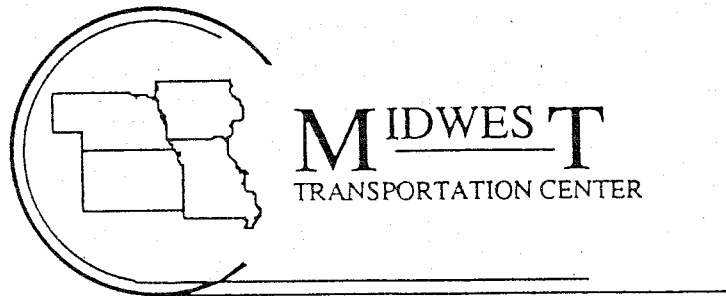


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**Assessing
the
Independence, Mobility, and Safety
of
Older Drivers**



September, 1994

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EXECUTIVE SUMMARY

The research presented in this report examines one of the determinants of driver safety, the cognitive skills of older drivers. In addition, it investigates the hypothesis of a possible link between personality and driver performance. A questionnaire was used to gather data on personality and other information related to demographics, driving experience, and "exposure" to potential for accidents.

The study utilized a sample of 100 older (age 65 and older) Iowa drivers, selected randomly from the list of all licensed drivers in Story County, Iowa, and the eight contiguous counties. Respondents were almost evenly balanced between males (n=54) and females (n=46). Letters were mailed to the drivers selected from the list, briefly explaining the goals of the study and what participants would be asked to do. A followup telephone call was used to ascertain their willingness to participate, respond to any questions, and provide information on scheduling. Slightly more than a quarter of those receiving letters took part in the study.

Respondents completed a 114-item questionnaire and were tested for their cognitive abilities in two different cognitive processing skills—spatial processing and selective attention (both auditory and visual). This was followed by the third component of the study, completion of a driving protocol in a specially equipped automobile on a closed driving course designed specifically for the project. The driving protocol consisted of a variety of performance tasks, planned as part of a continuous sequence of driving situations. Protocol included commonly encountered tasks, chosen for their potential relationship to cognitive skills selected for the study and for their relationship to specific accident categories, which involve older drivers at higher rates than younger drivers.

Data from the three research components of personality, cognitive skills, and driver performance tasks were grouped for purposes of statistical analysis. A preliminary analysis of the questionnaire items pertaining to personality was completed, yielding two significant dimensions of personality among the respondents, factors which might be called "Competence" and "Emotional Stability." Cognitive skills test results were consolidated into three scores for spatial processing (number correct, mean time per item, and total time required) and one score for each of the visual attention and auditory attention tasks. The elements of the driving protocol were grouped into fourteen inclusive variables.

The final analysis utilized the cognitive skills test results and the two dimensions of personality to examine correlations between these variables and the fourteen driving task variables. The goal was to determine whether any significant correlations existed between the personality and cognitive skills scores and how well the respondents performed the driving tasks incorporated in the driving protocol. Generally, levels of significance of $p < .05$ were considered significant.

Results were generally as expected, although there were some surprises. Analyses outcomes are discussed very briefly below.

1. **Demographics:** The driver study participants could be considered as the **young-old**, as the mean age was 69.4 years, with the range of 65 to 83. For the most part, they considered themselves to be comparatively healthy. A substantial portion of the group was taking medication for blood pressure (41 percent), but 39 percent indicated that they were not taking **any** medication. As a group, they seemed to be quite active, especially as related to mobility. Over half (52 percent) indicated that they drive over 50 miles each week and only three drive fewer than 10 miles each week. However, the older drivers (compared to the younger drivers) drive less (especially to the most common destinations) and indicated greater difficulty with driving (difficulty in seeing signs and pavement markings, rarely drive in snowy and icy conditions).
2. **Personality:** Although the research hypothesis regarding relationships between personality and driver performance was not established, the analysis of questionnaire items related to personality did yield some interesting results. Instead of a generally accepted cluster of dimensions of personality frequently called the “Big Five” factor structure, the respondents seemed to fit a two-factor structure, which could be described as “Competence” and “Emotional Stability.” The results were nearly identical to those from two groups from pilot studies —comprised of undergraduate students from Iowa State University. Although followup studies are indicated, the results are counter to outcomes described by many personality investigators during the last decade.
3. **Cognitive:** The primary emphasis of this study was based on the hypothesis that there would be a significant relationship between cognitive skills scores and performance of driving tasks. Significant correlations ($p < .05$) were established between scores in the test both for spatial processing and visual attention.

Seven driving task variables correlated significantly with spatial processing test scores. (1) Drivers with lower test scores took more time to complete the driving protocol and were more likely to (2) drive into an opposing lane of traffic when making a turn, and (3) react incorrectly to traffic signs, a problem encountered at intersections. They were (4) slower and less confident in driving through the prescribed obstacle course and (5 and 6) had difficulties in parking the test automobile, in both parallel and angle parking. And (7), although data on lane position were not collected on all drivers, the data collected and analyzed indicated significant relationships between lower spatial processing scores and a tendency for

these drivers to wander from left to right to a greater extent than did drivers with higher spatial processing scores.

Ten driving task variables correlated significantly with the visual attention task; three related to time. Drivers with lower scores in the visual attention task took more time to complete the driving protocol and took more time to complete the spatial processing test (both in mean time per task and total time to complete the test). In addition, drivers with lower scores in the visual attention task were more likely to drive into an opposing lane of traffic when making a turn and drive more slowly through the prescribed obstacle course. They tended to have greater difficulty reading and responding to information signs (requiring additional oral directions). When maneuvering in traffic, they had the propensity to do so from the wrong lane, crossing a traffic lane in their direction to complete the maneuver, creating the potential for unexpected conflicts with vehicles in that lane.

Drivers with lower visual attention scores also had difficulty with parking maneuvers (as in the case of spatial processing), both parallel and angle. The last driving variable correlating significantly with these lower scores related to lane position. Although data on lane position were not collected on all drivers, there was a propensity for drivers with lower visual attention scores to drive closer to the driving lane's right edge. This would lessen potential for headon collisions, but would increase the possibility of conflict with obstacles near the right edge of the driving lane, such as parked vehicles.

There were no significant correlations between scores on the auditory attention task and the driver performance tasks. However, this lack of significant correlation does not suggest that this cognitive skill does not have any relationship to driving safety. It is perhaps more likely that the lack of dual-processing conditions (monitoring two sources of input at the same time) among the driving tasks was the more proximate cause of this lack of significant correlation.

There were enough significant correlations between the cognitive skills tests used and the driver task performance variables to confirm the study hypothesis relating to cognitive skills: diminished cognitive skills scores are related to driving safety, and that driving variables correlating significantly with lower cognitive skills test scores are clearly associated with the potential for accidents, especially at intersections where a high percentage of accidents involving older drivers occur.

Although there is an abundance of significant correlations from the study, unanswered questions still point toward the need for expanded research of a similar nature. Several questions remain to be answered such as, Did the "young-old" age characteristic of the sample of drivers have an effect on study results? (The mean age was 69.4, indicating a shortage of drivers 75 and older.) Would the results have been different if more older drivers had participated in the study? Would a similar study of younger drivers produce comparable results?"

Although further study is indicated, analyses of data from this project confirm several hypotheses regarding relationships between driving skills and cognitive skills. We have planned further research that may lead to the addition, based upon this study, of a badly needed psychological component for driver license examiners as they evaluate the driving abilities of drivers flagged for review.

CHAPTER 1

INTRODUCTION

The Problem

Older drivers are becoming more common in the United States. Nationally, about 13 percent of U.S. citizens are 65 years and older, with the age group over 85 growing most rapidly. Bureau of Census figures show that, between 1960 and 1980, the number of people over age 65 grew by 54 percent. The numbers of those over 75 are expected to double by the year 2000 (Koltnow, 1985).

Elderly population growth has been accompanied by an improvement in this group's health and welfare. Such improvements have been significant, so more elderly are able to participate fully in normal life activities. Higher activity levels have led to increased ownership and use of motor-vehicles and, of course, longer retention of driver licenses. Not only are numbers of elderly increasing, but so is the likelihood they will retain their driver licenses. In the early 1950s, about 40 percent of all men over 70 held driver licenses, increasing to almost 90 percent by 1984 (Rosenbloom, 1988). Although women's licensing rates have traditionally lagged behind those of men, the percentage increase for women has been about the same as for men; the percentage of women holding a driver license increased from 8 to 43 percent during the same time span. And the proportion of women over 65 holding licenses climbed from 43 percent in 1969 to 62 percent in 1983.

These statistics are important to highway safety, as increasing age is frequently accompanied by varying degrees of vision loss, hearing loss, and cognitive skills deterioration. Public policy on renewal of driver licenses has recognized the potential effects of vision loss on highway safety and provided for vision tests as a condition for renewal. There have been no required tests for hearing (connections between hearing loss and highway safety have not been established) and none for cognitive skills loss, although the negative effect of cognitive skills deterioration on highway safety has generally been acknowledged. Although elementary tests are available to show cognitive skills deterioration, research has not provided information adequate to formulate public policy on the use of cognitive skills levels in making decisions on driver license renewals. Until that happens, such decisions will be made on a fragmented basis, responding to individual situations.

License renewal decisions are of great importance to the elderly. Being able to drive is frequently synonymous with psychological well-being, because driving symbolizes independence and a sense of control over their world. Because few smaller cities and towns and rural areas provide highly accessible alternative means of local transportation, loss of driving privileges may result in many older persons becoming homebound and less able to obtain needed goods and services or to participate in activities and socialize with family and friends. Even if their income would permit hiring of a taxi or other similar transportation service, often there are no other

transportation services available. Thus, continued possession of a valid driver license, which may be threatened by problems associated with aging, becomes critical to their personal welfare and sense of control and self-esteem.

Independence, Mobility, and Safety

A closing of the gap between the number of men and women drivers also contributes to the increasing number of older drivers on the road. In 1982, 92 percent of women age 30 to 39 held driver licenses. This means that, in the first part of the 21st century, about 90 percent of all women age 60 to 69 will have been licensed and driving for over 30 years (Rosenbloom, 1988).

Life changes that accompany aging and reaching retirement status do not eliminate an older person's mobility needs. Work trips may no longer dominate personal travel, but the non-work trips remain important. Free time associated with retirement allows for additional interests which may translate into mobility needs. Reaching age 65 is not expected to reduce mobility; independence and mobility are still very high priorities, although safety issues may ultimately force reduction in both.

Independence

Retention of driver licenses is important to older persons for many reasons. One is independence. Just as receipt of the first drivers license is an important rite of passage to adulthood and independence, license loss formally identifies one as being "over the hill" (Carp, 1988).

Loss of license inhibits the ability of the elderly to go where they need to go and meet their needs independently. It means that they are unable to provide rides to others and, consequently, to feel useful. It makes them "feel old," which is negatively related to social and emotional well-being (Carp and Carp, 1981). Ex-drivers report much more difficulty in getting to places they need to go to than do drivers, and even somewhat more than persons who have never driven (Carp, 1971). Ex-drivers feel ineffectual, dependent, and demeaned.

Mobility

The retention of a driver license is important to older persons from the standpoint of mobility because of a shortage of alternative transportation modes, particularly rural and suburban. Recent Administration on Aging (AoA) studies showed that, in our society, most older persons rely on the private automobile to meet their transportation needs. Studies indicate that probability of car ownership increases directly with household income and place of residence. Older individuals who own and continue to drive automobiles tend to have higher incomes and live in rural and suburban areas. In all probability, the automobile will continue to be the primary mode of transportation in rural and suburban areas in the future (Tolliver, 1984).

It is a given that, as our population ages, more older citizens will try to retain licenses longer. Rural older drivers will have a particular need to continue driving as long as

possible, due to non-availability of public transportation. Even when available, it is often not very accessible for the aging individual.

Safety

Various changes in mental and sensory functions occur as humans age (Charness, 1985; Reff and Schneider, 1982; Welford, 1981). Performance of such important driving tasks as reading signs at night (Sivak, Olson, and Pastalan, 1981) and perceiving and reacting to roadway hazards (Olson and Sivak, 1986) has been shown to decline with age.

Older drivers tend to compensate for such changes by adjusting their driving patterns. They tend to drive at slower speeds (Rackoff, 1974) and restrict their driving to lower stress environments. They avoid driving after dark, on icy roads, and on high speed, busy freeways (Ysander and Hernes, 1976).

Even considering compensatory measures, National Highway Traffic Safety Administration (NHTSA) figures confirm that, when adjusted for exposure, older driver accident rates are highest of any age group over age 24. Exposure, in this context, refers to driver vehicle-miles of travel (McKelvey and Stamatiadis, 1989).

Accident studies place older drivers within a specific cluster of accident situations. Typically, older drivers experience high involvement rates in specific types of accidents, those caused by driver errors such as failure to yield, improper turns, and ignoring stop signs and red traffic signals. For example, a study of accident data in North Carolina showed that unsafe left turns were, at least in part, the cause of about 25 percent of crashes involving drivers over age 65, almost twice the rate of average age drivers (Waller, House, and Stewart, 1977). Older drivers are involved at higher rates than average in accidents resulting from changing lanes, merging with traffic, or leaving a parked position; this suggests that older drivers have difficulty when they must react to more complex driving situations.

The problems associated with older driver license renewal, however, are further complicated in that some older drivers score higher on psychomotor laboratory tests and driving tasks than some younger drivers (Rackoff, 1974). Thus, restriction of driver licenses based simply on chronological age cannot be justified.

Older driver self-analysis of abilities. Many older drivers become aware of changes in their driving abilities and of driving situations that become more difficult as they grow older. That is undoubtedly the reason for changes in driving habits and voluntary reduction of exposure to traffic noted earlier.

This awareness is confirmed by a survey of older drivers in a metropolitan area (Carp, 1980). Survey results indicated several problems that were noted for older drivers by a majority of respondents. These included visual problems (82 percent), slowing of motor response (75 percent), stiffness and crippling, especially by arthritis (62 percent) and difficulty adjusting to new situations (55 percent).

Deteriorating skills associated with aging may influence the older driver's awareness of cognitive processes that are related to driving, such as attention and information processing (Winter, 1988). Such skills may once have been taken for granted, but awareness of deteriorating skills emphasizes a greater sense of risk derived from the older driver's own experience in traffic, his/her own perceptions of other older drivers, and his/her impression of the safety of conditions surrounding driving. The way older people appraise a driving situation has important consequences for the manner in which they cope and for subsequent emotional, physiological, and behavioral reactions. Winter (1988) theorized that older drivers' perceptions of self efficacy may cause them to develop compensatory attitudes towards their driving. As a result, they may become more responsible, law-abiding, non-competitive, courteous, and cautious than when they were younger. They may also adopt too many avoidance behaviors to maintain their skills (such as driving in moderate to heavy traffic) and thus their mobility declines. As suggested by Faletti (1984), emphasis should not be on what older drivers have lost but what they maintain, and how to modify the environment to aid the older drivers to continue to function at a level commensurate with their skill levels. In other words, the older driver should not be intimidated into giving up a license for invalid reasons since transportation is essential in maintaining a high quality of life (Weiner, 1973).

Older drivers as a risk to other drivers. People armed with anecdotal data can make a case that older drivers represent a risk to other drivers. Reasonable interpretations of recent accident data, however, do not support this contention (Yanik, 1985). In fact, it can be shown that older drivers do not constitute a threat out of proportion to others who drive on public streets and highways. Though they are involved more often with specific types of accidents, they are underrepresented (in absolute terms) in most accident data relative to the number of licensed drivers within other age groups.

This is true even when considering traffic accidents involving fatalities. Although older driver involvement in fatal accidents is greater (relative to their numbers) than the safest age group (age 55 to 64), it is less than that of drivers under age 20, or age 21 to 24, or even 25 to 34 (Yanik, 1985). This is in contrast to higher overall crash rates (when relative exposure to accidents is considered) experienced by older drivers (McKelvey and Stamatidis, 1989).

It could be argued that this more favorable fatality rate is due to lower exposure to possible accident situations. It has already been noted that older drivers appear to compensate for deficiencies in sensory/cognitive abilities by driving at lower speeds and in less stressful environments, accompanied by a trend to drive fewer miles, also limiting exposure. This conclusion, however, is called into question by at least one study (Waller et al., 1977).

Waller et al. (1977) indicate that low mileage drivers of any age are worse drivers per mile than high mileage drivers. If this is true, perhaps it is not so much aging that

increases the risk of older drivers as it is limiting their exposure, which could lead to a loss in their driving skills. It is equally likely that many older drivers reduce their exposure in view of their own perception of sensory/cognitive deficiencies occurring as part of their aging process.

It is difficult, however, to quantify effects of voluntary reduction of exposure on automobile accidents. There is a shortage of data on driving exposure and any association with deterioration of sensory/cognitive functions and/or driving skills.

Predictors of Driving Performance

Researchers have attempted for many years, with little success, to discover the bases for increased risk of accidents among older drivers. One problem is the difficulty of establishing valid dependent measures of driving performance. Although accident frequency and accident rate have been most often used, other studies often emphasize performance in driving simulators and road tests. Although all have strengths and weaknesses, the optimal choice of measures will probably depend on researcher study goals. Assuming that adequate dependent measures of driving can be obtained, the question then becomes what variables will adequately predict performance of these driving measures. This section will examine measures either known or assumed to be related to driving safety, and include personality, vision, hearing, useful field of view, and cognitive skills.

