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The Older Driver and Navigation Assistance Systems

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16. Abstract

Reduction in attention resources, cognition, and perception makes navigating an automobile more difficult as people age. Since mobility is important to maintain quality of life, older drivers compensate for effects of aging by avoiding difficult, dangerous, and stressful situations and possibly by copiloting, that is, sharing piloting and navigation tasks with a passenger. This study examined navigation and copiloting of older people, with and without ITS in-vehicle navigation systems, and explored their need for special training for the navigation units. Group interviews of 18 drivers over age 64, who had substantial experience with two ITS in-vehicle navigation systems tested in the FAST-TRAC ITS deployment project were conducted. Most participants in the study indicated that their own navigational skills did not change much as they aged, but that changes in the roads, traffic, and environment made navigating harder. Copiloting was found to be a common practice among the participants. Copilots served as an "extra set of eyes" and compensated for declines in reaction time and attention deficits. ITS in-vehicle navigational systems were thought to be reasonable copilots when driving alone, but a combination of both human and ITS in-vehicle copilots was preferred. Participants expressed a strong preference for "hands-on" training with the ITS in-vehicle navigation systems and some follow-up training after they had the unit for a few weeks. Also desired was a context-specific help feature that could provide instructions as the in-vehicle navigation system was being operated.

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BACKGROUND

This study was carried out as part of the FAST-TRAC project, a multiyear implementation and evaluation of an Intelligent Transportation System (ITS) in Oakland County, Michigan. The FAST-TRAC project included tests of two in-vehicle advanced traveler information systems (ATIS) that provided drivers with in-vehicle navigation assistance. These systems, Ali-Scout and TetraStar, both made by Siemens Corporation, provided drivers with turn-by-turn route guidance through visual and auditory commands. Brief descriptions of the two systems can be found in Appendix A.

We investigated the perceptions and behaviors of users of these systems with the intent of understanding how they used these systems in their everyday driving, whether they perceived any advantages or disadvantages of the ATIS devices and whether they liked the systems well enough to consider buying them and, if so, at what price. Our investigations included two *natural use* studies, in which subjects were given a project vehicle equipped with an in-vehicle navigation device for one month, kept detailed driver's logs of their trips, and completed a detailed survey about their perceptions and valuations of the systems. (Kostyniuk et al., 1997a, 1997b)

A two-factor experimental design, with three age categories (19-to-29, 30-to-64, and 65-to-80) and the two sexes, was used in both natural use studies. In the first study, 102 subjects drove a project vehicle equipped with the Ali-Scout system for a month. In the second study, 60 of the original 102 subjects drove a project vehicle with the TetraStar system for one month.

Analysis of the experimental data showed differences in the way the oldest group, that is, drivers over 64 years of age, used the navigation systems. As compared to the two younger groups of drivers, their trip patterns were different; they traveled at different times of day; and they tended to make more recreational trips than other drivers. They also had more problems learning and understanding the navigation systems, and, in the case of the Ali-Scout, greater difficulty programing the destinations. However, once the oldest group of subjects learned the system, they tended to use it more than other drivers. In our interactions with the subjects, we noticed that the older drivers were likely to copilot (i.e., team up with their spouses or companions when using the system). The older drivers also tended to comment more often about the location of the navigation displays, the glare on the displays, and the difficulty in seeing some of the information on the displays. It was clear that older drivers had some unique problems, requirements, and uses of in-vehicle navigation systems.

THE STUDY

This study started with questions that came from our natural use studies of the two in-vehicle navigation systems concerning copilot activities of the older drivers and their special training needs. Specifically, we were interested in exploring the following:

> How important was copiloting for the older drivers?
>
> Was copiloting compensating for difficulties with the in-vehicle navigation system?
>
> Was the lack of experience with personal computers responsible for some of the problems in learning to use the system?

To address these questions, we decided to invite the drivers from our natural use studies who were over 64 years of age, together with their spouses, for a group interview about their experiences in navigating vehicles with and without in-vehicle navigation systems and learning to use the navigation units. The objectives were to gain an understanding of how older drivers use the in-vehicle navigation systems in copiloting; to identify problems that older drivers have in learning and understanding in-vehicle navigation systems; and to propose ways in which these problems can be overcome.

In preparation for the interviews, we examined the literature on related topics. The review of the literature is summarized in the second section of this report. The rest of the report is organized as follows: The third section describes our methods and procedures and the fourth summarizes the sociodemographic characteristics of the group interview participants. The fifth section presents the summary of the group interviews. The findings and implications of the study are in the sixth section.

LITERATURE REVIEW

The tasks of piloting and navigating an automobile become more difficult as people age. There is a deterioration of vision (Schieber, 1994), particularly at night, as sensitivity to glare increases (Olson and Sivak, 1984) as well as an increase in reflex and reaction times (Sivak et al., 1994). There is also a reduction in attention resources, which leads to reductions in cognition and perception (McDowd and Birren, 1990). As people age, the ability to divide attention between several tasks decreases (Salthouse, 1984; Ponds et al., 1988) as does the ability to ignore irrelevant information (Comalli et al., 1962; Rabbitt, 1965; Salthouse, 1991).

