Spatial Orientation and Navigation in Elderly Drivers

Final Report

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16. Abstract (Limit: 250 words)

This report details a research study that was conducted to determine whether elderly drivers have more difficulty than younger drivers in maintaining orientation when they learn routes in unfamiliar neighborhoods. Drivers learned an approximately three-mile irregular route through a novel neighborhood. After they could drive the route without errors, they were asked to indicate the direction of out-of-sight landmarks from various station points along the route. Elderly drivers (60 years and over) made almost double the size errors in their judgments than the younger drivers (25 - 35 years). Unexpectedly, there was also a gender difference with women, especially elderly women, making larger errors than men.

Although actually driving along a real route gives the experimental task considerable face validity, the situation lacks considerably in experimental control. Traffic conditions can vary, weather conditions can vary, there may be road construction, etc. The nature of the route itself cannot be experimentally manipulated. With all these factors, it is difficult to investigate how orientation affects vehicle control. Much greater control can be gained by driving in a simulator and it is much safer. The orientation study described above was replicated in a simulator with similar results. Initial crude observations indicated that when attention was on wayfinding, vehicle control was poorer. A more refined study of how vehicle control is affected by wayfinding followed this project.

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Executive Summary

Most of the research on elderly drivers is understandably concerned with vehicle control. The elderly are an increasing proportion of the total population and they are already overly represented in the number of accidents occurring per mile driven. However, because of this emphasis on control, research on how the elderly actually drive from one place to another has received little attention. A major facet of this topic involves spatial orientation and navigation. Besides being of interest in its own right, difficulties maintaining orientation and finding one's way may interact with vehicle control as a driver becomes distracted or even alarmed by losing their way, and pays less attention to vehicle control or possibly makes erratic corrections en route.

This report details a research study that was conducted to determine whether elderly drivers have more difficulty than younger drivers in maintaining orientation when they learn routes in unfamiliar neighborhoods. Drivers learned an approximately three-mile irregular route through a novel neighborhood. After they could drive the route without errors, they were asked to indicate the direction of out-of-sight landmarks from various station points along the route. Elderly drivers (60 years and over) made almost double the size errors in their judgments than the younger drivers (25 - 35 years). Unexpectedly, there was also a gender difference with women, especially elderly women, making larger errors than men.

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Chapter 1: Introduction

Most of the research on elderly drivers is understandably concerned with control of the vehicle. The elderly are an increasing proportion of the total population and they are already overly represented in the number of accidents occurring (see Figure 1). However, because of this emphasis on control, research with the elderly on the main function of driving, getting from one place to another, has received relatively little attention. A major facet of this topic involves, at a practical level, spatial orientation and navigation. Besides being of interest and importance in its own right, difficulties in maintaining orientation and finding one's way may interact with vehicle control as a driver becomes distracted or even alarmed by losing their way and pays less attention to vehicle control or possibly making erratic corrections in route.

