance of considering personal differences when designing virtual environments for applications like work, therapy, or learning.

6 CONCLUSION AND FUTURE WORK

Based on the data collected from our study, we found unexpected results. Contrary to our expectations, participants in the calming beach environment did not perform better; in fact, they averaged higher completion times compared to the other environments. Surprisingly, the best performance was observed in the dark environment, which was designed to induce stress. These results suggest that factors such as individual coping mechanisms to stress or intrinsic motivation might have influenced the outcomes. Given the between-subject design of our study, it's important to consider that personal skills and predispositions could have skewed the data.

In light of these findings, future studies could adopt a within-subject design, allowing each participant to experience each environment at least once. This approach will allow for a clearer conclusion as to the actual effects that different virtual environments have on productivity. Additionally, exploring the creation of more immersive and varied environments may get an even better result. Through these methodological improvements and expansions, future studies can provide more conclusive evidence on the impacts of virtual environments, ultimately contributing to the design of more effective virtual spaces.

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