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Multitasking And Memory Attainment In VR

Research study assessing the ability to retain the order of a sequence of colors depending on the environment and audio cues surrounding them. The research was created and tested in a virtual reality setting.

CCS Concepts: • **Virtual Reality**; • **User Interface Controls**;

Additional Key Words and Phrases: Virtual Reality, Memory, Multitasking, Observation Study

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1 INTRODUCTION

Memory is an important factor in everyone's lives as it is constantly present and can have a great effect on simple tasks as well as large-scale problems. Memory is a subject that has often been studied, but the importance of determining the best way to maintain strong memories and retain visible stimuli is important to understanding the concept of memory at large.

Many studies have assessed what objects are easier to remember as well as the time frames that provide for the strongest memory, but the concept of atmospheric location impacting how well memory is retained is a subsection of memory that has received very little attention.

The importance of location to memory is a crucial aspect since it is always present when forming these memories, but also easily overlooked. The following study attempts to better analyze and interpret how these locations and settings can alter the reliability of memory in participants.

2 RELATED WORK

Some previous work on the topic of memory retention through VR is mainly oriented to simple memory attainment assessments done through VR, either using it to determine how well users can replicate certain motions with the controllers or simply picking the correct option. Many of these previous projects come from university student projects but tend to be more focused on using VR solely as an assessment tool and not using unique immersion of VR software to benefit their studies. One of the specific previous works I found revolved around showing users in VR a sequence of symbols and having them input them back at a station in front of them, the project I am proposing would have a similar basic framework but more focus on immersion in the environments affect their ability to remember the information being presented to them. VR headsets have also been found to be an especially delicate tool when it comes to replicating

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some of the reliability of physical space tests. According to [3], the interface and poor controls of virtual spaces were found to result in worse results than the same task done outside of VR. This brings into consideration the importance of having the processes streamlined and as accessible as possible to not alter test results due to the hardware present.

2.1 Situational Memory

Memory retention was also assessed based on the different ways that situations can be experienced through virtual reality. According to [4], it was found that the perspective of virtual reality being third person compared to a first-person perspective was found to increase the spatial memory and awareness of users. There have been plenty of studies looking into the memory recollection of users, but this more focused view on the perspectives that can impact various types of memory introduces a more in-depth and focused view of the larger concept. Similar to the perspective differences in memory retention, other studies have also looked at the existence of immersion on this subject. According to [8], it was found that changes to the amount of immersion present in VR impact the relative speed of memory tasks relying on finding previously seen objects in a virtual space. This once again analyzes more deeply the importance of how VR is administered in memory recollection and how changes in the interface can alter the results on memory.

Many other factors can either help or aid in the recall of memory such as Timing and location travelled. It was found by [1] that the amount of time between presentation and recall held a significance with VR having no effect on quick recall, but long-term recall tended to be less reliable in a virtual space. This difference in timing was important to consider as a long pause before recalling could throw off the reliability of the experiment. It was also found by [10], that the location of the user in VR and how much they were traveling held importance to recall and would affect how much was remembered in VR depending on how much the user traveled. The stress and environment that memory is assessed in were found by [5] to provide a significant impact on memory with stress being a negative factor. The differences between unsettling and stressful are quite large though, with some of these findings suggesting at possible findings.

2.2 Memory in 3D Spaces

Other previous works into the use of VR in the realm of memory assessments are shown through tests designed to view memory on a three-dimensional spatial plane where a location compared to a symbol had to be remembered. A study into these spatial memory tasks, [7], found that there were large variations in the ability of users to remember the location of a flag in a spatial arena setting depending on the strategies employed by those users in virtual reality. This study showcased the benefit of virtual reality in testing environments due to the large scale of virtual studies that can not be as easily replicated in a physical place. Studies have also taken this concept onto a much larger scale with participants being in a full virtual town. The study by [6] found the importance of the level of interaction in the virtual world to the amount of memory retained, as the participants who had to plan an itinerary and drive a virtual car in the world remembered much more than just being in the world without these tasks.

These 3D environments help assess memory close to a level as being in the non-virtual world, with [9] finding that simulated worlds can provide the same sense of embodiment and sense of presence that non-virtual worlds provide. With this sense of embodiment, it can more accurately be assessed how environments are affecting the users found in them. Sound cues are also an important consideration when it comes to VR interfaces. A study was done into the effect the presence of sound had on users with [2] finding that users would be more confident about recall with sound present compared to without sound. This led to the question of how different forms of sound could affect this recall.

3 METHODOLOGY

The project works on creating a memory assessment by showing people symbols on screens in VR in a specific sequence that they must work to remember long enough to input the sequence into a station with buttons to press that relate to the sequence. This general concept is always present throughout the project, but what changes to determine what factors affect this memory is: how easy it is to input the sequence on the final terminal, the environment the user is found in, and how long they have to wait before being able to input the sequence after witnessing it. This is a very new approach to this type of VR memory assessment, since previous ones tended to focus simply on the memory aspect without much variation in how their information was presented to the users. The different environments of my experiment are the focus of the project and give a good sense of what kind of environments are the best for longer memory retention and which environments are the worst for users to remember what they were shown.