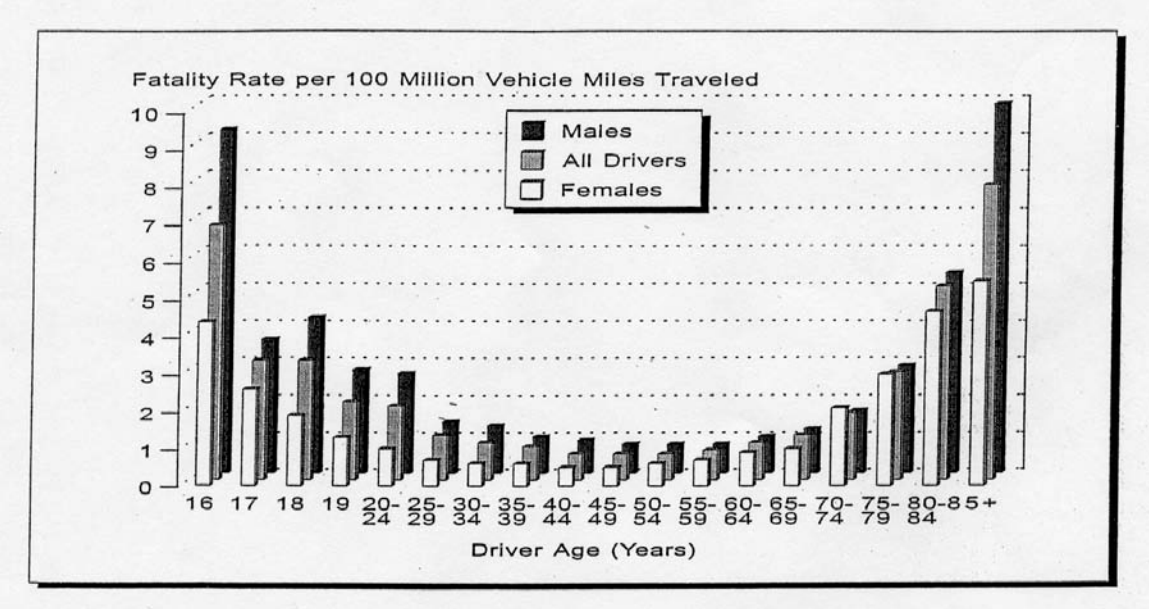


Figure 1

There is a body of research concerned with the spatial cognition of the elderly (e.g. Kirasik & Allen, 1985, Salthouse, 1987, Simon, Walsh, Regnier, and Kraus, 1992). There is also, of course, considerable research on other basic processes related to driving and driving accidents in the context of adult age differences, e.g. selective attention (Arthur, Barrett, & Alexander, 1991; Kahneman, Ben-Ishai, & Loran (1973), reaction time (Mihal & Barrett, 1976; Lerner, Huey, McGee, & Sullivan, 1995), etc., etc. However, there is relatively little research concerned with orientation and way finding in relation to elderly drivers. What little research there is on this topic such as studies by McKnight and McKnight (1992) and Wochinger and Bochm-Davis (1995) has been mainly directed toward evaluation of navigational aids. The research has not been directed towards understanding the orientation problems experienced by elderly drivers or the processes normally used to maintain orientation and to navigate from one place to another.

Research on the organization of spatial knowledge has suggested the existence of three different modes or levels: landmark knowledge, route knowledge, and configurational knowledge. Developmentally with children, the organization of spatial knowledge has been observed to shift from landmark-bascd, to route-based, to configurational (Siegel and White, 1975; Pick and Acredolo, 1983). A similar shift has been observed with older children and adults with increased experience in a spatial layout. Initially spatial knowledge may simply involve landmark recognition; a person may know, that their hotel is near a particular tall building but may not know how to get from that tall building to the hail park, but they know the ball park is near the railroad station. With experience the person comes to learn routes from one place to another but doesn't know the spatial relations among the locations. Thus detours and shortcuts are difficult. Finally spatial knowledge comes to be organized configurationally and a person may have a simultaneous appreciation of a large number of spatial relations in the environment. Then it is easy to make shortcuts and detours and to perform other kinds of mental operations such as shortest-route planning and mental perspective taking, etc.

One way of assessing whether drivers possess configurational knowledge as opposed to route knowledge is to have them estimate the straight-line (Euclidean) direction (and distance) between pairs of locations. Those with configurational knowledge should be good at both, while those with route knowledge alone should do relatively poorly on the straight-line judgments. (Another way of assessing configurational knowledge is by means of map drawing. From which the researcher can measure route and straight line distances as well as other measures of configurational and route accuracy. However, the difficulty with using map drawings as an independent variable is that what is included and the scale can be idiosyncratic and difficult to compare from person to person. However, this can be somewhat overcome by instruction to include certain key features and by initially providing two features on the map which implicitly provides a scale and orientation.)

The object of this study was to investigate issues of maintenance of spatial orientation and way finding in the context of adult driving and how it changes with age. Staying oriented while one is traveling involves being aware of the changing distances and directions of locations relative to one’s own position. Of course, there is no problem in doing this for locations that are in view. However, maintenance of orientation is problematic with respect to occluded locations of interest, such as one’s goal destination, place of origin of travel, and other referent landmarks. How well orientation was maintained by drivers of different ages was assessed by obtaining estimates of direction to target locations with probe questions posed periodically during a standardized trip.

Chapter 2: Method

A younger group of drivers, age 25 to 40 years, was recruited from students and faculty of the University of Minnesota and an older group of drivers, age 65 to 85 years was recruited from retired university staff, faculty, and alumni. All driver participants had a valid driver's license and drove at least once each week.

Participants met with an experimenter usually at the University. The general procedure was explained and informed consent was obtained. The participant was asked to drive their car with the experimenter as passenger to the site of the beginning of the standardized route. This took about 20 to 30 minutes and accustomed the participant to driving under directions of the experimenter. The participant used their own car so there was no need of getting used to the operation of a strange vehicle.