Personality

A variety of personality factors have been associated with driving accidents (Elander, West, and French, 1993; McGuire, 1976; Shaw and Sichel, 1971). Extraversion and neuroticism (or emotional stability) have frequently been noted. Other reported correlates with driving accidents have been external locus of control, Type A behavior personality pattern, hostility, psychopathy, and impulsiveness and sensation-seeking (the latter two components of extraversion).

McGuire (1976, p. 439) succinctly presents his conclusion: "In summary, it may be said that highway accidents are just another correlate of being emotionally unstable, unhappy, asocial, anti-social, impulsive, under stress, and/or a host of similar conditions under other labels."

Vision

Among the various measures of driving, visual measures have received the greatest attention, because driving is a highly visual task. It is important to note that many older adults have significant deficits in visual function (Owsley et al, 1991). Thus far, however, research has failed to establish a strong link between vision and accident frequency. There have been several large-scale studies which have found statistically significant correlations between accidents and various vision tests, but these correlations are very low, accounting for less than 5 percent of the variance in predicting accident rates (Henderson and Burg, 1974; Hills and Burg, 1977; Shinar,

1977). This lack of known relationship severely limits usability of simple visual acuity tests in identifying at-risk older drivers.

Some research involving another measure of vision, contrast sensitivity, has been conducted. Whereas visual acuity testing is a high-contrast vision test, a test for contrast sensitivity recognizes that lower light levels exist when driving in less-than-ideal conditions. Examples, of course, include nighttime driving, and driving in fog or rain. Contrast sensitivity (visual acuity at lower light levels) varies for all drivers but can be a particular problem for older drivers, as they tend to have lower contrast sensitivity (Evans and Ginsberg, 1985). Lower contrast sensitivity translates into the need for more light to read signs or for increased letter size on traffic signs in order to read the sign message. However promising this measure appears to be, there have been no studies examining relationships between contrast sensitivity and accident rates.

Hearing

Although the prevalence of hearing impairment rises sharply with age, the connection between hearing loss and safe driving has not been established (Henderson and Burg, 1974). Surprisingly, little research has been conducted which examines the relationship between hearing loss and safe driving, although common sense would dictate a strong relationship exists.

Consequences of hearing loss accompanying aging may be less important in driving due to ambient noise levels. Ambient noise levels inside automobiles traveling over 35 miles per hour provide a level of masking similar to severe loss of hearing, a factor apparently mitigating the role of hearing for all ages in driving.

Useful Field of View (UFOV)

Driving is a skill requiring visual input plus more central cognitive functions, such as attention. Because of present interest in visual attention at the preattentive level, significant research has been conducted based on the concept of *useful field of view* (UFOV). It is defined as the visual field area over which information can be acquired during a brief glance (Sanders, 1970). Size of UFOV is a function of target presentation (duration of presentation, conspicuity, and distance from central vision) and competing attentional demands.

UFOV has proven useful as a predictor of accidents. Regressing visual function measures on accidents alone in a study of visual/cognitive correlates of accidents among older drivers, however, did not produce a significant relationship (Owsley, et al., 1991). Nevertheless, the zero-order correlations between both UFOV and a composite score for the test of mental status (assessed using the Mattis Organic Mental Status Syndrome Examination (MOMSSE)) were significantly related to the number of driving accidents. They jointly accounted for 20 percent of the accident variance covered by the study, a far better predictive performance than that experienced utilizing vision only. (Note: MOMSSE is a test that evaluates 14 categories of cognitive functioning; examples include abstraction, digit span, and block design.)

Cognitive Skills

A general finding in cognitive aging literature is that of inevitable deterioration as aging occurs (Poon, 1985). Deterioration is loosely defined as both poorer cross-sectional performances in the older cohorts as well as longitudinal change toward poorer performance over time. While cross-sectional data support the theory of general loss in cognitive skills, there can be widely varying loss rates between individuals, hence the need to avoid making generalized assumptions regarding older drivers.

The success of adding the cognitive element to vision in the UFOV research supports theories on the negative effect of cognitive motor impairment on driving. The literature on movement slowing with age suggests that there are alterations in cognitive-motor processes, including (1) failure to use advance preparatory information (Botwinick, 1965); (2) difficulty in processing stimuli and making responses that are spatially incompatible (Rabbitt, 1968); (3) initiation deficit in dealing with increased task complexity, which gradually diminishes with practice (Jordan and Rabbitt, 1977); and (4) inability to regulate performance speed (Rabbitt, 1979; Salthouse, 1982; Somberg and Salthouse, 1982). All these elements can become critical to traffic safety when a driver encounters a situation which does not fit expected traffic flow patterns or when driving in an unfamiliar locality.

Olson and Sivak (1981) studied drivers with brain damage and found that those who exhibited impaired perceptual/cognitive skills showed effects of impaired driving; those who scored well on certain perceptual/cognitive skills tests tended to show good driving performance. They also concluded that "different perceptual/cognitive tests are good predictors of driving performances by persons with and without brain damage."

A study by Temple (1989) examined the relationship between a variety of measures of perceptual and cognitive skills and driving performance on a driving simulator and on a road test. Study participants were volunteers, evenly divided between younger (mean age = 30.04) and older drivers (mean age = 67.02).

The tasks predicting driving ability differed between the younger and the older drivers. Ability for the younger drivers was predicted by experience (including miles driven and years licensed), age, color identification, health, long-term memory, cognitive interference, and short-term memory abilities. Older driver ability was predicted by miles driven, visual tracking, memory strategies, discrimination ability, motion detection, target detection, cognitive interference, and form detection. Thus, it appears that the driving ability of younger drivers can be predicted by a wide range of factors, while that of older drivers can be predicted mostly by perceptual and cognitive abilities.

Temple (1989) recommended further research to include development of better driving measures and continued emphasis on the role of perception and cognitive

skills on driving ability. Of special interest was that further investigation into relationships between cognitive abilities of selective attention, dual task performance, and cognitive flexibility to driving ability was advocated by the study.

Study Objectives

Driving on a clear day in light traffic does not overtax any dimension of performance (perceptual, cognitive, or physical), but other, more complex situations can place demands on drivers that may exceed their abilities to respond safely. Smith (1968) described driving as consisting of four discrete phases. The driver must

- (1) See or hear a situation developing (stimulus registered at the perceptual-visual or auditory level),
- (2) Recognize it (stimulus recognition at the cognitive level),
- (3) Decide how to respond (cognitive level), then
- (4) Execute the maneuver (motor level).

Cognitive and physiological changes that coincide with aging raise questions about how well drivers perform in all four phases. How attentive is the driver to the environment? Does a lapse in attention affect the ability to see or hear a potentially hazardous situation developing? Are older drivers slower to respond? Are older drivers less able to perform the physical tasks of braking and steering?

Cognitive performance is fundamental to the first three of the four phases of driving. It affects driving in terms of attentiveness and information processing. Deficits in such cognitive skills may be predictive of potentially unsafe driving practices.

Hypotheses

The purpose of this study was to evaluate the relationship between both personality and the loss of certain cognitive skills and the relation to their loss on driving performance in older drivers. It was hypothesized:

- There is a relationship between personality traits and driving variables, especially those (previously noted) that have been implicated by earlier studies. Additionally, in an exploratory, yet systematic vein, any relationship between driving variables and what has come to be known as the “Big Five” personality structure will be examined.
- There is a relationship between some of the socio-demographic variables incorporated in the questionnaire and age or gender. The amount of driving and categories of destinations were of special

interest, possibly indicating future trends related to exposure to accidents.

- Older drivers with deficits in ability to perceive information, including the ability to judge distances between objects, will experience similar problems in driving. These might include the inability to judge relative distances in avoiding obstacles in the roadway, in various parking maneuvers, and even in the potentially dangerous steering error of turning into the opposing lane of traffic at intersections.
- Older drivers with deficits in the ability to focus attention on a task will experience difficulty in separating relevant from irrelevant stimuli, thus failing to make appropriate decisions in executing driving maneuvers. The deficit in the ability to focus attention on a task includes the inability to associate information available (visual and auditory) to decision-making which must accompany the task of driving. One example would be the ability to read the information on traffic signs and to apply that information to driving tasks.

An analysis of recent literature suggests that these cognitive skills variables would show the greatest likelihood of significant relationships with driver performance. Therefore, the primary emphasis of the study plan was to include driving tasks that might tax cognitive skill at various levels.

Research Objectives

Research objectives were to ascertain effects of identifiable personality traits and the selected cognitive skills on older driver performance. A long-term research goal is to develop some scalar values for the cognitive variables which are found to correlate with driver safety. These measures could contribute to the development of public policy for license renewals and for older driver evaluation. However, the first task is to correlate the cognitive skills loss with driver task performance. Once this has been accomplished, it should be possible to develop scalar values.

Summary/Methodology

The research consisted of several unique components designed to assess the older person's driving ability and the ability to react properly to stressful driving situations. It approached the problem from four directions (socio-demographic, personality, and cognitive skills—as independent variables, and driver performance as the dependent) and merged them to provide the resulting assessment. Subjects taking part in the project consisted of a group of 100 licensed drivers age 65 and older, randomly selected from a complete list of Iowa licensed drivers.

Study Components

The first component consisted of the development and administration of a questionnaire completed by the older drivers. It was designed to gather such information as respondent driving experience and exposure, driving habits, self-report assessment of driving performance, personal health, certain socio-demographic variables, and family structure. It also contained a series of questions designed to develop a personality profile for the respondent which applies especially to attributes relating to driving, such as risk-taking and anxiety.

The second component involved the testing of all respondents' cognitive skills with three tasks, one spatial and two attentional. Prior to evaluation, participant hearing and vision were checked, to ensure that deficits in either sensory function would not affect cognitive skills performance.

The third component was actual driving. Each driver completed a driving protocol on a closed driving course, designed especially for the project. Driving performance tasks were selected based on their ability to simulate the driving experience. Care was also taken to include tasks which would test driver abilities in spatial processing and selective attention. A mid-size vehicle furnished by General Motors was used for the study, equipped to collect lane tracking data.

Analysis and Results

The set of independent variables used in the analyses was the (1) a list of self-report variables included in the questionnaire, (2) personality dimensions defined by a separate analysis of the data from the questionnaire, and (3) subject scores resulting from each of the three cognitive skills tests administered. The dependent variables included the sixteen driving task variables resulting from consolidation of the driving tasks in the protocol, which measured the actual driving performance. The resulting data were analyzed, using basic descriptive statistics, multiple regression, and factor analysis. These analyses revealed those independent variables that effectively and parsimoniously predict driving performance.

Study results are described very briefly below. See Chapters 5, 6, and 7 for more detailed information on the relationships of significance.

- Statistical analyses revealed essentially no correlation between any dimension of personality and driver performance variable.
- Seven driving task variables correlated with spatial processing test scores at the $p < .05$ level of significance.
- Ten driving task variables correlated significantly with the visual attention task, three related to time.
- There were no significant correlations between driver performance tasks and auditory attention. However, this might have been due to

a shortage of driver performance tasks requiring concurrent driving maneuvers.

The significant correlations between cognitive skills test scores and the driver performance task variables supported some of the study hypotheses. The fact that the demonstrated relationships are clearly associated with potential for accidents, especially at intersections (where a high percentage of accidents involving older drivers occur), is encouraging; the research is on track. However, it is obvious that more study is indicated, to translate what has been learned into practical usage (see Chapter 7).

Report Organization

A description of the research plan and design is presented in Chapter 2. The summary of how the driver performance raw data were organized into the sixteen dependent variables is provided in Chapter 3. Analysis results are provided separately in Chapter 4 (The Questionnaire), Chapter 5 (Personality Dimensions and Driving) and Chapter 6 (Cognitive Skills and Driving). Conclusions drawn from the results discussed in Chapters 4, 5, and 6 are summarized in Chapter 7. Implications of the study are also discussed in Chapter 7.

CHAPTER 2 RESEARCH PLAN AND DESIGN

Specific Aims

The purpose of this study was to identify relationships between two sets of independent variables—personality and cognitive (spatial processing skills and attentional skills)—with performance on the sixteen driving task (dependent) variables. The population of interest was the older driver, holding a valid driver license and age 65 or older.

This chapter describes the research plan and design. Specifically, it provides a description of instruments used for data collection and how data were analyzed. It begins with a brief description of the procedure for choosing subjects for participation in the study.

The Respondents

Drivers participating in the study were selected randomly from the population of licensed drivers in Iowa. Selection began with a list of licensed drivers from the entire state, which yielded a subset of drivers age 65 and older. The respondents came from a final list of drivers 65 and older residing in Story County and in the eight contiguous counties. Although the list of all licensed drivers in Iowa was available, drivers from these counties were selected so that study participants would not have to drive longer than about one hour to the research site in Ames. Letters were mailed to drivers (randomly selected from that final list) describing the research and asking them to participate. (A sample of the letter used may be found in Appendix D.) Follow-up telephone calls were used to ascertain their responses and to arrange a date for those agreeing to participate. Slightly more than one quarter of those receiving the letters took part in the study.

Personality/Demographics Questionnaire

First, a questionnaire consisting of 114 items was completed by respondents. Questions included those designed to

- assist in developing respondent personality profiles, especially as related to the driving task, and
- ascertain data relative to the respondent's background, driving experience, driving performance, and driving exposure.

Personality

The intent of the "personality profile" portion of the questionnaire was to determine whether there are personality characteristics related to impairment of driving behavior in the older driver. Questions were included that would assist in identifying variables such as impulse control, accident proneness, risk-taking, and aggressiveness. A total of 37 of the items pertained directly to the personality profile development, with the balance utilized for other self-report assessments.

Self-Report Assessment

Some responses to the self-report assessment were compared to actual driving performance, so that a measure of driver perceptions and the reality of their driving skills could be obtained. Additional questions were included pertaining to

- personal concerns about maintaining mobility,
- frequency of travel to a list of destinations,
- self-report of health and health concerns, and
- health problems requiring medication.

The above questionnaire also included items of Malfetti and Winter's (1986) self-rating instrument for drivers aged 55 and older. These items were rephrased slightly in order to fit the study questionnaire's format.

Malfetti and Winter summed individual item scores (with attention to direction of the item keying—"good" or "bad") to obtain an overall, composite index of self-reported assessment. Our analyses of the questionnaire results did essentially the same, although one item was inadvertently omitted ("I find it difficult to decide when to join traffic on a busy interstate highway."), and another was dropped because of low response ("I check with my doctor about the effects of my medications on driving ability."); many of the subjects were not on medication.

Questions used in the instrument were submitted by the research team, representing academic disciplines of gerontology (demographic data, health concerns, and special concerns), personality (including marker variables), and traffic safety (including a self-report of changes in driving habits and accident experience). It was then pre-tested on two groups of undergraduate students at Iowa State University.

Responses to the personality items in the questionnaire were used to develop the personality variables described in the next section. This is followed by a description of the research plan and design for data collection on the cognitive tasks and the driver performance variables.

Personality Profile

For perhaps the last decade or so, personality investigators have favored what is frequently called the "Big Five" factor structure (e.g., Costa and McCrae, 1992; Digman, 1989 and 1990; Goldberg, 1993; McCrae, 1989; Wiggins and Trapnell, in

press), which is basically five essentially independent dimensions of personality. These dimensions are based on a number of factor analyses conducted by many researchers. Typically, the dimensions are labeled Agreeableness (or pleasantness), Extraversion/Introversion (or surgency), Emotional Stability (vs. neuroticism/emotionality), Conscientiousness (or dependability), and Openness to Experience (or intellect).

Given this rather strong consensus (not total consensus: cf. critics Eysenck, 1992, in press, and Zuckerman, 1992), a variety of marker variables selected to reflect these five dimensions was built into the personality/demographics questionnaire. Due to the large number of other self-report variables examined, a smaller number of marker variables, rather than complete scales, were included.

The analytic aim was twofold: first, to form a priori (theoretical) scales for measuring the Big Five by summing salient items; and second, to form empirical scales through factor analyses (summing those items salient on the factors that would emerge). Additionally, personality items were constructed and included in the factor analyses that a priori (based on literature review and logic) appeared to be particularly relevant to driving competence, for a total of 37 personality items.

Cognitive Performance

Cognitive performance is crucial for the recognition and decision phases of driving, but there are no valid tests for screening drivers with impaired cognitive performance and little evidence that training will compensate (McKnight, 1988). The Committee for the Study of Improving Mobility and Safety for Older Persons (who issued Special Report 218) strongly recommends more basic research on how cognitive performance relates to driving.

One specific cognitive skill which affects driving is attentiveness. This is the ability to focus attention on a given task, and is widely perceived to diminish with age (Botwinick, 1978). Evidence also suggests that older persons are more easily distracted by irrelevant stimuli (Kausler, 1982) and that older persons have more difficulty than younger persons in selectively responding to salient stimuli (Staplin et al., 1987). But their importance to driving and the magnitude of such differences have not been adequately determined.

