Perceptual Sensitivity to Point-light Biological Motion: A Forced-Choice Eye Tracking Paradigm

Savana King
Clemson University
Clemson, USA
sking8@clemson.edu

Rohit Mallick
Clemson University
Clemson, USA
rmallic@clemson.edu

Davis Weitzel
Clemson University
Clemson, USA
wweitze@clemson.edu

ABSTRACT

Highlighting the biological motion of vulnerable road users (VRUs) interacting with traffic at night can make them more conspicuous to approaching drivers. The purpose of this research was to further our current understanding of biological motion, with the hope that these findings may contribute to improving nighttime VRU safety. Observers in this study were presented with a fifteen-dot point-light sequence of a human performing a full-body turn (masked by a scrambled effect using PLAViMoP software). Using digital manipulation, the figure within this video will be presented in two ways: in an upright (natural) position and an upside-down (unnatural) position. These two variations were displayed side-by-side and participants were asked to focus on the group of dots that were most salient. Participants who fixated more often on the upright (natural) point-light figure were more accurate in answering questions about the figure in the post-experiment survey, however, these results were found to be insignificant (p=.059). Overall, the use of a two-alternative forced choice (2AFC) eye tracking method was relatively successful when applied to assessing perceptual sensitivity to biomotion. If the limitations within this study are properly addressed, this method could be promising for future research in nighttime VRU safety.

KEYWORDS

Biological motion, eye tracking, pedestrian conspicuity, perception, point-light display, retroreflective markings, visibility aids, vulnerable road users

ACM Reference Format:
Savana King, Rohit Mallick, and Davis Weitzel. 2021. Perceptual Sensitivity to Point-light Biological Motion: A Forced-Choice Eye Tracking Paradigm. In *Proceedings of ACM Conference (CPSC 6120).* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Pedestrian fatality rates have continuously risen in the United States, with a disproportionate percent of them occurring after dark [8]. Visual limitations of nighttime drivers and the reduced conspicuity of pedestrians at night contribute to the prevalence of pedestrian-vehicle collisions [11]. To counter their reduced visibility to drivers at night, pedestrians are urged to consider the conspicuity provided by their own clothing. Retroreflective material is a cheap and highly effective solution to remedy the effects of drivers' limited acuity at night. Retroreflective markings placed on the torso, as seen within vests including built-in retroreflective materials, can effectively increase a pedestrian's visibility to drivers.

In addition to being visible to motorists, it is important that they are also correctly perceived as pedestrians. When retroreflective materials are strategically placed on a pedestrian's knees, ankles, and wrists, a pedestrian's conspicuity (ie recognition) is maximized. The reason retroreflective markings positioned on the extremities produces increased conspicuity is because this configuration capitalizes on human's perceptual sensitivity to recognize other humans based on their movements. This is known as biological motion (biomotion), and it includes the motion produced by any living creature. Research on biomotion began with the use of point-light displays, which revealed that reducing a moving human figure to a simple dot configuration can still convey motion in a way that allows other humans to accurately recognize and perceive the figure's actions [6].

The motivation for our current research is to further our understanding of biological motion, with the hope that these findings may contribute to improving nighttime pedestrian safety. In order to approach this topic in a way that may benefit the field, one goal within this project will be to utilize a two-alternative forced choice (2AFC) eye tracking method as a unique assessment of perceptual sensitivity to biomotion. Another goal of this project is to leverage point-light sequences that are more perceptually complex than previous traditional point-light walker studies have relied on. This means that we will include a point-light figure with a more complex action sequence than the average point-light walker, and our stimuli will include a more challenging mask (as deemed within previous research: [10]). We also intend to replicate previous findings that suggest unnatural point-light walker positions do not yield the same perceptual advantages that can be seen from natural biological motion. Finally, this study hopes to contribute to the sparse amount of literature using eye tracking as a way to improve pedestrian safety.

Terms that are relevant to understanding our study include eye fixations, eye saccades, and Areas of Interest (AOIs). Although a much larger part of the visual field is peripheral, a significant portion of the V1 is dedicated to the few degrees surrounding the center of our vision (AKA cortical magnification). In order for a person to see an object clearly, their fovea must fixate on the location of the object within their visual field. Eye fixations are achieved when the fovea stops scanning the visual field and attends

CPSC 6120, Fall 2021, Clemson, SC, USA

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/10.1145/nnnnnnn.nnnnnnn

to a specific target. Saccades are the quick eye movements that occur between fixations. Saccadic eye movements indicate that the fovea is rapidly shifting from one area that is of interest to another. Within the processing of eye tracking data, Areas of Interest (AOIs) are locations within a stimulus that researchers want to compare against each other, due to their predetermined hypotheses. AOIs are useful when needing to evaluate the performance of more than one area of a stimulus.