Many studies indicate that the deterioration of cognitive processing due to aging has an effect on spatial ability and way-finding skills. For, example, a study of spatial abilities of older persons (Walsh et al., 1981) found that older adults were less familiar with the geography of their neighborhoods than younger people, and tended to be less accurate and organized in drawing maps of their neighborhoods. Ohta (1983) and Kirasic and Allen (1985) found that older individuals develop inefficient and inaccurate route plans and recognize fewer landmarks than do younger people. Salthouse (1987) reported that age-related reduction in spatial ability may affect map reading and navigational skills. Aubrey at al. (1994) found that older subjects had more difficulty than younger subjects when reorienting contraaligned maps.

Loss of confidence may be another perceptual aspect that affects mobility of older persons. Some studies have reported that older drivers perceive greater risks associated with driving (e.g., Winter, 1988), suggesting that some older drivers experience fear and anxiety about their vulnerability in a fast and complex traffic world.

Older drivers compensate for the effects of aging by avoiding situations that they feel are dangerous, difficult, or stressful. As a group, older drivers tend to give up driving at night, drive less frequently in bad weather, and avoid limited access highways and unfamiliar areas (Laux and Brelsford, 1990; Rothe 1990;

Benekohal et al., 1994). Older drivers compensate for as long as they can because mobility is extremely important to maintain a good quality of life, and driving a vehicle is a way of maintaining one's mobility and independence (Cutler, 1972, 1975; Jette and Branch, 1992).

ITS technology offers opportunities to compensate for some of the deficits that come with aging and may extend the time some people can safely and securely operate an automobile (Mollenhauer et al., 1995; Mitchell, 1997). According to Brickfield (1984), older persons are very accepting of new technologies that will enhance their capabilities for independent living. In particular, older persons are interested in technologies that will increase their opportunities to socialize and reduce the possibility of isolation. Brickfield also pointed out that it is important not to single out older persons as the sole consumers of advanced technologies to aid drivers because there is considerable resistance to products that label purchasers as old or in need of special assistance. In-vehicle navigation systems fit the criteria of such driver-aid products. These systems are of interest to the general population of drivers and have the potential to compensate for some of the deterioration in way-finding ability that comes with age.

There has been some interest in the effects of age on the requirements of in-vehicle navigation systems. Human-factors studies of in-vehicle navigation have found that older drivers spend significantly more time looking at navigation displays than younger drivers (Pauzie et al., 1991; Dingus et al., 1989). This has raised some safety concerns because older drivers have been found to need to view the road for a greater percentage of time than younger drivers to maintain vehicular control (Rackoff, 1975).

Walker et al. (1990) used the U.S. Federal Highway Administration's Highway Driving Simulator to investigate several in-vehicle navigation system formats and video displays. Navigation and driving task loads were manipulated by varying the complexity of route information and by the addition of cross winds, traffic, gauge monitoring, narrowing the road width, and doing mental arithmetic. Age-related deficits in driving and route-following performance were noted at moderate levels of task loads and grew disproportionately as the task loads increased. The magnitude of the age difference was reduced when the navigation information was presented via auditory instructions. While this has important implications for in-vehicle navigation system design, it should be noted, that hearing loss is extremely prevalent among older adults (Schieber, 1992).

Several studies have compared driving and navigating performances of older drivers using standard navigation aids such as maps and written instructions against various in-vehicle navigation systems. In general, these studies confirm that older drivers perform worse than younger drivers, but they also find that their performance improves when using in-vehicle navigation systems as compared with using maps or written instructions. This result is documented by Wochinger et al. (1995) in their study of the effects of age and other factors on navigation performance.

A study conducted as part of the evaluation of the TravTech ITS system, looked at the effect of various navigation aids on the number of driving errors by age and familiarity with the area. Findings indicated that drivers over age 65 made more errors than younger drivers, regardless of their familiarity with the area. However, older drivers made fewer errors when using the in-vehicle navigation system than with standard maps (Hulse et al., 1995).

Barham et al. (1995) examined older drivers' use of route guidance systems as part of the EDDIT (Elderly and Disabled Drivers Information Telematics) program of the DRIVE 2 project. A sample of 35 drivers over 65 years of age drove a car equipped with the Travelpilot route guidance system in a real driving situation, in an unfamiliar car in a largely unfamiliar area. The study found that the overall standard of driving was not adversely affected by the route guidance system, but that for some of the subjects, there was some deterioration of performance when faced with the dual task of driving and following the route guidance system's instructions. The researchers suggested that subjects with better short-term memory use the technology more effectively than others because they do not need to look at the display screen as long to gather relevant route guidance instructions and, therefore, can keep their eyes on the road more.

Displays in the windshield or head-up displays (HUD) for in-vehicle navigation systems have been suggested as possible solutions to the age-related problem of divided-attention deficits. An experiment reported by Mollenhauer et al. (1995) compared the navigation abilities of older drivers using written directions and a HUD in-vehicle navigation system. The study was conducted in an interactive driving simulator at the Midwest Transportation Center in Iowa with 32 subjects over 65 years of age. The driving performance of the subjects, as measured by the time required to complete the navigation drive and the number of correct turns, was much better with the in-vehicle navigation system than the with conventional written instructions. The study did not compare a HUD in-vehicle navigation system against an in-vehicle navigation system without HUD.

