

Examining Effective Navigational Learning Strategies for the Visually Impaired

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This study focuses on navigational learning strategies and the influence they may have on participant's memory recall accuracy. Peripheral vision loss was simulated using eye goggles and replicating the experience of peripheral vision loss due to biological factors such as aging or eye disease. This study hopes to determine if there is a favorable navigational learning strategy when trying to navigate a new environment with compromised vision. Participant's explored an unfamiliar lab space where they were asked to determine the location of five various colored objects. The participants were asked to explore the lab space twice using a different navigational learning strategy each time. Each participant was then asked to perform three post tasks to determine the participant's memory recall accuracy. Our hypothesis was that the navigational learning strategy that involved object-linking would have the least amount of error during the recall. Our results showed that there was a trending effect in one of our three post tasks to support our hypothesis. This research may contribute to determining if there are more favorable navigational learning strategies when attempting to acquire knowledge of a new environment with peripheral vision loss.

INTRODUCTION

Visual impairments can cause many complications and difficulties for people in their day to day lives. Knowing which navigational learning strategies best assist patients that are visually impaired will help with many factors during the adjustment period patients will go through while experiencing loss in their field of vision (FOV). This study will investigate whether different navigational learning strategies will have an effect on the accuracy of recalling object locations from memory. The study will also factor in the patients' field of vision loss to see if these navigational learning strategies have a more profound impact for a patient with a greater severity of vision loss. Our hypothesis is that the navigational learning strategy that involves object-linking will have fewer errors when the participants are attempting to recall the location of the objects. Object-linking is the process of establishing a connection between two objects, and we believe that having the interaction with the objects will help the participants with recalling the object positions.

If we can find that one navigational learning strategy is superior to others in assisting a patient to more accurately locate an object in a new environment, then we can greatly reduce many of the complications and difficulties associated with the adjustment period these individuals go through while experiencing loss in their field of vision such as physical, emotional, and psychological stress these patients must endure due to their sudden loss of vision. Quillen, (1999) explained that "vision loss among the elderly is a major health care problem. Approximately one person in three has some form of vision-reducing eye disease by the age of 65. The most common causes of vision loss among the elderly are age-related macular degeneration, glaucoma, cataract and diabetic retinopathy." (p. 99-108). With this many people experiencing some form of eye disease that causes vision loss, learning which navigational strategies are most efficient in recalling object location in a new environment will be of great importance when working with patients.

There have been other research studies performed using clinical patients with low vision. Simulating the experience allows us to have more control over the vision loss while clinical patients with low vision are extremely variable. Independent spatial orientation is a problem for many people with visual impairments, and more so for some than for others. Skillful orientation requires information-processing strategies that are aimed, for example, at locating objects in unfamiliar environments and keeping up to date on self-to-object relations while exploring familiar and unfamiliar environments. For many people with visual impairments, learning and traveling in unfamiliar areas can be difficult and stressful (Barth & Foulke, 1979).

Hill and Reiser created a study allowing the participants to choose their own strategy while exploring and observing a novel space. They then compared the strategies used by the group of participants that judged the location of the objects accurately against the group of participants that judged the location of the objects inaccurately. Hill et al. (1993) determined that once objects have been located within a space, strategies can be implemented that facilitate the learning of the objects' locations relative to one another. A study by Tellevik (1992) extended the work on exploration strategies with blindfolded subjects whose vision was normal. The subjects were asked to find four target objects located in the open space of a room and were tested under two conditions. In the first condition, they were taken to a living room of a house and asked to locate four target objects in the middle of the layout. In the second condition, which occurred the next day, the subjects were tested on a similar task in the same room but with the target objects rearranged. Both conditions were videotaped, and the spatial exploration patterns were observed--the perimeter method, the gridline method, and the reference-point strategy (defined as a directional change of a subject when contacting a target object or departing from a wall of the room at angular directions other than 90 degrees).