The participant stopped the car at the beginning site, a church parking lot, and the specific procedure was described. The participant was to drive over and learn a route following the experimenter's instructions. The experimenter pointed out and named specific intersections and landmarks which the participants were to remember. They drove this standardized route until they could follow it themselves without experimenter instructions and anticipating correctly verbally the identified intersections and landmarks. The map of the route is depicted in Figure 2. The route was approximately 4 miles in length. It ended back at the beginning location. The locations of the specified intersections and landmarks are indicated by the colored marks.

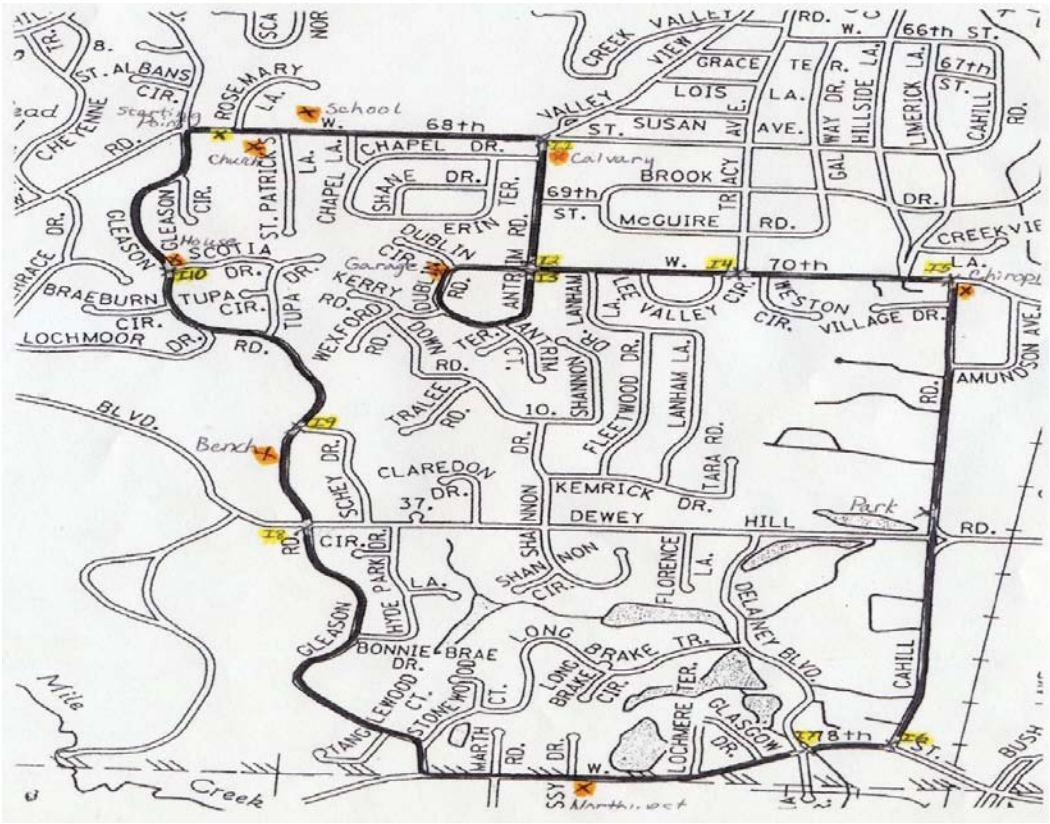


Figure 2

Examples of some of the landmarks used are shown in Figure 3.

Figure 3

After learning the route the participants were tested for their configurational knowledge of the area enclosed by route. They were asked to drive the route one more time. During this trip they were instructed to stop at two locations. From each location they were instructed to point at 5 of the landmarks or intersections which they had been identifying along the route. For example, they stopped at intersection I4 and were asked to point directly at the starting location, the school, the chiropractor office, the bench, and the Northwest Athletic Club. See Figure 2.

The pointing was done by means of a simple pointing board, consisting of a rectangular board with an arrow pointer affixed to the center which could be rotated manually. The pointer board was held in the participant's lap and was aligned with the direction of the car. It was emphasized that the pointer was to be directed straight towards the target location and not along the direction of the route. The pointer board is depicted in Figure 4. The pointer board had a circular numerical scale on it from which the participants' directional judgments could be converted to degrees.