Several of these studies also queried their subjects about their perceptions of the in-vehicle navigation system used in the experiments and about possible effects of such systems on their mobility. Generally, the subjects liked the equipment, were able to use it effectively, and found it useful. In the EDDIT study (Barham, 1995), about half the subjects said that having a route guidance system in their car would change their driving habits in some way, either by encouraging them to drive more often or by giving them confidence to go places to which they would not otherwise go. In the Iowa study (Mollenhauer et al.,1995), the subjects reported that they felt the navigation system was easy to learn, helped them find their way to destinations, helped them pay more attention to navigating, and did not interfere with their driving. They also indicated that they would be more willing to drive to an unknown destination if they had a system like the in-vehicle navigation system used in the experiment

Mollenhauer et al. (1995) note that in discussions that were not part of the formal study, their subjects revealed that they rarely drove to unknown destinations by themselves using just a map or list of instructions. This note and other anecdotal evidence raise the issue of copiloting, i.e., sharing the task loads associated with piloting a vehicle, among older drivers. However, none of the studies reviewed looked at copiloting as a strategy used by older drivers to compensate for the effects of aging on piloting and navigating an automobile.

PROCEDURE

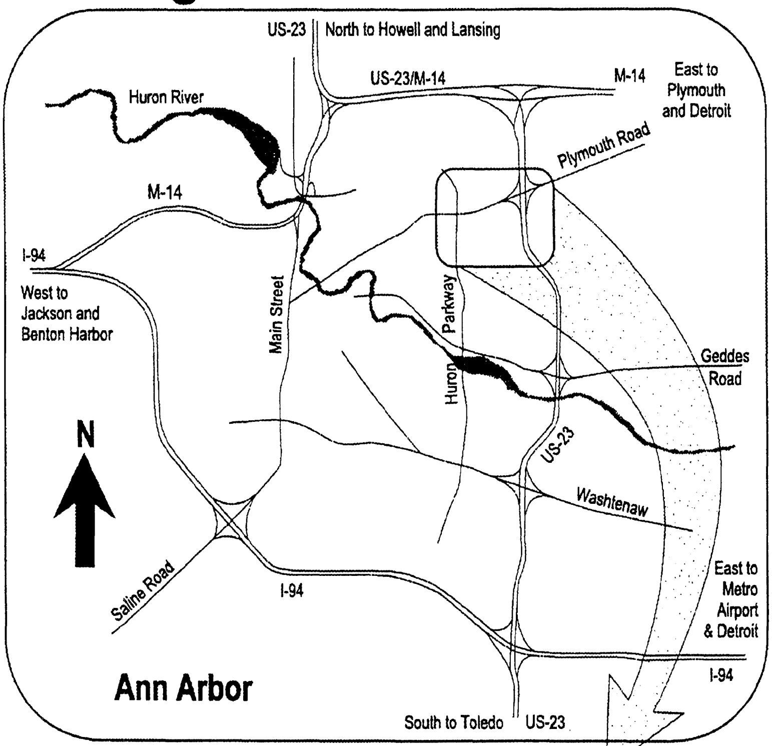
People over 64 years of age who participated in the Ali-Scout and TetraStar natural use studies were invited for a group interview to discuss how they navigate in general and their experiences with learning, understanding, and using the in-vehicle navigation systems in particular. Because driving and navigating a vehicle are often team activities, their spouses were also invited to participate. Two sessions of up to ten participants each were organized. Participants were mailed a map showing the location of the University of Michigan Transportation Research Institute (UMTRI) relative to the freeway network, which is shown in Figure 1.

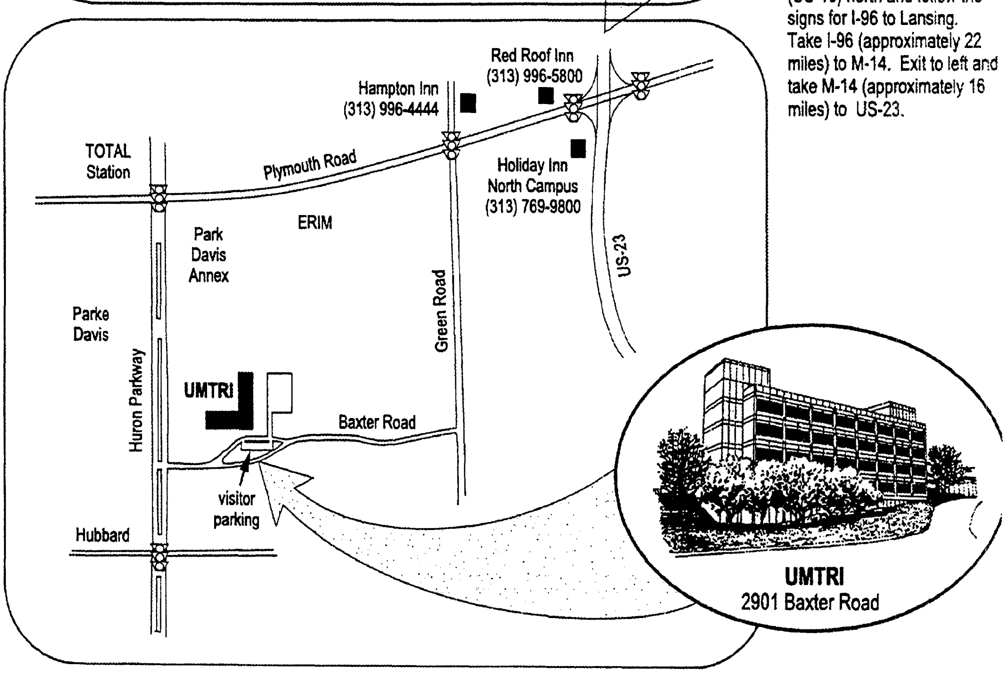
The themes covered in the group interviews were:

- General navigation
- Assisted navigation
  - human copilot
  - in-vehicle navigation unit as copilot
- Training preferences

The group interviews were held in a conference room at UMTRI in Ann Arbor, Michigan on October 15 and 16, 1997. One member of the research team moderated each session. This researcher asked the questions, facilitated the interactions, and ensured that all participants contributed to the discussion. The moderator kept the atmosphere of the discussions relaxed, comfortable, and enjoyable to the participants. Each session lasted for three hours and ended with a light lunch. The sessions were videotaped and audiotaped. Detailed notes of the proceedings were recorded by a secretary. All members of the research team, except the moderator, made notes during the group interviews. The records of the sessions were first reviewed to get an overview of the entire process, and then systematically and carefully analyzed to identify common trends and patterns of responses. The research team, then met to discuss the implications of the findings from these interviews on in-vehicle navigation systems and the mobility of older drivers.

Getting to UMTRI





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From Detroit Metro Airport
Take I-94 west to Ann Arbor (approximately 18 miles). Turn north onto US-23 (Exit 180). Get off at the Plymouth Road exit and head west (left) on Plymouth Road. At the third stop light, turn south (left) onto Huron Parkway. The first street to the left is Baxter Road, and UMTRI is on the left-hand corner. There is ample designated visitor parking on the south side of the lot south of the building.

From downtown Detroit
Take the Lodge Freeway (US-10) north and follow the signs for I-96 to Lansing. Take I-96 (approximately 22 miles) to M-14. Exit to left and take M-14 (approximately 16 miles) to US-23.

Figure 1 *— Map to UMTRI*

PARTICIPANTS

Eighteen people participated and were paid $100 each for their time. Of these, ten had been subjects in the FAST-TRAC natural use studies of the Ali-Scout and TetraStar in-vehicle navigation systems. The other eight were spouses of some of the participants. The amount of the subject fee was set at a value high enough to ensure that a sufficient number of the original older subjects from the natural use studies would participate. All eighteen participants were licensed drivers.

The participants were equally divided by sex with nine each of men and women. Furthermore, five of the men and five of the women had been subjects in the navigation system natural use studies. The average age of all the participants was 72.2 years with a range from 64 to 82 years. The average age of the men was 72.6 years with a range from 65 to 82 years and the average age of the women was 71.9 years with a range from 64 to 81 years. The average annual household income of the participants was in the $25,000-to-$35,000 category. However, the incomes ranged from below $15,000 to $55,000-to-$65,000.

SUMMARY OF GROUP INTERVIEWS

General Navigation

Participants were asked about their trip to UMTRI and how they navigate in general, when they travel in their vehicles. All participants had been provided with a map and instructions of how to get to UMTRI when they agreed to participate in the study.

The participants immediately categorized their trips by whether they were in familiar or unfamiliar areas. In familiar areas, the subjects said they know where they are going and do not need help in finding their way. For trips in unfamiliar areas, however, most indicated that they do some pretrip planning. For example, several of the participants reported comparing the map they received from us with their own maps. One couple asked their daughter, who lived in Ann Arbor, for instructions for how to get to UMTRI, and wrote them down. They commented that

"At our age we usually write things down."

Those who were generally familiar with the Ann Arbor area reported turning to our map once they reached the freeway exit to Ann Arbor. These participants found the drawing of the UMTRI building on the map we provided particularly helpful in reaching their destination.

With one exception, participants also reported that when they are driving with their spouse or companion in unfamiliar areas, one of them drives and the other follows the map and navigates. For the trip to UMTRI, most of the participants told us that one of them drove and their spouse navigated. One of the subjects commented,

" It takes two people. It does take a navigator if you are reading a map."

The one couple that does not engage in copiloting reported getting lost on their trip to UMTRI.

Participants were asked if their general way of navigating a vehicle has changed from what it was in the past. In response to the question, "is there a change in how you navigate now than in the past (e.g., 40 years ago)" approximately three-quarters of participants said that essentially there was no change. The rest stated that it was more difficult now.

However, those who did not report a change in their navigating, went on to identify other changes in the environment that made driving and getting around different than in the past. One subject mentioned that she has problems getting around in areas she once knew very well but has not visited for a while. She said,

" It doesn't fall into place like it used to."

Another subject mentioned that the roads are more complex and that

"Lives have been complicated by the road system."

Another subject also stated that driving is more complex now, and that "super aggressive" drivers are more difficult to cope with. He prefers routes that let him get around congestion or traffic problems, and on certain trips he avoids expressways. He stated that he can drive and navigate very well, but has difficulties dealing with aggressive drivers.

Still another participant said that it is hard to compare past and present navigation because long trips, such as those to Florida, were once driven on slower roads and

" ... there was plenty of time to make decisions, now it's all expressways."