Predictions for the results of this study include that participants will exhibit eye fixations that are longer and more frequent on the video displaying biomotion with a figure in an upright, natural position than they will for a video displaying an upside-down figure. It is also expected that those who fixate longer/more often on the upright figure will be more accurate in answering questions about the figure in the post-experiment survey (i.e. what the person was doing, what gender they were, etc.).

2 BACKGROUND

Modern research on biological motion began in the 1970s with the use of point-light displays. These sequences of walking figures depicted by dots reveal that humans are unusually sensitive to perceiving the movement of other human beings [6]. Since this fundamental discovery, numerous follow-up studies using point-light walkers (PLWs) have replicated and contributed to what we understand about the processing of human movement. They have revealed that the PLW's gender, weight, actions, and even mood can be discerned [3]. Another key finding is that unnatural conditions, like upside-down walkers or those with walking sequences played backwards, are more perceptually ambiguous than their natural counterparts [7][9].

A variation of this manipulation was more recently made while studying the eye movements of infants to determine if walking direction of a PLW would convey information about which impact their visuo-spatial orientation [2]. In the first experiment, their stimulus was a PLW who was either facing left or right, and was displayed either in an upright (natural) position or an upside-down (unnatural) position. Another manipulation was whether the PLW appeared in a location that was congruent with the direction of the previously presented PLW, or incongruent (which means it appeared in the opposite location). By recording eye movements of these infants, they found that saccade latencies were significantly faster in the congruent than incongruent trials, but only when the image was upright.

This suggests that the walking direction of a PLW triggers automatic orienting of visuo-spatial attention in infants, and that's why we see this effect when the PLW is displayed upright, but not when it's upside down. The importance of these findings are that it further supports our understanding of biological motion detection as an innate neural process, since these 6-month-old infants had received relatively little socialization by this point in their life span. These results also support previous findings that suggest our sensitivity to biomotion is greatly reduced in unnatural conditions, like when walkers are displayed upside-down. Lastly, they highlight the importance of biomotion in predicting walking direction, which is relevant when considering that one of the most striking utilizations of biomotion is for increasing pedestrian conspicuity.

Fundamental research using point-light displays has inspired experts in nighttime pedestrian safety to leverage biomotion within the clothing configurations of vulnerable road users. Numerous studies have confirmed that increasing the distance from which drivers recognize the presence of a pedestrian is far less effective when retroreflective markings are placed on the torso than when they are placed on the bodily joints [11]. One open-road study tested the distance from which participants within a moving vehicle could recognize the presence of a pedestrian, depending on the retroreflective marking configuration the pedestrian wore [1]. Five clothing conditions were tested: black clothing alone, retroreflective torso, retroreflective ankles, retroreflective ankles and wrists, and a full biomotion suit (which includes retroreflective markings placed most similarly to the point-light displays from Johansson's 1973 experiments) [6]. Their findings suggest that movement of the pedestrian is instrumental to increasing driver response distances, regardless of what the pedestrian is wearing. They also found that the greatest response distances were found for the pedestrian wearing the full biomotion suit. This validates the theory that retroreflective materials are effective at promoting pedestrian visibility, however, effectively positioned retroreflective markings highlight biomotion in a way that makes the pedestrian more conspicuous to drivers.

Wood et al. [13] further contributed to this topic by studying the effects of different retroreflective clothing configurations on drivers' eye movements. Participants drove a closed-road circuit at night and indicated when they recognized a pedestrian was present, and also when they recognized the direction the pedestrian was facing. The pedestrians in this experiment stood in two different directions (facing the road or facing away from the road) and wore three different types of clothing (black clothing, a retroreflective vest, or a retroreflective vest with markings on their extremities to convey biomotion). They found that participants were better at detecting which direction the pedestrian was facing in the biomotion condition. This finding is supported by previous research that found motion of the feet aided in judging the direction that the pedestrian was walking [12]. Their eye tracking data also revealed that the biomotion configuration provided additional conspicuity because of drivers "fixating on pedestrians earlier and more efficiently." This earlier awareness may provide additional time for the driver to adjust their driving to avoid collision with a pedestrian.