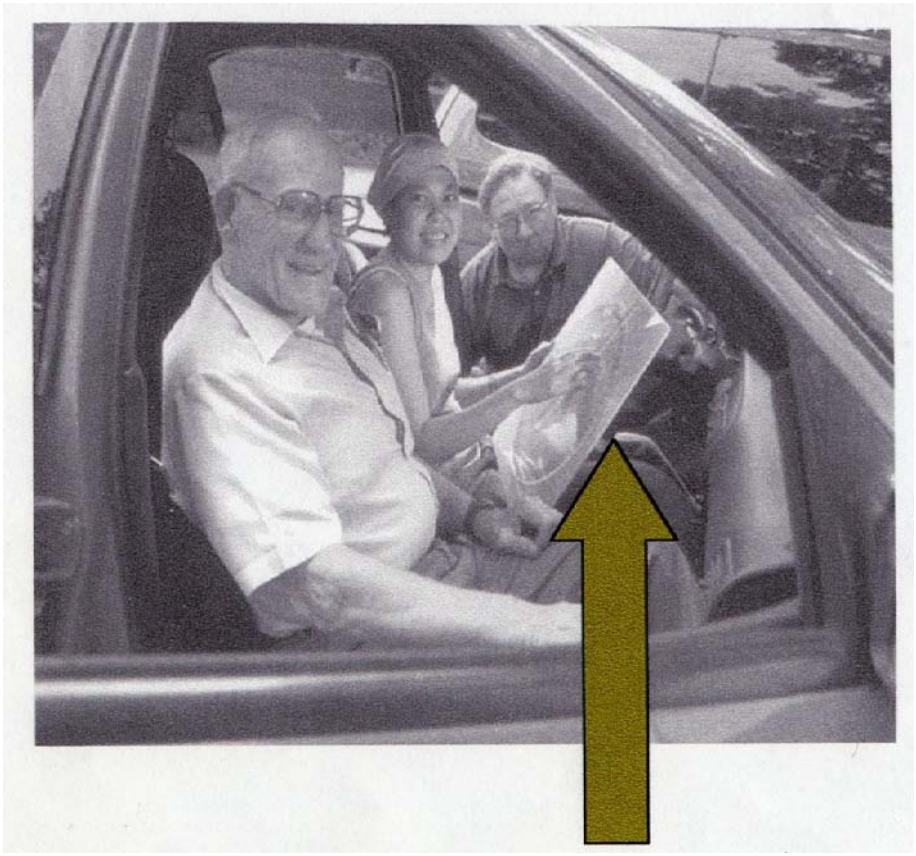


Figure 4

Chapter 3: Results

For each participant the number of degrees of error in pointing at landmarks and intersections was averaged separately. These were then averaged across participants separately for young and old participants. The results are presented as a graph in Figure 5. It is clear that the younger participants point more accurately than the older and the accuracy in pointing at intersections and landmarks is approximately equal. The results were also averaged separately for men and women and these are presented graphically in Figure 6. These results again indicate the substantial age difference but also show a significant gender difference with the men pointing more accurately than the women.