Another cognitive skill relating to driving is spatial processing, the ability to judge distance relationships between objects. An example is underestimating relative depth separating visual targets (Hill and Mershon, 1985). If this skill declines with age, perhaps older drivers are more likely to encroach upon the lane of oncoming vehicles than younger persons (Kline, 1986), which may partly explain the higher incidence of turning accidents among older drivers.

There also appears to be a consensus that older persons process information more slowly than younger ones, which impairs their performance of complex, multifactor tasks (Staplin, et al., 1987). A slower speed of information processing, particularly for complex decisions, would suggest that more time is required for older drivers to complete the cognitive components of the four-phase driving model (outlined earlier in Chapter 1). Accordingly, related cognitive tasks were chosen and skill levels tested in the areas of spatial processing, and visual and auditory attention, as they relate to older drivers.

Perceptual Tasks

Vision and hearing are the two sensory functions thought to be most clearly involved in driving a vehicle. While hearing has not been empirically demonstrated to have much effect on ability to drive (Henderson and Burg, 1974), the relationship between driver vision and driving ability is clearly established in the literature (Yanik, 1985). Measures of visual acuity and hearing were taken from each subject in order to ensure that neither vision nor hearing problems would affect cognitive skills test results nor differentially bias driving performance.

Having these results on hand, it was also possible to determine significant relationships between these variables and driver performance on the closed course. Therefore, significant correlations were examined and a discussion of their possible importance is included in Chapter 6.

Visual acuity. A Bausch and Lomb Vision Tester was used to measure static visual acuity. Test objects consisted of a large square with its diagonals at 90 degrees and 180 degrees respectively. The subject's task for each test object was to identify the corner of the square containing the target. The target consisted of a checkerboard with individual squares, reflecting a specified acuity level. Acuity was measured in 12 steps of progressive difficulty over a range equivalent to Snellen ratings of 20/200 to 20/17.

Each respondent was tested for visual acuity prior to the administration of the cognitive tasks. Knowledge of subject visual acuity was important in collecting cognitive skills data, since poor visual acuity could bias the cognitive skills data.

Subjects were tested wearing corrective lens if they also used corrective lens for driving. A subject's score was the number of correct choices.

Hearing. Deaf individuals can safely drive automobiles, whereas the same is not true of blind individuals. Basic literature on audition suggests that perception of an auditory stimulus depends not only on basic driver auditory capability, but also on the environment in which the stimulus is presented. Ambient noise tends to mask much of the auditory stimuli while driving, though this varies as a function of many vehicular and environmental factors. A strong argument can be made regarding the primary value of hearing to driving safety, especially reacting to warning/attention-getting stimuli, such as sirens and train whistles (Henderson and Burg, 1974).

However, the driving protocol included no such stimuli; the only critical use of hearing was to receive oral instructions from the researcher-monitor in the vehicle.

Nevertheless, knowledge of the subject's hearing ability was important to this study, as poor hearing could bias the data collected on the auditory attention task. Therefore, a Beltone 100 Series Portable Audiometer was used to test hearing. Subjects were tested via the audiometer for their responses to pure 70 dB tones at frequencies ranging from 125 to 8000 Hz. Those who wore hearing aids were tested without hearing aids in place, as it was necessary to remove them for the auditory attention task (a hearing aid produces feedback when covered with the audiometer headphones). Hearing test scores reflected the range of frequencies that the subject could hear, given the constant 70 dB tone at all frequencies.

Cognitive Tasks

In two recent reports on older person mobility and safety, overrepresentation of older drivers in some accidents, particularly in crashes when turning, is explained in terms of failing attentional capacity. It is implied that these drivers could cope if they had more time or needed to perform fewer tasks simultaneously. Of particular importance are situations said to require "information treatment and decision making under a severe time constraint" (OECD, 1985), most pronounced in urban areas and related to the complexity of that environment (Maleck and Hummer, 1986). When older drivers speed up their performance, they tend to make significantly more errors than do younger drivers (Brouwer et al, 1991).

Although specific relationships between age, cognitive processing, and driving performance are not well understood, there are several cognitive abilities that have been shown to relate to effective motor performance, two of which are selective attention and spatial processing (Avolio, Kroek and Panek, 1985; Barrett, Thornton and McCabe, 1968; Harano, 1970; Kahneman, Ben-Ishi and Lotan, 1975, Milhal and Barrett, 1976). Three cognitive tasks were used (one spatial and two attentional) to assess the processing capabilities of older drivers. The hypothesis was straightforward: performance impairments observed in the sample of older drivers on these cognitive skills may correlate with difficulties experienced during the driver performance portion of the study.

Spatial processing. Clearly, the extent objects encountered while driving can be identified (e.g., traffic signals, crossing pedestrians, traffic signs) will have a significant influence on driving effectiveness. To substantiate such theorizing, respondents were asked to complete the Embedded Figures Test (EFT) (Witkin, et al., 1971) and were monitored as to how well it predicted driving performance.

The EFT is a visuospatial task. Performance in the Embedded Figures Test has been previously shown to predict accident involvement in adult drivers (Barrett et al., 1969; Harano, 1970). The test consists of 12 timed trials in which subjects are to extract an embedded geometric figure from an intricate visual background. The subject's task on each trial is to locate a simple figure embedded within the larger

complex figure. Completion of the EFT yields three scores; number correct, mean time per item, and total time required.

Selective attention. Ability to focus attention on a task is widely perceived to diminish with age (Botwinick, 1978). Evidence also suggests that older persons are more easily distracted by irrelevant stimuli (Kausler, 1982) and that older persons have more difficulty than younger persons in selectively responding to the most important stimuli (Staplin et al, 1987). Yet, these skills and their importance to driving (as well as the magnitude of the differences) have not yet been adequately determined. This discriminative ability is directly related to the process of attention. In this component of the study, two attentional tasks were utilized.

The first is the Visual Attention Task. Attentional capacity was monitored by a task in which a series of 3–15 letters was randomly presented to different locations on a computer screen for very brief periods of time. Subjects were asked to report how many letters comprised the set size for each trial. The prototypical pattern of performance in this task is such that as the number of letters increases, the lower the accuracy in detecting the number of letters presented. If older drivers are indeed impaired in this component of information processing, their performance at the higher display sizes should be poor. Subjects completed 33 such trials. The measure of interest was the total number of correct estimates.

The second attentional task used was the Auditory Attention Task. Two similar sounding syllables (e.g., ga, pa, da, ka, ba, ta) were presented simultaneously, one to each ear via stereo headphones for this selective listening task. Subjects were asked to report the two syllables they heard for each trial by circling them on an answer sheet. After one block of 30 trials, headphones were reversed and another block completed.

The extent to which older drivers are successful at identifying each syllable reflects their ability to process simultaneous stimulus inputs. This skill is known to predict accident proneness in professional taxi drivers (Kahneman, et al., 1975).

Driving Performance

The third component of the study was an assessment of respondent performance on sixteen driving tasks. This was made possible by use of a specially equipped automobile navigated on a closed driving course designed specifically for the project. The driving protocol consisted of a variety of tasks, planned to be part of a continuous sequence of driving situations. The protocol included many commonly encountered driving tasks, selected for their potential relationship to the cognitive skills measured, and their relationship to specific accident categories which involve older drivers at higher rates than younger drivers. An example is a left turn against opposing traffic, one type of accident involving older drivers more frequently than younger drivers.

Closed Driving Course

The driving tasks were performed on an enclosed driving course, converted from previous use by driver education classes. A combination of two-way and one-way streets were laid out using reflective marking tape. Most were two lane, except at the one signalized intersection, which included two-lane approaches from each direction. Pavement marking tape was used to define parking spaces used in the protocol, including parallel and 45 degree and 90 degree angle parking spaces.

The traffic signal was wired for observer operation, so that the same, planned signal phase sequence was presented to each driver. In addition, a traffic-actuated inductive loop provided an opportunity to observe driver reaction to a green-amber-red sequence as the vehicle approached the intersection.

A variety of regulatory, warning, and destination signs were placed along the "streets," planned to place a "demand" on the drivers to select pertinent instructions from visual information presented either simultaneously or sequentially and, subsequently, to react properly to the given message. Included were regulatory signs (stop, yield, do-not-enter, one-way), warning signs (chevron, curve), and several destination signs. A course schematic is shown in Figure 1.

Movable traffic cones were used to define the obstacle course and to restrict vehicular movement in the various parking tasks. They also aided in subjective evaluation of how accurately driving maneuvers were accomplished by observing whether cone position was disturbed by vehicle motion.

Test Vehicle

A four door Pontiac 6000 sedan with an automatic shift was used for driving. In general, it matched with the vehicles currently driven by the respondents in terms of size and features; thus, respondents were able to easily adjust to driving this somewhat familiar automobile. There was concern on the part of the research team that driving an unfamiliar vehicle might produce an element of bias in the results. Consequently, each driver was provided the opportunity to test the vehicle via a brief, but structured, driving experience just off the driving course.

The vehicle was equipped with two measuring systems, attached to a Dolch 486 personal computer, operating on D.C. electric power and used for data acquisition. One system monitored steering wheel movement, using a potentiometer attached to the steering wheel. The other system involved the use of a miniature television camera with a super wide-angle lens mounted such that images of the space between the vehicle and the right edge line of the traffic lane could be recorded. The system accommodated vehicle displacements of up to 12 feet from the right edge line.

Data was recorded in real time, using a Data Translation Quick Capture frame grabber for the video image. At the end of each run, data collected were moved to the hard disk. Data processing was done offline.

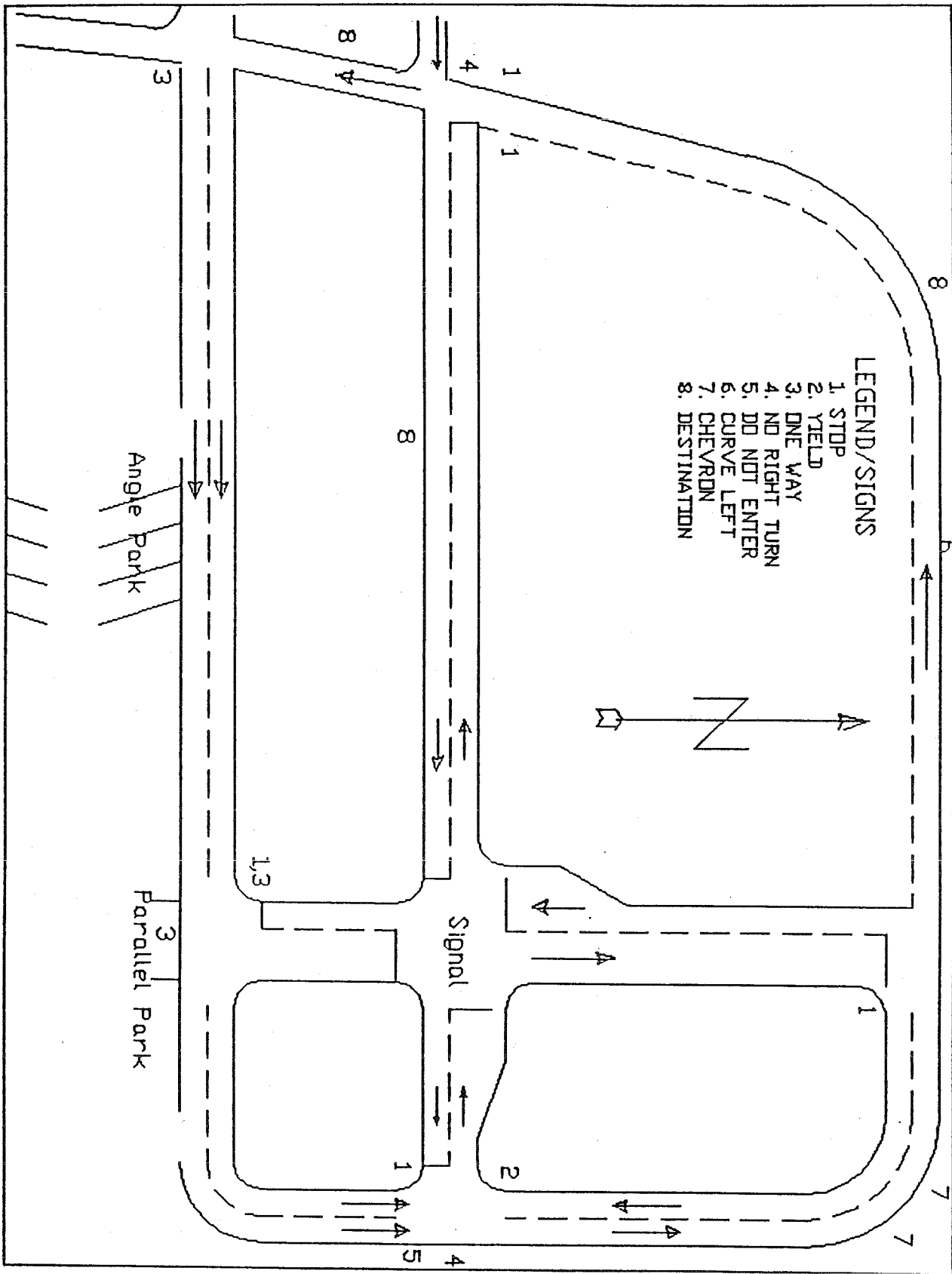


Figure 1. Schematic of layout of closed driving course

Driving Tasks

The driving protocol was designed to maximize positive features of the driving course. The driving experience was structured so that uniformity of the driving experience was emphasized with all drivers facing similar situations. Tasks chosen for the study included maneuvers involving more than one stimulus present and multiple movements in performing the tasks. Although a qualified driving instructor was in the vehicle during the driving experience, use of oral instructions was minimized. Destination signs were used whenever possible to provide route navigation guidance. Oral instructions were only used to supplement sign use.

A subjective pencil and paper grading system was utilized for most of the protocol, with the Principal Investigator completing nearly all the ratings. Ratings were either set up to provide for dichotomous (yes or no) data, or descriptors that would provide for ordinal variables. Steering wheel operation and lane position data were gathered via the personal computer described earlier.

Summary

Although the process of questionnaire development and the data collection itself was somewhat complicated, data were grouped logically, so that the result was a small set of scores which reasonably represented each variable. All the data for the personality variables were contained in the questionnaire, as well as the 15 elements for the Malfetti-Winter self-rating score. The discussion of the analysis, and the influence of these two independent variables' relationships to drivers is provided in Chapter 5. The analysis of demographic data is detailed in Chapter 4.

The embedded figures test for spatial processing produced three scores, while the selective attention yielded two scores, one for each of the two attentional tasks used (i.e., visual and auditory attention). The discussion of the relationship between these three independent variables and the dependent driver task variables is presented in Chapter 6. The process used for the re-organization of the driver task variables is described separately in Chapter 3.

CHAPTER 3

ORGANIZATION OF DRIVING TASK DATA

Protocol used to conduct the driving portion of the study was important because it provided the framework for measuring the experiment's dependent variables. It assured, as much as possible, that each driver would encounter similar problems to solve while driving, thus making it possible to compare outcomes statistically. It also streamlined data collection, since the observer was able to use a standard form for recording data. [See Appendix A for a copy of the data collection form used.]

It was also the most complicated part of the study, both from the standpoint of data collection and its analysis. This chapter briefly describes (1) how the data were translated into a form relevant for analysis and (2) resulting driving task variables used.

Data Collection Format

A shortcoming in the data collection procedure was the subjective nature of the evaluation of some of the driving tasks. An example was that of driver performance in completion of the obstacle course. Counting missed spaces and cones struck was easy and nearly all the drivers performed these tasks satisfactorily. However, some of the drivers navigated the course confidently, smoothly, and at moderate speeds while others completed the obstacle course without missing spaces or hitting any traffic cones, but in a far more cautious manner. Therefore, an attempt was made to evaluate whether the driver was "driving too cautiously." For most of the drivers, evaluation of that variable was quite easy. For some, however, the subjective nature of the evaluation might have produced a slight variation in ratings. However, most of the evaluations were precise and less subject to subjective evaluation of driver performance. The driver either stopped at a stop sign or failed to stop. The driver responded correctly to an information sign or did not.

The fact that one observer did nearly all the driving task evaluations is an important moderating factor of data collection. The conscientious effort exercised by the observer should have minimized any adverse effects to collected data quality.

Effects on Analysis

A weakness of the data collection format was that they were not compiled in a form convenient for analysis. For example, subjects were presented with the need to react to a variety of regulatory signs while driving. More than one opportunity was presented for the driver to turn into an opposing traffic lane.

Therefore, before data entry into spreadsheet format convenient for analysis, an intermediate step was completed in which tasks were grouped into logical categories

to provide for more appropriate driving task variables. Examples include data on whether the subject ever failed to stop when encountering the signal light in the red phase. The variable was expressed as an ordinal variable by indicating how many times the driver failed to stop. [See Appendix B for a sample form.]

Final List—Dependent Variables

Reorganization of driving data provided a total of 16 variables for analysis, including time required for driving the complete protocol. Statistical analyses comparing personality variables and cognitive score variables against driving ratings utilized these 16 driving tasks. The list of variables is provided in Table 1. Assignment of a score for each of the performance tasks was based on descriptors provided with each item on the evaluation form. A complete list of the descriptors is provided in Appendix A, the original evaluation form, and Appendix B, the summary form for which lists the 16 dependent driver performance variables used.