One of the subjects who said that navigating was different now than in the past stated,

" ... the need for trips is less now, and you are doing less of it; you are a bit more fearful of the unknown."

The subjects were asked about their preference for expressways. About 40 percent of participants indicated that they preferred expressways unconditionally. Another 40 percent stated that it depended on where and when they were going, but most of them preferred expressways for longer trips and stayed off expressways during peak periods. This included two men who reported that they stayed off expressways when their wives were in the car, but tended to use expressways when alone. The rest had a strict preference for driving on surface streets and, in several of these cases preferred surface streets even when they were passengers.

In a discussion of whether it is travel time or comfort that is more important when selecting routes, one of the subjects answered that for him, "it is time." He feels that he has to drive more defensively on expressways but it saves much time. He said that he has to pay more attention now because it is a "little more hazardous" and people do not drive like they used to. Another subject said that this question is hard to answer, but when asked to choose either time or comfort, he chose time. One of the women, who does not drive on expressways, stated that since the speed limit has increased to 70 mph on expressways, she feels frightened and uncomfortable with others going so fast. For her,

" the choice is comfort."

The groups were also asked about driving at night; whether they avoid it, and whether it changes how they drive or navigate. About a quarter of the participants replied that they self-regulate their night driving; that is, minimize or forgo it completely. The rest of the participants drive at night. Several indicated that driving at night is not a problem. However, most mentioned that they have problems with the glare of headlights when driving at night. One person said that she will drive at night but not on rainy nights, and another stated that while he does not like it, he does drive at night.

Participants' techniques for driving and navigating at night included driving more slowly, driving on surface streets, watching taillights, looking for familiar landmarks, paying more attention to signs and stopping more often for coffee. Several participants mentioned their concern about security and their preference to drive on well-traveled, well-lighted routes. Additional pretrip planning for night trips included asking for landmarks to watch for and having the passenger read directions.

Participants were asked to estimate how many miles they drove in a year. The annual mileages ranged from 2,000 miles to 25,000 miles. Overall, men reported driving more miles than women. The average annual miles driven by the men was 14,000 miles with a range from 6,500 to 25,000 miles. For women, the average was 6,400 miles with a range from 2,000 to 10,000 miles. One subject mentioned that he has driven over 2,000,000 miles in his life.

Assisted navigation

Human copilot

Most of the participants agreed that if they are driving in unfamiliar areas it is useful to have their spouse or traveling companion assist in navigating. The facilitator referred to this function as copiloting. An enumeration of the benefits of a copilot, as perceived by the participants included:

- extra set of eyes
- reads map
- checks location
- security
- helps find way when lost
- keeps you company
- keeps you awake
- checks on you
- feeds you lunch

The participants also indicated that the copilot reads road signs, helps in spotting unsafe and aggressive drivers, and

"... is helpful when traffic is pushing you".

The participants felt that a human copilot made driving the car easier, more comfortable, and more safe. About two-thirds of them said that they use or prefer using a copilot more now than they did in the past (e.g., 40 years ago), The following are comments from the subjects on this topic:

"Years ago, in Detroit everything was simpler— with right angles, now there are more complex street patterns."

"You must pay more attention to signs now, [because] *roads are narrower and* [you can] *turn only from certain lanes. There is much congestion and road construction."*

"When you first learned to drive, each time out was a learning experience. Now it is more difficult to recognize a situation you should not be in, and your ability to react is slower, too. A copilot helps with that security, recognition."

One subject mentioned that,

"... as I age I need him [copilot] *more and depend on him more".*

Another subject stated that he has problems with vision and relies on the copilot because he does not like to change his eye glasses. Still another subject mentioned that he can get to the general area, but he needs help seeing smaller signs. Another subject stated that her memory retention is not as good as it once was. She makes sketches of the directions for herself. Participants agreed that copilots are useful for reminding drivers about directions.

When asked what they did when they had to make a trip without a copilot, the participants indicated that they do more pretrip planning. Some outline the trip or highlight the route on a map. One subject, who drove a senior citizen bus when he retired, said that he made "dry runs" before he drove the route with passengers.

In-vehicle navigation systems

The participants in the group interviews were either subjects or spouses of subjects who were in the natural use studies in the FAST-TRAC project and had experienced two different in-vehicle navigation systems, Ali-Scout and TetraStar, for about a month each. They had used two different types of in-vehicle navigation technologies and did not have to imagine hypothetical systems. The discussions focused on the TetraStar system, the second system they used because TetraStar better represented what in-vehicle navigation systems would be like in the near future.

Participants were asked if having TetraStar was similar to having a human copilot. One subject answered that he is more comfortable with TetraStar than with a human copilot. Another subject stated that it was different in that he had to take his eyes off the road to use it and he does not like to take his eyes off the road when driving. Several persons mentioned that they were surprised at the navigational system's accuracy. Another subject mentioned that while the unit guided them to their destination, some of the routes suggested by the unit were much longer than the routes they usually take. Still another participant stated that,

"TetraStar was almost as good as a copilot if [I am]
alone and going a long way."