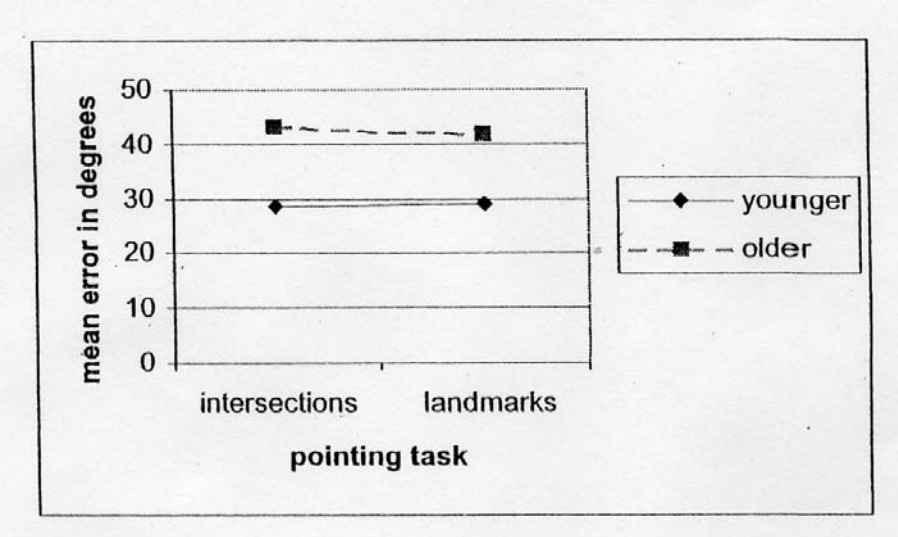
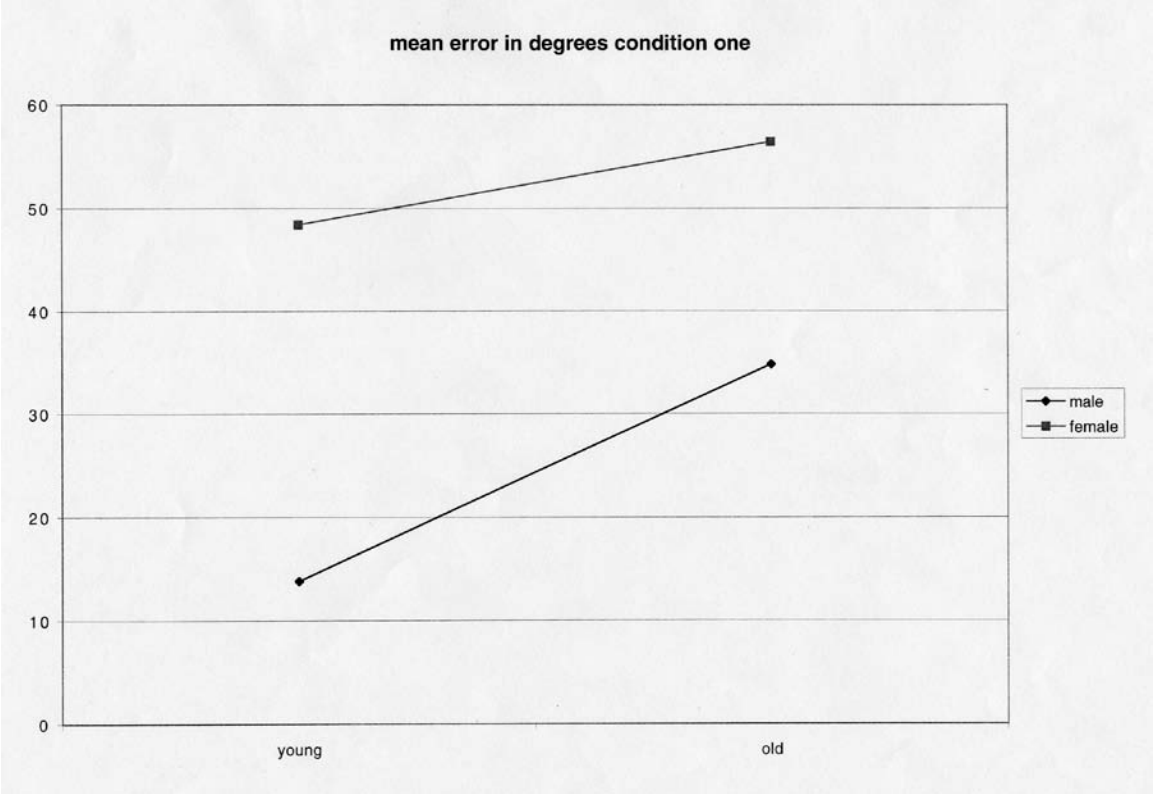


Figure 5


mean error in degrees condition one
60
50
40
30
20
10
0
young
old
male
female
Figure 6

Chapter 4: Discussion and Conclusions

In this study the participants knew the route they were trained to travel over in an unfamiliar neighborhood. They were all trained to be able to traverse the road from memory, anticipating the sequence of intersections. In contrast the experimental test assesses to what extent they had integrated the route knowledge into configurational knowledge which captures the spatial layout of the neighborhood. That test asks the participants to judge the Euclidean direction between pairs of landmarks in with which they have no direct experience. Here the results indicated significant age differences with the young participants performing better. The results also indicated a significant gender differences with males performing better than females.

How to account for the age differences? It is well known that a number of basic sensory and sensory-motor functions diminish with age: reaction time, visual acuity, contrast sensitivity, peripheral vision. The level of these functions doesn't appear to be highly correlated with frequency of driving accidents. One cognitive-perceptual function that has not been thoroughly investigated in relation to driving accidents is the demand of undivided attention. Yet aging substantially affects ability to divide attention among tasks. In driving, especially in an unfamiliar environment, there are two tasks which demand attention: vehicle control and way finding. A diminished ability to multitask is likely to impair performance on one or both of these tasks. Since vehicle control is the more vital of these tasks it is very possible that attention to way finding would suffer most.

The results of the present study indicate a significant age difference on a measure of way finding. However it is important to note that vehicle control was not investigated in the study.

The origin of the results of gender differences is not clear. In the research literature, a variety of spatial tasks have been reported to exhibit gender differences. Explanation of these is often controversial, some investigators positing a genetic explanation others an environmental explanation: girls are not brought up to engage in spatial activities as much as boys.

There are at least two important directions to follow up the present results. One is to investigate the extent to which way finding demands interfere with a vehicle control. Another is to investigate whether way finding performance such as measured here (as well as by other measures) can be generally improved by training.

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