Some explanation is needed for the lane position data. First, it should be noted that there is no reference to lane position in relevant literature and no standard against which to judge how well or poorly a driver maintains lane position. However, logic suggests that driver performance could be at least described by how close the vehicle is driven to the roadway centerline (or, conversely, how far away from the edgeline) and how well driver maintains lane position. These variables could be described via the simple statistics of mean and standard deviation of vehicular distance from either right edge line or centerline. For this study, distance from right edge line was used.

Table 1. Composite list of driving task variables

Driving Task Variables Analyzed	Variable Names
Time required for completion	TIME (Ti)
Reacted properly to signal change: green to red	CHANGE (Ch)
Failed to stop at red light	FAILED (Fa)
Wrong reaction to stop sign	STOP (St)
Turning into a one-way street	TURN (Tu)
Making a turning movement	INSIDE (In)
Drove into opposing lane	OPPOSE (Op)
Turn into correct lane in a multilane situation	CORRECT (Co)
Correct response to restricted movement sign	SIGN (Si)
Correct response-destination sign information	INFO (IF)
Execution in obstacle course	OBSTACLE (Ob)
Parallel parking effort	PARALLEL1 (P1)
Parallel parking execution	PARALLEL2 (P2)
Angle parking execution	ANGLE (An)
Lane position	LANE1 (L1)
Lane position	LANE2 (L2)

Figures 2 and 3 provide lane position plot examples. They describe lane position for a short segment of the course driven by two different drivers. The driver in Run 59 (see Figure 2) steered closer to the centerline than did the driver for Run 57 (see Figure 3), with a difference in means of over 14 inches. (Mean and standard deviations of vehicle offset distance from the right edge line are provided in Figures 2 and 3.) But the driver for Run 57 was steering much more loosely, almost wandering back and forth across the lane. Indeed, the standard deviation for lane position differed by 4.4 inches.

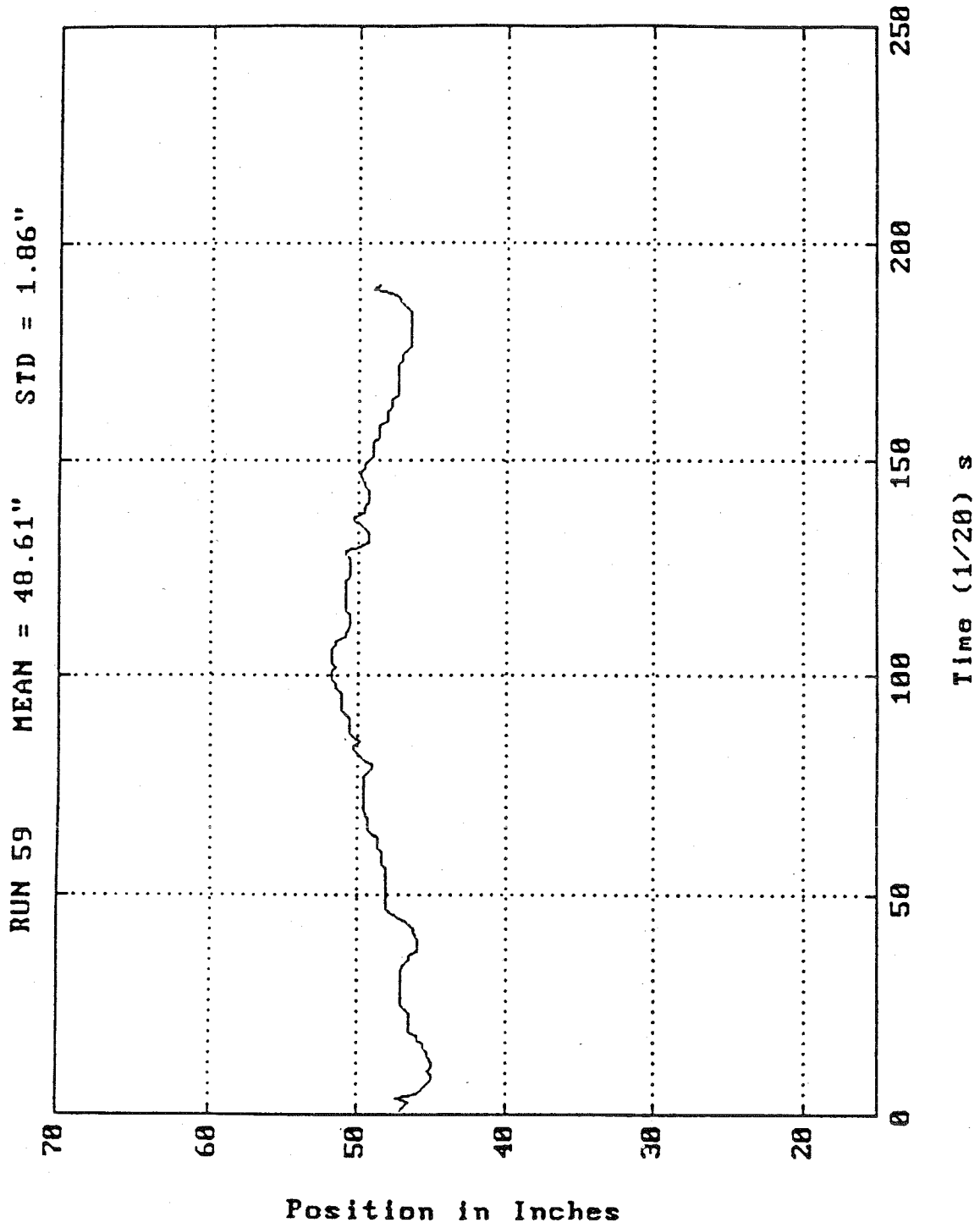


Figure 2. Graph of lane position - Driver Run Number 59

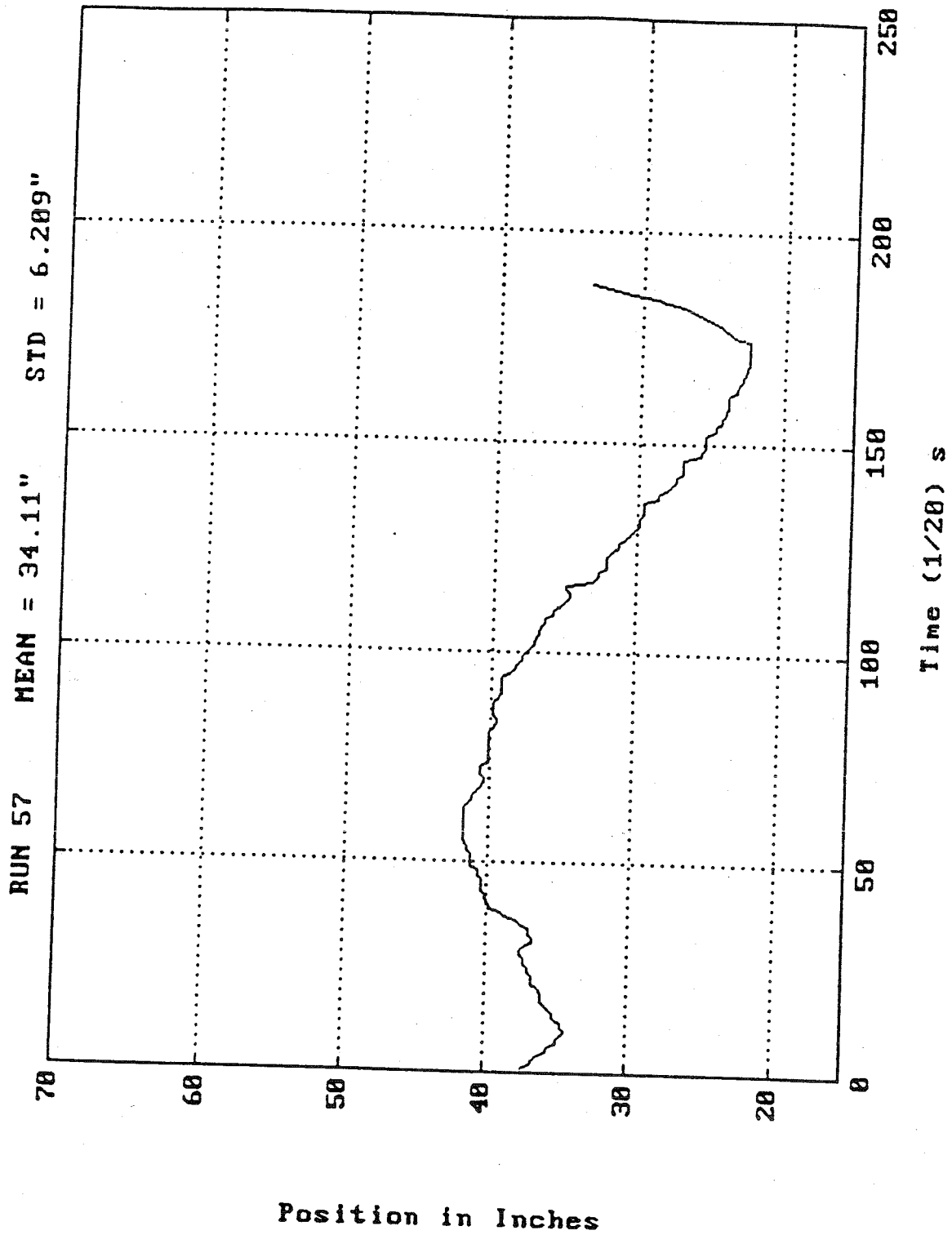


Figure 3. Graph of lane position - Driver Run Number 57

Summary

The protocol developed enabled researchers to gather driver performance data based on tasks presenting situations that parallel driving experiences known to present difficulty to older drivers. Being grouped into the sixteen dependent variables, discussed earlier in this chapter, made it possible to test for possible correlations between either personality factors or specific cognitive skills tested and appropriate driver task variables. Examples of relationships tested would be the use of parking tasks as part of the driving protocol; the assumption is that the scores received on these tasks would correlate with spatial processing cognitive skills scores.

Analyses were completed, using the personality and cognitive skills scores as independent variables and comparing them to the driver variables described in this chapter. Significant relationships are noted and discussed in Chapter 5 (with personality factors as the independent variables) and Chapter 6 (with the cognitive skills scores as the independent variables).

CHAPTER 4

RESULTS: THE QUESTIONNAIRE

The questionnaire was developed to collect a variety of data. Some results of the data analysis were of interest primarily as descriptive statistics, such as questions regarding changes respondent in driving patterns in recent years. This chapter describes outcomes of interest from the first part of the questionnaire, relating to demographic information or self-reported information regarding mobility or driving patterns. The rest of the questionnaire results, including examination of possible relationships with driver performance variables, are discussed in Chapter 5.

Questionnaire Organization

The questionnaire was organized into three different segments. Questions 1 through 63 requested either demographic information or self-reported information regarding mobility or driving patterns. Questions 64 through 77 were questions from the Malfetti-Winter study (14 questions), and the balance—78 through 114—were 37 questions designed to gather data on personality.

Analysis of responses to questions 1 through 63 are discussed separately in this chapter, as there was no attempt to correlate these responses to the driver performance variables for this report. The emphasis in the analysis of responses to questions 1 through 63 was the relationship of driver age to the answers.

Statistical Procedures Used

Two different statistical analyses were used. First, frequencies were computed for the group, providing some general socio-demographic epidemiological data for the subject group. The second procedure, the SAS System Correlation Analysis package, provided correlations and levels of significance comparing responses to each question against responses to each of the other questions. Some of the significant results were of particular interest to the researchers and are included in this report.

Driver Demographic Data

The 100 respondents taking part in the study were close to evenly balanced between males (n=54) and females (n=46). Their ages ranged from 65 to 84 years (mean=69.4) and all but one owned a motor vehicle (automobile or pickup truck). More than three quarters (78 percent) of the group was married and most (77 percent) were living with their spouse. Also, over three quarters (79 percent) had another licensed driver in their household. The same percentage indicated they did most of

the driving for themselves or for others with whom they went places. All had driven over five years, but only three had ever taken a driver education course.

Just over one-third (36 percent) lived in an urban area. Another 30 percent were living in small cities (10,000 to 49,999), with the balance being split about equally between large towns (16 percent) and rural/small towns (18 percent). (Large towns were defined in the questionnaire as having a population of 2,500 to 9,999; rural areas and small towns were grouped together as having a population under 2,500.)

Transportation Consumption Patterns

As a group, they seem to be quite active, especially as related to mobility. Over half (52 percent) indicated that they drove over 50 miles each week and only three indicated they drove fewer than 10 miles each week. One-in-eight never drove on trips over 100 miles, but two-thirds (68 percent) took trips of 100 miles or more frequently. One-third of the drivers reported driving over 10,000 miles annually, while 14 indicated that they drive 2,000 miles or less each year.

These statistics ignore age as a factor. With the mean age of 69.4, the group has to be considered heavily as the “young-old” (ages 60–75). Simple frequencies imply exceptional mobility, ignoring possible age effects in transportation consumption patterns. The use of the SAS System Correlation Analysis package produced results of a statistically significant nature that suggested the existence of age-related changes in driving patterns. But it should be noted that data gathered represents a “snapshot” taken in time and do not give as accurate a picture as would longitudinal data.

The analysis provided some interesting significant results. For example, there were statistically significant correlations between increased age and reduced travel. As these drivers have grown older, they report reductions in the number of miles they drive each week ($p < .05$) and in the frequency of long trips—trips exceeding 100 miles in length ($p < .06$). They report reduced frequency of trips to retail stores, such as grocery, pharmacy, and shopping malls ($p < .06$), for entertainment, such as to movies and restaurants ($p < .002$) and visiting friends and relatives ($p < .0001$).

They are driving less ($p < .06$), especially at night ($p < .03$), probably because they have difficulties seeing signs by the roadway at night ($p < .03$) and in seeing pavement markings ($p < .0003$). The oldest subjects are less likely to drive on snow and ice ($p < .04$). (See Table 2.)

But as a group, they drive most often to local destinations. Of particular interest is the high percentage driving for common trip purposes more than once each month. This included driving to the grocery store or pharmacy (88 percent); driving to movies, dinner, or other entertainment (60 percent), and frequent driving to visit friends or relatives (61 percent).

Table 2. Significant relationships of age with driving practices

Correlation of age with:	Correlation	Significance Level
Miles driven each week	-.20	.05
Frequency of long trips	.19	.06
Frequency/drive to stores	-.19	.06
Frequency/drive-movie, etc.	-.30	.002
Visit to friends, relatives	-.32	.001
Choose to drive less	-.19	.06
Drive less at night	-.22	.03
Have difficulty seeing signs	-.21	.03
Difficult to see pvmt mrkgs	-.35	.0003
Rarely drive on snow, ice	-.21	.04

Health Concerns

From the responses to questions on their health, it is apparent that the group of respondents considered themselves to be comparatively healthy. Most of the drivers (82 percent) indicated that they were seldom or never limited in doing what they liked to do by chronic bad health, sickness, or pain (see Table 3). Most (84 percent) had no disabilities that limited driving.

Table 3. Respondents limited in doing what they wanted by chronic bad health, sickness, or pain

Extent of Limitation	Relative Percent
Never limited	42.0
Seldom limited	40.0
Limited some of the time	16.0
Limited most of the time	2.0

A substantial portion of the group was taking medication for blood pressure (41 percent), but 39 percent indicated that they were not taking any medication. Small

percentages indicated that they were taking medication for arthritis (18 percent), diabetes (11 percent), heart conditions (20 percent), or for anxiety (3 percent).

No matter how healthy the respondents may be, one needs to be careful in data interpretation. For this reason, data were tested for correlation between increasing age and self-rating of health. The analysis revealed a significant correlation between the two of $-.21$ ($p < .04$). The trend of diminished self-rating of health with increased age suggested by these results indicates that, even using self-ratings (which are likely to reflect respondent perception of "what could be expected in comparison to others the same age" in relating personal health to age), health is likely to deteriorate with age.

Special Concerns

It was anticipated that a group of older drivers might have concerns about their future mobility, assuming that they were inclined to try to foresee what lifestyle changes might be required in the event that they were unable to drive. Therefore, a group of questions were included related to their mobility concerns.

Surprisingly, more than half the respondents (53 percent) indicated that they never worried about such a possibility. Another 35 percent indicated that they seldom worried about it, but only one in eight expressed concern.

Concern about not being able to continue to live independently was more prevalent. Though many seemed not to be worried about this (44 percent), the balance of the group expressed some (31 percent) or significant (25 percent) concern about being able to live independently. There is no way to determine whether their mobility concerns are related to availability of public transportation, but their concerns about being able to continue to live independently are most likely related to news reports on nursing homes and the fear of loss of control of their lives.

Public Transportation

About two-thirds of the respondents lived either in an urban area or small city, so it would be reasonable to assume that many have access to public transportation. A list of common destinations was provided and respondents were asked about accessibility by public transportation. Over a quarter (27 percent) indicated that most of the places, including medical facilities, were accessible, while 28 percent indicated that some were. For the balance of the respondents, few or none of the destinations were accessible. Though public transportation was reasonably accessible for many, about two-thirds (65 percent) never used it, and only two of the respondents used it frequently.