A natural road environment is ideal for researching biomotion for the sake of improving pedestrian safety, particularly because roadways are more complicated than the lab environments used within PLW studies. Although we are unable to perform our research on an open road due to a variety of constraints (later highlighted in our discussion section), we will be implementing more perceptually complex point-light sequences in an attempt to emulate more realistic roadway conditions. A majority of PLWs used within biomotion research are performing a simple walking sequence, frequently from the profile view. This viewing angle maximizes biological motion, however, it is not as externally valid to natural road environments because motorists approach pedestrians from a variety of angles. Pedestrians also perform more complicated actions than simple walking sequences. While the action performed within the point-light sequence stimuli within our study is not entirely common for pedestrians (a full-body turn), this figure does offer a wider range of mobility than the standard PLW. We also hope that our challenging masking technique will add to how realistic the study is, given that retroreflective materials are found throughout the roadway for purposes other than pedestrian conspicuity (i.e. road signs, pavement markings).

3 METHODS

3.1 Participants

Seventeen students and faculty members from Clemson University initially participated in the study, however, only 15 of these participants were included in analyses. The ages of the 15 participants ranged from 18 to 54 years old, with 26.4 as the mean age. All participants reported ownership of a valid driver's license. Two-thirds of our participants had owned a driver's license for five years or more. Use of corrective lenses were reported by 8 participants (53.3 percent). The two participants who disclosed having a visual pathology were excluded from analyses. No rewards were given to any of the participants.

3.2 Design

A between-subjects design was used within this experiment. Although participants were presented with both point-light stimuli side-by-side, they were asked to pick the side of the screen that immediately grabbed their attention and to stick to that group of dots for the duration of the experiment. This two-alternative forced choice (2AFC) method meant that each participant was placed in one of two groups based on their gaze data: those that fixated more than half of the time on the upright figure, and those who fixated more than half of the time on the inverted figure.

The independent variable within our study was which point-light figure the participant primarily looked at, operationalized by a gaze duration consisting of more than half of the stimuli display time. The dependent variable was their score on the post-experiment assessment. Areas of interest (AOIs) were created for the two point-light figures, in order to determine which figure the participant looked at the most. AOIs were also created for three locations on the body: the head, the arms, and the feet. This was due to our interest in the gaze and fixation patterns of our participants for each region of the point-light figure.

3.3 Materials

PLAViMoP software was used to create the point-light figure and the mask. The point-light sequence was downloaded from their database and a mask was created using the "scrambled" effect. This effect was chosen because it adds randomly positioned points with trajectories that mimic those of points that already exist in the scene [4]. This means that it translates the same speed and direction of the overall movement of the point-light figure, increasing it's masking ability (making the task of identifying the PLW more difficult). Comparative density of the mask and the point-light figure size was the same within both the upright and inverted conditions, since there is evidence to support that both of these variables may impact the ability of participants to detect a PLW [5]. Fifteen dots were used for each point-light figure.

Using digital manipulation, the figure within this video were presented in two ways: in an upright (natural) position and an upside-down (unnatural) position. These two variations were displayed side-by-side. Counterbalancing was used to eliminate participant biases toward favoring one side of the screen over the other. This meant half of the participants viewed the video with the upright figure on the left-hand side, and the other half of the participants viewed the upright figure on the right-hand side.

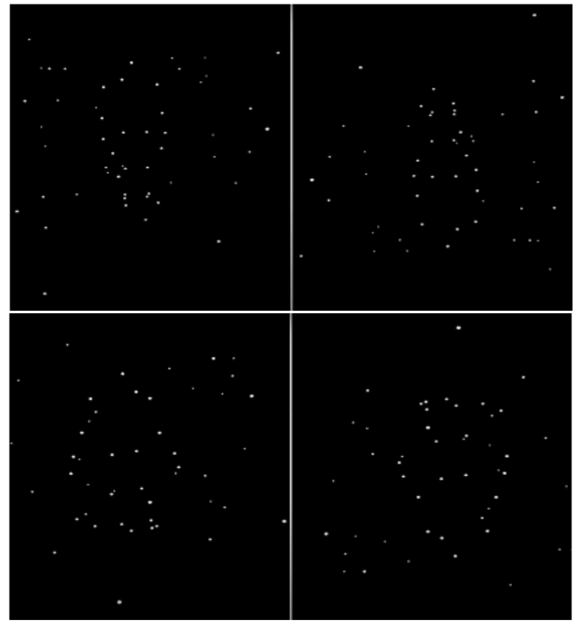

Figure 1: Top: Point-light figure in stationary position at start of stimuli video. Bottom: Point-light figure beginning full body turn at 1.5 seconds.

