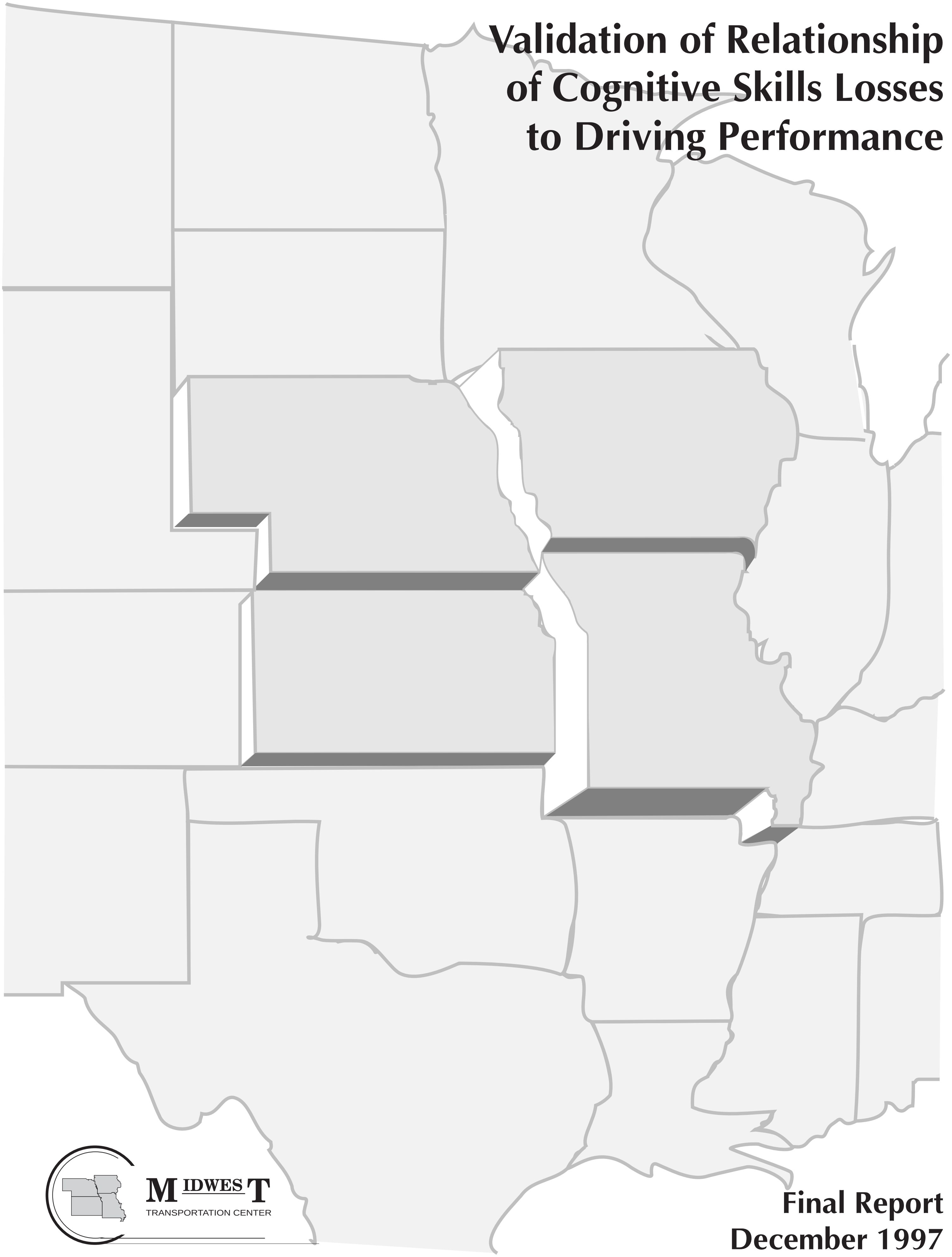
Validation of Relationship of Cognitive Skills Losses to Driving Performance



MIDWEST TRANSPORTATION CENTER

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VALIDATION

of

RELATIONSHIP OF COGNITIVE SKILLS LOSSES

to

DRIVING PERFORMANCE

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EXECUTIVE SUMMARY

The purpose of this project was to validate results of an earlier study of older drivers (Phase 1). The goal of the current project (Phase 2) was to compare the results of testing drivers age 20 through 64 with the test results of the older drivers from Phase 1, using the same methodology.

Research results presented in the Phase 1 project report examined one determinant of driver safety, the cognitive skills of older drivers. Results from that study confirmed hypothesized relationships between selected cognitive skills and driving performance, using a sample of 100 drivers age 65 and older (the mean age was 69.4, with age of respondents ranging from 65 to 84). In addition, the hypothesis of a possible link between personality and driver performance was investigated. A questionnaire was used to gather data on personality and other information related to demographics, driving experience, and accident "exposure" potential.

This study utilized a sample of 62 Iowa drivers, age 20 through 64, selected randomly from the list of all licensed drivers in Story County, Iowa and the eight contiguous counties. Letters were mailed to drivers selected from the list, explaining study goals briefly and what participants would be asked to do. A followup telephone call ascertained their willingness to participate, answered any questions, and provided information on scheduling. Respondents were almost evenly balanced between males (n=30) and females (n=32).

Respondents completed a 114 item questionnaire, plus a 100 item self-report instrument developed by Goldberg (1992), used to develop personality scales. (It should be noted that the self-report instrument was not used initially in the Phase 1 study, but mailed later to respondents for them to complete and return.) Respondents in Phase 2 were then tested for their cognitive abilities in two different cognitive processing skills - spatial processing and selective attention (both auditory and visual). These tests were followed by the third component of the study, completion of a driving protocol in an automobile provided by General Motors 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, selected for their potential relationship to cognitive skills selected for the study and for their relationship to specific accident categories, which are known to involve older drivers at higher rates than younger drivers. The protocol was revised slightly to include additional dual-processing tasks, testing driver performance relative to auditory attention cognitive skills.

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 were named "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 23 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 23 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: Phase 2 study participants were about evenly split between males (n=30) and females (n=32), with a mean age of 42.5 and an age range from 22 through 64. Although Phase 1 drivers considered themselves to be comparatively healthy, Phase 2 drivers reported better health, rating their health as good (32.3%) or excellent (67.7%). Phase 1 drivers rated their health primarily as good (65%) or excellent (22%), but 12 percent rated their health as fair, and one as poor. Phase 2 respondents reported significantly fewer limitations due to chronic health problems than did Phase 1 respondents, confirmed by the fact that a significant correlation was noted between age and health for the Phase 1 drivers, with no significant correlation for Phase 2 drivers. A substantial portion of the Phase 1 group (57%) was taking some medication, but most of the Phase 2 drivers (61.3%) indicated they were taking none. Significant correlations regarding driving patterns for Phase 2 drivers differ greatly from significant correlations for the Phase 1 group. No variables that correlated significantly with age for the Phase 1 drivers including driving mileage, self-restriction of driving, frequency of trips to retail stores and for entertainment significantly correlated with age for the Phase 2 drivers. In some ways, however, the older Phase 2 drivers were similar to the Phase 1 group - they were less likely to take longer trips (over 100 miles) or to drive at night, and were more likely to report having difficulty seeing signs or pavement markings at night and reducing driving when there was snow or ice on the highways.

2. Personality: Although the research hypothesis regarding relationships between personality and driver performance was not established for either the Phase 1 or the Phase 2 study, the analysis of questionnaire items related to personality did yield identical results from both groups of respondents. Instead of a generally accepted cluster of dimensions of personality frequently called the "Big 5" factor structure, respondents seemed to fit a two-factor structure, described as "Competence" and "Emotional Stability". Phase 1 and Phase 2 study results were nearly identical to those from two groups from pilot studies - comprised of Iowa State University undergraduate students, giving a striking similarity of personality structures in three different age groups. Though followup studies are indicated, 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 for the Phase 1 participants. (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 or problems 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.

There were four driving task variables that correlated significantly with spatial processing test scores for Phase 2 participants, although there was a shortage of variables common to both groups. The variables included driving into a lane of opposing traffic when making a left turn, backing out of an angle parking spot plus two tasks not included in the Phase 1 study, involving the assignment of tuning the radio while the vehicle was moving.

Ten driving task variables correlated significantly with visual attention in the Phase 1 study; 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). Also, drivers with lower scores in visual attention 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 same analyses using Phase 2 study data linked the younger subjects' performance on this visual attention task with only one driving task; parallel parking. Interestingly, the same significant correlation was obtained in the Phase 1 study, suggesting that individuals who have difficulty with this visual attention task will have difficulty in parallel parking, regardless of age.

There were no significant correlations between scores on the auditory attention task and the driver performance tasks in the Phase 1 study. However, this lack of significant correlation was deemed not to suggest that this cognitive skill does not have any relationship to driving safety. It was judged 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 correlations.