Not using public transportation may relate to past experience in driving. Almost all (89 percent) described their driving routine as unchanged over the years, while 8

percent indicated they were only driving when necessary, and less often for social occasions.

For most, this reliance on driving their own vehicle is not likely to change soon. Though a few had considered no longer driving for a variety of reasons, most (85 percent) had never considered it.

Summary

As a group, the respondents seem to be healthy and very mobile. These health and mobility characteristics are probably reasonably representative of the older driver population from which the sample was drawn. But the self-selection process (in the form of those willing to participate from the sample population) which determined the makeup of the group of 100 participants most likely produced a younger, healthier, and more mobile group than the generally older driver population in the sample.

The use of age as the independent variable in the correlation analysis produced significant correlations relating to self-report of mobility and independence and in self-rating of personal health. In each instance, increasing age correlated with less desirable circumstances—less mobility, less independence, and poorer health. The relationship of age to decreased consumption of transportation services is very important in terms of social contact and sense of well-being and is of great interest to gerontologists. The same relationships with mobility patterns plus problems encountered in nighttime driving is of importance to traffic operations professionals.

CHAPTER 5

RESULTS: PERSONALITY DIMENSIONS AND DRIVING

Chapter 4 described the results of analyses of responses to items 1 thru 63 of the questionnaire. The balance (items 64 through 114) of the questions were either from the Malfetti-Winter study or designed to gather data on personality. This chapter describes the results of analyses of these questions.

Personality Factors

As noted in Chapter 2, 37 personality items were included in the questionnaire that, based on the literature and logic, might be considered particularly salient predictors of driving performance, as items intended to reflect the "Big Five" dimensions of personality. Due to the large number of self-report variables examined, a smaller number of marker variables were included, rather than complete scales.

Questionnaire Pre-Test

The questionnaire was pre-tested, using undergraduate students at Iowa State University in two large pilot studies (the number of participants was on the order of 100 for each). Factor analyses of data gathered in the pilot studies suggested that a priori five-factor structure could not be substantiated. A number of empirical analyses (principal factor extraction with varimax rotation) were performed, with rotation of 2, 3, 4, 5, and 6 factors. The best solution (in the sense of interpretability and relative independence of factor scores constructed by summing salient items) in both studies appeared to be the two-factor solution. The factors might be called "Competence"—an amalgam of four of the Big Five's Extraversion, Agreeableness, Conscientiousness, and Openness—and the Big Five factor Emotional Stability.

Participant Personality Factors

The same data analytic procedure was followed using the older driver data, in an attempt to determine whether the five-factor structure could be affirmed for this subject group. However, results revealed a pattern similar to that of the pre-test group of undergraduate students. The five a priori scales showed reasonable internal consistency (alpha coefficients ranging from .59 to .81), but were not even approximately orthogonal. (In other words, the five-factor structure doesn't apply to older drivers either.) Intercorrelations ranged from an (absolute) low of .01 to .56 with four of the ten intercorrelations .48 or higher.

Thus the empirical factor analytic approach was depended upon to form scale scores through the summing of salient individual items. As in the pilot study, the rotation of 2, 3, 4, 5, and 6 factors was completed (using the varimax procedure following

principal factor extraction). And, as before, the two-factor solution appeared to be the best. Criterion for inclusion of an item in one of the two scales (as a salient items) was that it load (absolutely) at least .40 on the given factor and no more (absolutely) than .39 on the other. The 15 items that comprise what was called Competence and the 11 items that comprise what was called Emotional Stability are found with their rotated factor loadings in Table 4.

Internal Consistency

Alpha coefficients for the Competence and Emotionality scales were .89 and .86 respectively, indicating a high degree of internal consistency. (These alpha estimates were somewhat positively biased, of course, because they are based on the same data that were factor analyzed.) The essential non-redundancy of the scales is shown by their negligible correlation ($r = .10$). (There is some bias toward zero correlation for the same reason as stated above.)

Comparison to Malfetti-Winter Scale

The two personality scales were compared to the Malfetti-Winter (MW) scale. The alpha coefficient for MW was .50, indicating a moderate degree of internal consistency for this a priori variable. Competence did not significantly predict the MW scale ($r = .04$). But Emotional Stability did significantly correlate with MW ($r = -.43, p < .001$).

Table 4. Item composition—2 personality scales,
Varimax-rotated factor loadings

Competence	Factor 1	Factor 2
Sociable, outgoing	.57	-.06
Thoughtful	.69	.03
Moral, ethical person	.56	-.04
Important to be self-sufficient	.64	-.03
Patient person	.60	-.27
Cultured person	.57	.03
Likes to keep busy	.60	.28
Capable	.68	.06
Like excitement	.46	.38
Important to obey rules	.53	.18
Likes to get things done	.49	.24
Pretty satisfied	.69	-.08
Competent person	.64	.10
Likes close attention to detail	.52	.07
Polite, courteous person	.62	-.11
Emotional Stability		
Tense, high-strung	.05	.80
Impulsive person	.08	.58
Easily distracted	-.12	.67
Takes chances when in a hurry	-.14	.71
Accident prone	.12	.46
Don't like to have to wait	-.01	.65
Like to do things my way	.24	.45
What happens is out of people's control	.18	.52
Get flustered easily	.00	.62
Irritated by small setbacks	.01	.57
Impatient when have to wait	.14	.60

Subjects reporting emotional stability tended to say that they were better drivers than those reporting emotional instability.

Relationship to Driving Performance

Despite the attractive features of the two personality scales—their psychological interpretability, internal consistency, and near independence—they were not significantly predictive of actual driving performance (Perf) on the closed driving course ($r = -.10$ for Competence, $r = .03$ for Emotional Stability). (For these tests, a composite variable—Perf—was derived, incorporating all the driving performance tasks (except for Time, Lane1 and Lane2) as a single variable.)

Time was kept separate because its metric was substantially different from that of the other performance items; its inclusion would have led to its domination of Perf because it had much greater variance than the other items. In addition, Lane1 and Lane2 (the lane tracking variables) were omitted due to the small sample size for these particular variables.

In an exploratory vein and in an effort to be comprehensive, additional analyses were performed. In one, the 37 individual personality items were correlated with Perf and MW, obtaining a few significant correlations (at $p < .05$), but no more than might be reasonably expected by chance.

In another analysis, MW correlated nonsignificantly ($p > .05$) with Perf, ($r = -.02$). Likewise, MW variables did not correlate significantly with any of the individual Perf items. Moreover, none of the individual MW items correlated significantly with Perf.

In still another analysis, the personality factors of Competence and Emotionality were compared to each of the different dependent driving task variables that formed the composite variable Perf. In this instance, neither factor correlated significantly ($p < .05$) with any of the driving tasks.

There were expectations that some significant correlations would be ascertained between elements of personality and driving tasks, but none was obtained in the statistical analyses. This lack of relationship held both at the scale level and at the individual item level. The two scale-level variables that were derived analytically—Competence and Emotional Stability—exhibited good psychometric characteristics: interpretability, internal consistency, and near independence. They were also the same dimensions discerned in pilot studies with undergraduate students. The questionnaire items included marker variables for the “Big Five” as well as items reflecting personality variables previous research has implicated as relevant to driving variables.

The lack of relationships in this study may be due to our construal of the dependent variable—judgement of actual driving on a closed course—rather than the more typical construal as number of accidents or traffic violations. Also pertinent may be the fact that our sample portrayed themselves as quite safe drivers. Two of the items of the MW scale (self-report) address the issue of contact with law enforcement, i.e.,

the number of traffic tickets, warnings, or “discussions with enforcement officials” and number of accidents, both within the past two years. Very low mean scores were obtained for these items (suggesting that respondents were “safe” drivers) . To the extent that this portrayal is accurate, range restriction considerations would suggest lower predictability.

Summary

Neither of the factor analytic personality dimensions—competence and emotional stability—correlated with any of the driving performance task dependent variables (including the composite, Perf), at any reasonable level of significance. Though there was some expectation that one or more of the personality dimensions would correlate with driving, such was not the case. It may very well be that in dealing with a very competent sample of older drivers, traditional factor structures are inappropriate, specifically the Big Five.

CHAPTER 6

RESULTS: COGNITIVE SKILLS TESTS AND DRIVING

The primary emphasis of the study described in this report was to identify significant relationships between cognitive skills and how well a driver completed a challenging driving task protocol. Test scores from each of the cognitive skills tests conducted were utilized in analyses with the individual driver performance tasks to detect relationships of significance. Results are described in this chapter.

General

Earlier studies have established (1) there is an age-related decline in some cognitive skills which may be important to driving and (2) the loss in cognitive skills is not uniform for all individuals of a given age group. Results of analyses of study data confirms the age-related decline in the cognitive skills tested, at $p < .05$ levels of significance when testing relationships between increased age and the cognitive scores. The lack of uniformity of the decline seems to be confirmed also by study results, as there is a shortage of demonstrated relationships between age and the driving tasks at the same level of significance.

The driving protocol was designed to provide opportunities for subjects to make driving errors that could place them at serious risk for accident involvement; in some cases, the type of accident which could occur carries a high probability of serious injury. To that end, statistical analyses tested cognitive skills scores against subject scores in each driver task. The following describes the significant correlations found.

Spatial Processing

The basic premise of the embedded figures test (EFT) is it measures ability to process spatial relationships. Spatial relationship problems permeate driving tasks.

Subject scores on EFT correlated with experimental ratings on several driving tasks. As noted earlier, EFT performance yielded three scores: number correct, mean time per item, and total time required. Each of the scores was compared with the ratings given on each of the driving tasks and are discussed in the order noted.

First, the analysis revealed significant (at $p < .05$) correlations between *number correct* and subjective ratings on six driver task variables (first described by variable name). These were *Time* required to complete the driving course (-.45); *Oppose*—driving into a lane of opposing traffic when making a turn (-.38), *Sign*, not reacting correctly to sign messages (-.24); *Obstacle*, encountering difficulty in negotiating the obstacle course (-.26); *Parallel* (-.27) and *Angle* (-.35), which index problems with parallel and angle parking; and *Lane2*, a lane tracking variable (-.59) [See Table 5 for a

summary of correlation coefficients and attendant significance levels. The graph on Figure 4 shows comparative correlation factors more clearly.]

Other scores recorded during the embedded figures test (Mean time and total time) show similar correlations ($p < .05$) with the driving performance, including Time (.44/.43), Oppose (.44/.40), Obstacle (.28/.30), and Angle (.40/.37). Two of the driving variables, Sign and Paralle11, show smaller correlations which were marginally reliable ($.05 < p < .10$). (Note: The first correlation coefficient denotes mean time and the second, total time.)

Table 5. Significant relationships: EFT number correct and driving tasks

Variable	Correlation	Significance Level
Time used to complete course (Time)	-.45	.0001
Drive into opposing lane (Oppose)	-.38	.0002
Wrong reaction to traffic sign (Sign)	-.24	.02
Execution-obstacle course (Obstacle)	-.27	.01
Parallel parking (Paralle11)	-.27	.01
Angle parking (Angle)	-.35	.0008
Lane position-Std Dev/dist (Lane2)	-.59	.007

The highly significant correlation between time for completion of the embedded figures test and driving course completion time suggests much about older drivers ($p < .0001$). They were consistently slower at completing the various driving tasks. Subjects were under minimal time constraints during cognitive testing and driving. In fact, it was suggested that they perform the tasks at their own optimal speed. The most important correlations involved decisions made while driving. EFT scores were highly (negatively) correlated with how the older drivers manage the necessary maneuvers at intersections. The high correlation of EFT number correct with the variable *Oppose* indicates a propensity for the older drivers to make a left turn into the opposing lane of traffic. The high correlation with *Sign* implies a problem with processing sign information at intersections. Specifically, the variable suggests a difficulty with intersections having restricted turning movements, and the tendency to incorrectly turn into a one-way street. Each of these types of errors creates potential for a serious accident, with the most probable category being the head-on collision.

Correlations Between Embedded Figures Scores and Driving Scores

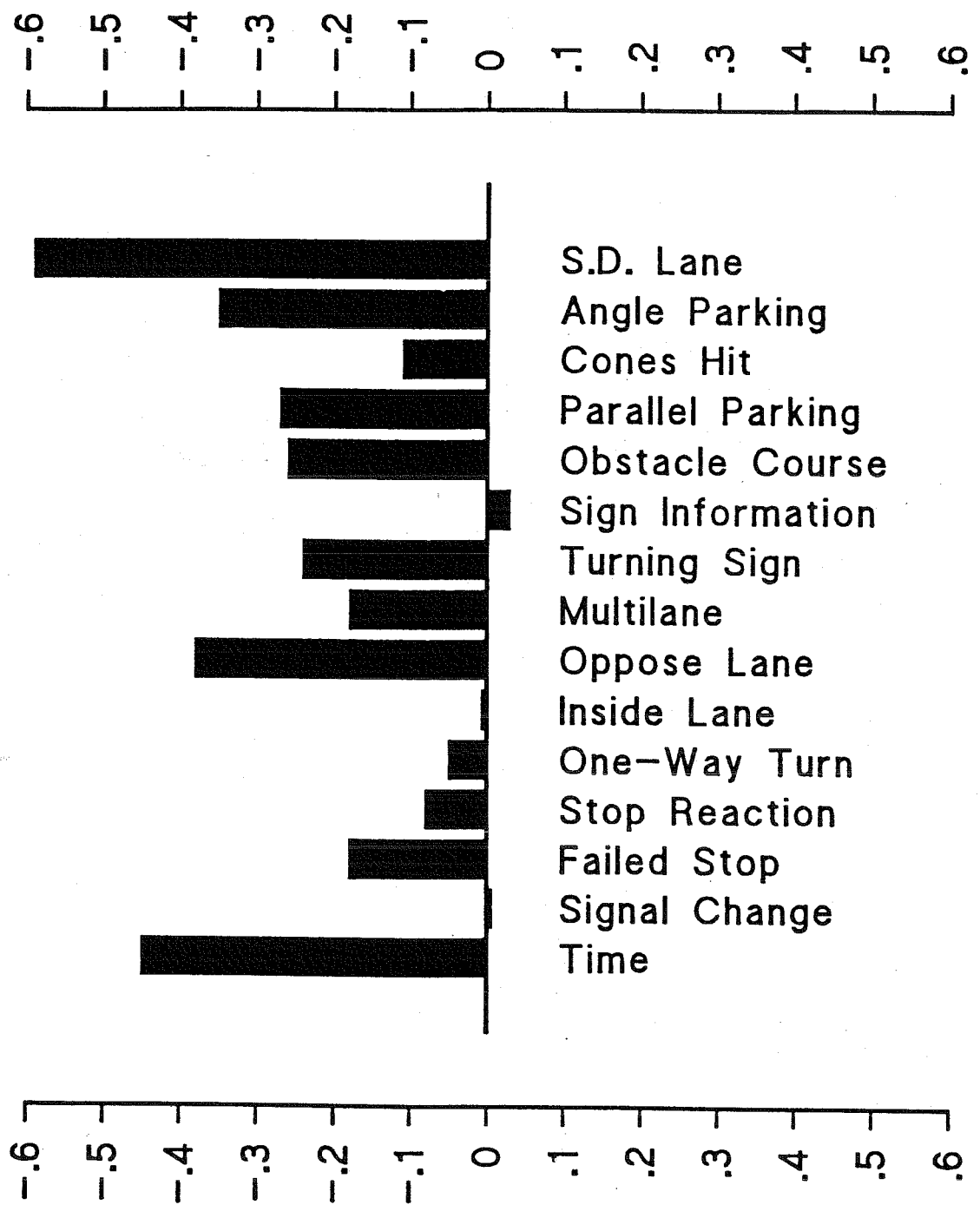


Figure 4. Correlation between Embedded Figures Test scores and driving scores

The remaining significant correlations are associated with other aspects of driving and spatial relationships. Proper completion of angle parking tasks required drivers to stay in their lane (for 90 degree parking, with traffic cones marking the centerline of a generously wide lane), turning into a parking stall, and being aware of the locations of vehicles on both sides of the stall (again represented by the traffic cones). Some of the lower driving scores were due to problems backing out of the parking stall. Though the measure was somewhat subjective, the evaluator noted situations under which the driver would have struck a parked car, given the path followed in backing out of the parking place and scored according to the scale provided.

Of course, parallel parking offered many problems. To some extent, problems encountered in parallel parking involved poor technique, but mostly they seemed related to spatial relationships. Drivers were asked to park in a parallel parking place of generous length, but had to maneuver to avoid hitting vehicles parked in adjacent parking places; this produced significant difficulty for some.

EFT scores correlated significantly with the Lane2 variable, which describes lane position in terms of standard deviation from the mean, calculated as the mean distance that the vehicle is offset from the right edge line. The negative correlation indicates that lower EFT scores correlate with a higher standard deviation in lane position. This would mean that, though these drivers were within the confines of the lane, they did tend to wander from left to right to a greater extent than did drivers with better EFT scores. The very high correlation value (-.59), along with the high level of significance ($p < .007$), suggests that this is a reliable indicator of someone with problems in spatial processing. However, the small amount of data available for analysis of lane position precludes an overly strong conclusion.