3.4 Apparatus

For this experiment, a Gazepoint GP3 eye tracker was used in order to collect gaze information in respect to the point-light simulation. The eye tracker was positioned under the bottom of a display monitor. The eye tracker captured the reflection of infrared light off of the retina of the subject and calculated the gaze position based off of said reflection. The GP3 eye tracker recorded at a rate of 60hz. It was programmed to use a 5-point calibration sequence and it had a .5-1 degree angle of visual accuracy. The GP3 eye tracker also had a ±15 cm range of depth, meaning that it could accurately monitor gaze within 15 cm of its optimum range.

3.5 Procedure

Participants that passed the inclusion criteria of no visual pathologies and had given their consent were seated in front of the same testing computer as every other participant. Firstly, they were asked to answer a four-question demographic survey. Once completed, proctors asked the participant to get comfortable in their seats to limit head movement. Their position was then calibrated toward the eye tracker. Calibration involved following a single dot as it traveled to five different locations on the screen. Once successfully calibrated such that their gaze is accurately represented on screen, proctors verbally confirmed that the participant was ready to begin.

The experimental portion then began with the task instructions displayed on the screen:

“You are about to see two videos of some moving dots. These videos will be played at the same time, side-by-side on the screen in front of you. There will be a white line at the center of the screen to separate the two videos. We want you to look at the group of dots that immediately grabs your attention. You will only have 10 seconds to view the screen, so please pick one side of the screen and stick to it.”

Participants were then presented with a video containing two point-light sequences of a human performing a full-body turn. One side of the screen displayed the figure in an upright (natural) position and on the other side displayed the figure in an upside-down (unnatural) position.

Upon completion of the experimental portion, participants were directed to take the post-experiment survey via Qualtrics survey software. The post-experiment assessment asked questions about their perception of what the point-light walker was doing (worded ambiguously to avoid any biases). Some examples of the questions included were: "Did you see anything interesting in either sets of the moving dots or did they appear random?", "What object did you see in the dots?", and "If you had to attribute the sex of the object, what do you think it was?" If participants indicated in the first question that the dots appeared random to them, no further questions would be asked. Five questions were included in this post-experiment survey and a score was given to participants based on the accuracy of their responses.

4 RESULTS

4.1 Post Experiment Assessment

An independent samples t-test was performed to assess the relationship between which point-light figure the participant primarily fixated on and what their post-experiment score was. Nine participants (60 percent) spent more than half of the experiment looking at the upright (natural) figure, while six participants (40 percent) primarily looked at the upside-down (unnatural) figure. Participants who had longer gaze duration’s for the upright point-light figure demonstrated greater knowledge about the figure (M = 46.67 percent) than those who primarily looked at the upside-down figure (M = 23.33 percent). Despite this, the difference between these two groups were not found to be statistically significant, $t(13)$ = 2.071, p = .059, d = 1.072. It is also worth noting that the post-experiment scores for both groups were low, with neither of the group averages reaching a passing score. The highest score from any participant was 80 percent accuracy and only two participants correctly identified the figure as a female, human being that was spinning.

4.2 Gaze Duration

Data about gaze duration was analyzed next. Across both groups, the region least looked at was the head of the point-light figure. This is consistent with previous literature on biomotion, since the head offers less movement than a person’s extremities do (like the wrists and ankles). This effect was most prominent for the natural, upright pedestrian (in seconds: M=.009s, SD=.034s), but less prominent for the unnatural, upside-down pedestrian (M=.527s, SD=1.013s) (see Figure 3). We hypothesize that this is due to participants having a more challenging time discerning where to look in the unnatural condition, while more quickly detecting the movement of extremities in the natural condition. This is supported by data on duration of fixation for the arms AOI. The upright point-light figure received greater gaze duration on the arms (M=3.367s, SD=3.097s) than the upside-down point-light figure did (M=1.456s, SD=1.909s), but this difference was not found to be statistically significant, $t(14)$ = 1.703, p = .111, d = .440. An unexpected finding was that the upside-down figure received longer duration fixations on the feet (M=.920s, SD=1.361s) than the upright figure (M=.778s, SD=1.830s), however, this result also was not significant, t = .212, p = .835, d = .055.

