Maze Experiment

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Experimental Design

Since the goal is to eventually move this experiment online, the constraints will now be determined by the participant number, as opposed to being determined by the researcher there with the participant. The constraints are: participant number, maze type (egocentric, allocentric, or both), condition (A, B, or C), timeout per maze, number of attempts, and number of perfect runs. Only one of the following needs to be completed to move from the training phase to the testing phase for each maze: timeout, number of attempts or perfect attempts. For the experiment, the user will run through fifteen mazes while listening and responding to audio cues as the condition dictates. If the researcher selected both egocentric and allocentric the user will complete an egocentric maze then an allocentric maze of the same design before moving to the next maze. The mazes are split into three sections of five mazes each in a randomized order. Each set of five has a separate audio type. Once the instructions and consent are given the participant will have five practice attempts on a practice maze. They will then have a training phase where they run through based on the constraints until finished. Once one of the constraints is satisfied, they will move onto the testing phase. In the testing phase they will have two attempts to run through the maze at a random starting location to test how well they have learned it. They will run through five mazes with allocentric audio cues, five with egocentric audio cues, and five with no audio cues (in that order). The goal of the experiment is to test the efficiency of maze solving with and without audio cues. The experiment seeks to see whether the audio cues reduce the performance on the maze solving. Once the experiment is complete the user will complete a survey. The survey currently asks for gender and number of hours of video games played a week.

Literature Review

The first research paper, titled Multiple Resources and Mental Workload written by Christopher D. Wickens[5], discusses multiple resource theory and how it can be used as a guideline in design, as well as a way of predicting workload overload. Multiple resource theory suggests that humans only have so many resources available at a certain time, that is, we can only really focus simultaneously on tasks which utilize different mental operations. An example of this is how we are able to listen to music and drive at the same time. Wickens goes on to talk about the results, which indicate that there is a strong correlation between what the theory predicted and the resulting data. This research is related to our experiment, given that it investigates MRT and how well people are able to accomplish tasks while multitasking. On the other hand, we are expanding on the current research on MRT by adding both egocentric and allocentric (or egocentric) perspectives in both the visual and auditory tasks required.

The second research article is Navigation in virtual environments using head-mounted displays: Allocentric vs. egocentric behaviors by Hadziq Fabroyir and Wei-Chung Teng[1]. This experiment used virtual reality headsets to show virtual environments in both egocentric and allocentric perspectives. There were also multiple types of input being tested with participants using either a gamepad or a multitouch screen to navigate and complete a given task. What was found is that there was a difference in preference and performance based on both gender and gaming experience. Females would often favor allocentric perspectives and tasks while males preferred egocentric. Also if a user was said to have past gaming experience they would almost always perform better in the egocentric environments. This experiment is different from what we will be doing as we will only be using one form of input for the user. Instead of testing forms of input we will be testing how their ability to solve a maze in different perspectives changes when given an audio cue to solve as well. We will be seeing how performance changes when a user has to multitask when solving a visual maze and an audio riddle. We will then be comparing it when they are just solving the maze as well as testing participants in different perspectives. This experiment conducted in this article gives us good ground for what to expect and we will see if we experience similar results between gender and video game players.

The third research paper is Allocentric and Egocentric Spatial Representations: Definitions, Distinctions, and Interconnections by Roberta L. Klatzky [3]. This paper was the first to create a formal definition for egocentric and allocentric perspectives. It also discusses how the brain interprets and derives these different perspectives. There are also empirical studies included on how well a person performs within the differing spatial views. This article is relevant to our research because it was the first study to thoroughly describe the egocentric and allocentric view from the human perspective. This article also shows how the human mind processes information differently through egocentric and allocentric viewpoints. This paper's research is different from ours because Klatzky focused on general definitions and in depth analysis on the views. Our research seeks to determine if egocentric and allocentric tasks affect a person's performance on solving a maze. By differing the view and tasks of the participant on egocentric and allocentric, our research can show which has the greatest effect on multitasking.

The next research paper we chose is titled Design Applications of Visual Spatial Thinking: The Importance of Frame of Reference by Christopher D. Wickens [6]. In it, he discusses the use of spatial cognition when performing tasks which involve the manipulation of an object which is in a different frame of reference. A frame of reference is defined by three axes of location and three axes of rotation. This forces the user to transform the frame of reference from what it is originally in, to what the user desires. Wickens goes on to describe the importance of this limitation on human cognition in relation to human performance and efficiency when it comes to these transformations. We can then apply this to our own experiment, when it comes to the audio cues being played from an egocentric or an allocentric perspective, and recognize the resources that are used when the frame of references changes. In the egocentric perspective, the user does not need to transform the frame of reference, and so theoretically performance with egocentric audio cues should always be slightly better than performance with allocentric audio cues.