Therefore, several dual-processing tasks were added to the driving protocol for Phase 2. Most were related to tuning the vehicle's radio while performing other driving tasks. One task proved to be significantly correlated to the auditory attention score that was also in Phase 1, backing out of a parking place. A second driving variable significantly correlated with auditory attention involved the task of tuning the radio while making a turn.

Although there was an abundance of significant correlations from the Phase 1 study, there were unanswered questions pointing toward the need for expanded research of a similar nature. Several questions remained 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?"

There were enough significant correlations between the cognitive skills tests used and the driver task performance variables from both studies to confirm the portion of the study hypothesis relating to cognitive skills; that diminished cognitive skills scores are related to diminishing 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.

In conclusion, results from both studies provide support for the original hypotheses, that losses in certain cognitive skills can be identifed as being related to increasing potential for driving errors that are increasingly serious. Including age in the equation with the cognitive skills confirms the premise of the Phase 2 study: a significant relationship exists between cognitive skills and ability to safely accomplish a variety of driving tasks that are commonplace in any driving experience. **That** conclusion is independent of age.

The consistent significant correlations of cognitive skills scores with age, however, would support the general finding of cognitive aging literature which is that of inevitable deterioration of cognitive skills as aging occurs. Without question, the study affirms the opinion of many that one or more cognitive skills tests is needed to provide an appropriate element of information to include in a package of data which can be used in decisions on license renewal.

Based on study findings, the researchers recommend use of one of the tests used in the studies, the test that measures spatial processing. The Embedded Figures Test (EFT) can be adapted for easy use by trained driver examiners, and is a reasonable predictor of driving problems that could have serious consequences. EFT also tests a cognitive skill that has a strong age-related component, in that it significantly correlated with age in both studies.

CHAPTER 1

INTRODUCTION

Study Purpose

The purpose of this study is to validate the results of an earlier study of older drivers, hereinafter referred to as Phase 1. Results from the Phase 1 project confirmed hypothesized relationships between selected cognitive skills and driving performance. Older drivers were selected as the population to be studied (age 65 and older) because of " a general finding in cognitive aging literature is that of inevitable deterioration (of cognitive skills) as aging occurs (Poon, 1985)". The purpose of Phase 2 is to validate those findings, not assuming that older drivers per se are less safe, but that some are unsafe drivers because of loss of cognitive skills, those skills identified and verified via the Phase 1 study.

Therefore, this report will compare the results of a study of drivers age 20 through 64 with the Phase 1 drivers, utilizing the same methodology. The emphasis remains on the older driver, because of the "inevitable deterioration of cognitive skills". The purpose of the validation is to test younger drivers to find some variance in cognitive skills levels and to examine the relationship of that variance with driving performance. In doing so, we will place emphasis on cognitive skills, rather than driver age. This report will continue to stress the importance of cognitive skills loss to driving safety, but also to place it in the context of the right-to-drive for older drivers.

The Problem

Older drivers are becoming more common in the United States. In 1994, there were 33.2 million U.S. citizens 65 years and older, (about 12.7% of the total population), with the age group over 85 growing most rapidly. Between 1960 and 1980, Bureau of Census figures show that the number of people over age 65 grew by 54 percent. The numbers of those over 75 are expected to double by year 2000 (Koltnow, 1985). And by 2030, there will be about 70 million persons age 65 and older, about 20 percent of the country's population.

Elderly population growth has been accompanied by an improvement in this group's health and welfare. 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 longer retention of driver licenses. Not only is the number of elderly increasing, but so is the likelihood they will retain their driver licenses. In the early 1950's, about 40 percent of all men over 70 held driver licenses, increasing to almost 90 percent by 1984 (Rosenbloom, 1988). Though women's licensing rates have traditionally lagged behind those of men, percentages have increased for women about the same as for men; the percentage of women holding a driver license increased from 8 to 43 percent during the same time. And the proportion of women over 65 holding licenses climbed from 43 percent in 1969 to 62 percent in 1983.

This statistic is 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 (and in some states, peripheral 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, though the negative effect of cognitive skills deterioration on highway safety has generally been acknowledged.

Dementia, one form of cognitive impairment, is a particular problem among older adults. It is a clinical syndrome of impaired memory with at least one other change in cognition, judgment, or personality severe enough to interfere with work or social activities. The earliest signs of dementia are evidenced by a decline in the ability to perform complex tasks, such as driving an automobile, even while holding a valid license to drive.

Alzheimer's disease (AD), one of the most common dementing disorders, is only one of a broad group of dementing conditions (including Parkinson's disease and multi-infarct disease) occurring among older adults. In its earliest stages, AD is often difficult to distinguish from cognitive changes and other problems associated with normal aging. Difficulties caused by early stage AD or minor cognitive deficits may become apparent only when the older adult faces challenging tasks, such as operating a motor vehicle (Waller, 1993). Unfortunately, AD is a fairly common condition among older drivers, especially among the 85+ age group. Risks of dementia among adults 65 and older are estimated to be as high as nearly 12 percent and among those 85 and older as high as 47 percent, with the latter age group estimated to increase in size from 2 million in 1980 to 9 million in 2030 (Evans, et al, 1989).

Though 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 then, such decisions will be made on a fragmented basis, in response to individual situations.

License renewal is considered automatic by younger adults, but the potential for either refusal to renew by license examiners or voluntary decisions to quit driving are of great importance to the elderly. For most adults, being able to drive is frequently synonymous with psychological well-being, because driving symbolizes independence and a sense of control over their world. For many older drivers, there is great concern about being unable to drive at some point in the not-too-distant future.

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 as well as able 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 such alternative transportation services available. Thus, continued possession of a valid driver license, threatened by problems associated with aging, becomes critical to their personal welfare and sense of control and self-esteem.

Independence, Mobility, and Safety

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). This proportional increase is particularly significant among drivers age 85 and older, as by 1994, the ratio of women to men over age 85 was 2.6.

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 all drivers 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).

The maintenance of independence in the community is one marker of successful aging. An aspect of this independence is the ability to continue driving into old age. Access to health care, maintaining social contacts, shopping, and getting to appointments are among the primary functions of driving in older age groups.

Mobility. Retention of a driver license is important to older persons from the standpoint of mobility, because there is a shortage of alternative transportation modes, particularly in rural and suburban areas. 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 alternative modes of 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 perceiving and reacting to roadway hazards (Olson and

Sivak, 1986) and reading signs at night (Sivak, Olson, and Pastalan, 1981) have 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, 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 rates 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.

Enabling or Policing?

There is a troubling emphasis on the negative rather than enabling aspects of medical fitness to drive. There is evidence to show that appropriate intervention may improve driving ability and comfort (McCoy et al., 1993), even as some experience many difficulties in driving. Many stroke victims do not return to driving after experiencing a stroke, yet rehabilitation and specialized driver re-education may return some to independence (O'Neill, 1996).
The accent seems to be on who should not drive, stressing the safety of other people as taking precedence over the right to drive, conferring a policing role on physicians, a discomfort to many of them. This poses a dilemma for physicians, both from a clinical and ethical viewpoint and the policing mentality may have a negative impact on attitudes to older drivers. It may also deter patients from going to their physicians if they fear that disclosure of illness may result in limitation or loss of driving privileges.

Models of Driver Behavior

An extraordinary range of guidelines exists on fitness to drive for **all drivers** among states in the United States and in the European Union, representing both an opportunity for academics and a problem for clinicians. Geriatricians are aided in assessment and rehabilitation of problems of balance and gait by an understanding of underlying mechanisms, but driving is a complex task and there has been a marked lack of progress in developing a comprehensive model of driving behavior (O'Neill, 1996). Michon has outlined criteria for models of driving behavior; his emphasis on a hierarchy of strategic, tactical and operational factors has been helpful to researchers in developing the driving protocol (Michon, 1985).

Strategic performance in the driving context includes planning the route, choosing the time of day, or even deciding not to drive and taking public transit. Tactical decisions are aspects of driving style characteristic of the driver and are either consciously or unconsciously adopted for a wide range of reasons. Examples might be a decision whether or not to overtake and pass another vehicle or how to react to a traffic signal light changing to amber. Operational performance is driver response to specific traffic situations, such as speed control, braking, and signalling. Operation of a motor vehicle requires organization of action at and between all three levels.

There are at least five main types of models which have been explored: psychometric, motivational, hierarchical controls, information processing, and error theory. There has been considerable interest in motivational models which have incorporated a hierarchical control structure and which has given emphasis to motives other than risk. Also factored into the model is concurrent activity at operational, maneuvering and strategic levels that portrays the driver as an active decision-maker, rather than a passive responder as implied in some of the early information-processing models.