The study completed by Hill and Reiser focused on strategies for locating objects in a novel space, determining

which strategies were most effective by comparing which were used by those participants that judged the location of the objects more accurately and those strategies that were used by participants that judged the location of the objects less accurately. The study presented here concentrated on just two learning strategies. The first strategy focused strictly on observing the objects while staying along the perimeter of the room (the “Perimeter” strategy), and the second strategy focused on a perimeter to object strategy allowing the participant to move between the perimeter and the objects (the “Perimeter-to-Object” strategy). Our study compared navigational learning strategies to determine if one strategy is more effective than the other.

In our study the order of strategies was counterbalanced across participants with half of them performing the perimeter test before the perimeter-to-object test and the other half of the participants performing the perimeter-to-object test before the perimeter test (described in more detail below). The study presented here will also be comparing participants to see if those who are asked to use the perimeter strategy condition prior to the perimeter-object strategy condition will perform more accurately when locating the objects than do the participants who were asked to use the perimeter-object strategy condition prior to the perimeter strategy condition (i.e., assessing the effect of the order of the conditions). Looking into this could show us if there is a significant difference in the accuracy of object location between strategies when comparing one strategy order against the other. Tellevik found in his experiment that participants performed better when already familiar with the environment they are exploring. Tellevik had subjects with 20/20 vision blindfolded during his research. In one condition the participants utilized the perimeter and gridline search patterns more frequently than they did a reference-point strategy while exploring the novel space. In the second condition the participants explored the same novel space but with the target objects rearranged. In the second condition the participants utilized a reference-point strategy more frequently than either the perimeter or gridline strategies. In the second condition, there was little need to utilize the perimeter and gridline strategies because the subjects were already familiar with the task and space and therefore were able to quickly implement an object-link type of strategy.

There are no definitive studies that have tested these navigational learning strategies while implementing two different degrees of field of vision loss. This study will determine if there is a direct relation between the severity of the participant’s field of vision loss and the effectiveness of one strategy over another. We hypothesize that the navigational learning strategy that involved object-linking would have the least amount of error during the recall. We also expected that the effectiveness of the strategy would be greater in the more restricted FOV condition.

METHOD

Participants

All of the participants were undergraduate students from the University of Utah. 20 participants completed the experiment with thirteen of them being female and 7 being male. The average age was 20.3 (SE=.91). Nine participants completed the perimeter first strategy order and 11 participants completed the perimeter-object first strategy order. Nine participants completed the task wearing the 60 degree goggles and 11 participants completed the task wearing the 10 degree goggles. All participants were compensated for their participation in the experiment through credit for school or a monetary compensation.

Materials

The equipment used for this experiment included 4 pairs of goggles and 5 different colored bean bags. There were also various other supplies needed for measuring out the lab area as well as marking the spots in the lab where the bean bags would be placed. The goggles were designed to have monocular viewing, with one side completely covered while the other side of the goggles have a hole cut out of the lens. Each participant was given a dominant eye test to determine if they are right eye dominant or left eye dominant. Left eye dominant participants were given a pair of goggles with the right eye completely covered and vice versa for right eye dominant participants. Both left eye dominant goggles had different sized holes cut into the left eye lens. One allowed the participant to be able to see with 60 degrees of their field of vision, while the other pair allowed the participant to only see with 10 degrees of their field of vision. Although the intended field-of-view for each set of goggles was 10 degrees and 60 degrees, we observed an average FOV for the small goggles of 18.28 (SE=1.6) and for the wide goggles of 75.8 (SE=8.37). This slight imprecision has been observed in other studies such as the one performed by Barhorst-Cates, Rand, and Creem-Regehr (2016) and may reflect between-subject variability in head size, height, or other factors. The objects that the participants observed were different colored bean bags. These various colored bean bags were placed around the room in a pre-designed fashion. Each of the bean bags was the same size and shape. The bean bags differed only in their coloring. The colors red, blue, green, yellow, and orange were used for this study.