Selective Attention

Two attentional tasks were employed to test driver capacity to attend to relevant stimuli. They were (1) a Visual Attention task and (2) an Auditory Attention task.

Visual Attention Task

All drivers are bombarded with a profusion of visual information while driving, much of which is not essential to the driving task. Good drivers are able to select, from the information available, those elements relevant to good driving performance. An example would be the existence of pedestrians in or near the roadway. Those walking on a sidewalk parallel to the road are of only passing interest, but any walking toward or in the roadway are of immediate concern.

Drivers scoring low in this cognitive task theoretically should have trouble in selection of the relevant information available while driving. They should also be unable to ignore extraneous information and thus would be more likely to make the wrong driving decisions or, perhaps, to delay too long in making the correct choice.

In the test utilized, subjects were scored on the number of correct estimates of the number of letters appearing randomly on the computer screen. The measure of interest was the number of correct estimates.

Analyses linked performance on this visual attention task with several driving tasks, some of which overlap with correlations with the embedded figures test, while, interestingly, others do not. [A complete list of those significant at the level of $p < .05$ appears in Table 6. The graph shown in Figure 5 also shows the relationships.]

The significant correlations can be grouped into two categories; those related to either parallel or angle parking, and those which pertain to decisions made when the vehicle was moving. Two features make the groups unique; one is the differences in the severity of potential accidents that might arise from errors (primarily due to speed) and two, those involving operating speed differentials between parking and driving maneuvers on streets and highways (with the accompanying emphasis on speed of selection of relevant visual stimuli).

Table 6. Significant relationships: Attention number correct and driving tasks

Variable	Correlation	Significance Level
Time required for completion (Time)	-.36	.0004
Mean Time (EFT)	-.33	.001
Total Time (EFT)	-.31	.002
Drive into opposing lane (Oppose)	-.32	.001
Maneuver from correct lane (Correct)	-.21	.04
Responding to destination signs (Info)	-.20	.05
Execution-obstacle course (Obstacle)	-.22	.03
Parallel parking (Parallel1)	-.27	.007
Parallel parking (Parallel2)	-.32	.001
Angle parking (Angle)	-.31	.002
Lane position-mean displacement (Lane1)	.48	.02

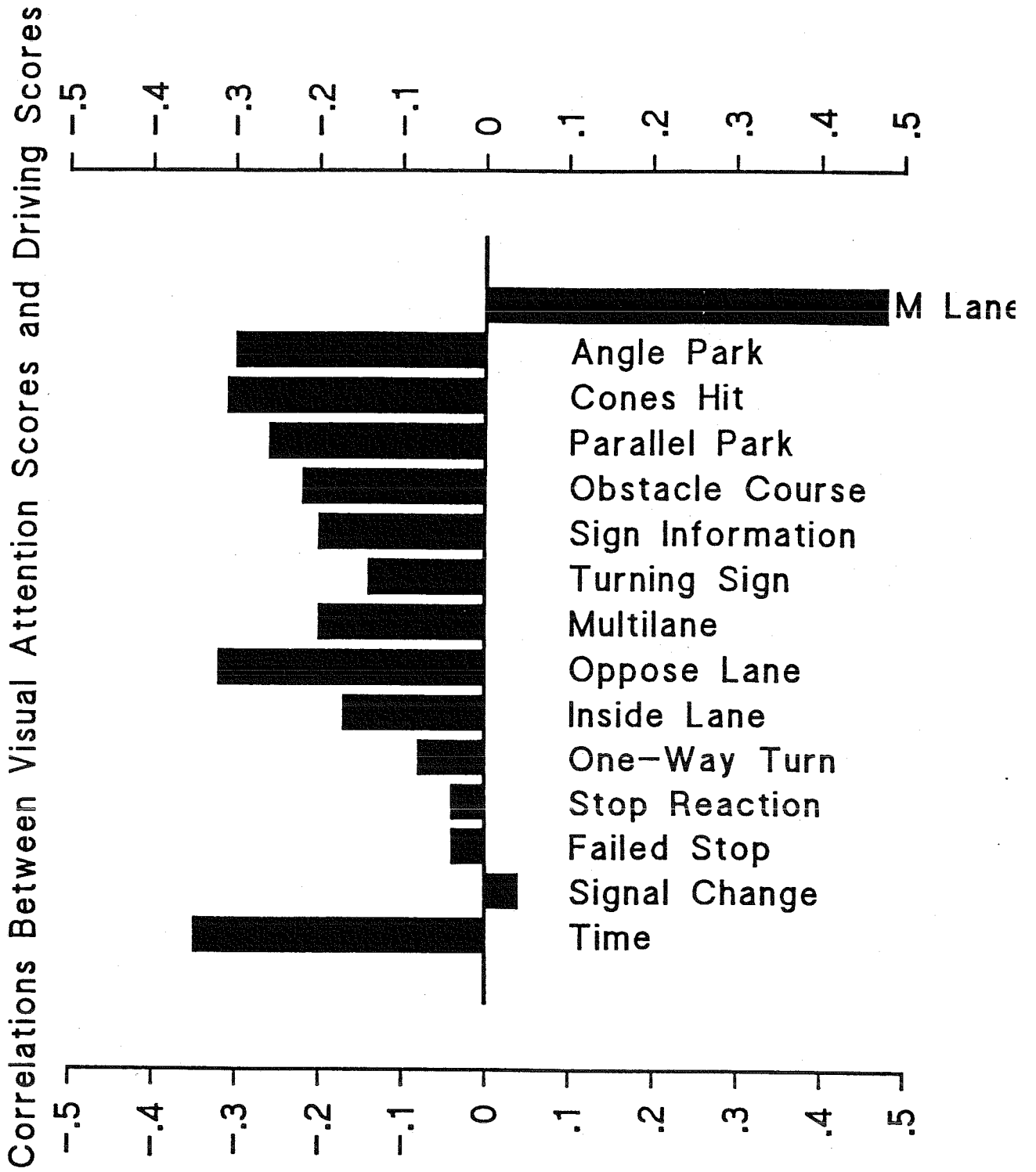


Figure 5. Correlations between Visual Attention scores and driving scores

Significant correlations associated with vehicle movement are consistent with visual attention problems. Most driving is performed “automatically” or without the need for close attention. This is particularly true while driving a familiar route, with a minimum of driving situations requiring close attention for timely driver response. But driving is a task that involves the interactive influence of a second type of information processing—controlled processing (Rogers and Fisk, 1991).

Controlled processes govern performance of unique tasks, which require greater effort and are characteristically slow and serial in nature. Controlled processes are also called upon when unique situations are encountered, or when particularly relevant information is needed to govern a driver's response. Younger adults are better able (than older adults) to inhibit that which is irrelevant and focus on that information important to the task at hand. The pattern of relevant research suggests that older adults have difficulty inhibiting the distracting information (see Rogers and Fisk, 1991).

The closed driving course represented an unfamiliar situation to the older drivers. Therefore, each task required controlled processing, and this in turn required a selection of relevant information and the appropriate response—all within a brief period of time. For some of the older drivers, this caused them to turn as directed, but into the opposing lane. It also caused some drivers to make turns (after coming to a stop) in which they drifted across the path of traffic into the adjacent lane.

While driving the obstacle course, this same group of drivers tried to compensate for information overload by driving more cautiously. Their primary concern was to avoid missing some of the spaces or striking a traffic cone.

In many ways, correlations with problems in vehicle parking address similar issues. A driver processes many pieces of information while maneuvering into a parking space, such as operating speed, steering wheel position, and location of curb and adjacent vehicles. Continuous adjustments to speed and steering wheel position are required. Elements of information used in the maneuver change many times in hierarchal order during the procedure, requiring the driver to “inhibit” the less relevant information, while raising more immediate information to a higher status in the decision-making process.

The strong correlation with lane position (Lane1) may reflect another automatic response. This variable represents mean distance of vehicle from the right edge line, and provides a measure of the distance of the vehicle from the centerline. For older drivers, a subconscious decision may have been made to drive with a greater offset between road centerline and vehicle, recognizing higher risks present for a head-on collision or side-swipe with an oncoming vehicle, should the subject vehicle meander across that centerline. This might represent a subconscious awareness of information-processing problems on the part of the driver.

Auditory Attention Task

No significant correlations were established between the selective listening test and respondent driving performance. One explanation is that the selective listening task measures attention under dual-processing conditions (i.e., monitoring two sources of input at the same time). Driving on a closed course with no other traffic does not always require the driver's full attention, nor were any tasks performed concurrently while driving. An example might be making a left turn while simultaneously tuning the radio or making a call on a cellular phone. The graph shown in Figure 6 shows the values of the correlations.

It is a matter for speculation only, but it would seem logical that one or more significant relationships might have been found had the driving protocol required dual-processing situations. At most, it suggests that future research should include such dual-processing situations in the driving protocol.

Perceptual Tests

Data were gathered on respondent sensory functions of vision and hearing prior to collecting cognitive skills data. With these data available, possible relationships were explored between these sensory functions and driving. Since outcomes are of some interest (especially in view of past research efforts concerning these functions and highway safety), a brief discussion of these results has been included in this report.

Vision

Visual acuity scores correlated significantly with two aspects of driving performance; Turn (-.27) and Inside (-.28). Both scores relate to the traffic lanes that drivers selected when making a turning movement. Neither variable relates to the driver turning into an opposing lane (the variable Oppose), but refer to selection of the "best" lane. The "best" lane referred is the inside lane, whether turning into a one-way street (Turn) or into a two-way street, with the choice of two or more lanes going in the appropriate direction. (Note: "best" lane is described by driver education and is not fully supported by traffic law.)

None too surprisingly, these correlations suggest that the better the subjects' visual acuity, the more likely they are to turn into the correct lane. Visual acuity scores did not reliably predict performance on any other driving maneuver (see Figure 7.)

Hearing

Even though hearing has not been empirically demonstrated to have much effect on ability to drive (Henderson and Burg, 1974), there were two driving variables that correlated significantly with hearing scores: Fail (-.22) and Lane1 (-.42). Scores for the Fail variable were dichotomous; that is, either the driver stopped for the red

Correlations Between Selective Listening Scores and Driving Scores

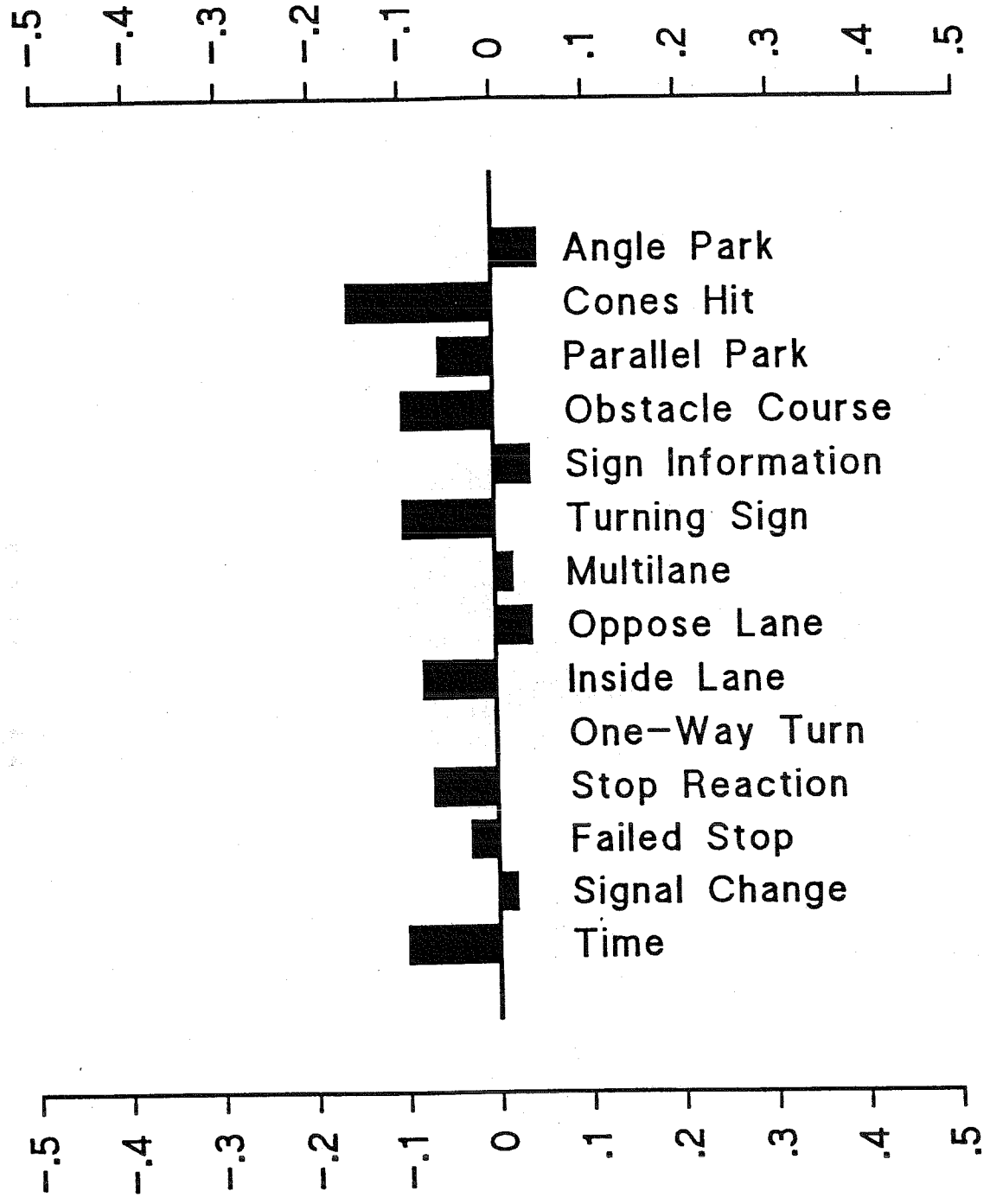


Figure 6. Correlations between Selective Listening scores and driving scores

Correlations Between Vision Test Scores and Driving Scores

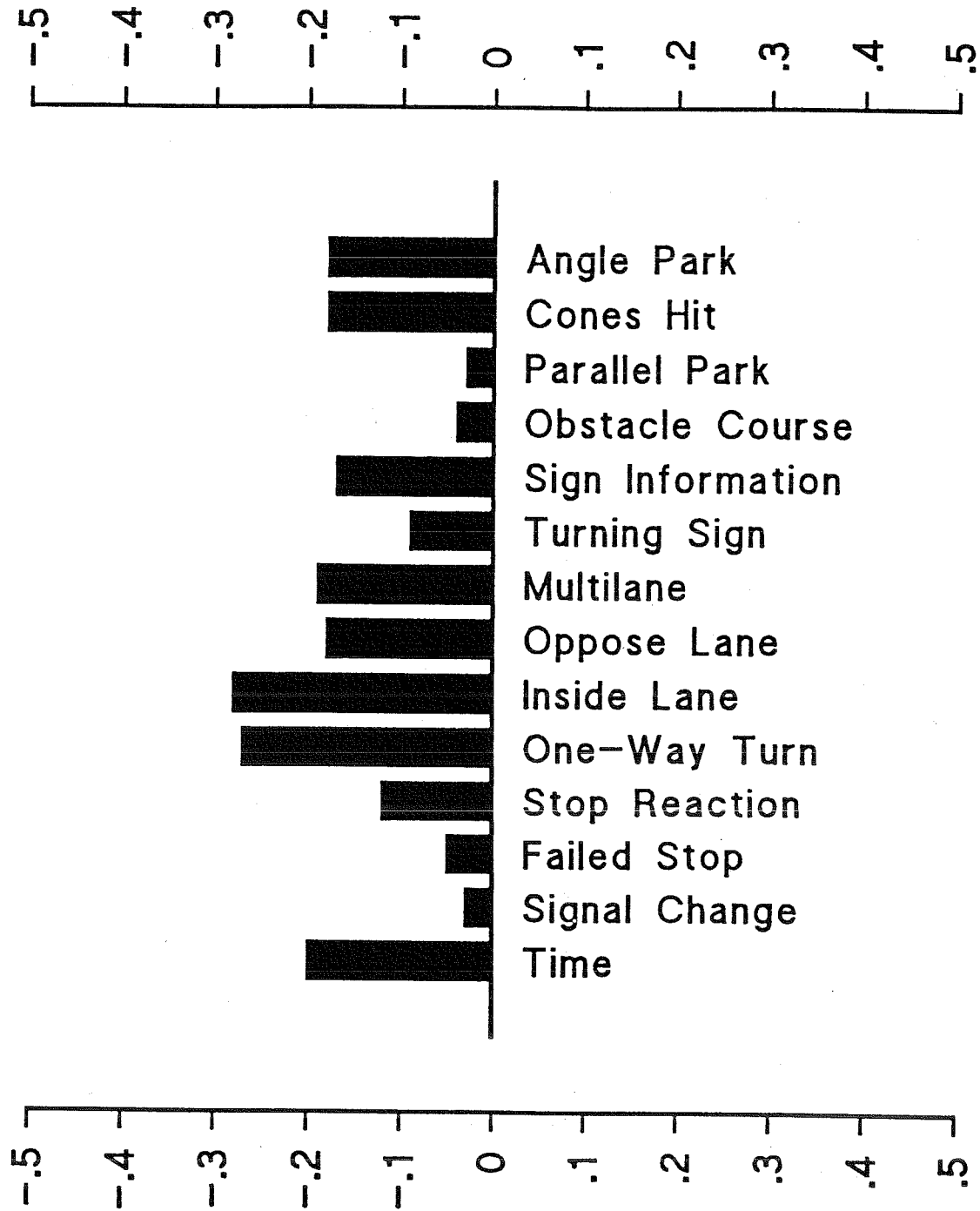


Figure 7. Correlations between vision test scores and driving scores

traffic signal or he/she did not. Values for the Lane1 variable were continuous, and scored with the aid of a video camera. While both variables were significant at $p < .05$, certainly the Lane1 correlation coefficient is considerably larger. See Figure 8 for a display of all correlations of hearing with driving variables.