Driver allocation of attention depends on the immediate driving situation and driver motives, which include level of risk and other motives relating to trip purpose. The main research interest in this model is in identifying factors influencing driver allocation of attention among the driving tasks. Much of driving is routine and done automatically, and requires fast, effortless cognitive processing. This contrasts to control processing, which is demanding of attention and cognitive resources.

Assessment and Screening

Risk assessment of older drivers is affected not only by our understanding of models of driving behavior but as well by empirical studies of disease and crash risk and clinical attributes common to assessment of function in older patient/drivers. Individual variability is very important, meaning we have to take a case-by-case approach. Also, within the rubric of a single illness there may be a number of influences on driving skills. As an example, an increased risk of crashes may occur for drivers with Parkinson's disease (Dubinsky, et al., 1991), involving a number of problems, including motor function, depression, and impaired cognitive function. It is important to take the phenomenological approach, treating depression and motor function problems and assessing cognitive functions before any decision is made about fitness to drive.

Predictors of Driving Performance

For many years, researchers have attempted, 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. Though accident frequency and accident rate have been used most often, other studies often emphasize performance in driving simulators and road tests. 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 instability) 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).

One group of scientists have grouped personality characteristics into five groups of "descriptive dimensions", which have become known as the "Big 5" (Costa and McCrae, 1992; Goldberg, 1993). While there is some disagreement on the specific grouping of personality characteristics and whether there should really be a "Big 5" grouping, reviews of literature have concluded that personality measures, when classified within "Big 5" domains, are systematically related to a variety of criteria of job performance, which can include the performance of driving. The five factors include Extraversion, Agreeableness, Conscientiousness, Emotional Stability (or Instability), and Openness.

The theory of planned behavior offers a systematic way of integrating attitudes and beliefs relating to driving into a model describing causes of individual differences in driving style. The theory states that "intentional behaviors are a product of attitudes toward the behavior, perceived norms regarding the behavior, and beliefs about the likelihood that the behavior can be undertaken" (Ajzen and Madden, 1986). A recent study used the theory to investigate intentions to perform driving violations. Researchers reported an over-representation of young-male drivers in accident statistics that may arise in part from their over-confidence in their own skills, to be less constrained by possible negative consequences of their behavior and to take risks deemed to be unacceptable by drivers with a more realistic appraisal of their own abilities (Parker, et al., 1995). Though speeding is known to play a significant role in crash involvement, it is not yet clear which of these contributors toward a tendency to commit driving violations is important for crash involvement and whether violations other than speeding play a significant role in all but exceptional cases.

McGuire (1976, p. 439), in an extensive review of the literature, 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." Tsuang, Boor, and Fleming (1985) similarly concluded that certain personality characteristics, such as low tension tolerance, immaturity, personality disorder, and paranoid conditions, are risk factors for traffic crashes.

Findings of relationships between antisocial motivation and crash involvement are remarkably consistent. Judd et al. (1987) suggested that problem-behavior theory can be usefully applied to the results in this area. This suggests dangerous driving will be associated with other risky behaviors and that "problem behaviors" can be predicted by interactions between personality system, representing the individual's attitudes and beliefs, and the perceived environment system, representing the individual's perception of the social world.

Vision. Among various measures of driving, vision has 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. Several large scale studies have found statistically significant correlations between accidents and various vision tests, but 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 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 intuition would suggest that some relationship might exist.

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 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 individual loss rates, hence the need to avoid making generalized assumptions regarding older drivers.

The success of adding cognitive elements to vision in the UFOV research supports theories on the negative effect of cognitive motor impairment on driving. Literature on movement slowing with age suggests there are alterations in cognitive-motor processes, including (1) failure to use advance preparatory information (Botwinick, 1978); (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 is driving in an unfamiliar locality.

Sivak et al. (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 appeared 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 was advocated by the study into relationships between cognitive abilities of selective attention, dual task performance, and cognitive flexibility to driving ability.

A recent research project (project report issued in 1994) by Mercier, Mercier, O'Boyle, and Strahan studied 100 drivers age 65 and older, exploring possible relationships between selected cognitive skills and driving performance. Researchers hypothesized that it was possible to demonstrate relationships between cognitive skills and performance in 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.

Confirmation of the relationships between cognitive skills and driving performance represented a significant advancement in knowledge about older drivers. However, because the study used only data from drivers age 65+, data from younger drivers is needed to complete the picture - to see if results were age or cognitive skill related.

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:

- see or hear a situation developing (stimulus registered at the perceptual-visual or auditory level)
- recognize it (stimulus recognition at the cognitive level)
- decide how to respond (cognitive level)
- execute the maneuver (motor level)

Cognitive and physiological changes that coincide with aging (especially cognitive changes) 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 those drivers with cognitive skills losses slower to respond? If this is true, are we talking about older drivers or just drivers with cognitive skills deficits.

Cognitive performance is fundamental to 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. It was hypothesized that:

1. A relationship exsists between personality traits and driving variables, especially those (previously noted) that have been implicated by earlier studies. This was explored, even though no link was found using data from the Phase 1 study. Additional personality items were added to Phase 2, to confirm or refute the earlier results. Additionally, in an exploratory, yet systematic vein, any relationship

between driving variables and what has come to be known as the "Big 5" personality structure were examined.

2. A relationship exists between some 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.
3. Responses to Malfetti-Winter questionnaire items will predict driving performance.
4. Drivers with deficits in the ability to perceive information, independent of age, 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.
5. Drivers with deficits in the ability to focus attention on a task (independent of age) 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 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 selected cognitive skills on older driver performance. A long-term research goal is to develop some scalar values for cognitive variables found to correlate with driver safety. These measures could contribute to 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 study consisted of several unique components designed to assess driving ability and ability to react properly to normal driving situations. It approached the problem from four directions (socio-demographic, personality, 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 62 licensed drivers age 22 to 65, randomly selected from the list of Iowa licensed drivers.

Study Components. The first component consisted of the administration of a questionnaire completed by the drivers. It was nearly identical to the questionnaire utilized for the earlier study, 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. Because an analysis of questionnaire responses from the earlier study appeared to contradict some widely held theories on personality, the questionnaire was expanded to include Goldberg's 100 unipolar item questionnaire (1992), so that a more complete analysis of driver personality could be accomplished.

The second component involved testing of all respondent's 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 driving. Each driver completed a driving protocol on a closed driving course, similar to the protocol used with Phase 1. Driving performance tasks were selected based on their ability to simulate the actual driving experience. Care was also taken to include tasks which would test driver abilities in spatial processing and selective attention. The protocol from Phase 1 was modified to add dual-processing tasks which could be utilized to explore relationships with auditory attention cognitive skills scores. A mid-size vehicle furnished by General Motors was used for the study.

Analysis and Results. The set of independent variables used in the analyses were (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. Dependent variables include 23 driving task variables resulting from consolidating driving tasks in the protocol, which measured the actual driving performance. The resulting data were analyzed, using basic descriptive statistics, simple and 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.

1. Statistical analyses again revealed essentially no correlation between any dimension of personality and driver performance.
2. Four driving task variables correlated with spatial processing test scores at $p<.05$ level of significance. Seven driving task variables correlated significantly in Phase 1. Two of the four involved a set of tasks added to the Phase 1 driving protocol.
3. Only one driving task variable correlated significantly with the visual attention task, compared to ten for Phase 1.
4. There were no significant correlations between driver performance tasks and auditory attention for Phase 1. However, the researchers felt that this might have been due to a shortage of driver performance tasks requiring concurrent driving tasks. Therefore, a set of tasks involving tuning the radio was added to the Phase 2 driving protocol. Study results found two driving tasks significantly correlated with this cognitive skills test, one of which was added to the driving protocol.

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 for both the Phase 1 and Phase 2 groups of respondents (where a high percentage of accidents involving older drivers occur), is encouraging;

that our hypotheses are on the mark. However, it is obvious that more study is indicated, to translate what has been learned into practical usage (see Chapter 7).

Report Organization

The research plan and design is described in Chapter 2. The summary of how the raw driver performance data were organized into the twenty-one 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 results discussed in Chapters 4, 5, and 6 are summarized in Chapter 7, together with study implications.

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 twenty-one driving task (dependent) variables. The population of interest for Phase 2 was a group of younger drivers (under age 65), holding a valid driver license.

This chapter describes the research plan and design. Specifically, it describes the 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. The respondents came from a final list of licensed drivers under age 65 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 half of those receiving letters could be contacted by telephone and of those contacted, 30 percent took part in the study.

Demographics/Personality Questionnaire

First, respondents completed a questionnaire consisting of 115 items plus the Goldberg 100 unipolar items. (A sample of the questionnaire may be found in Appendix C.) Questions included those designed to:

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

Demographics. 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) and used in Phase 1 of the study, which had utilized older drivers as subjects. Prior to its use, it had been pre-tested on two groups of undergraduate students at Iowa State University.