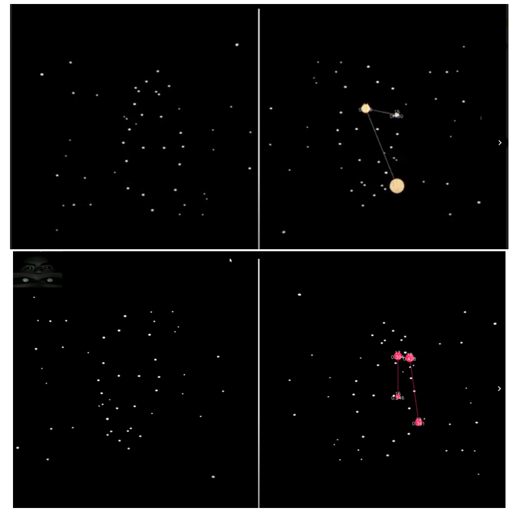

Figure 2: Top: Example of a fixation map from a high performing participant (post-assessment score of 80 percent). Fixations primarily occurred on the side of the screen that displayed the upright figure. 9. Bottom: Example of a fixation map from a low performing participant (score of 40 percent) who received the counterbalance condition. Fixations primarily occurred on the upside-down figure, which was now displayed on the right.

4.3 Number of Fixations

Results from the number of fixations found for each AOI align with the data received on gaze duration. Participants fixated the least on the head AOI for both the upright (M=0.67, SD=0.258) and upside-down figure (M=2.00, SD=4.018). The AOI designated for the point-light figure’s arms received the most fixations. The upright figure received more fixations (M=6.33, SD=5.98) than the upside-down figure (M=2.80, SD=3.32), but this wasn’t found to be significant, $t(14)$ = 1.669, p = 0.117, d = .431. Figure 4 illustrates how many fixations each AOI region received in both conditions.

5 DISCUSSION

The prediction that more participants would exhibit longer gaze durations and a greater number of fixations on the upright, natural figure than the upside-down, unnatural figure was supported by

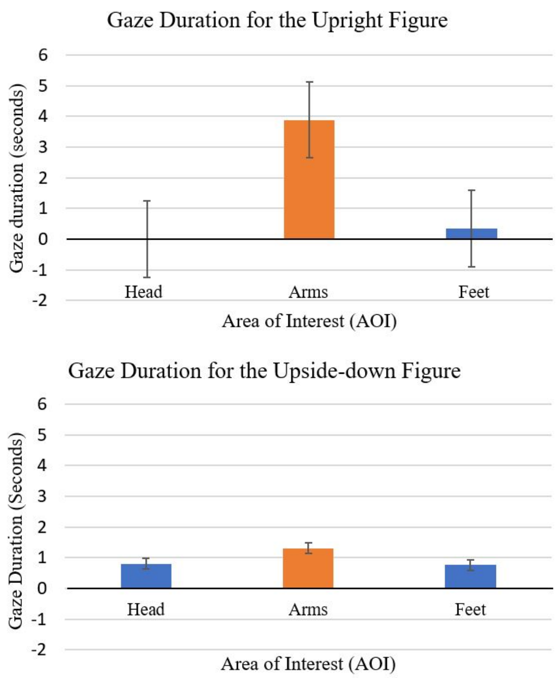

Figure 3: Gaze duration in both conditions. The top showcases the upright condition, while the bottom showcases results in the upside-down condition.