There seems to be another interesting effect. The significant correlation with the variable Fail occurred with the hearing score of the left ear and the correlation with the variable Lane1 occurred with the hearing score of the right ear.

There is no logical explanation for the correlation of the left ear hearing with Fail and only a weak explanation for the correlation of the right ear hearing score with Lane1. Lane1 is the variable associated with lane position, measuring the mean distance from the right edge line of the traffic lane.

The correlation between the two variables suggests that poorer hearing in the right ear is associated with a tendency to drive closer to the right edge of the lane. Perhaps the hearing problem in the right ear causes some slight disorientation, leading to an unconscious modification in lane tracking techniques. However, the results could be passenger-related. The driver may be concentrating on trying to hear what the passenger is saying with the right ear.

Other Results

Although not directly related to cognitive scores, there is another set of significant relationships worth reporting, and that is the relationship between the amount of time (Time) the driver took to complete the driving protocol and other driving task variable scores. The indirect relationship occurs because nearly all of the variables significantly correlated with Time also correlate with either the spatial processing cognitive test score or the visual attention test score or both. Table 7 provides a complete list of all significant correlations with Time.

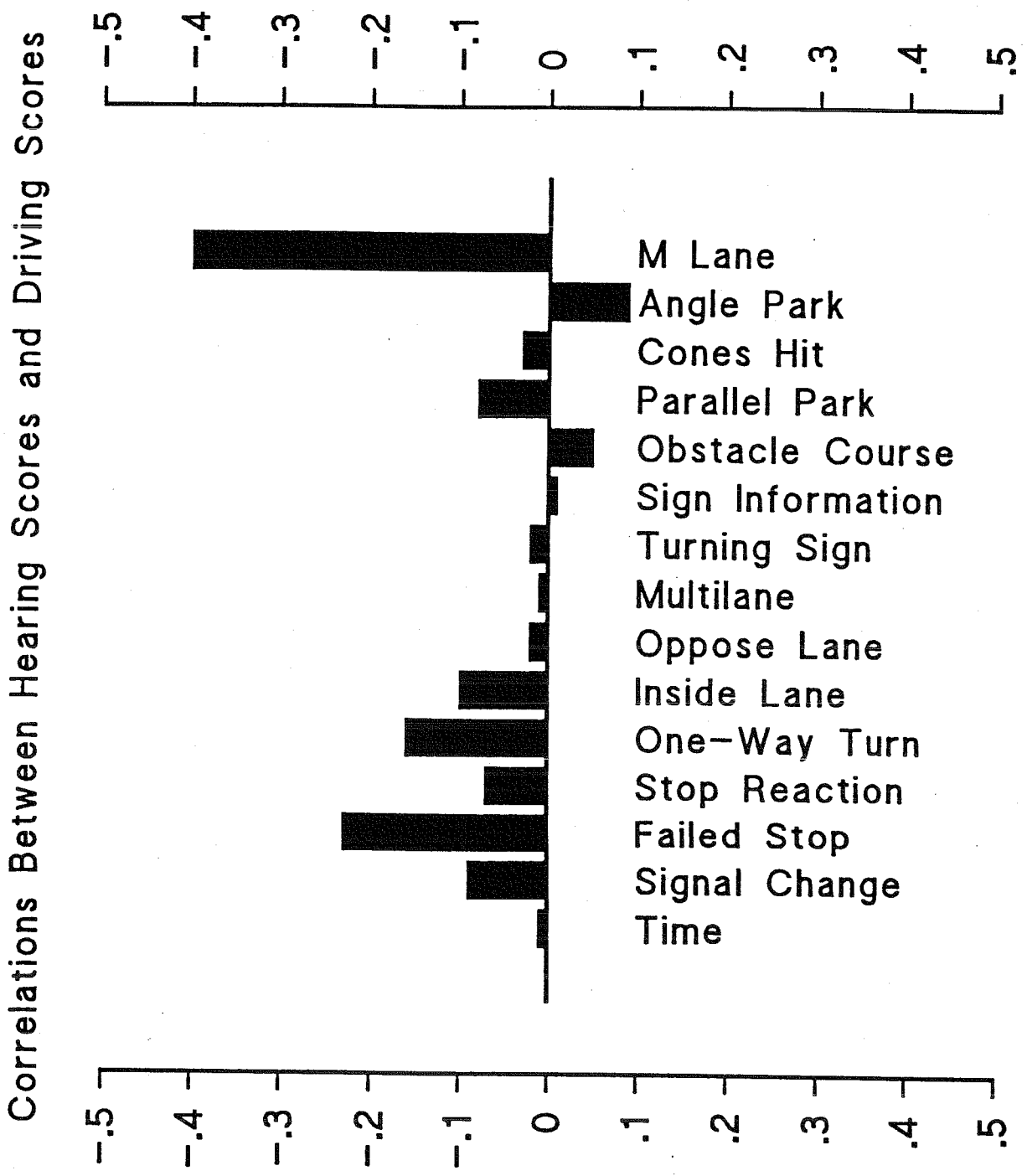


Figure 8. Correlations between hearing scores and driving scores

**Table 7. Significant relationships with time used
to complete the driving protocol**

Correlation of Time with:	Correlation Coefficient	Significance Level
FAILED to stop @ red light	.21	.04
Drove into OPPOS(E)ing lane	.25	.02
Execution-OBSTACLE course	.30	.004
PARALLEL(1) parking effort	.51	.0001
ANGLE parking execution	.20	.05
LANE(1) position	-.39	.07

The logical interpretation of these correlations is that, although taking more time may cause drivers with cognitive skills problems to do better than they might do under some time constraints, these drivers still tend to make significantly more errors than do younger drivers. This is consistent with other, fairly recently completed research (OECD, 1985; Maleck and Hummer, 1986; Brouwer et al., 1991).

Summary

Although the first hypothesis was not confirmed (relationship between personality and driver performance), the hypotheses regarding relationships between the cognitive skills of spatial processing and attention and some driver performance variables were confirmed. A complete discussion of project conclusions, including the research hypotheses, is provided in Chapter 7.

CHAPTER 7 CONCLUSIONS

General

While the drivers involved in this study were, for the most part, representative of the “younger” elements of the age 65 and older driving population, they seem to provide a microcosm of what we know of the general older population in many ways. For example, they remain very active, participating in a variety of activities and using their automobile to continue their accustomed mobility. Although they seem to drive less as they grow older, both local and longer distance driving remains high. Their health seems to be quite good. Although nearly half (41) take medication for blood pressure, a nearly equal number take no medication at all (39). Very few were seriously limited in doing what they want by chronic illness or pain.

Availability of public transportation in their lives seems to be good, considering the rural nature of the area where the respondents reside. However, even among those respondents indicating that public transportation was available for a high percentage of their mobility needs, very few ever used it, suggesting that they will continue to drive as long as possible.

Personality

The near-total lack of relationship between personality variables is surprising. One explanation may be that the bulk of the literature on personality-driving variable relationships involves accidents or violations rather than judgments of actual driving performance, the class of driving variable in this study. In one of the few studies similar to the present one (Wilson and Greensmith, 1983), measures of the personality variables aggression and anxiety likewise did not predict driving performance.

Also surprising (to some extent) is the absence of a “Big Five” factor structure in the 37 personality items. Rather, we obtained one of the “Big Five”—Emotional Stability—and an amalgam of three of the other four. This is not likely a chance finding, as a similar factor structure was obtained from the undergraduate student pilot study.

Nevertheless, individual marker items represent the “Big Five,” and these items also failed to predict driving performance. (Of course, lower reliability of individual items as compared with scales comprised of sums of individual items would lead to expectation of lower predictabilities. Still, essentially no predictability was in evidence.)

Contributory to the lack of relationship perhaps also might be our having tested only a subset of the full range of drivers—the very safe ones. It does seem at least plausible that “bad” drivers would tend not to volunteer for a driving test, and our sample did describe themselves through Malfetti-Winter (MW) items as safe drivers.

Cognitive Skills

Expectations were met with regard to demonstrated relationships between cognitive skills and driving. Lower scores in both spatial processing and visual attention were significantly correlated with several driver performance variables that could indicate serious problems in driving safety. The most important of these were tasks relating to selection of the proper lane to turn into, especially making a left turn into an opposing lane of traffic, stopping at traffic signals, and responding properly to regulatory signs at intersections. There were also problems associated with parking for those drivers with lower scores in spatial processing and visual attention. Errors in these driving maneuvers are not quite so critical to the public, unless you represent an insurance company paying claims for scraped and mashed fenders.

The problems that these drivers (with lower cognitive skills scores) had with intersections is not surprising, in view of many researchers who have analyzed accident records. These drivers had trouble with intersections even knowing that they were on a closed driving course and did not have the additional complicating ingredient of other oncoming vehicles on the driving course. A vehicle driving through the intersection would have added an important additional dimension to the driving protocol, but even without that dimension, correlations were significant enough to verify the study's original hypotheses regarding these relationships.

Although some of the significant correlation coefficients were not so strong, others were quite high. Time (required for completion of the driving protocol), Oppose (driving into the opposing lane after making a left turn at the intersection), and (perhaps a surprise) Angle (angle parking) were strongly related to driving performance.

The highest correlation coefficients established by statistical analyses were between the two cognitive skills of spatial processing and visual attention and the two variables associated with lane position. Up to this point, the main concern regarding lane position has been that the driver remain in his or her traffic lane, unless changing lanes to maneuver. However, there seems to be no relevant literature describing research relating to this element of driving.

Even lacking the availability of standards against which to judge, the lane position correlations are consistent with the other findings. Although no driver maintains a course straight down the middle of a traffic lane without deviation, the variations of either variable to the extreme could lead to serious accidents. Examples might

include side-swipe accidents with other moving vehicles (either oncoming or going in the same direction), head-on collisions, or striking parked vehicles.

Somewhat disappointing was the lack of significant correlation of the auditory attention with any driving task. However, as was noted earlier, this could have been due to a shortage of concurrent driving situations which relate strongly to this cognitive skill in the driving protocol. Therefore, it would be premature to dismiss auditory attention as having no relationship to driving safety.

In conclusion, it seems safe to say that the study provides support for the initial hypothesis—that losses in certain cognitive skills can be identified as being related to increasing potential for driving errors and potentially, that of a serious nature.

Implications

Study results have the potential for influencing future policy decisions in driver license renewal, particularly for older drivers. Driver license officials regularly face decisions on renewals for drivers of questionable competence, but often lack the information (especially in the cognitive domain) needed to make an intelligent and fair decision. Even so, there is much yet to learn before any test for cognitive skills should be included as a criterion for license renewal. For example, what effect do the limits on interpretability of cognitive skills test results have on the use of these tests on driver evaluation? Are there any ways to help these drivers to operate their vehicles more safely? Are there any logical countermeasures, including therapy and education, that might enable a driver considered a potentially unsafe driver to continue driving?

Additional questions remain related to driver age. Did the “young-old” age attributes of the sample drivers have an effect on study results? (The mean age was 69.4, indicating a shortage of drivers 75 and older.) Would the results have been different if more drivers age 75 and older had participated in the study? Would a similar study of younger drivers produce comparable results? One key recommendation from this study is that additional research be conducted using younger drivers (and perhaps some over age 80 as well), using the same methodology. This would confirm our theory that driver performance is cognitively related and that older drivers are affected only to the extent that they experience a deterioration of such skills.

Convincing answers to many of these questions will be needed before cognitive skills will become a criterion for license renewal. However, the technology involved in cognitive skills testing is not a problem, once satisfactory answers to the questions posed above are found. The cognitive skills tests administered were relatively simple and could, with little effort, be modified so as to be usable by driver license examiners with minimal additional training.

There are also major implications related to the equipment used to measure the lane-tracking variables. These are of special interest to the researchers for two reasons. First, the combination of equipment used in gathering lane-tracking data represents a break-through in technology for this type of data collection and could have a significant impact on a new and important technology related to highway transportation, Intelligent Vehicle-Highway Systems (IVHS).

The second reason is the ability to gather information on another variable which is significantly related to driving and driving safety. Any inclination to study lane position as a measure of driving safety would necessarily be hampered by limited ability to gather data. The success in technical development achieved as part of this project will undoubtedly lead to real-time data processing of lane-position data and make it possible to continuously monitor driver performance of lane-tracking.

The combined success of establishing definitive links between cognitive skills loss in spatial processing and visual attention and driving tasks (especially those relating to decisions made while driving) and the definitive links between those cognitive skills and lane-tracking suggests that lane-tracking may be a variable related to safe driving.

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**APPENDIX A
DRIVER EVALUATION FORM**

DRIVER EVALUATION - CHECK CORRECT SPACE

Auto _____ # _____

* After driver enters section "JM", instruct "GO TO STORY CITY".

- 1) At "M" (driver has to make a left turn). Driver:
- a. obeys traffic signal, makes left turn to correct lane _____
 - b. disobeys signal, but turns to the correct lane _____
 - c. obeys signal, turns to outside traffic lane _____
 - d. obeys signal, turns to opposing traffic lane _____
 - e. Does not make the left turn _____

* Give oral instructions to make right turn at "H"

- 2) At "H" Driver:
- a. gets into right lane, stops & makes the right turn correctly _____
 - b. does not get into correct lane before making right turn, _____
but stops at STOP sign & turns to the correct lane
 - c. Does not stop at STOP sign, turns to the correct lane _____
 - d. Attempts to make the turn from incorrect lane, fails to stop _____

- 3) At "F" (driver coming through "G" to "F")
- a. Yields to on coming traffic and makes the right turn _____
 - b. Attempts to go straight _____

- 4) At "M" Driver:
- a. Obeys traffic signal _____
 - b. Attempts to go through RED _____

- 5) At "J" Driver:
- a. Turns left _____
 - b. Attempts to go straight (through "DO NOT ENTER") _____
 - c. Attempts to turn right _____

* Go thru loop, back to J. Instruct driver to go to Gravity (S).

- 6) At "M" Driver:
- a. Responds to signal & turns right to the correct lane
 - b. turns right but to opposing traffic lane
 - c. does not turn right
 - d. Does not respond to signal, turns right to correct lane
 - e. turns right but to opposing traffic lane
 - f. does not turn right

- 7) AT "D" Driver:
- a. Stops at STOP sign & turns left to left lane
 - b. turn left to right lane
 - c. & attempts to turn right
 - d. Does not stop at STOP sign & turns left to left lane
 - e. & turn left to right lane
 - f. & attempts to turn right

* Score steering, lane position thru E,F,G,H,I,J. @I, "to Gold City"

- 8) At "B", the Driver:
- a. Turns left into one-way street, inside lane.
 - b. Turns left into one-way street, outside lane
 - c. Does not turn left

* Allow driver thru D,E,F,G and H. Instruct to turn left at H.

- 9) At H. driver:
- a. Turns into correct lane
 - b. Turns into opposing traffic lane

- 10) At M (RED): monitor instructs driver: make left turn at M).
- a. Makes a left turn to the correct lane
 - b. Makes a left turn but crosses the center line

- 11) At "F" Driver:
- a. Stops at STOP sign & turns left
 - b. Stops at STOP sign & attempts to turn right
 - c. Does not stop at STOP sign & turns left
 - d. Does not stop at STOP sign & attempts to turn right

* Travel F through H, I, & J. Monitor (@I) "Go to Red City".

- 12) AT "J" Driver:
- a. Turns left to the correct lane
 - b. Does not turn left

* Signal changes: AMBER to RED while vehicle approaches "M".

13) <u>At "M"</u> , Driver:	Trial #	1	2	3
a. Stops comfortably		—	—	—
b. Accelerates and go through "M"		—	—	—
c. Does a panic stop		—	—	—

* Complete the circuit F,G,H,I,J,B. Instruct to go to Gold City. As driver approaches D, instruct driver to turn left at D.