Some 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
- 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, though one item ("I check with my doctor about the effects of my medications on driving ability") was dropped because of its inapplicability due to the large number of subjects who were not on medication.

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. Developed for the Phase 1 study, this portion of the questionnaire contained items that seemed, from our reviews of the literature and our own theorizing, to be particularly relevant to driving behavior. Additionally, it contained marker items from the popular “Big 5” personality literature (e.g., Costa & McCrae, 1992; Digman, 1990; Goldberg, 1993). The Big 5 dimensions (factors) have been found by many investigators in many settings and with many instruments. Typical names for these dimensions are Agreeableness, Conscientiousness, Extraversion, Emotional Instability, and Openness. The 37 items arrived at also included a few more distractor or filler items intended to camouflage to some extent the nature of our inquiry in hopes of obtaining more valid responses.

Responses to the personality items in the questionnaire were used to develop personality scales. The analytic aim of the Phase 1 study 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).

Results of analyses of responses for Phase 1 of the study, using only the original 37 personality items, raised as many questions as were answered. As an attempt to provide for more thorough tapping of the Big 5, we decided to also include in the overall self-report package Goldberg’s (1992) 100 - item unipolar instrument. Therefore, copies of Goldberg’s 100 unipolar item questionnaire were mailed to those respondents and results were included in subsequent analyses of those data. Even with the additional data, results were much the same. Overall, our analyses of Phase 1 data (including the responses to the Goldberg items) supported more strongly two, rather than five personality dimensions.

The same Goldberg items were included in the questionnaire utilized for Phase 2 (with the questions related to demographics, Malfetti-Winter, and the original 37 personality related questions), so that a more complete analysis of respondent personality would be possible.

Cognitive Performance

Cognitive performance is crucial for the recognition and decision phases of driving, but no valid tests are available for screening drivers with impaired cognitive performance and little evidence exists that training will compensate (McKnight, 1988). The Committee for the Study of Improving Mobility and Safety for Older Persons (which issued Special Report 218) **strongly** recommended more basic research on the relationship of cognitive performance to driving. (Note: Special Report 218, titled “Transportation in an Aging Society; Improving Mobility and Safety for Older Persons”, was issued in 1988 by the Transportation Research Board).

One specific cognitive skill which affects driving is attentiveness. This is the ability to focus attention on a given task, which is widely perceived to diminish with age (Botwinick, 1978). Evidence also suggests that older persons are more easily distracted by irrevelant stimuli (Kausler, 1982; Dewing et al, 1995) 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 higher incidence of turning moving accidents among older drivers.

Older persons process information more slowly than younger ones thus impairing 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.

A Bausch and Lomb vision tester was used to measure static visual acuity. Test stimuli consisted of a large diamond, divided into smaller diamonds. The subject's task was to identify the corner of the diamond containing the target. The target consisted of a checkerboard with individual squares, reflecting different acuity levels. 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 administration of the cognitive tasks. Knowledge of the subject's 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.

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 data collected on the auditory attention task. Thus, hearing was measured via a Beltone 100 Series Portable Audiometer. Subjects were tested for their response to pure 70 dB tones at frequencies ranging from 125 to 8000 Hz. Those with 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 audiometer headphones). Hearing test scores reflected the range of frequencies that the subject could detect, 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 is explained in terms of failing attention capacity, particularly in crashes when turning. It is implied that these drivers could cope with more time or fewer tasks to perform 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, several cognitive abilities previously 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 driver processing capabilities. The hypothesis was straightforward: performance impairments observed in the sample of drivers on these cognitive skills may correlate with difficulties experienced during the study's driver performance portion.

Clearly, the extent to which objects encountered while driving can be perceived (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 EFT previously has been 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 two scores; number correct and mean time per item.

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 sets of letters (ranging from 3 - 15 letters in a given set) were presented on a computer screen for 500 msec. The letters were presented simultaneously and their position on the computer screen was random (i.e., they could appear in any spatial relationship to one another).

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 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 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 twenty-one driving tasks. This was made possible by use of a mid-size automobile (donated earlier by General Motors) navigating 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 of one such type of accident is a left turn against opposing traffic. The original driving protocol was modified to include tasks designed to force dual-processing, which could be utilized to explore relationships with auditory attention cognitive skills scores.

Closed Driving Course. 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 was laid out using standard pavement marking. Most were two lane, except at one signalized intersection, with two-lane approaches from each direction. Pavement marking tape was used to define the parking spaces used in the protocol, including parallel and 45 degree and 90 degree angle parking spaces.

The traffic signal was wired for traffic actuated inductive loop (modified for possible observer intervention), so the same, planned signal phase sequence was presented to each driver. The arrangement also 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 various parking tasks. Traffic actuated induction loops were used for the obstacle course, so that time used by the driver to negotiate the course could be measured. The traffic cones also aided in subjective evaluation of parking maneuvers by observing whether cone position was disturbed by vehicle motion.

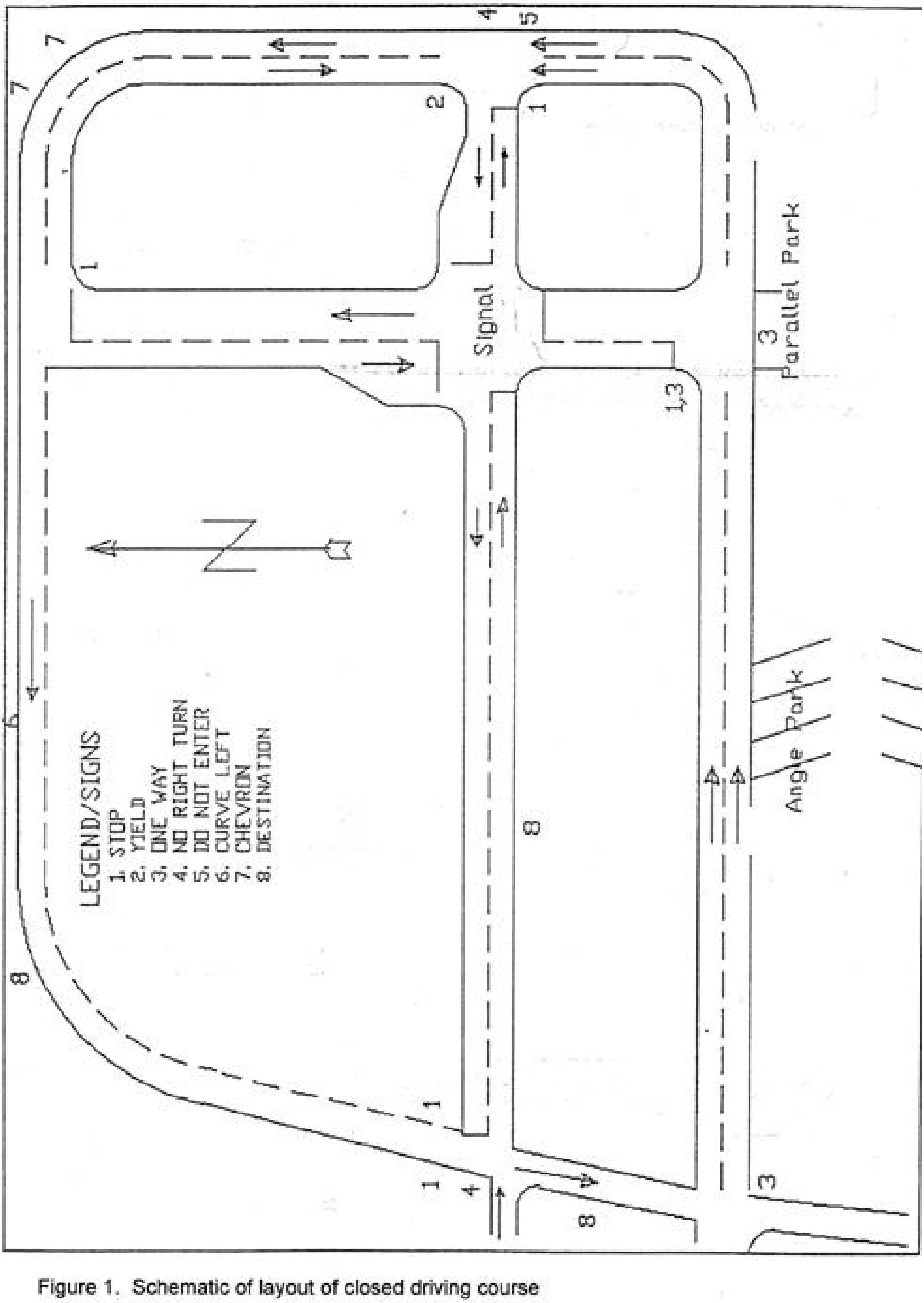

Figure 1. Schematic of layout of closed driving course

Figure 1. Schematic of layout of closed driving course

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.