In the paper Multiple resources and performance prediction by Christopher D. Wickens [4], the author describes how multiple resource theory(MRT) has taken account for dual task interference; also known as multitasking. Wickens discusses the origin of MRT which goes back to the bottleneck theory. This 'single channel bottleneck' is a neurological limitation on performing more than one high speed task simultaneously and is the basis for MRT. Wickens stated that the difference in efficiency could not be solely attributed to the quantitative demands but rather the qualitative demands of the task. He gives an example of this with a driver given audio tasks. This example is very close to our research with navigating a maze and answering audio cues. We wish to show how multitasking is affected by multiple resource theory with a significant difference in performance on the tasks given. This paper will support that having the audio cues playing while navigating the maze will affect performance. This paper is different from ours because it describes more of a history, creation, and examples of MRT. Wickens shows many examples of how this theory places a role in efficiency of tasks. Our research is seeking to be another example of how using multiple resources can affect performance.

The study Frames of Reference for Navigation by Chistopher D. Wickens [2], explores the use of different frames of reverence and how they perform in different tasks. These three tasks were movement control, awareness of surrounding, and finally map view in relation to a forward facing view. The two that are the most relevant to that of our experiment is movement control and awareness of surroundings. He states that navigation requires three forms of knowledge, where am I (ego state), where do I need to go (goal), and how do I get there(action). The last form of action is actually hidden in our experiment as the whole point is that they do not know where the goal is and how to get there as they are solving a maze. When Wickens did his testing on movement control, he found that immersed (1st) for most users it made the most sense than navigation from any other perspective. This is because it is a more natural and realistic approach and as such easy for people to learn and understand. When it comes to awareness of surroundings, the immersed view suffers, this is because of a looking through a keyhole effect. One is unable to see the full picture of one's environment and because of this suffers in navigation. This is especially true for solving a maze. To make top down harder when solved we had to also apply this keyhole effect, only allowing a small point of view for the user to see paths. Finally we have added to this idea of how to get to the goal. This is supposed to be hidden to the user in our experiment. While there are different options of this like a map we can not use this as Wickens did. We added a way of a sort of learning map with different sections being of different colors. This is so when learning the maze the user can hopefully recognize where they are.

Current Prototype

As of right now, we have a version of the application which is nearing completion of its initial design. The menu screens, including the title screen, maze creator screen, constraints screen, consent screen, instructions screen, transition screens, and survey screen are all done. The mazes and audio cues have been uploaded and implemented for the experiment. We also now have an automated data recording with a csv file. The constraints can be set through the menu or through a text file; the training phase of a maze can be completed through the number of attempts, number of perfect runs, or amount of time taken. The maze creator can be used as it is now to add a new maze to the experiment, whether that be the developers or the researchers making those additions; this screen is only available through unity. The scenes have been linked together, which currently allows the user to move on from the menu scene to a specified maze scene, chosen in the constraints. When the user loads a maze scene, a random maze is selected and generated in an egocentric or allocentric perspective, again depending on the constraints selected. Movement in both perspectives is complete. The egocentric, or first person, movement allows the player to press the W key to move and rotate their camera to the left or right with the A and D keys respectively. The allocentric, or top down, movement allows the player to move up, left, down, and right, with the W, A, S, and D keys. In both movement types, the player will move automatically to the next specified intersection upon one key input. During this they will also be answering audio cues; an audio cue will play and the participant will have three seconds to answer yes or no with the y/n keys. After one of the constraints set has been reached the participant will move from training to a testing run. In the testing run the participant will be placed at a random spot in the maze to test how well they have learned the maze. We have also completed the survey screen which will record in the csv gender and hour of games played a week. The executable will run on Windows and read the participant number from a file in the same path. Due to something called Translocation, there are issues with running the executable on MacOS.

REFERENCES

[1] Hadziq Fabroyir and Wei-Chung Teng. 2018. Navigation in virtual environments using head-mounted displays: Allocentric vs. egocentric behaviors. *Computers in Human Behavior* 80 (2018), 331–343.

[2] Daniel Gopher and Asher Koriat. 1999. *Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application*. MIT Press. 113–144 pages.

[3] Roberta L Klatzky. 1998. Allocentric and egocentric spatial representations: Definitions, distinctions, and interconnections. In *Spatial cognition*. Springer, 1–17.

[4] Christopher D Wickens. 2002. Multiple resources and performance prediction. *Theoretical issues in ergonomics science* 3, 2 (2002), 159–177.

[5] Christopher D Wickens. 2008. Multiple resources and mental workload. *Human factors* 50, 3 (2008), 449–455.

[6] Christopher D Wickens, Michelle Vincow, and Michelle Yeh. 2005. *Design Applications of Visual Spatial Thinking: The Importance of Frame of Reference.* Cambridge University Press.