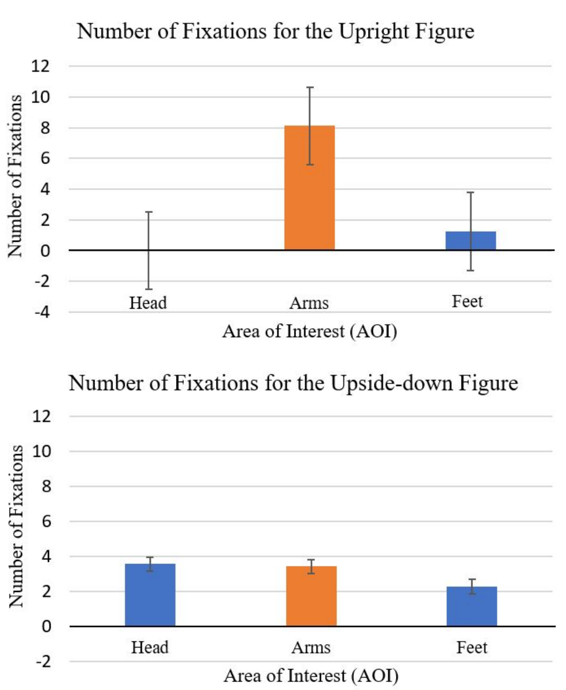

Figure 4: Number of fixations in both conditions. The top image showcases the upright condition, while the bottom showcases results in the upside-down condition.

our results. Sixty percent of participants fixated more and spent more time looking at the side of the screen with the upright figure. This supports past research on biological motion that has found that biomotion in unnatural conditions are more perceptually ambiguous than their natural counterparts [7][9].

Participants who looked at the condition exhibiting natural biomotion did score higher on the post-assessment asking questions about the figure, but this trend was not found to be statistically significant. The more interesting finding from this analysis was how low the post-experiment scores were for both groups. Only two participants were able to describe the figure as a female, human figure that was spinning. We hypothesize that this is because of the stimuli used. Traditional point-light walker studies often include a point-light sequence where a walker is viewed from the profile, maximizing their biological motion. The full-body turn of our point-light figure, in combination with the scrambled masking effect, may have made the task exceedingly difficult. A scrambled mask is the most effective masking technique because the local motion of the masking dots mimic those within the individual point-light stimuli [10]. The local motion and density of the scrambled mask might have been too effective at masking the movement of the point-light figure.

5.1 Limitations

One of our hypotheses was that those who exhibit longer gaze durations and a greater number of fixations on the upright figure will be more accurate in answering questions about the figure in the post-experiment survey. We did not find a statistically significant difference. One possible explanation for this lack of results is that our sample size may not have provided sufficient statistical power. An a priori power analysis indicated that a sample size of 34 participants would be necessary to reach a desired power of .80 or greater (medium effect size of r = .50 and an alpha of .05 was used). Our group had intended to use SONA for recruitment purposes. This wasn't possible within the project timeframe because prior IRB approval needed to gain access to SONA. Between participant exclusions and the aforementioned constraints, only 15 participants were included in analyses. Had we reached the appropriate sample size of 34 participants, it is possible that we may have found our primary hypothesis to be statistically significant.

Another possible limitation was the measures used within the post-experimental survey. How the five questions about the figure were worded was key to avoid leading participants to answer in a particular way. The questions used often referred to the point-light figure as a "collection of dots" or an "object." This vague description was likely successful in hiding the true intention of the experiment, but it also may have unintentionally lead participants to believe the dots were of something that was inanimate. Seven of the nine participants who reached the question "What object did you see in the dots?" answered with an inanimate object, like a DNA sequence or whirlpool. The responses to this question may also be a consequence of the perceptual complexity of the point-light stimuli used (as mentioned previously).

Similarly, we speculate that the wording of the task instructions could also have been more clear. Gaze duration data offered insight into how well participants understood the task instructions that they should "look at the group of dots that immediately grabs [their] attention" and "pick one side of the screen and stick to it." Eleven of the 15 participants included in analyses clearly demonstrated following the instructions, with less than one second spent viewing the opposing video. This still meant that four participants (26.7 percent) exhibited fixation and gaze patterns that implied they did not follow the instruction to focus on the collection of dots that were initially most salient. This made categorizing their data more challenging, since they may have only looked at the upright or upside-down figure slightly over 50 percent of the time. In theory, a participant who viewed the upside-down figure for 51 percent of the time could still have had time to view the upright figure and score more highly on the post-experimental assessment than a participant who solely focused on the upside-down figure.

5.2 Future Research

In continuation of this work, a recreation of our stimuli would likely be beneficial. Although a scrambled effect was key for successfully masking the motion of the point-light figure, reducing the density of the mask could help reduce the task difficulty. Another option for improving the stimuli could be to ensure that the more perceptually complex action for the point-light figure to perform still emphasizes the figure's biological motion. Actions that may more successfully demonstrate biomotion (while still remaining more complex) could be a figure walking up or down the stairs, or riding a skateboard or bike (viewed from a 90 degree angle to maximize movement of the limbs).