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 presentation and multiple movements in performing the tasks. Although an occupational therapist 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.

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

The 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, because 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) how the resulting driving task variables were used.

Collection Format

The researchers were concerned about the potential of subjective evaluation 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". Evaluation of this element for Phase 1 was subjective. For most of the drivers, evaluation of that variable was quite easy. For some of this group of subjects, the subjective nature of the evaluation might have produced a slight variation in ratings. For Phase 2, this element was “quantified”. This was done by using the traffic induction loops to actuate and stop a timing mechanism, to measure how much time the driver used on the obstacle course.

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 evaluation is an important moderating factor of data collection. The conscientious effort exercised by the observer should have minimized any adverse effects to the quality of data collected.

Effects on Analysis

A weakness of the data collection format was that they were not compiled in a form convenient for analysis. As examples, subjects were presented with the need to react to a variety of regulatory signs while driving and 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 23 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 23 driving task variables. 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 each respondent which lists the 23 dependent driver performance variables.

Table 1. Composite list of driving variables.

DRIVING TASK VARIABLES ANALYZED	VARIABLE NAMES
Time required for completion	TIME
Weather, light conditions	WEATHER
Reacted properly to signal change: green to red	CHANGE
Accelerated through on amber while going straight	ACCEL
Failed to stop at red signal light	FAILED
Wrong reaction to stop sign	STOP
Turning into a one-way street	TURN
Lane selected when making a turning movement	INSIDE
Turned into opposing lane	OPPOSE
Turn into correct lane in a multilane situation	CORRECT
Correct response to restricted movement sign	SIGN
Responding to information signs on destination	INFO
Execution in obstacle course: striking a traffic cone	OBSTAC
Time through the obstacle course	TIME2
Parallel parking effort	PARALLEL1
Parallel parking execution	PARALLEL2
Angle parking execution	ANGLE
Angle parking, backing	BACK
Tuning radio problems	TUNE
Tuning radio: Trial #1 - driving straight ahead	TUNE1
Tuning radio: Trial #2 - while making a turn	TUNE2
Naming of cities on destination signs	NAME
Naming of regulatory signs on closed driving course	SIGNS

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 23 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 for the Phase 1 study of older drivers to collect a variety of data. The same questionnaire was used with the younger set of drivers (Phase 2), so that comparisons could be made with the findings on the Phase 1 drivers. Some of the results of the data analysis were of interest primarily as descriptive statistics, such as questions about changes in driving patterns Phase 1 respondents said they experienced in recent years. This chapter describes the outcomes of interest in Phase 2 data from the first part of the questionnaire, relating to 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 (1986) study (14 items) and the balance-- 78 through 114 -- were 37 questions designed to gather data on personality (along with the 100 Goldberg items).

Analysis of responses to questions 1 through 63 are discussed separately because no attempt was made to correlate these responses to driver performance variables for this report or for the Phase 1 report. Emphasis in the analysis to responses to questions 1 through 63 was the relationship of driver age to the responses.

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 which can then be compared to the Phase 1 subject group of older drivers. The second procedure, SPSS for Windows Correlation Analysis package, provided correlations and levels of significance comparing responses to each question against responses to each of the other questions. Only significant results of these correlations have been included in this report.

Driver Demographic Data

The 62 respondents taking part in the study were about evenly split between males (30) and females (32) Their ages ranged from 22 to 64 (mean age=41.5).
All but two of the respondents owned a motor vehicle (automobile or pickup truck), which is very similar to the older drivers in the Phase 1 study (99% compared to 96.8%). Over three quarters (79%) of the Phase 2 group were living with a spouse or spouse and children while the Phase 1 drivers were nearly all living with a spouse (78%). Most (91.9%) of the younger drivers had another driver in the household, compared to 78 percent of the older drivers. All of the older drivers had driven more than five years, and the majority (95%) of the younger drivers had driven more than five

years as well. Only three of the older drivers had ever taken a driver education course, but 79 percent of the Phase 2 drivers had.

Nearly half (48.4%) of the Phase 2 sample live in an Standard Metropolitan Statistical Area (SMSA). Most of these lived in a central city (40.3%), with a smaller group (8.1%) living in a suburb. The rest of the sample lived in an urban area (32.3%), or in a rural/small town (village) (19.4%). This compares to over a third of the older Phase 1 drivers (36%) living in an SMSA, 46 percent living in an urban area, with the balance from rural/small towns (18%). Bureau of Census definitions categorize “small towns” as one of two classes of villages, rural areas and communities with a total population of under 1000 and a second class of village with a population between 1000 and 2500. Any community with a population exceeding 2500 but not large enough to qualify as an SMSA (community consisting of at least one city with a population of 50,000 or more) is classified as urban.   The size of the respondent home community is somewhat important, in that the researchers desired a mix, taking steps to ensure that a good proportion of the respondents did not have access to public transportation.

Transportation Consumption Patterns

Frequencies. Some important differences between the two samples of drivers are seen when frequencies relating to mobility are examined. Although the sample of older drivers seemed to be quite mobile for their age group, the younger drivers are more active. For the younger (Phase 2) drivers, nearly three-fourths (71%) responded they drove more than 50 miles per week, compared to slightly more than half (52%) of older drivers. Those driving very little, less than 10 miles per week, were very similar for each group; 1.6 percent for the younger drivers and 3 percent of the older group.

Answers to questions about total annual driving showed some major differences, with younger drivers driving more over a year’s time. None of the Phase 2 group of drivers indicated they were driving less than 2000 miles annually, while more than an eighth (12.9%) of the Phase 1 (older driver) sample said they drove that amount or less. One third (33%) of the older drivers had indicated that they drove over 10,000 miles each year, compared to a higher portion (37%) of younger drivers driving the higher mileage.

Frequency analysis can tell something about mobility of the two groups as simple frequencies of one group are compared to the other. The use of SPSS for Windows Correlation Analysis produced results which suggested the existence of age-related changes in driving patterns. But it should be noted here as in the Phase 1 report that data collected represents a “snapshot” taken in time and do not provide as accurate a picture of mobility as would longitudinal data.

Correlations. The Correlation Analysis provided some significant results related to epidemiological data for the Phase 2 drivers. Significant correlations with age included who the respondent was living with ($r=-.26$, $p<.04$), marital status ($r=-.27$, $p<.04$), and taking blood pressure medication ($r=-.38$, $p<.002$). Thus in the group of Phase 2 drivers ($n=62$), the older subjects were more likely to be living with a spouse and/or children, to be married, and to be taking blood pressure medication.

Malfetti-Winter (1986) items were also correlated as separate items with age for drivers in both phases. These correlations produced some significant and interesting findings (Table 2). Older drivers in Phase 2 were more likely to be keeping informed of current health information, reacting more slowly, staying informed about current regulations about driving, and having regular eye checks. The younger drivers in Phase 2 were more likely to have their emotions reflected in their driving, to allow their thoughts to wander when driving, to have family and friends concerned about their driving, to wear seat belts and to get angry over traffic situations. Within Phase 1 drivers, only two of the items were significantly correlated with age. The younger drivers in Phase 1 respondents were more likely to stay informed about driving regulations while the older drivers in Phase 1 were more likely to allow their thoughts to wander while driving.

Table 2. Results of Correlation Analysis of age with Malfetti-Winter questions.

VARIABLES	Phase 1		Phase 2	
	Correlation	Significance	Correlation	Significance
Keeps informed/current health information	.01	.90	-.29	.02
Stays informed on driving regulations	-.21	.04	-.44	.001
Upset emotions reflected in driving	.09	.37	.35	.006
Allows thoughts to wander while driving	.20	.04	.44	.000
Gets angry over traffic situations	.15	.12	.26	.04
Is slower to react	-.02	.81	-.29	.03
Has friends and family concerned	-.09	..40	.35	.006
Wears seat belts	-.18	.07	.44	.000
Has regular eyechecks	.16	.11	-.43	.000

Note: Not all of the variables in the Malfetti-Winter items correlated significantly with age. These are the items that were significant at $p<.05$ for the Phase 2 study. Correlation analysis of several of the same variables for the Phase 1 study did not prove to be significant at $p<.05$, but are shown as a means of comparison.

Significant correlations regarding driving patterns for Phase 2 drivers differ greatly from correlations that were significant for the Phase 1 drivers who ranged in age from 64 to 84. None of the variables reflecting driving mileage, self-restriction of driving, or frequency of trips to retail stores and for entertainment were significantly correlated with age for the Phase 2 drivers. The analysis summary for these items is in Table 3. Compared to many significant variables from Phase 1, only variables measuring the frequency of long trips ($r=.34$, $p<.006$), having had a driver's education course ($r=.39$, $p<.002$), frequency of driving to visit friends and relatives ($r=-36$, $p<.004$) and to church or the senior center ($r=.33$, $p<.01$), and never having received driving instruction ($r=-.30$, $p<.02$) were significant with age for Phase 2 drivers.

