Age Related Decrements in Steering Control: The Effects of Landmark and Optical Flow Information

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Introduction

An important perceptual task during driving is the ability to use visual information to steer. Failure to accurately detect changes in the moving path of the vehicle and then make corrections accordingly could have serious consequences for driver safety. Optical flow information has been demonstrated to be useful for the perception of heading (Warren, Morris, & Kalish, 1988; Warren, Mestre, Blackwell & Morris, 1991), the perception of self-motion (Andersen & Braunstein, 1985), and the perception of egospeed (Larish & Flach, 1990).

In addition to optical flow, recent research (Hahn, Andersen, & Saidpour, 2003) has indicated that observers could determine the path of motion using scene based information. Previous research has demonstrated age-related decrements in the perception of motion and using optical flow information for 3D shape perception (Andersen and Atchley, 1995).

The goal of the present study was to examine age-related differences in the use of optical flow and scene-based information for steering control. Drivers were presented with computer generated displays simulating forward vehicle motion through a 3D scene of random dots on a ground plane. The horizontal position of the vehicle was perturbed according to a sum of sine functions, and drivers were asked to steer the vehicle to maintain the initial path of motion. On half of the trials landmark information was presented by color coding a subset of the dots.

hypotheses

1. **Spatial integration hypothesis**: Older drivers, as compared to younger drivers, will show a decreased sensitivity to spatially integrated velocity information for steering control from optical flow. To test this hypothesis, the dot density display was manipulated so that fewer dots resulted in a greater spatial separation of the velocity information.
2. **Landmark position hypothesis**: Older drivers may have difficulty encoding and using landmark position information as reference information to maintain the initial path of motion. To examine this hypothesis, on half of the trials red dots were presented serving as landmark information.

Experiment

Drivers: 31 older (mean age of 71.0) and 16 younger (mean age of 28.3).

Task: maintain a fixed heading direction relative to the moving dots.

Independent variables :

- •Age (between-subject).
- •number of dots in the optic flow field (25 or 325);
- •landmark condition (presence or absence);

Figure 1. Display in the experiment, with 325 dots and red dots as landmark information.

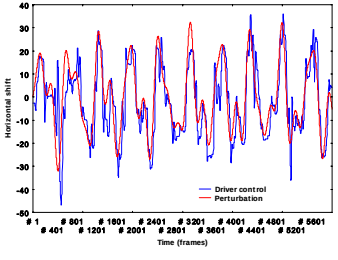

Figure 2. Steering response from single trial.

Results

Steering performance was assessed by calculating RMS (root means square) tracking error for each driver on each trial in each condition. In addition squared coherency between the input and response at a particular frequency was derived.

1. An ANOVA (analysis of variance) revealed that younger drivers had significantly less tracking error than older drivers ($F(1,46)=8.6$, $p<.05$). Both older and younger drivers had less tracking error with a greater number of dots in the flow field ($F(1, 46) = 52.4$, $p<.05$). (see Figure 3).
2. Younger drivers had less tracking error when landmark information was present. In contrast, older drivers showed no effect of the presence or absence of landmark information.

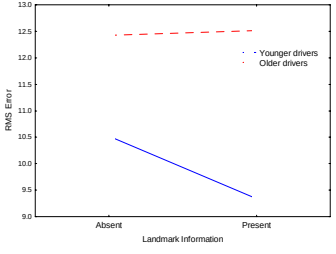

Figure 3. Averaged tracking error for younger and old subjects, with or without landmark information.

3. The average squared coherency results indicated greater squared coherency for the 325 dot condition than 25 dot condition. The main effect of frequency was significant, $F(2,92) = 10.6$, $p<.05$ indicating greater squared coherency with a decrease in frequency.
4. The three way interaction of squared coherency is shown in Figure 4. Although younger drivers showed little effect of the landmark condition for the 325 dots condition. However, they had a significant increase in squared coherency for the 25 dots condition when landmark information was present.
5. Older drivers showed a different pattern of results. For the 325 dots condition the presence of landmark information increased squared coherency. However, for the 25 dots condition older drivers showed a decrease in squared coherency with landmark information. These results indicate, that older drivers show a trend towards reduced performance when landmark information is present with reduced optical flow information.

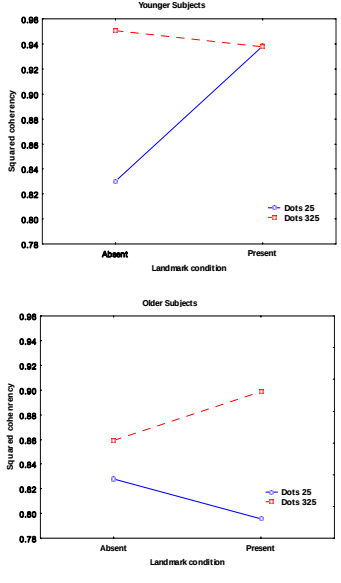

Figure 4. Averaged squared coherency for younger and old subjects, in 25-dot or 325-dot displays, with or without landmark information.

Conclusions

1. Overall the results of the present study suggest that greater accuracy and less steering control error occurred for younger as compared to older drivers.
2. Both groups showed an improvement in driving performance with an increase in optical flow information. However, older drivers may be more reliant on optical flow information for controlling a vehicle and may have a reduced ability to use alternative sources of information for steering control.
3. The decreased reliance of landmark information for older drivers, when optical flow information is reduced, may be the results of attention.
4. An important issue for future research will be to examine age-related differences in attention under reduced driving conditions.

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