The demo/prototype looks like memory games where people are presented with a short sequence of numbers or symbols and then asked to remember them well enough to repeat them back in the correct order. These sequences of symbols are to be shown on virtual screens of the same dimensions each time, and then the user is asked to repeat them back through the act of typing them in by pressing buttons with the VR controllers in the right order. The variables that change between this retrieval and assessment are the environments the users are immersed in as well as the time before submitting back the sequence. It uses a VR headset to take part in the experiment. The project is created in Unity engine from a blank template. The project is also mainly coded for HTC Vive controllers but also can be controlled by classic keyboard controls to help with ease of editing.

The experiment focuses on the differing environments and the amount of time between the original sequence and the user-entered sequence. The independent variable of the experiment is the sequence of symbols, including the number of symbols and the size of the in-software visualization of it. The dependent variables for the project are the environments the users are put into with some potential environments being noisy, scary, relaxed, and completely blank to get a baseline of how well the memory of the user is. The experiment has the same user first assess their memory in a blank environment without distractions or other stimuli. Then after this baseline is acquired the project seeks to determine how much better their memory retention is in various other environments and how long it takes for their memory to drop off in reliability. The final step of the experiment is to assess this memory drop-off time with a focus on how the environments of the users have affected their ability to retain information presented to them

3.1 Research Questions

My research focused on answering a few research questions concerning the impact of virtual settings and audio cues on the retention of memory of users. The first question was worded as, how does the memory retention rate differ (if at all) from the control situation without developed virtual environments compared to the altered environments? This question led to the second research question which focused on specific environments. The second question was worded as: How do the differences in virtual environments and various relaxing or unsettling atmospherical elements affect the memory retention of users? These two questions combined to guide much of the methodology and research of the project.

4 RESULTS

The experiment found that there was a significant difference in the memory retention of participants depending on which condition they were presented with. The control experiment tended to be the more mid-way point between

Table 1. Correctly Remembered Colours

Control Environment	Relaxing Environment	Unsettling Environment
6	9	5
8	6	4
5	6	5
7	10	7

the two other environments. The control environment resulted in an average of 6.5 colors out of 10 being correctly identified with some variance in the outcome depending on the participant.

The relaxing environment was the only variable that had any participant who got all of the colors correct when recalling them. It also had an average of 7.75 with some high values of individuals but also some values that did not change much from the base environment.

The unsettling environment had the worst results out of any of the variables, but still not bad results when it came to recall. The average amount of colors recalled in the unsettling environment was 5.25 which was just a bit lower than the average of the control environment. Attached above is a table with the amount correct of individuals in each of the 3 environments.

5 DISCUSSIONS

The findings of the research tended to show a trend that the relaxing environment in VR results in significantly higher rates of recall; while the unsettling environment had a smaller but not very statistically significant decrease in recall compared to the base environment. The findings show a strong connection with relaxing and calming environments with audio having a positive condition for individuals when recalling what they saw. The audio and environments were found to clearly have an impact on the recall of the user, but it really depends on the specific user in the end with certain users doing great at recalling no matter what environment they were put in. The overall trends and the averages of the users still show a trend of improved recall and memory retention of simple patterns depending on the environment. The general rule of our findings was the more relaxing and calming the environment was the easier it was for users to focus on remembering the pattern and recalling it when inputting it.

5.1 Limitations

The research project encountered many limitations and factors that made progress harder to achieve. One of the largest limitations that the project encountered was various bugs and issues found in Unity both when coding and when operating the research. The most common problems found when operating Unity were with project components changing between saving and reloading the project for some reason. There were some assets and items that would be rebuilt upon reload even when they were previously deleted and some of these issues would result in problems with controls and operation of users in VR. Most of these problems were solved by reloading multiple assets and making fine-tuning adjustments when problems arose.

Some of the other limitations of the project were found through the way the research was conducted and the nature of the smaller sample size which limited the scope and complexity of the research. A larger sample size would have helped address these limitations by providing more users to analyze the data. Also, the diversity in tech experience of

the users was limited and did not provide much insight into a larger population including those less experienced with technology.

6 CONCLUSION

In the present study, the aim was to understand the effects that these changes in environment and ambiance have on memory. The results show a positive trend between the environment's calming nature and the amount of memory retention that the user showcased. There were still some outliers in most of the variables and the causation can not be determined by the research that was done in this study, but there is a clear correlation shown between the environments and the user's memory ability. Further studies should be done to assess where this difference in memory retention comes from and what the absolute optimum environment for memory retention is.

7 FUTURE WORK

Future work on this research would be focused more on expanding the type of environments that are being tested as well as furthering the level of involvement of the participant. Future research could focus on providing the user with more ways to view the environment as well as interact with the memory-assessing devices with people having to interact more and move to look for what they are meant to remember. More environments would help to understand how small changes to the limited environments that I provided as well as new environments entirely contribute to new findings.

Further research focusing on the separation of audio and visual components would be beneficial to the research by removing some of the confounding variables to fully understand the extent to which the audio cues changed memory retention compared to just the overall environment the user was in. These changes and expansion to the research in the future would be quite beneficial to understanding and having much clearer statistics on how memory retention is altered by these variables.

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