Table 3. Results of Correlation Analysis of age with driving patterns.

VARIABLES	Phase 1		Phase 2	
	Correlation	Significance	Correlation	Significance
Miles driven per week	-.20	.05	-.19	.14
Frequency of long trips	.19	.06	.34	.006
Frequency/driving to stores	-.19	.06	-.03	.83
Frequency/driving to movie, etc	-.30	.002	-.07	.61
Frequency/driving to visit friends, relatives	-.32	.001	-.36	.004
Choose to drive less	-.19	.06	.01	.93
Drive less at night	-.22	.03	-.25	.055
Have difficulty seeing signs at night	-.21	.03	-.03	.82
Difficulty seeing pavement markings	-.35	.0003	.089	.56
Rarely drive in snow/ice	-.21	.04	-.25	.051

Note: correlation analysis of several of the Phase 2 variables did not prove to be significant at $p<.05$, but are shown as a means to compare Phase 1 and Phase 2 results.

Driving more frequently to local churches or senior centers were more likely events for older drivers in the Phase 2 study while the younger drivers were likely to drive more frequently to visit friends and relatives. The older drivers in this group (n=62) were also less likely to have ever received driving instruction or a driver education course than the younger drivers. The younger Phase 2 drivers were more likely to take frequent long trips (over 100 miles). The older drivers in Phase 2 were driving less at night, having difficulty seeing signs or pavement markings at night, and reducing driving when there was ice and snow on the highways, as the Phase 1 drivers had indicated in their responses. However, the younger drivers in Phase 2 were significantly more likely to be driving on ice and snow than were the older Phase 2 drivers.

Health Concerns

Although the Phase 1 drivers had indicated they considered themselves to be comparatively healthy, Phase 2 drivers reported even better health, rating their health as good (32.3%) or excellent (67.7%). This compares to drivers in Phase 1 who rated their health as primarily good (65%) or excellent (22%) as well, but 12 percent of whom rated their health as fair, and one as poor.

Chronic health problems can limit individual activity. Phase 1 respondents noted few limitations, but Phase 2 respondents reported even fewer limitations. About 63 percent of the Phase 2 drivers said that chronic bad health, sickness, or pain never limited them from doing what they wanted to do. Another quarter of the sample respondents (27.4%) reported that they seldom were limited by health problems (see Table 4).

Table 4. Respondents limited in doing what they wanted by chronic bad health, sickness, or pain.

Extent of Limitation	Phase 1 Relative Percentage	Phase 2 Relative Percentage
Never Limited	42.0	62.9
Seldom Limited	40.0	27.4
Limit some of the time	16.0	8.1
Limited most of the time	2.0	1.6

This compares to 42 percent of the Phase 1 drivers who responded that they were never limited, 40 percent who were seldom limited, and 16 percent who were limited some of the time. Although the Phase 1 drivers reported that 84 percent of them had no disabilities that limited their driving, the Phase 2 drivers reported that nearly all (96.8%) of them had no disabilities that limited their driving.

Interestingly enough, 38.7 percent of the Phase 2 drivers indicated that they were taking some form of medication, with the rest reporting none. The drivers in Phase 1 of the study almost reversed the statistics, however, with over half of them (57%) stating that they were taking some medication and 37 percent replying that they did not take any form of medication. On questions regarding medications for blood pressure, arthritis, diabetes, heart disease, or for anxiety, over 90% of the Phase 2 drivers indicated that they did not use them. The highest usage of any single medication was reported for blood pressure medicine which was reported by nearly a tenth of the respondents (9.7%).

In the Phase 1 study, a significant correlation was noted between age and health for those drivers; however, there was no significant correlation between age and health for the Phase 2 drivers. The Phase 2 drivers were apparently not at the stage of life where age was related to their perceptions of their own health.

Special Concerns

None of the special concerns older people have about their ability to continue to drive in the future were signicant for the Phase 2 drivers. In fact, there was no variability in the responses given to these questions which makes it obvious that the drivers expressed no concern at all. Concerns that older people expressed were more likely to be about not being able to live independently rather than about not being able to drive.

Public Transportation

Most (74.2%) of the Phase 2 sample lived either in an urban area or small city compared to about two-thirds of the Phase 1 sample, thus there is reason to suspect that public transportation is available to the majority.

Use of public transportation may relate to past experience in driving. Almost all the respondents in Phase 2 either indicated there was no change in the amount they had driven in the past few years (58.1%), or either an increase (30.6%) or a great increase

(6.5%) had occurred. Less than 5% indicated the amount driven was a decrease and none had a great decrease. With use of the private automobile so high, there was little likelihood these respondents would be utilizing public transportation too frequently. In fact, with 62.9 percent of Phase 2 drivers responding that they had access to some (11.3%) or all (51.5%) of a list of common destinations by public transportation, less than 10 percent (9.7%) used public transportation at all. Again this is even more pronounced than for Phase 1 drivers who initially responded that common destinations they might frequent were all accessible (27%) by public transportation or that some were accessible (28%). The balance of the respondents stated that few or none of the destinations were accessible by public transportation. Though public transportation was reasonably accessible for over half of the Phase 1 respondents, about two-thirds never used it and only two respondents stated that they used it frequently.

This reliance on driving their own vehicle is not likely to change soon for both Phase 1 and Phase 2 drivers. Though a few Phase 1 drivers had considered no longer driving, most (85%) had never considered it. And no drivers in Phase 2 had considered it at all.

Summary

As a group, respondents in both Phase 1 and Phase 2 seem to be healthy and very mobile. These health and mobility characteristics are probably reasonably representative of both the younger and the older drivers. But the self-selection process (those willing to participate from the randomly sampled populations) which determined the makeup of the group of respondents probably included drivers more confident about their driving abilities than were those who chose not to be part of the studies.

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 for drivers in Phase 1. In each instance, increasing age correlated with less desirable circumstances — less mobility, less independence, and poorer health. These relationships were not significant for the Phase 2 respondents, indicating age becomes more of a concern generally and in driving situations as a person reaches the later years in his/her life. Some interesting age-related relationships showed up when examining Malfetti-Winter (1986), items suggesting that even in the Phase 2 sample age is beginning to be a factor in the way a person approaches his/her driving situation.

CHAPTER 5

RESULTS - PERSONALITY DIMENSIONS AND DRIVING

Chapter 4 described the results of the analyses of responses to the first 63 items of the questionnaire. The balance of the questions were either from the Malfetti-Winter study or otherwise designed to gather data on personality. This chapter describes the results of analyses of responses to these questions.

Questionnaire Pre-Test

The questionnaire was pre-tested before use as part of Phase 1, utilizing undergraduate students at Iowa State University in two large pilot studies (the number of participants was on the order of 100 for each study). Factor analyses of the pilot studies data suggested that a priori five factor structure (discussed in Chapter 2) 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 way to describe the personality dimensions (in the sense of interpretability and relative independence of factor scores constructed by summing salient items) in both pilot studies appeared to be the two-factor solution. One of the two factors might be called “Competence” - an amalgam of four of the Big 5’s factors of Extraversion, Agreeableness, Conscientiousness, and Openness. The other factor would be the Big 5 factor “Emotional Instability”.

Phase 1 Participant Personality Factors

The same data analytic procedure as above was followed in the Phase 1 study, using the data collected from the older drivers. This was an attempt to determine whether the five-factor structure could be affirmed for this subject group. However, results indicated a pattern similar to that of the two pilot study groups. The five 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 did not apply with this group either. Intercorrelations ranged from an (absolute) low of .01 to .56, with four of the ten intercorrelations at .48 or higher.

Participant Personality Factors: Data from Phase 2

One question of interest was whether we would see the same factor structure for our 37 personality questions as before. Although our two-factor varimax rotation was quite similar — though of course not identical — to the pre-test and Phase 1 solutions, it was based on (for factor analysis) a rather small sample. Consequently, we formed factor scores of Competence and Instability using results from the larger sample pre-test and Phase 1 data.
Specifically, our criteria for item selection was that an item to be included on a given scale if it loaded >=.30 on the same factor (say, Competence) and <.30 on the other factor (Emotional Instability) for both a pre-test sample and the Phase 1 sample.

This procedure helped generate scales that, in the present Phase 2 study, as before, were clear and essentially independent measures of the two dimensions consistently seen in this research program.

Correlation between Competence and Emotional Instability was -.11, and coefficients alpha were, respectively, .79 and .78. Items comprising the two scales are found in Table 5.

Table 5. Item composition - 2 personality scales.

