Motion Parallax and Angle of Declination as Visual Depth Cues in Low Vision Navigation

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ABSTRACT

BACKGROUND INFORMATION

Safely and effectively navigating on foot through the everyday world is a concern of primary importance, and individuals with low vision face a unique set of challenges when navigating complex environments. Past research has indicated that motion parallax and angle of declination may be especially useful cues for individuals with low vision. [1]

MOTION PARALLAX: Motion parallax refers to the phenomenon that when a viewer moves through an environment, surrounding stationary objects shift on the retina. The speed and direction in which these objects move, along with their relative size, provide the viewer information about the relative depths and locations of the objects. [2]

ANGLE OF DECLINATION: Angle of declination refers to the position information we glean through the vertical position of an object in the visual field in reference to the horizon line. Typically, objects that are further away from the viewer tend to sit higher up towards the horizon line, and objects that are closer to us sit lower down. [3]

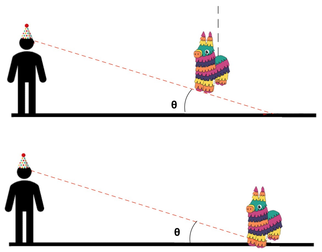

Figure 1: In the top image, the viewer perceives the piñata as sitting on the ground, at a greater depth than it truly is hanging at. The second image shows the position the piñata would be at if it were on the ground, with the same angle of declination, θ.

INTRODUCTION

CURRENT STUDY

- While research has been done regarding the motion parallax and angle of declination, almost no research has been done focusing on the intersection between motion parallax, angle of declination, and relative distance.
- Existing research examining these cues is overwhelmingly focused on subject groups with normal vision.

The current study aims to test the utility of both motion parallax and angle of declination as visual cues in low vision participants.

The project is an extension of the dissertation of Dr. Siyun Liu, which used a similar design, but examined motion parallax independently and simulated low vision in fully sighted participants. [4]

HYPOTHESES

H1: Lateral movement will result in more accurate relative distance estimations.

H2: Target object elevation will affect the accuracy of relative distance estimations.

METHODS

PARTICIPANTS

N= 8 participants with low vision were recruited. Eligibility was determined based on visual acuity and contrast sensitivity.

MATERIALS

Reference object: Red, Styrofoam hexagon
Target objects: Two black Styrofoam spheres, large diameter 12", small diameter 8"
Elevation structure: 9" tall clear plastic stand

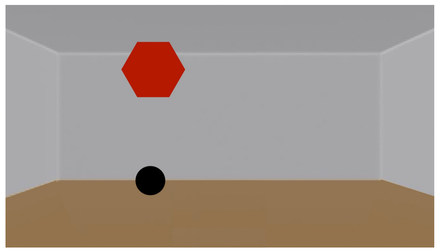

Figure 2: Digital illustration of the experimental room set-up.

DESIGN

Four within-subject variables (2x4x2x2)x2:
1) Participant motion: static viewing, lateral motion
2) Depth separation: -5ft, -2ft, 2ft, 5ft
3) Object elevation: 0", 9"
4) Object size: small (8"), large (12")

PROCEDURE

First, participants completed visual acuity (ETDRS), contrast sensitivity (Pelli-Robson), and stereopsis (Randot) testing.

For experimental trials, while the participant was turned away, the target object was placed at the prescribed elevation and location. Participants were then directed to either view the field stationarily or while walking nine feet to their right. Participants were then asked to estimate how far in front or behind the reference object the target object was. A total of 64 trials were completed.

Figure 3: Reference model of the room set-up from the perspective of the participant.

RESULTS

ANALYSIS METHOD

Depth separation responses were split into four main groups: elevated trials with lateral motion, elevated static trials, non-elevated trials with lateral motion, and non-elevated static trials. For each of the four condition combinations, a linear regression was run on each participant's responses.

$$y = ax + b$$

y- participant depth separation estimate
x- true depth separation
a- participant estimation scale
b- overall scale bias

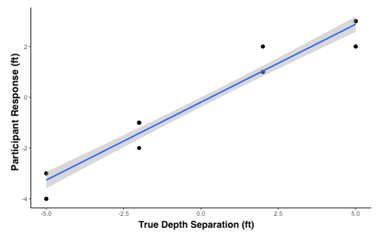

Figure 4: Linear regression for S1 responses under elevated trial conditions.

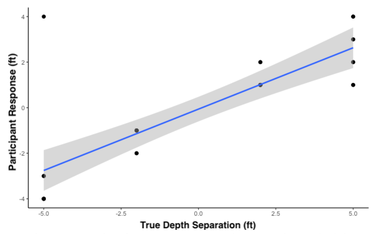

Figure 5: Linear regression for S1 responses under non-elevated trial conditions.

DISCUSSION

The p-values for both participant motion and object lift conditions were not low enough to indicate statistical significance.

POTENTIAL ERROR

- Participant fatigue
- .Variability of participant scale estimates

FUTURE DIRECTIONS

- Repetition of current study (larger sample size)
- More foundational research on both motion parallax and angle of declination in conjunction with low vision

FIELD IMPORTANCE

Visual accessibility is an issue of growing importance. As the average age increases, both globally and nationally, so does the prevalence of low vision.[5] More research could provide a better understanding of salient low vision visual cues and improve the implementation of accessible infrastructure.

CONCLUSION

- **The study aimed to assess the efficacy of motion parallax and angle of declination as salient visual cues in low vision navigation.**
- Participants underwent several vision tests before completing experimental trials estimating the relative distance between a reference object and a target object.
- Variables included depth separation of the target and reference objects, object elevation, participant motion, and target object size.
- **While results did not indicate a statistically significant difference in means between object elevation or motion type conditions, further research is needed.**

REFERENCES/ CONTACT

REFERENCES

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CONTACT

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