14) <u>Before coming to intersection D to turn left driver:</u>	
a. Gets in to the left lane	—
b. Does not get in to the left lane in time	—
c. Turns into inside lane	—
d. Turns into outside lane	—
e. Turns into opposing lane	—

15) <u>At M</u> , Driver:	
a. Reacts correctly to signal	—
b. Doesn't react correctly to signal	—

16) <u>Obstacle course</u>			
# of missed spaces	—	# of cones struck	—
Driving too cautiously	YES	NO	—

17) <u>Parallel park</u> Driver:	
a. Parked easily, with minimum of effort	—
b. Parked satisfactorily, but required additional effort	—
c. Parked satisfactorily, but required repeated efforts	—
d. Failed to park satisfactorily	—
e. Gave up after several attempts	—

18) <u>Angle park to right</u> Driver:	
a. Parked well spaced between lines	—
b. Between lines, but not spaced properly	—
c. Crossed the lines (could have struck parked vehicle)	—

19) <u>Right angle parking</u> Driver:	
a. Parked well spaced between lines	—
b. Between lines, but not spaced properly	—
c. Crossed the lines (could have struck parked vehicle)	—

20) <u>Angle park to left</u> Driver:	
a. Parked well spaced between lines	—
b. Between lines, but not properly spaced	—
c. Crossed lines (could have struck parked vehicle)	—

APPENDIX B DRIVING COURSE EVALUATION FORM

DRIVING COURSE EVALUATION

Vehicle _____ Time Req. _____ No. _____

0) COL. 1-3 RESPONDENT NUMBER

00) COL. 4-5 Time for driving the course (TIME)

1) Reacted to traffic signal properly: changing from green to red COL 6 (CHANGE)

- 1. Always stopped _____
- 2. Accelerated thru on amber at least once _____
- 3. Failed to react by stopping once _____
- 4. Failed to react by stopping twice _____

2) Failed to stop at red light COL 7 (FAILED)

- 1. Never _____
- 2. Once _____
- 3. Twice _____
- 4. Three times _____

3) Reaction to stop signs COL 8 (STOP)

- 1. Complete stop each time, OK at stopline _____
- 2. Complete stop each time, rolled past stopline _____
- 3. Rolling stop, stop at stopline _____
- 4. Rolling stop, rolled past stopline _____
- 5. Failed to stop at sign at least once _____
- 6. Failed to stop at sign two or more times _____

4) When turning onto a one-way street, COL 9 (TURN)

- 1. Always turned into near lane _____
- 2. Turned into near lane all but once _____
- 3. Turned into near lane all but twice _____
- 4. Always turned into outside lane _____

5) When making a turning movement COL 10 (INSIDE)

- 1. Always turned into inside lane _____
- 2. Failed to turn into inside lane once _____
- 3. Failed to turn into inside lane more than once _____
- 4. Always turned into outside lane _____

5A) When making a turning movement COL 11 (OPPOSE)

- 5. Turned into opposing lane once _____
- 6. Turned into opposing lane more than once _____

6) When in a multilane situation and making a turn, COL 12 (CORRECT)

- 1. Always turned from correct lane (got to lane in time) _____
- 2. Failed to get to correct lane once _____
- 3. Failed to get to correct lane twice _____
- 4. Failed to get to correct lane more than twice _____

- 7) Approaching intersection with restricted turning movements, COL 13 (SIGN)
 - 1. Always reacted to sign correctly, made correct turn _____
 - 2. On 1 occasion, tried to turn into 1-way street incorrectly _____
 - 3. On more than 1 occasion, tried to turn into 1-way incorrectly _____

- 8) Responding to information signs on destination. COL 14 (INFO)
 - 1. Always responded to signs correctly _____
 - 2. Would have missed turn once without additional oral directions _____
 - 3. Would have missed turn twice without additional oral directions _____
 - 4. Would have missed turn 3 or + times without additional directions _____

- 9) Obstacle course COL 15 (OBSTAC)
 - 1. No spaces missed, no cones hit, did not drive cautiously _____
 - 2. No spaces missed, no cones hit, but drove cautiously _____
 - 3. Struck cones, drove cautiously _____
 - 4. Struck cones, missed spaces, drove cautiously _____

- 10) Parallel parking COL 16 (PARALLEL1)
 - 1. Park easily, minimum of effort _____
 - 2. Required some additional effort _____
 - 3. Required considerable additional effort _____
 - 4. Failed to park satisfactorily _____
 - 5. Gave up after several attempts _____

- 11) Parallel parking COL 17 (PARALLEL2)
 - 1. hit no cones _____
 - 2. nudged cones at least once _____
 - 3. knocked over cones _____

- 12) Angle parking COL 18 (ANGLE)
 - 1. Parked well-spaced between lines _____
 - 2. Between lines, but not spaced properly _____
 - 3. Cross lines (would have struck parked vehicle) _____
 - 4. Parked OK, but would have backed into parked vehicle _____

- 13) Lane position: COL 19 (LANE1)
 - 1. Mean value of lane position relative to _____
 - 2. right edge line. Continuous values.

- 14) Lane position COL 20 (LANE2)
 - 1. Standard deviation of lane position, increasing values of _____
 - 2. deviation from the mean position. Continuous values.

APPENDIX C DRIVER QUESTIONNAIRE

DRIVING QUESTIONNAIRE

M F

Directions: Below are a number of questions relating more or less directly to automobile driving behavior. This is an exploratory questionnaire, hence some of the questions may turn out to have little relevance to driving and then will be dropped. Your honest participation will be of great help in determining which questions will be useful in measuring driving behavior.

Do not put your name on the sheet. First, mark M or F (at middle top) to indicate your sex. Then continue with the questions below. Please circle the number of the response or write the number of the response you feel is most appropriate and answer as truthfully as you can. There are no 'correct' answers.

- 1) Have you completed a driver education course
(for example, in high school)?
1. Yes 2. No
- 2) Does anyone else in your household have a license to drive?
1. Yes 2. No
- 3) About how many years have you driven a car?
1. Never driven 3. 1-2 years 5. More than 5 yrs
2. Less than a year 4. 2-5 years
- 4) Please indicate your age in years. _____
- 5) Please indicate your marital status.
1. Married 3. Divorced 5. Never been married
2. Widowed 4. Separated
- 6) With whom do you live?
1. Spouse 3. Other relative(s) 5. Live Alone
2. Children 4. Friend(s)
- 7) Do you presently drive?
1. Yes 2. No
- 8) Does anyone else in your household drive?
1. Yes 2. No
- 9) Do you own your own car?
1. Yes 2. No
- 10) How much, in an average week, do you drive?
1. 0-10 miles a week 3. 31-50 miles a week
2. 11-30 miles a week 4. over 50 miles a week

- 11) How often do you drive on long trips, such as vacations or business trips which are over 100 miles...
- | | | |
|---------------------------|-------------------------|----------|
| 1. More than once a month | 3. Several times a year | |
| 2. Once a month | 4. Once a year | 5. Never |
- 12) How much, would you estimate, that you drive annually?
- | | |
|-------------------------|----------------------|
| 1. less than 2000 miles | 3. 5000 - 10,000 |
| 2. 2000 - 4999 miles | 4. over 10,000 miles |
- 13) The response given in item 12 represents a(n) _____ in driving over the past few years.
- | | | |
|-------------------|-------------------|--------------|
| 1. Increase | 3. Decrease | 5. No change |
| 2. Great increase | 4. Great decrease | |
- 14) Do you do the majority of driving for yourself and others that you go places with?
- | | |
|--------|-------|
| 1. Yes | 2. No |
|--------|-------|
- 15) Do you live in a ...
- | | |
|--|-------------------------------|
| 1. Rural area or small town (under 2500) | 3. Small city (10,000-49,999) |
| 2. Large town (2500-9999) | 4. Suburb of a city |
| | 5. Large city (50,000+) |
- 16) Do you worry about not being able to drive?
- | | | |
|-----------|---------------------|--------------------|
| 1. Never | 3. Some of the time | 5. All of the time |
| 2. Seldom | 4. Most of the time | |
- 17) Do you worry about not being able to live independently?
- | | | |
|-----------|---------------------|--------------------|
| 1. Never | 3. Some of the time | 5. All of the time |
| 2. Seldom | 4. Most of the time | |
- 18) Do you worry about having to rely on others for transportation?
- | | | |
|-----------|---------------------|--------------------|
| 1. Never | 3. Some of the time | 5. All of the time |
| 2. Seldom | 4. Most of the time | |
- 19) How would you rate your health? Is it...
- | | |
|---------|--------------|
| 1. Poor | 3. Good |
| 2. Fair | 4. Excellent |
- 20) As a driver (compared to all drivers), I would rate myself as...
- | | | |
|------------------|------------|------------------|
| 1. Below average | 2. Average | 3. Above Average |
|------------------|------------|------------------|
- 21) Compared with other drivers my age, I would rate myself as...
- | | | |
|------------------|------------|------------------|
| 1. Below average | 2. Average | 3. Above Average |
|------------------|------------|------------------|
- 22) Does chronic bad health, sickness, or pain stop you from doing things you would like to do?
- | | | |
|-----------|---------------------|--------------------|
| 1. Never | 3. Some of the time | 5. All of the time |
| 2. Seldom | 4. Most of the time | |
- 23) Do handicaps or disabilities limit your ability to drive?
- | | | |
|-----------|---------------------|--------------------|
| 1. Never | 3. Some of the time | 5. All of the time |
| 2. Seldom | 4. Most of the time | |

For questions 24 to 29 the response alternatives are these:

1. Yes 2. No

- 24) I am currently taking medication for high blood pressure.
- 25) I am currently taking medication for arthritis.
- 26) I am currently taking medication for diabetes.
- 27) I am currently taking medication for a heart condition.
- 28) I am currently taking medication for anxiety.
- 29) I am not currently taking any medication.

For questions 30 to 37 the response alternatives are these:

1. True 2. False

- 30) I have considered stopping driving because my health is poor.
- 31) I have considered stopping driving because I have had recent accidents.
- 32) I have considered stopping driving because of my age.
- 33) I have considered stopping driving because of my family members.
- 34) I have considered stopping driving because I do not have a license.
- 35) I have considered stopping driving because I have no insurance.
- 36) I have considered stopping driving because my vision is poor.
- 37) I have not considered stopping driving.

For questions 38 to 42 the response choices are these:

1. Hardly ever 3. Monthly
2. Several times a year 4. More often

- 38) How often do you drive to the grocery store, pharmacy, or shopping malls?
- 39) How often do you drive to movies, restaurants, or other entertainment?
- 40) How often do you drive to the doctor or dentist's office or hospital?
- 41) How often do you drive to friends or relatives homes in the local area?
- 42) How often do you drive to your local church or senior center?
- 43) How many of the above mentioned places are accessible by public transportation?

1. Most 3. Few
2. Some 4. None

- 44) How frequently do you use public transportation?
- | | |
|---------------|-----------|
| 1. Frequently | 3. Rarely |
| 2. Sometimes | 4. Never |
- 45) Which best describes your situation?
1. My driving routine has been unchanged over the years.
 2. I drive more now since the person I used to ride with can no longer drive.
 3. I drive only when I have to - less often for social occasions.

For questions 46 to 63 the response alternatives are these:

- | | |
|---------|----------|
| 1. True | 2. False |
|---------|----------|

- 46) I drive less at night.
- 47) I consciously choose to drive less often on busy streets.
- 48) I often feel I need someone with me to provide directions.
- 49) I am increasingly bothered by headlight glare.
- 50) I have difficulty deciding when to merge into traffic.
- 51) I drive closer to the centerline so I can see it better.
- 52) I have difficulty seeing signs by the roadway at night.
- 53) I have never received formal driving instruction.
- 54) I am interested in receiving formal driving instruction.
- 55) I rarely drive when there is snow or ice on the pavement.
- 56) I regularly have difficulty in turning my head.
- 57) Sometimes I think my headlights are not on when they are.
- 58) I have great difficulty in seeing yellow or white markings on the pavement at night.
- 59) Glare from street lights and/or highway intersection lights really affects my ability to see at night.
- 60) Sometimes my fingers are so stiff I have difficulty gripping a steering wheel.
- 61) I have particular difficulty reading signs with red background.
- 62) I have particular difficulty reading signs with white background.
- 63) I have particular difficulty reading signs with yellow background.

For questions 64 to 75 the response alternatives are these:

1. Always or almost always
2. Sometimes
3. Never or almost never

- 64) I signal and check to the rear when I change lanes.
- 65) I wear a seat belt.
- 66) I try to stay informed on changes in driving and highway regulations.
- 67) Intersections bother me because there is so much to watch for from all directions.
- 68) I think I am slower than I used to be in reacting to dangerous driving situations.
- 69) When I am really upset I show it in my driving.
- 70) My thoughts wander when I am driving.
- 71) Traffic situations make me angry.
- 72) I get regular eye checks to keep my vision at its sharpest.
- 73) I check with my doctor about the effect of my medications on driving ability (if you do not take any medication, skip this question).
- 74) I try to stay abreast of current information on health practices and habits.
- 75) Family members or friends are concerned about my driving ability.

For questions 76 and 77 the response alternatives are these:

1. None
2. One or two
3. Three or more

- 76) How many traffic tickets, warnings, or "discussions" with officers have you had in the past two years?
- 77) How many accidents have you had during the past two years?

The next set of questions tend to be of a more general nature and have the following response alternatives:

1. Not at all like me
2. Somewhat like me
3. Pretty much like me
4. Very much like me
5. Extremely like me

- 78) I'm a sociable, outgoing person.
- 79) I'm a tense, high-strung person.

- 80) I'm concerned that other people think well of me.
- 81) I'm an impulsive person, tending to do things on the spur of the moment.
- 82) I'm a thoughtful person.
- 83) By conventional standards I'm a moral, ethical person.
- 84) I think it's important to be self-sufficient.
- 85) I'm a patient person when it comes to consideration of other people.
- 86) I'm easily distracted if a lot of things are happening at once.
- 87) I don't get angry very easily.
- 88) When I'm in a hurry I tend to take chances I otherwise wouldn't.
- 89) I consider myself a cultured person.
- 90) I like to keep busy, to have a lot of "irons in the fire."
- 91) I tend to be accident prone.
- 92) I'm cautious, tending to look before I leap.
- 93) I don't worry very much about things.
- 94) I'm easily embarrassed.
- 95) I'm a capable person in general.
- 96) I'm better at some things than at others.
1. Not at all like me
2. Somewhat like me
3. Pretty much like me
4. Very much like me
5. Extremely like me
- 97) I don't like to have to wait.
- 98) On political matters I tend to be more conservative than liberal.
- 99) I like to plan things in advance.
- 100) I like to have some excitement in my life.
- 101) I like to do things my way.
- 102) What happens to people is pretty much out of their control.
- 103) It's important to obey rules even if they aren't always the best ones.

- 104) Current events interest me more than history.
- 105) I get flustered easily.
- 106) Literature interests me more than science.
- 107) I enjoy spectator sports.
- 108) I'm a person who likes to get things done.
- 109) I'm pretty satisfied with the way I am.
- 110) Other people view me as a competent person.
- 111) I like activities that call for close attention to detail.
- 112) Small setbacks irritate me more than they should.
- 113) I get impatient when I have to wait.
- 114) I'm a polite, courteous person.

APPENDIX D SAMPLE LETTER

Date

Respondent name
Street address
City, IA Zip

Dear Mr. (or Mrs.) name,

A team of researchers from Iowa State University is conducting a study of older drivers in Iowa. The purpose of the study is to examine the changes that occur in driving abilities and related functions as one ages. We hope to determine those changes that are compatible with safe driving and those changes that a person experiences that may cause problems but can be altered due to education and training. We are hoping that you will be willing to be a part of our study. Your participation is very important to us and your insights are important in helping us better understand the older driver.

Your participation in the research project means that you will be involved in several activities at Iowa State University. Each participant will be asked to complete a questionnaire consisting of many general items relating to driving and personality. Next, each participant will take part in a series of tasks designed to look at relationships between cognitive abilities and driving. Following this, you will be given time to rest and relax before completing the final part of the study. In the final part of the study, you will go to a closed driving course and participate in the driving portion of the project. Completion of all tests will take about three hours of your time.

Each person who cooperates in the study will be reimbursed for mileage from your home to Iowa State University and back. Lunch will be provided for you and your spouse, if your spouse accompanies you to Ames. As an incentive to you and to show you how much your participation means to us, we will provide you \$50.00 as compensation for your time and the effort involved as a result of taking part in this research project.

The anticipated dates for this research project are June and July, 1992. We ask that participants schedule a weekday morning and early afternoon that they will be able to come to Ames to participate. The study itself should take about three hours, but with breaks, you should plan on about four to four and one half hours at Iowa State University.

Study results are strictly confidential. Your name will not be associated with the results. No one will know your individual scores nor will any results be reported to any official agency in the state of Iowa. If you would like, we will send you a brief summary of our findings after the research is completed.

Your participation in this study is completely voluntary; and if at any point you may wish to withdraw, you are free to do so.

We hope that you will be willing to be a part of our research. Your participation is very important in studying driving among older individuals. Our purpose is to help older drivers remain safely on the highways. We can only do that by working with people like you.

You will receive a phone call from one of our staff to talk with you about participating in the study and to help you in scheduling your visit to Ames. Your participation is highly significant to the success of the project.

Sincerely,

Cletus R. Mercier, Ph.D.
Project Director
Engineering Fundamentals and
Multidisciplinary Design

Joyce M. Mercier, Ph.D.
Co-Project Director
Human Development and
Family Studies

Enclosure: map of campus