Competence
Sociable, outgoing
Thoughtful
Moral, ethical person
Important to be self-sufficient
Cultured person
Cautious
Capable
Likes to get things done
Pretty satisfied
Competent person
Likes close attention to detail
I'm a polite person
Emotional Instability
Tense, high-strung
Impulsive person
Easily distracted
Takes chances when in a hurry
Easily embarrassed
Don't like to have to wait
Like to do things my way
What happens is out of people's control
Get flustered easily
Irritated by small setbacks
Impatient when have to wait

Relationship of Personality Scales to Driving Performance

As in the Phase 1 work, an overall measure of driving performance (Perf) was formed for correlation with the personality measures. Perf was the summation of individual driving performance items. Because some of the items were rather strongly skewed or of rather widely different variances, we sought an alternative measure that summed dichotomized or trichotomized items (or approximately median-split) to achieve approximately equal variance items. This summation of polychotomized items (Perfpoly) yielded essentially the same results as did Perf.

As in the earlier Phase 1 work, here too we found nearly the same results. Neither our Competence or Emotional Instability scales, nor the Malfetti-Winter measure, nor Goldberg's Big 5 factor scores predicted significantly ($p<.05$) Perf or Perfpoly. Among the many more personality-performance item correlations there were a few significant coefficients, but none strikingly so and not very many. It is perhaps of particular interest that an instrument (the Malfetti-Winter questions) devised specifically to assess driving competence would fail to do so, but that was our finding, both here and earlier in the Phase 1 study.

Thus, as in our earlier work, we conclude that there appears to be little more than chance association between personality and driving performance, as these constructs have been operationalized here.

Summary

Neither of the factor analytic personality dimensions — Competence and Emotional Instability — correlated with any of the driving performance task dependent variables (including the composite variable Perf, supplemented with Perfpoly) at any reasonable level of significance. This finding is consistent with results of Phase 1, which certainly did not indicate that we should expect any significant correlation of personality with driving performance for this study. Likewise, more thorough measurement of the Big 5 dimensions in the Phase 2 study failed to show a personality-driving behavior linkage.

Finally, self-assessment of driving skill via the Malfetti-Winter (1986) measure again was not predictive of closed-course driving performance. In fact, none of these self-assessment instruments appear to be appreciably related to actual driving competence — neither with the study covered by this report nor in our earlier work.

CHAPTER 6

RESULTS — COGNITIVE SKILLS TESTS AND DRIVING PERFORMANCE IN YOUNGER AND OLDER ADULTS

The 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 were correlated with driver performance measures to detect any relationships of significance. Results are described in this chapter.

General Findings

Earlier studies have established there is:

- an age-related decline in some cognitive skills which may be important to driving, and
- the loss in cognitive skills is not uniform for all individuals of a given age group.

Analysis of data from the Phase 1 study confirmed the age-related decline in some of the cognitive skills tested and driving performance. However, the study did not address the question of whether the observed relationships were restricted to older adults (Phase 1 used only individuals age 65 or older) or also existed for younger individuals as well. Thus in Phase 2, the same cognitive skills tests and driving protocol were administered to young adults, ranging in age from 20 to 64.

As in Phase 1, the driving protocol was designed to provide opportunities for subjects to make the types of driving errors that could place them at serious risk for accident involvement; in some instances, the type of accident that carries a high probability of serious injury. Again, statistical analyses tested the cognitive skills scores against subject scores in each of the driver tasks for the younger adults, and the obtained relationships were compared with those previously found in the older adults. The following describes the significant correlations found in Phase 2 and compares the performance of each of the two (Phase 1 and Phase 2) groups.

Spatial Processing

The basic premise of the Embedded Figures Test (EFT) is that it measures the ability to process complex spatial relationships. And as is well known, the driving experience is filled with spatial relationship problems, thus logically, performance on one should be related to performance on the other.

In Phase 2, subject scores on the EFT correlated with performance ratings on several of the driving tasks. As noted earlier, EFT performance yielded two scores: number correct and mean time per item. Each of the scores were 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 on the EFT and performance ratings on four driving tasks (first described by variable name). These were: **Oppose** - driving into a lane of opposing traffic when making a left turn (-.46), **Back** -backing out of an angle parking spot (-.28), **Tunex4**- a tendency to wander over the lane line while tuning the radio (-.29), and **Tune1**- the effectiveness of tuning the radio while driving straight ahead (-.31). [See Table 6 for a summary of correlation coefficients and corresponding significance levels. Figure 2 shows the comparative correlation factors more clearly.]

Table 6. Significant relationships: EFT variables and driving tasks.

VARIABLE	**Correlation Coefficient**		**Significance Level**	
	Correct	Mean Time	Correct	Mean Time
Drive into opposing lane (**Oppose**)	-.46	.35	.0002	.003
Backing out of angle parking spot (**Back**)	-.28	.22	.0270	.095
Lane wandering/tuning the radio (**Tunex4**)	-.29	.31	.0240	.014
Driving straight/tuning the radio (**Tune1**)	-.31	.29	.0160	.026

Mean time for each item on the EFT shows similar correlations ($p<.05$) with the driving performance, including **Oppose** (.35), **Tunex4** (.31) and **Tune1**(.29). However, the relationship with the **Back** variable was only marginally reliable (.22, $p<.095$).

Perhaps the most significant correlation found in these younger adults involved decisions made while turning. Both number correct and mean time on the EFT were highly correlated with how the younger drivers managed left turns. These high correlations indicate that the lower the performance on the EFT, the greater the propensity for these drivers to make a left turn into the opposing lane of traffic. Analysis of the Phase 1 data (drivers age 65 and older) also showed this same tendency.

The remaining significant correlations are associated with other aspects of driving and spatial relationships. Proper backing out of an angle parking place requires drivers to stay in their lane (with traffic cones marking the centerline of a generously wide lane), backing out of the parking stall, and being aware of the location of vehicles on both sides of the stall (again represented by the traffic cones). 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. Lower scores on the EFT were predictive of such difficulties in both the younger (Phase 2) and the older (Phase 1) driving group.

EFT scores also correlated significantly with Tunex4 and Tune1. Both results suggest that lower performance on the EFT was predictive of difficulties keeping in the correct lane (while driving in a straightaway) and tuning the radio for these younger drivers.

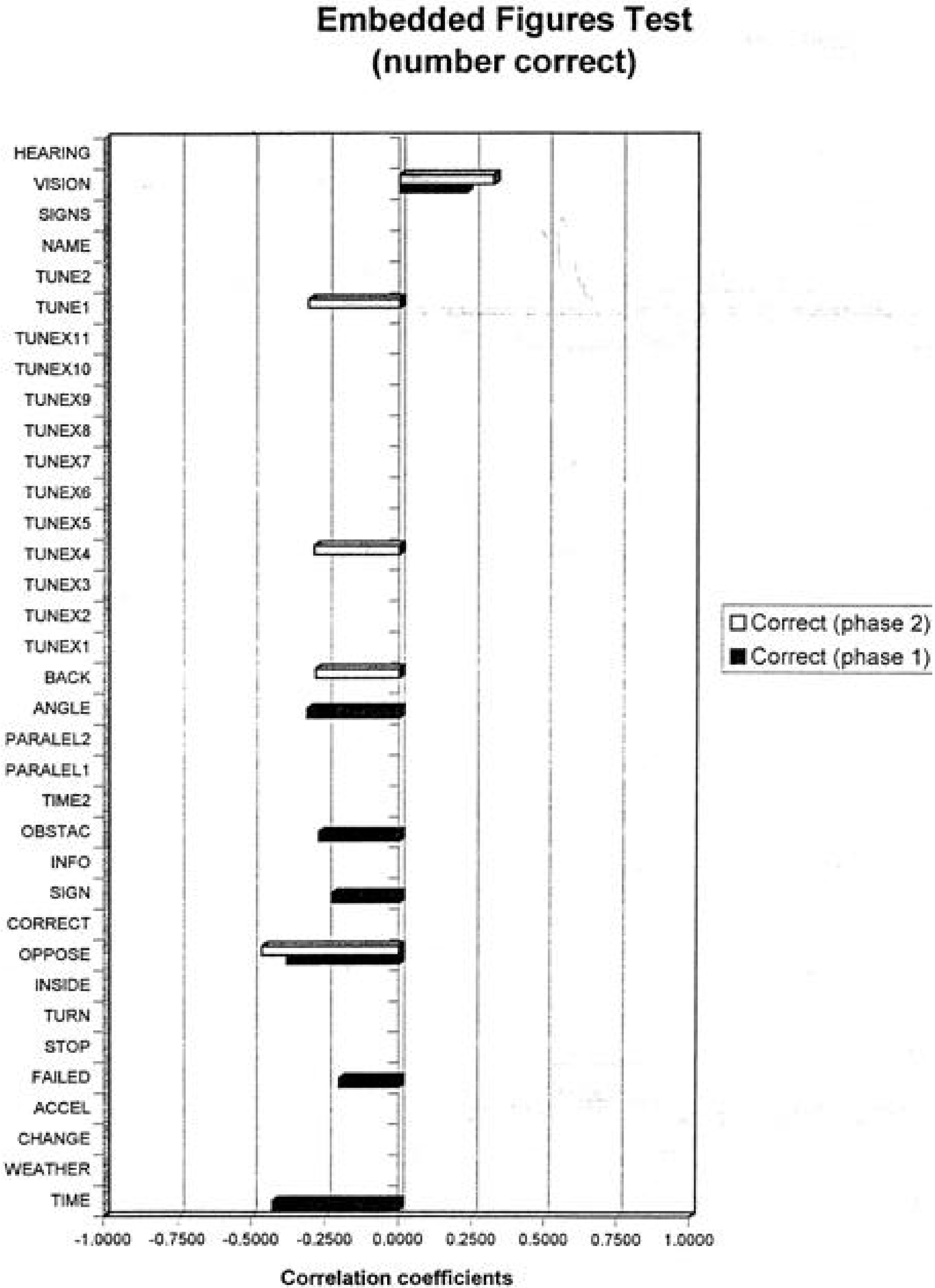

Figure 2. Correlation between Embedded Figures Test scores and driving scores.