Procedure

This experiment consisted of two separate rooms. Participants were unable to see into the lab room where the actual experiment was taking place. A door was used to separate the two rooms. The participants were first administered a demographics form and a consent form. Upon completion of these two forms each participant was then given a brief description of the experiment. Three eye tests were also performed with each of the participants prior to beginning the experiment. The first of the three eye tests administered was the dominant eye test. This test was administered to determine which goggles the participant would be wearing. If the participant tested left eye dominant then they were given goggles with a hole cut in the left eye lens and vice versa for

right eye dominant participants. The second of the three eye tests administered for each of the participants was the vision test. This test was administered to ensure that each of the participants had natural 20/20 vision or corrective eye surgery/glasses giving them 20/20 vision. The third eye test administered is an aperture test to determine the degree of vision in which the participant is experiencing. For the participants using the goggles designed for 10 degrees a measurement of the height of their eye from the ground was taken. For the 10 degree vision goggles the participant was asked to look through the goggle at a small black circle measuring 5 inches in diameter on the wall. Two measurements were taken of the distance between the participant's eyes and the wall as soon as the participant has moved to a position where the black circle on the wall completely filled the hole cut into the goggle lens. For the participants using the 60 degree vision goggles the participant was asked to look at a large black circle on the wall measuring 58 inches in diameter and to move toward the wall until they could no longer see anything other than the black spot on the wall through the hole in the goggle lens. For the 60 degree aperture test two measurements were also taken for the distance from the wall to the participant's eye with the average distance taken.

After the completion of the three eye tests each participant was given an explanation of all three tasks that they would be given at the end of each navigational learning strategy condition. The first of these three tasks is the Dead Reckoning task where the participant was lead back into the lab space with a blindfold on, and asked to stand in the center of the lab space pointing to each of the objects. Each participant was asked to use a two-step verbal response when determining the location of where each object was. The two step verbal response included a quadrant and a degree system using a front-left quadrant, front-right quadrant, left-back quadrant, and a right-back quadrant, as well as the degree to which they believed the object to be located inside of the quadrant ranging between 0 degrees and 90 degrees. Each participant was given an explanation on how to respond using the quadrant and degree system. The second task explained was the JRD task (Judgement of Relative Direction). For this task rather than having each participant stand and point to an object from a position in the middle of the room, the participants were led to each of the objects in turn. The participants were then told which colored object they were standing on, as well as which colored object they were facing. From there the participants were asked to use the same quadrant and degree system as before, as well as to continue responding with the same two step verbal response. The third task explained to each participant was the spatial map task. In this task the participant was asked to locate on a paper scaled down map of the lab room where each of the different colored objects were located by placing a mark on the scaled down map where they believed each object to be, as well as an indicator as to what color each object they marked was. After the participant received an explanation regarding all three tasks to be performed the participant was then asked to put on the goggles and was led out into the lab area. The participants were asked to keep their eyes closed until they

were in the exploration area and then the participant was given five minutes to explore the lab space. The navigational learning strategy order determined whether the participant would be told to stay along the perimeter during the entirety of the 5 minutes or whether they would be allowed to move from perimeter to object during the 5 minute exploration. Once the five minutes lapsed the participant was led back into the prep room.

The participant was then administered a Subjective Units of Distress (SUDS) test to determine their level of anxiety (rating from 0 to 100) while exploring the lab room. The participant was then blind folded and led back into the lab room. The participant was then asked to complete the Dead Reckoning task. After completion of the Dead Reckoning task the participant was led through the JRD task. Upon completion of these two tasks the participant was led back into the prep room. Once in the prep room the participant was asked to perform the spatial map task. The participant was then asked to put the goggles back on and was led again into the lab room. The participant was given another five minutes to explore the lab area, however this time the participants were asked to perform the exploration using the strategy condition they had not yet performed. Those participants who performed the perimeter strategy were told they could now move from the perimeter to the object, and those who performed the perimeter-object strategy condition first were now told they must stay along the perimeter during their exploration. After the five minutes were up the participant was led back into the prep room. The participant was once again administered a SUDS test to determine their anxiety level during the exploration. After the SUDS test the participant was again blindfolded and led back into the lab area where the participant was again asked to complete both the Dead Reckoning task and the JRD task. After completion of these two tasks the participant was again led back into the prep room. The participant was then asked to complete the spatial map task once more.

