Spatio-Temporal Integration & Optic Flow Quality: Unpacking Factors that Influence Driving Performance

Bobby T. Nguyen
Faculty: Rui Ni, Ph.D.
Department of Psychology, College of Liberal Arts and Sciences

Abstract. Research has shown that optic flow plays an important role in self-motion, such as walking or driving. Further, research has demonstrated that spatial, temporal, and qualitative aspects of optic flow have an effect on motion perception. In the current study we investigated how spatial, temporal, and qualitative aspects of optic flow interact in motion perception. We examined how optic flow quantity (spatial) and lifetime (temporal) affect the detection a 2D shape in motion. The task for the participants was to identify a 2D shape from kinetic occlusion. The contrast threshold of optic flow was measured while optic flow quantity and lifetime were manipulated. The results show a stronger effect of temporal integration than spatial integration on 2D shape perception in motion.

1. Introduction

Past research has demonstrated that optic flow is a useful source of visual information used in driving. Optic flow is the changing pattern of light intensities at the eye of an observer [1]. Optic flow has been shown to provide information about the environment, perception of speed, and heading direction [2,3,4].

Recently, we showed that optic flow quantity (e.g., dot density) had a greater effect on driving performance than optic flow quality (e.g., dot contrast), especially for older drivers [5]. Although our research examined the qualitative aspect (contrast) and spatial aspect (density), we did not examine the temporal characteristic (e.g., dot lifetime) of optic flow, which has been shown to be important in motion perception [6]. Previous research has demonstrated that a 2D shape recovery task based on kinetic occlusion requires both temporal and spatial integration [6].

Using a 2D shape recovery task, the current experiment investigated how spatial and temporal characteristics of optic flow affect motion perception. Since driving is a vision-based task it is largely influenced by visual information processing. Thus, different visual situations may affect how a driver navigates through an environment. For example, with increased spatial information, such as an increase in the number of lane markers, it is easier to keep a car within its lane when driving at night. Similarly, an increase in temporal integration of visual information is also important during driving. For example, a longer glance at oncoming traffic may provide drivers greater information to judge whether it is safe to make a left turn across oncoming traffic.

2. Experiment, Results, Discussion, and Significance

Methods

Participants. There were eight participants (mean age = 21.3) in the experiment. All participants were undergraduate students at Wichita State University, had normal or corrected to normal vision, and were naïve to the purpose of the experiments.

Apparatus. The displays were presented on a 20-inch CRT monitor at a refresh rate of 60 Hertz (Hz). Participants viewed the displays binocularly at a distance of 57 cm from the screen in a darkened room. A four-button keyboard was used to input responses.

Stimuli. The stimuli were computer generated displays of dots (.10 deg by .10 deg) projected onto an opaque gray object and gray background with luminance of 6.4 cd/m². Four different object shapes were examined – square, circle, diamond, or triangle. The objects were positioned in the center of the display, and randomly moved from the center to the right or left, then back to the center at a velocity of 8.5 deg/second. Only the dots projected on the object moved while the background dots remained stationary.

Design. The independent variables were dot density (.67, 87, 1.04 dots/deg²) and dot lifetime (33, 67, 100 ms). The dependent variable was contrast threshold (Michelson contrast). All independent variables were
treated as within-subjects variables. A four-alternative forced-choice task using a 3-down, 1-up staircase was used to measure threshold levels.

Procedure. Participants were informed they would be shown a series of displays of a 2D object in one of four possible shapes – square, diamond, circle or triangle. Participants were instructed to identify which shape appeared in the display. Participants used a 4-button keyboard to indicate their answer.

Following a practice block consisting of 60 trials, participants were presented with 9 blocks of trials (3x3) in random order. Auditory feedback in the form of a beep indicated incorrect answers.

Results

A repeated measures ANOVA was conducted to examine the effect of dot density and lifetime on motion perception. The dependent variable was a measure of performance in terms of contrast thresholds. A lower contrast threshold indicated better performance.

The main effect of Dot Density was significant, \( F(2, 14) = 11.04, p < .01 \), multivariate partial \( \eta^2 = .61 \), indicating lower contrast thresholds with increased dot densities. Participants had significantly lower contrast thresholds in the 1.04 dots/deg\(^2\) condition than in the .67 dots/deg\(^2\) condition, \( p < .05 \).

The main effect of Dot Lifetime was also significant, \( F(2, 14) = 27.12, p < .001 \), multivariate partial \( \eta^2 = .80 \), indicating lower contrast thresholds with increased dot lifetimes. Participants had significantly lower contrast thresholds in the 33 ms condition as compared to the 67 and 100 ms conditions, \( p < .05 \).

The Dot Density x Dot Lifetime interaction effect was significant, \( F(4, 28) = 3.15 \), multivariate partial \( \eta^2 = .31 \), \( p < .05 \). The results indicate a stronger effect of dot lifetime as dot density decreases.

Fig. 1. Contrast thresholds for dot density and lifetime.

3. Conclusions

Results of this study indicate that temporal integration may play a larger role than spatial integration of optic flow in motion perception. This suggests that a motion perception task, such as the one used in the current study, might be a better candidate for performance predictor for driving behaviors. Thus, one future direction is to examine the correlation between the 2D motion task and a steering control task.

4. References


