Gaze Tracking with Path Markers in 2-Dimensional Mazes

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ABSTRACT

A study is reported on the time it takes participants to complete 6x6 square mazes based on the inclusion of path markers. In the experiments the participants use their eyes to navigate the mazes. Half of the participants navigates through mazes with path markers, while the other half navigates through mazes without path markers. We believe the information from this study can be insightful regarding how directional information affects pathfinding.

KEYWORDS

Wayfinding, Mazes, Path Markers, Gaze Detection, Eye Tracking, Fixation Duration

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1 INTRODUCTION

With the advancement of mapping technology, wayfinding technology, and visual search engines, it is important to know how people react and interact with the technologies on a basic level, so it can then be given a much broader application. It has been previously shown that visual cues and guides can lead to a more accurate visual search [2] or a shorter completion time on mazes in virtual environments. [10] But with the ever growing complexity of wayfinding in real-world applications, more complex methodology is needed. However, in order to establish a good foundation for the advancement of wayfinding on a large scale, there needs to be an establishment of wayfinding on a small scale.

Here, we will attempt to discover how much of an improvement simple pathmarking arrows make on the completion time and fixation points of a simple two-dimensional maze. The hypothesis is that there will be a significant reduction in completion time for the mazes that include marked pathways compared to those with no visual clues whatsoever. Paths will also be more direct without shifting and alternating focus to look ahead when the markers will guide the subjects along.

2 BACKGROUND

When a person is presented with a map, maze, or other task where the goal is to navigate to a certain point, pathfinding is an essential skill. Path markers have been shown to speed up the process of finding the way from Point A to Point B [7, 10]. This includes the use of arrows pointing in the direction the person needs to travel [1]. Arrows and other directional path markers have been used extensively in mapping technology, providing directions, and guiding navigation through an area such as an airport terminal [1, 4].

Directional guides have also been shown to reduce the time spent searching around to find the necessary path [8], and the length of pauses deciding which direction to take [2, 3]. When given clear visual instructions, people are able to more quickly find and take the correct path. Even in a simple search to find an object in an environment [6] or simply on a screen [5, 9], visual guides are useful to reduce both the time spent searching and the number of fixations used to search.

The most basic form of pathfinding is through a simple maze, and there is established literature showing how visual cues can assist people in a virtual reality environment, and the more clear the cues are, the less time and fewer fixations it took the participants to accomplish their goals [5]. Subjects were shown simple digital mazes and tasked with reaching a center point. The mazes were colored and some visual guides included a dynamic arrow pointing towards the center. Others involved simple static arrows.

This can be simplified even further to a very basic two-dimensional maze. This study will be employing simplistic black and white mazes. Some will be plain, others will have arrows guiding subjects through the maze. In order to further advance the broad and complex studies in pathfinding using visual cues, here using arrows through the mazes, the most simple and basic form must be studied as well. A foundational approach will lead to broad advancements in the fields of mapmaking, building design, and navigation. Further research can build upon the basic foundational theories to further advance the more dynamic and complex designs used in modern technologies.

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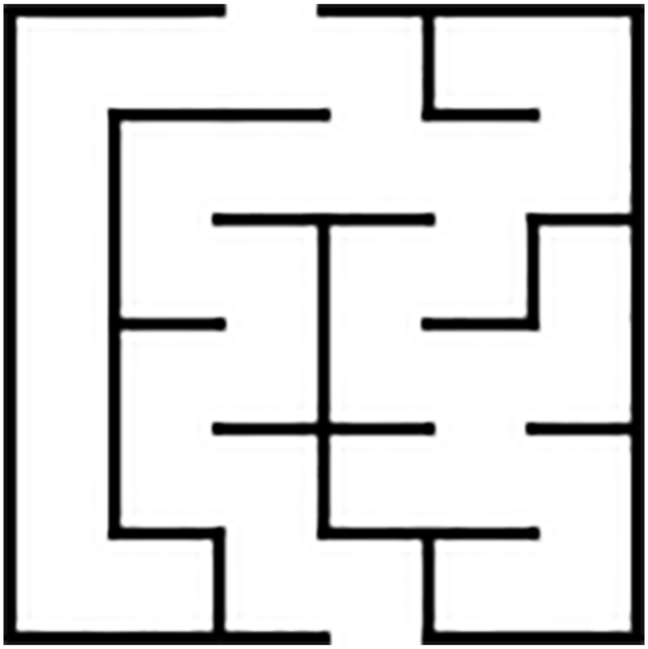

Figure 1: The first maze shown to Group A during the study.