Participants were asked if they needed a human copilot with them when they had the in-vehicle navigation unit. The participants agreed that at times a human copilot was useful in using the unit. One important reason was to have the human copilot read the screen. Apparently, the drivers were having problems reading the screen because of glare and because they had to take their eyes off the road. Some also had difficulties reading it because of their bifocal glasses. One subject suggested that an optical lens to magnify the screen would be helpful to older drivers. Another mentioned that the routes given by the unit are not always the shortest, and that there seems to be a bias toward certain roads. She stated,

"It loves Telegraph Road and always takes you there,"

implying that a human copilot could decide whether or not the in-vehicle navigation system's routes should be followed.

The participants were asked to compare TetraStar as a copilot versus a human copilot, on a scale of 1 to 10 where 1 was a strong preference for TetraStar alone and 10 was a strong preference for a human copilot alone.

The responses ranged from a 2 to 8 on the scale, with most of the responses at 4 or 5. Comments from participants, who selected low numbers on the scale, included:

"I really like the TetraStar system."

"It's a fun toy."

"It is a useful system when you are alone."

Subjects who selected the middle of the scale commented that

"TetraStar is good but it's always fun to have another person with you."

"A person copilot watches out for aggressive drivers, a computer can't do that."

"You really love it [TetraStar], *after you get used to it."*

"TetraStar is a great benefit when you are alone."

Some participants qualified their selections by giving a low score, that is a preference for the TetraStar system, if in an unfamiliar area or alone, and a high score if with another person or in familiar areas.

Training Needs

During the earlier natural use study of the TetraStar system, the only training provided to the subjects consisted of a brief demonstration in a stationary vehicle. The subjects were shown the features, talked through the process of inputting their home address as a destination, and were given a user's manual.

In discussing their experiences in learning about the TetraStar system, all the participants, except one, indicated that it was not too difficult to learn. One mentioned that he was computer illiterate, and yet he managed to use it. However, it was quite evident from his comments that he never mastered inputting destinations beyond the simplest "points-of-interest" method. In one of the sessions, when asked if they felt that they understood the entire system, several participants said that they did indeed understand it, but one subject stated that she "never got it." Most participants mentioned that the user's manual for TetraStar was not easy to follow and that it was too "computerese."

There was a short discussion of computer skills. The subjects reported a wide range of computer skills. Several participants indicated that they have personal computers (PC) at home. One subject built his own PC. However, the majority were not very confident about using computers. One subject said that while he had worked in a computer department, he was not very comfortable with today's computers. One couple said that training came with their computer purchase.

The participants were queried as to the type of training they would like to have if they were buying a car equipped with an in-vehicle navigation unit. The cost of the unit was given as between $2,000 and $5,000. There was definite agreement that training should come with the unit.

When asked if having the car salesperson show them how it works, the participants indicated concern that they might be shown the "gee-whiz" features and not the basics needed to operate the system. Several participants wanted a class lasting a few hours, but several other subjects indicated that a "hands-on" session in the car would be more useful. Others felt that an initial training followed by a session later, after they had some time with the unit, would be a good approach, because it gave them some time to know what questions to ask and then an opportunity to ask the questions. There were also suggestions for a help disk, a computer simulation, and a classroom overview with a computer simulation, or an actual driving experience. The participants liked the idea of a feature in the system that could "talk" them through the functions, a type of help feature built into the system itself.

There was general discussion about what features the subjects would like in an in-vehicle navigation system. One major concern was the ability to be able to read the screen. The subjects reported that they had problems with the glare on the screen, that they had to take their eyes off the road to look at it, and that they had problems with the image sizes, because of their bifocal glasses. A head-up display was discussed, provoked much interest, and seemed like a good solution to most of the participants. When asked if there would be a problem if only the driver could see the display, rather than both the driver and the passenger, most subjects responded in the affirmative. When asked if they had a choice to make the display more accessible to the driver, or to have it remain accessible to both the driver and human copilot, all the participants preferred the latter option.

Participants were asked what else would they like to have in the in-vehicle navigation systems, if the placement, glare, and image size problems were solved. Most of the comments concerned how to get help with using the unit. A computer-literate participant said that a help feature, similar to that with modern software would be useful.

DISCUSSION, SUMMARY AND CONCLUSIONS

The task of piloting and navigating an automobile becomes more difficult as people grow older. As people age, their reaction times increase and the ability to split attention among several tasks decreases. There is a deterioration of vision, particularly at night, as sensitivity to glare increases and the ability to focus decreases. In addition, many studies indicate that the deterioration of cognitive processing skills due to aging has an effect on spatial ability and wayfinding skills. Furthermore, older drivers perceive greater risks associated with driving and some experience fear and anxiety about their vulnerability in a fast-paced, complex traffic environment.

It has been well documented that many older drivers compensate for the effects of aging by avoiding situations they think are dangerous, difficult, or stressful. Specifically, older drivers tend to give up driving at night, drive less frequently in poor weather, and avoid limited-access highways and unfamiliar areas. What has received considerably less attention is the issue of compensatory practices that older drivers might use to overcome deleterious effects of aging on driving other than limiting their driving.

This study found that older people often use a "copilot" to help them overcome the challenges experienced in driving. The copilot serves a number of specific functions that are consistent with the changes in perception and cognition that older persons experience as they age.

One of the most common uses of a copilot described by our discussion participants was that the copilot served as "an extra set of eyes" for the driver. Because copilots do not have to keep their eyes on the road, they are free to scan the environment for navigation cues (e.g., landmarks, road signs, etc.) that may be useful for the driver.