This research also encourages other interesting (and more applied) approaches to improving nighttime pedestrian safety through furthering what we understand about biomotion. In a nighttime road environment, retroreflective markings are used to mark lanes, important signage, and even some residential mailboxes. These markings can be viewed as "visual clutter" that competes with the retroreflective clothing a pedestrian may wear to increase their conspicuity to drivers. Stimuli that includes point-light figures overlayed onto different nighttime road environments containing retroreflective markings would be a refreshing update to the traditional black backgrounds used in point-light research.

6 CONCLUSION

Although none of our results were found to be statistically significant, this research did meet some of the goals originally set. For one, the use of a two-alternative forced choice (2AFC) eye tracking method was relatively successful when applied to assessing perceptual sensitivity to biomotion. During the debrief, none of the participants indicated noticing that both sides of the screen displayed the same stimuli. This was found despite only a moderate manipulation being made to flip the figure in the upside-down, unnatural condition. Our findings also serve as cautionary evidence for what can happen when point-light stimuli is over-masked. While ineffective masking techniques can be a problem within point-light stimuli research [10], future research with similar intentions of improving pedestrian safety should find a balance in the masking technique. Instead of attempting to apply the most effective mask possible, a more appropriate aim is to effectively mimic the real-world complexity of a nighttime road environment that features retroreflective markings. Regardless of our lack of significant results, it is our hope that this research meaningfully contributes to the sparse amount of literature using eye tracking as a way to improve the safety of vulnerable road users.

REFERENCES

[1] Stacy A Balk, Richard A Tyrrell, Johnell O Brooks, and Thomas L Carpenter. 2008. Highlighting human form and motion information enhances the conspicuity of pedestrians at night. *Perception* 37, 8 (2008), 1276–1284.

[2] Lara Bardi, Elisa Di Giorgio, Marco Lunghi, Nikolaus F Troje, and Francesca Simion. 2015. Walking direction triggers visuo-spatial orienting in 6-month-old infants and adults: An eye tracking study. *Cognition* 141 (2015), 112–120.

[3] Randolph Blake and Maggie Shiffrar. 2007. Perception of human motion. *Annu. Rev. Psychol.* 58 (2007), 47–73.

[4] Arnaud Decatoire, Sophie-Anne Beauprez, Jean Pylouster, Patrick Lacouture, Yannick Blandin, and Christel Bidet-Ildei. 2019. PLAViMoP: how to standardize and simplify the use of point-light displays. *Behavior research methods* 51, 6 (2019), 2573–2596.

[5] Eric Hittle and Eric Hiris. 2003. Does density explain how moving dots mask biological motion? *Journal of Vision* 3, 9 (2003), 528–528.

[6] Gunnar Johansson. 1973. Visual perception of biological motion and a model for its analysis. *Perception & psychophysics* 14, 2 (1973), 201–211.

[7] Marina Pavlova, Ingeborg Krägeloh-Mann, Niels Birbaumer, and Alexander Sokolov. 2002. Biological motion shown backwards: the apparent-facing effect. *Perception* 31, 4 (2002), 435–443.

[8] Richard Retting. 2020. Pedestrian traffic fatalities by state: 2019 preliminary data. (2020).

[9] Shigemasa Sumi. 1984. Upside-down presentation of the Johansson moving light-spot pattern. *Perception* 13, 3 (1984), 283–286.

[10] Ian M Thornton. 2006. Biological Motion: Point-Light Walkers and Beyond. (2006).

[11] Richard A Tyrrell, Joanne M Wood, D Alfred Owens, Stephanie Whetsel Borzendowski, and Ashley Stafford Sewall. 2016. The conspicuity of pedestrians at night: A review. *Clinical and experimental optometry* 99, 5 (2016), 425–434.

[12] Li Wang, Xiaoying Yang, Jinfu Shi, and Yi Jiang. 2014. The feet have it: Local biological motion cues trigger reflexive attentional orienting in the brain. *NeuroImage* 84 (2014), 217–224.

[13] Joanne M Wood, Richard A Tyrrell, Philippe Lacherez, and Alex A Black. 2017. Night-time pedestrian conspicuity: effects of clothing on drivers' eye movements. *Ophthalmic and physiological optics* 37, 2 (2017), 184–190.