After completing the tasks for the second strategy condition the participants were then administered two post assessments/questionnaires called the Santa Barbara Sense of Direction questionnaire (SBSOD, 2002) and the Lawton & Kalai International Wayfinding Strategy Scale (Lawton & Kalai, 2002). These post assessments were questionnaires designed to determine what each participant thought of their own level of skill in orientation. Upon completion of these two post assessments the participants were debriefed and offered answers to questions they may have regarding the experiment.

RESULTS

Results

Dead Reckoning Pointing Error. We ran a repeated measures Analysis of Variance (ANOVA) on pointing error with strategy condition as a within-subjects factor and vision condition and strategy order as between subjects' factors. There was no significant difference between the perimeter strategy ($M=17.78$, $SE=1.37$) and the perimeter-object

strategy ($M= 16.27, SE=2.08$) ($p > .60$). There was no strategy condition X Vision condition interaction, suggesting that the difference in pointing error between strategies was the same for both vision conditions. There was no strategy condition X strategy order interaction, suggesting that the difference in pointing error between strategies was the same for both strategy orders. No other main effects or interactions were significant ($ps > .1$). There were also no differences in vision condition ($p=.12, \eta_p^2 = .145$), such that participants in the 10 degree goggles performed similarly ($M=15.32, SE=1.41$) to those in the 60 degree goggles ($M=18.72, SE=1.51$). There were no relationships between either of the self-reported measures (Santa Barbara Sense of Direction scale and Lawton and Kallai International Wayfinding Strategy Scale) and pointing error in either strategy ($ps > .45$).

Judgement of Relative Direction Pointing Error. We ran the same repeated measures Analysis of Variance (ANOVA) with strategy condition as a within-subjects factor and vision condition and strategy order as between-subjects factors. We used average Judgment of Relative Direction Pointing Error as the outcome variable. The analysis revealed a trending effect of strategy condition ($p=.107, \eta_p^2 = .154$), such that error from the perimeter condition ($M= 31.35, SE=3.32$) was greater than error from the perimeter-object condition ($M=26.78, SE=2.88$). This trending effect supports our hypothesis that the perimeter-object strategy may be a more effective learning strategy. This effect was qualified by a significant interaction between strategy condition and strategy order $F(1,16) = 9.728, p < .01, \eta_p^2$ squared = .378). In examining the post hoc contrasts, we observed that the significant difference between perimeter ($M=34.67, SE=4.53$) and perimeter-object ($M=21.73, SE=3.93$) was present only for those participants in the perimeter-object first strategy order. For those who completed the perimeter first order, there was no difference between perimeter ($M=28.04, SE=4.85$) and perimeter-object ($M=31.82, SE=4.21$). This suggests that participants who completed the perimeter-object strategy first performed very well on the perimeter-object strategy and then relatively much worse on the perimeter strategy. There were no relationships between SBSOD or the Orientation subscale of the International Wayfinding Strategy Scale on either strategy JRD error ($ps > .3$). However, we did find a significant relationship between the Route subscale of the IWSS and perimeter JRD ($B = -1.856, Beta = -.507, p < .023$). For every one unit increase in the Route subscale, Perimeter error JRD decreased by 1.86 units.

Subjective Units of Distress. We ran the same repeated measures Analysis of Variance (ANOVA) with strategy condition as a within-subjects factor and vision condition and strategy order as between-subjects factors. There was no difference in self-reported anxiety between the two strategy conditions ($p > .3$). There was also no strategy condition X vision condition or strategy condition X strategy order interaction ($ps > .7$). However, there was a significant three way interaction between strategy condition, vision condition, and strategy order $F(1,16) = 5.378, p < .04, \eta_p^2 = .252$.