Copilots also help drivers compensate for declines in reaction time and increased difficulty with divided-attention tasks. The copilot can provide the driver with information earlier than would be available without the copilot, thus reducing the negative impact that increased reaction times have on crash risk. Put simply, the copilot may serve to increase the amount of time available for making a decision. The copilot also serves as a second conduit of information, reducing the need for the driver to engage in divided-attention tasks. The copilot can pay attention to tasks that the driver may otherwise have had to attend to, thereby reducing the attentional load required from the driver, freeing drivers to focus more of their attentional capacity on the driving task.

Copilots also serve an important social function. They help to keep the driver company, making trips more pleasant. The companionship function of the copilot was frequently mentioned as an important role for the copilot, and one that should not be lost in the focus on improved driving safety and efficiency.

We found that ITS systems like TetraStar, and to a lesser degree, Ali-Scout can serve as a copilot for older drivers to a certain extent much like human copilots do currently. Discussion participants reported that they thought that an ITS unit would be almost as good as a human copilot, but most agreed that there are times that having an additional human copilot is helpful in using the ITS units. There may be several reasons for this response.

Older drivers may in large part be more eager to have both the ITS unit and a human copilot together because of difficulties associated with seeing, hearing and interpreting the information presented by the ITS unit. The human copilot provides another set of eyes and ears to perceive and interpret information presented by the ITS unit. In addition, while ITS navigation units may be able to present information to the driver, a human copilot provides a decision assist system that current ITS products cannot. The human is flexible, can respond to driver queries spontaneously, and can adjust more readily to the driving and information-processing style of the driver more quickly.

We have found that older persons have a wide range of computer skills, and this was certainly true among our discussion group participants. Despite this variation in skill level, participants had clear opinions about system functions and training that they thought would have helped them better understand and use the system and all its features. Specifically, discussion participants wanted the system to be able to provide context-specific help as the system was being operated. That is, if they are in the destination entry screen, they wanted to be able to call up a help screen/menu that was specific to the destination entry context.

Just as important, participants thought it would be valuable to have "hands-on" training time with the system. This could be as simple as having the installer take a brief trip with the customer describing and showing the customer specifically how the system works. Participants also expressed a strong preference for receiving follow-up training after using the unit for a few weeks to be able to get answers to questions that came up since they began using the system themselves.

Mobility is one of the key determinants in our society for maintaining a good quality of life. As people age their ability to pilot and navigate automobiles decreases, which in turn usually reduces their mobility. Copiloting is one possible strategy used by older drivers to compensate for the effects of aging on piloting and navigating an automobile. As such, copiloting may extend their mobility for a longer period of time. Further research is needed to determine the effects of copiloting on maintaining mobility of older drivers. However, we have found that in-vehicle navigation systems serve some of the copiloting functions for older drivers. The indications from this study are that it is the human copilot who monitors the ITS in-vehicle navigation unit and provides the driver with necessary information. In designing future navigation systems for older drivers, it is important that the copiloting environment be considered.

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APPENDIX A: THE IN-VEHICLE NAVIGATION-ASSISTANCE SYSTEMS

Ali-Scout

This in-vehicle navigation-assistance system (INAS), developed by Siemens Corporation, determined the fastest route between the vehicle's current position and a user-supplied destination. With Ali-Scout, the fastest route was determined by using road classification only (static route guidance) or by using this information combined with information about recurrent traffic congestion (dynamic route guidance). Nonrecurring traffic congestion or real-time information was not used by this system. Route information and link travel times were transmitted between the vehicle and roadside beacons with an infrared signal. The uploaded link travel times were used to update the network travel-time data base. Routes were calculated and link travel times were compiled on a central computer located at a traffic operations center run by the Road Commission for Oakland County (RCOC), Michigan. Communication between the central computer and beacons was through telephone links. Ali-Scout determined the vehicle's location through a dead-reckoning calculation between roadside beacons and provided turn-by-turn instructions to a driver as he or she drove using both visual and voice commands.

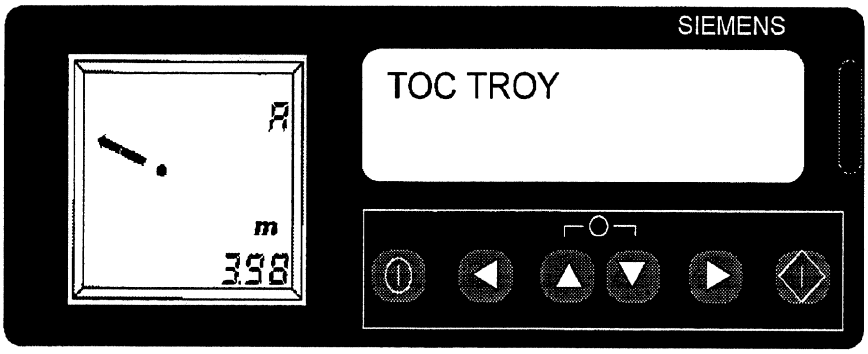

Figure A-1: Illustration of Ali-Scout unit in "autonomous mode" showing distance and direction to destination (TOC TROY).