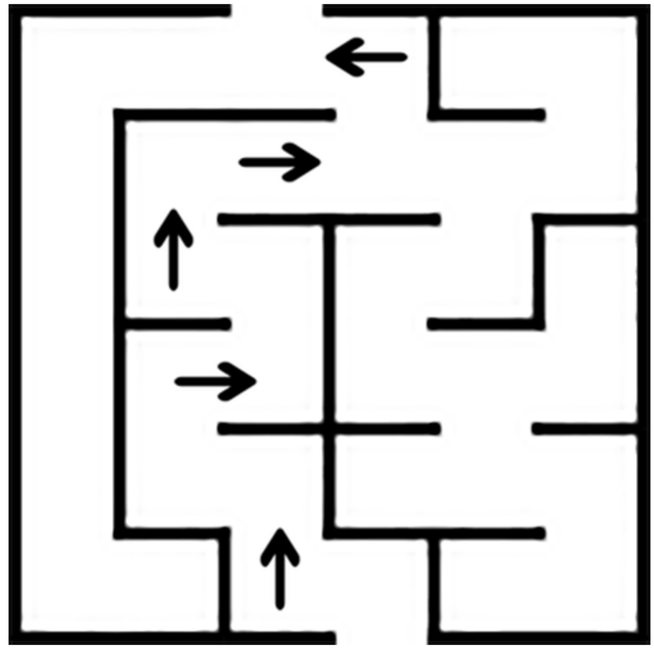

Figure 2: The first maze shown to Group B during the study with added arrows.

3 METHODOLOGY

3.1 Apparatus

The eye tracker that is used in the study is the Gazepoint GP3 eye tracker. The Gazepoint GP3 eye tracker has a 0.5-1 degree of accuracy, an adjustable sampling rate of 60Hz, and tracks movement within a 35 X 22 cm range. The eye tracker uses 5 point calibration. The experiment also uses a Dell 1680 x 1050, 22-inch desktop monitor. The monitor is used to display the maze. Key-press responses are made on the computer keyboard.

3.2 Stimuli

The stimuli for the experiment are three 6x6, two dimensional mazes. One group will be shown the three mazes without any pathmarkers added (Figure 1), and the other group will be shown the same mazes with arrows added on as pathmarkers (Figure 2). Each maze is a static image and will not be changed until the participant has completed the maze. One of the members of the study will notify the participant when it is time to begin the maze. Once the participant completes all of the mazes, they are told to stop which will signal the end of their participation.

3.3 Subjects

The subjects of our study are 20 undergraduate students from Clemson University. The subjects of the study are chosen at random. Since the study relies on vision and gaze tracking, only sighted individuals are able to participate in the study. The study does not have any other requirements nor does it prefer participants that belong to any specific sex, gender, race, or other demographic.

3.4 Experimental Design

This is a 2x3 experiment. The participants have to complete three mazes in total. We used two experimental conditions: direction-coded condition and uncoded condition. In the direction-coded condition, the mazes contain five arrows that point in the direction to lead the participant out. In the uncoded condition, the mazes are standard mazes without any arrows. The independent variables are the number of mazes to complete, the maze shape and design, and all mazes in the coded-direction condition contained five arrows. The dependent variables are completion time and area of fixation. This experiment is actually done with a mixed design due to the fact that we include elements of both between-subjects and within-subjects. During the course of the study, half of the participants will be shown the mazes with path markers, named Group B, while the other half will be shown mazes without path markers, designated Group A. The between-subject component lies in the inclusion of the arrows in the mazes shown to Group B. The within-subjects component comes from the fact that the study structure is consistent between both groups apart from the single addition of the arrows in Group B.

3.5 Procedure

Participants are first given a consent form to read and sign before we conduct the experiment. Afterwards, the participants will be asked to sit up straight in front of the computer and complete a calibration for the eye tracker. The participants will then be instructed to use their eyes to complete each maze, starting from the bottom to the top, and press the spacebar when finished to record the completion time and move on the the next maze.