Map Data Results. There was no difference between perimeter ($M=13.75, SE=1.00$) and perimeter-object ($M=13.40, SE=1.55$) strategies in overall Euclidean distance error ($p=.92$) and no other main effects or interactions ($ps > .1$).

DISCUSSION

In our study participants explored an environment using both a perimeter only strategy condition and a perimeter-object strategy condition. The participants were then tested on their memory recall accuracy using the three post tasks Dead Reckoning, Judgement of Relative Direction, and the Spatial Map task. We found that the results regarding the task Judgement of Relative Direction (JRD) were supportive of our initial hypothesis. When we analyzed the data using the average Judgment of Relative Direction pointing error as the outcome variable the results supported our hypothesis that the perimeter-object strategy may be a more effective learning strategy. These results showed that participants located the objects with greater accuracy when using the perimeter-object strategy than they did when they used the perimeter strategy. An observation during the analyses worth mentioning is that the increased accuracy during the JRD task was significant only when the participant completed the strategy order with the perimeter-object strategy first and the perimeter strategy second. This may be due to participants using object-linking strategies initially performing worse when forced to use a more restrictive strategy. This finding relates closely to what was mentioned earlier regarding Tellevik recognizing similar relationships during his study between accuracy and object-linking strategies.

Each participant was asked to complete two surveys at the conclusion of the experiment. When comparing the data analysis of these survey scores from the route subscale of the International Wayfinding Strategy Scale with the overall pointing error of the perimeter strategy JRD task we found some interesting results suggesting that people who self-reported better route reliance performed better on the JRD Perimeter condition. This could mean that individuals who follow routes well are successful at locating objects without extensively interacting with them. This was the only condition found during the data analysis where there was a significant correlation between those participants that self-reported to being good with directions and performing with a high level of accuracy during the post tasks Dead Reckoning and JRD. There were no significant differences found during the analysis between strategy conditions in overall Euclidean distance error on the map test. The coordinates where the participant placed each object on a scaled down map were compared to the actual coordinates, and results were compared between perimeter strategy and perimeter-object strategy. Although there were no significant differences found it should be mentioned that the data for the spatial map task was limited to just 12 participants of the 20 that participated in the experiment due to experimenter error, which may or may not have affected the results.

One confounding variable that may have had an influence on the experiment is that the overall pointing error for some of the participants may simply be the result of having

a good memory rather than the strategy condition they used. Some limitations that may have had an influence on the results are the number of participants, the number of objects that were located, and the size of the novel room the participants were asked to explore. Variations in any of these could potentially have an impact on the results, also increasing difficulty could potentially lead to larger differences in the strategies. Overall, the results that we found during this study show that there was not much of a difference between the perimeter strategy and the perimeter-object strategy in regards to the Dead Reckoning Pointing error average and the Judgement of Relative Direction Pointing error average with the exception of the significant difference observed between the two different learning strategies of perimeter and perimeter-object when the participant was in the perimeter-to-object first strategy order. There was, however, a trending effect supporting our hypothesis that when suffering from peripheral vision loss, using a strategy that involves interaction with the object rather than just distant observation of an object will help decrease memory recall error.

Conclusion

This study has helped to improve our understanding of how one navigational learning strategy may be more effective over another for the visually impaired when exploring a new environment. This study showed that there is a correlation between those who rate themselves a good at route finding and those who scored well when exploring the room using a perimeter navigational learning strategy. Our hypothesis was partially supported, showing that when the participants were allowed to interact with the objects during their exploration of the lab area they were more successful in determining the locations of the objects during the memory recall tasks, at least with one of the tasks. This research could have an impact on how we help those who are losing their peripheral vision by teaching them the most efficient navigational learning strategies.

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