For every trip taken with the Ali-Scout INAS, two conceptually distinct kinds of guidance are used. After a destination is entered into the Ali-Scout unit, guidance begins in what Siemens Corporation calls "autonomous mode." In this mode, only real-time distance and direction-to-the-destination information is displayed (i.e., "as the crow flies" information) without any turns being recommended. Figure A-1 shows an example autonomous mode guidance display. As the driver proceeds towards his or her destination, he or she eventually passes a roadside beacon where a communication takes place and a calculated route is downloaded by Ali-Scout. The system then changes to "guided mode," where the driver is given turn-by-turn instructions as he or she drives. An example driving maneuver icon for Ali-Scout is shown in Figure A-2. As the turn-by-turn instructions are followed, eventually the driver nears the destination. When the vehicle is within about one-half mile of the destination, Ali-Scout reverts back to autonomous mode guidance and the driver must look for the exact destination. Ali-Scout will also revert to autonomous mode guidance if the driver does not make a recommended maneuver or if communication at a beacon is disrupted (e.g., the beacon is not functioning or the infrared signal is blocked). When this occurs, Ali-Scout will remain in autonomous mode until another beacon is passed.

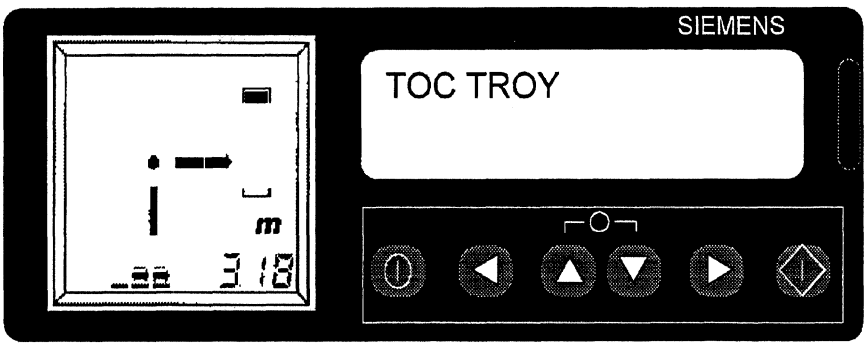

Figure A-2: Illustration of Ali-Scout unit showing a right-turn maneuver icon, recommended lanes, distance, and countdown bar showing relative distance to the maneuver.

TetraStar

This INAS, marketed by Siemens Corporation, was similar to other commercially available products such as GuideStar or PathMaster. TetraStar provided static route guidance only; that is, it determined the fastest route between some origin and destination without taking into account current traffic conditions. TetraStar determined the vehicle's location through an on-board global positioning system (GPS) and provided visual and voice, turn-by-turn navigation assistance to the driver. The visual guidance instructions consisted of driving-maneuver icons and an electronic map, in which a highlighted route to the user-supplied destination and the vehicle's current location were shown.

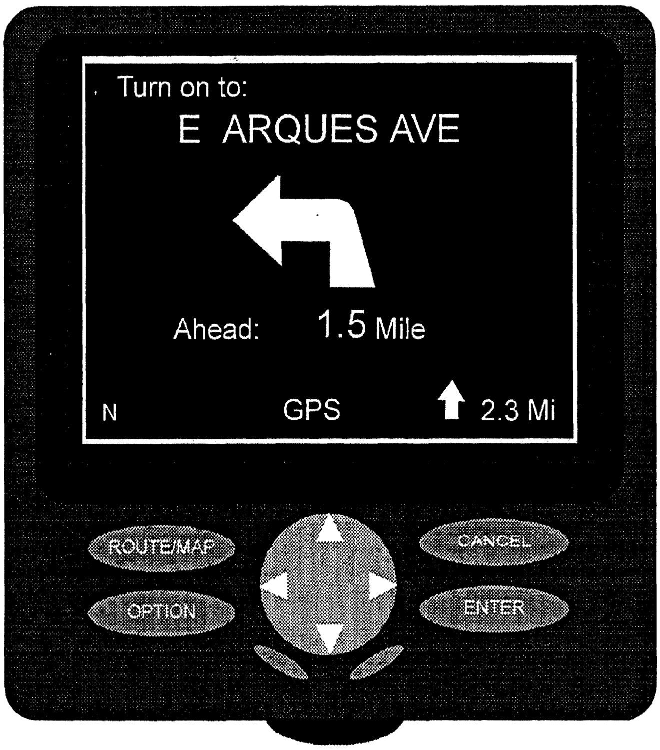

Figure A-3: Illustration of TetraStar unit showing a left turn maneuver icon, the name of the road to turn on to, the distance to the maneuver, the compass direction the vehicle is traveling (N), and the distance and direction to the destination.

As a trip starts, TetraStar shows the map display, with a highlighted route, and both verbally and visually tells the driver to "please proceed to the highlighted route," usually a few hundred yards from the vehicle's current location. Once on the route, TetraStar begins displaying turn-by-turn instructions by showing the next required maneuver, its distance away, and the name of the street where the maneuver will occur. The driver can switch between the maneuver icons and the map display by pressing a toggle button. Figure 3 depicts the TetraStar display showing a driving maneuver icon. Once the destination is within a few hundred yards, TetraStar reverts to the map display showing the highlighted route to the destination. If a driver fails to make a recommended turn, TetraStar recalculates a new route to the destination from the current position of the vehicle.