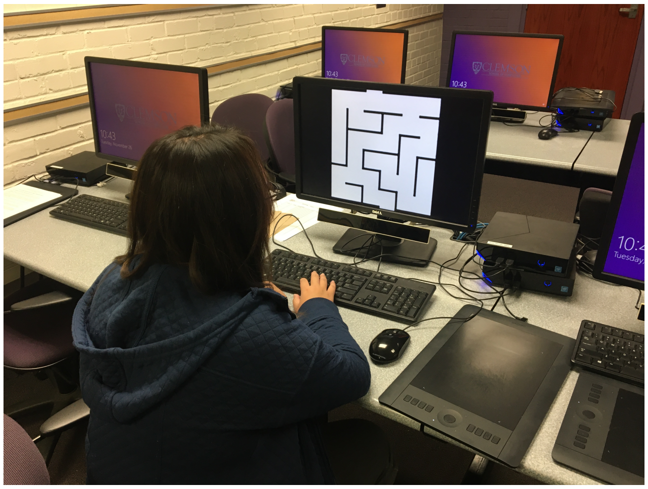

Figure 3: One of the participants of Group A in the middle of the study.

4 RESULTS

Our results show that on average, the amount of time taken to complete the mazes was reduced when the participants were given path markers. For maze 1, we saw a decline in completion time from 41.4 to 35.87 seconds. For maze 2, we saw a small increase of 37.75 to 39.74 seconds to complete the maze. The completion time for maze 3 decreased from 36.96 to 26.95 seconds.

We used a measurement of FPOGD to record the duration of fixation. On average, we found that the FPOGD measurement decreased when the participants were given path markers. In our study, group A's duration of fixation was 3.75 seconds while group B's duration was 3.42 seconds.

Even though completion time and fixation duration decreased from group A to group B, our ANOVA results also conclude that the variance is not significant. The p-value of our experiments is .903, which shows that our results are not significant. Our results also had an f-value of .02. Since our ANOVA results show that our data is not significant, we cannot say our experiment proves or disproves our hypothesis.

5 CONCLUSION

In conclusion, we were unsurprised to find that Group B's maze completion times were shorter than Group A's due to the arrow path markers added to those maps. That outcome was mostly expected since prior research indicated that overall time to complete would decrease with the addition of pathmarkers into the maze. However, there were some issues relating to outlying variables that would impact the results of our study by slightly altering the values. The best example of this is how Group B's average completion time for maze 2 which was a few seconds longer than the average of Group A. This happened because of one user in Group B taking around eight seconds total to complete maze two and that larger value skewed the overall average time for that maze due to either incomplete understanding of the instructions or ineffective explanation of the instructions on how to proceed. Despite this, the average time taken

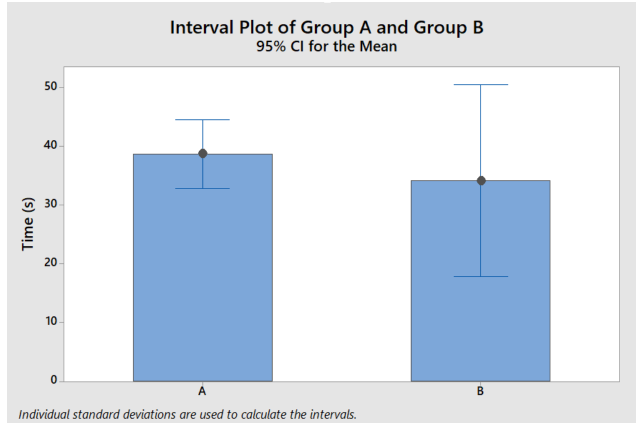

Figure 4: The ANOVA results for the average times for each of the 3 mazes. p = ns

to complete maze 2 was the only one effected by this change and shined a light on certain aspects that we could do to improve this study for future expansion.

The results of this study, despite not being as significant as we had hoped, still reiterated our original thesis regarding how path-markers can cause overall completion time to decrease. However, it also brought to our attention some changes that we will have to make if we choose to continue this study going forward. We will make changes to the presentation of the instructions for how to progress through the study since many participants were confused at first, expecting the progression to be automatic despite previous statements saying to progress with the spacebar. We will also take further steps to implement a better evaluation technique to gauge how accurate participants were in completing each maze. There was a plan in place at first to implement this with a grid structure as well as various formulas that would help calculate the accuracy of each maze, but due to time constraints and scheduling we ran out of time to utilize this form to analyze our data. Finally, we will explore into expanding this application into more complex mazes to get a better comprehension of exactly how useful these pathfinding mechanics are in a 2D space. Overall, this study helped reaffirm past research regarding the usefulness and efficiency of pathmarkers, and added another stepping stone in the path this line of research is building in the world of eye tracking.

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