Figure 2. Correlation between Embedded Figures Test scores and driving scores.

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 skills test should theoretically have trouble in selection of relevant information available while driving. They should also have some difficulty ignoring extraneous information and thus would be more likely to make wrong driving decisions or perhaps to delay too long in making the correct choice.

In this visual attention test, subjects were scored on how accurately they were able to enumerate the number of letters (3-13) appearing briefly in random positions on a computer screen. The measure of interest was the total number of times subjects made correct estimates.

Subsequent analyses linked these younger subjects' performance on this visual attention task with only one driving task: parallel parking. The graph shown in Figure 3 shows the degree (or lack of) relationship of the performance on this test with various driving tasks. Interestingly, in the Phase 1 study using older drivers, the same correlation was also obtained, indicating that individuals who have difficulty with this visual attention task will have difficulty in parallel parking, regardless of age.

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.

Auditory Attention Task. Two significant correlations were established between the selective listening test and younger driving performance: **Back** — backing out of an angle parking place (-.26); and **Tune2 —** tuning the radio while making a turn (-.28). One explanation for the latter is that the selective listening task measures attention under dual-processing conditions (i.e., monitoring two sources of auditory input at the same time). Thus, performing any other tasks concurrently while driving (i.e., making a left turn while simultaneously tuning the radio, or making a call on a cellular phone) would logically seem to impact driving performance in a negative way. Also, when backing out of an angle parking place, the ability to selectively monitor information from multiple sources of input would be useful, and the extent to which you can correctly identify the syllables presented to each ear simultaneously predicts how

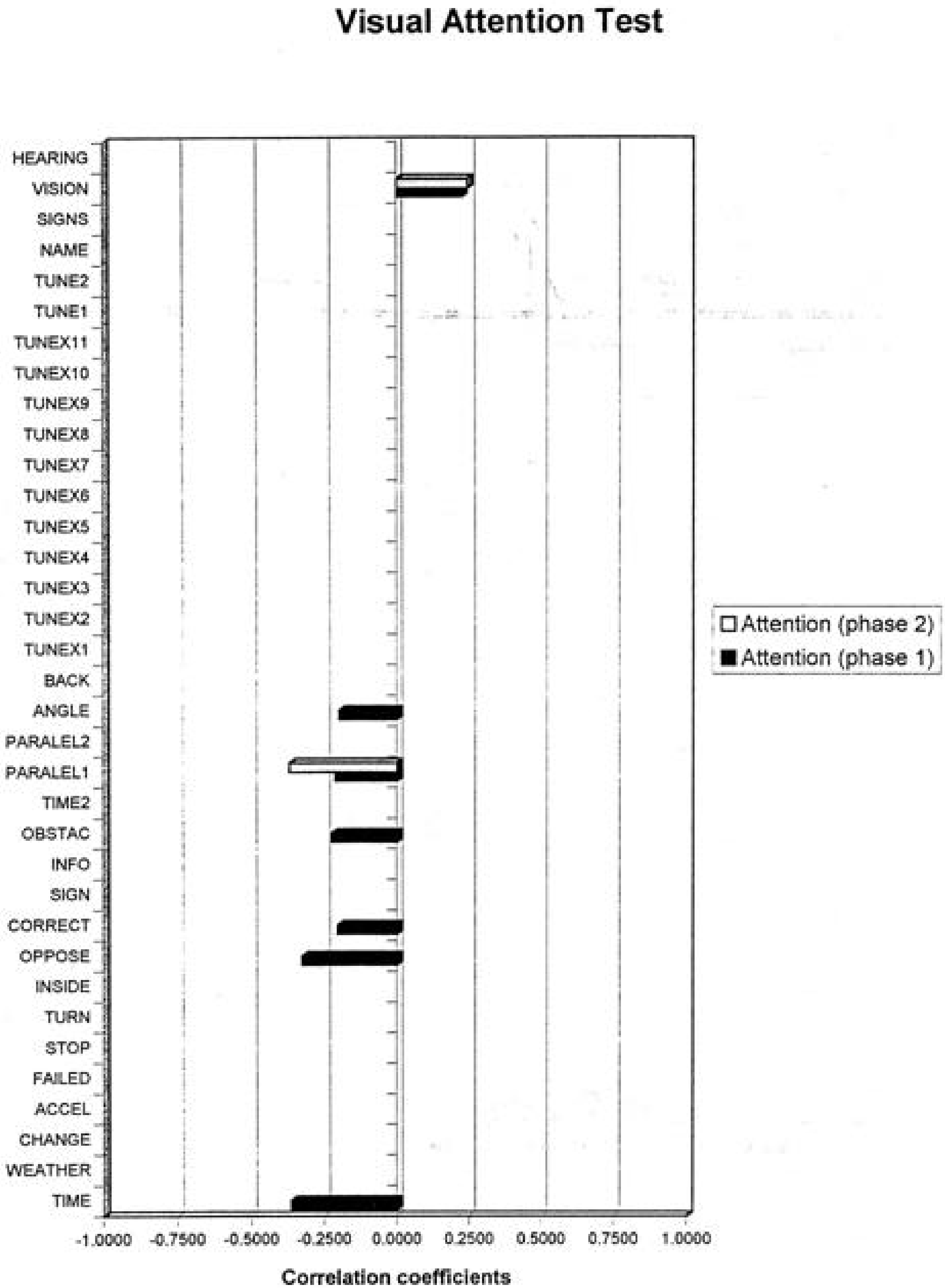

Figure 3: Correlations Between Visual Attention and Driving Task Performance.

Figure 3: Correlations Between Visual Attention and Driving Task Performance.

successfully these younger drivers exit an angle parking place. Figure 4 shows the values of the correlations obtained between selective listening and and the prescribed driving tasks.

Perceptual Tests

Data were gathered on subject vision and hearing prior to collecting the cognitive skills data. With these data available, possible relationships were explored between these sensory functions and driving. Since these relationships may be 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. For the younger Phase 2 subjects, static visual acuity scores correlated significantly with five driving manuevers: **Oppose** (-.34), **Tunex1**(.26), **Tunex5** (-.33), **Tune 2** (-.27) and **Signs** (-.27). With regard to the first variable, **Oppose**, the pattern suggested that the worse one's vision the more likely the individual was to turn into an opposing lane of traffic when executing a left-hand turn. However, in the Phase 1 study of older drivers, visual acuity did not correlate with this driving manuever. Concerning the second, third and fourth driving variables, recall that **Tunex1**, **Tunex5** and **Tune2** are measures of how well one can drive and tune a radio at the same time. The observed correlations suggested that the better one's vision, the more successful the subjects were at performing these concurrent tasks, particularly if on a curved portion of road. In fact, the correlation between visual acuity and **Tunex5** indicates that the poorer one's vision, the more likely he/she is to come to an inadvertant stop while performing these two driving tasks. Regarding the final driving variable, **Signs**, the correlation suggested that the poorer one's visual acuity, the more difficulty he/she had with naming from memory, the regulatory signs posted on the closed driving course. Visual acuity scores did not reliably predict performance on any other driving maneuver (see Figure 5.)

Hearing. Even though hearing has not been empirically demonstrated to have much effect on the ability to drive (Henderson and Burg, 1974), there were two driving variables that correlated significantly with hearing scores; **Inside** (-.31) and **Tunex 1** (-.30). Recall that the **Inside** variable indexes the propensity to turn into the inside (as compared to the outside lane) when making a correct left-hand turn. The pattern suggested was that the better one's vision, the more likely the driver was to turn into the **Inside** lane. Recall that **Tunex1** is a measure of tuning the radio and driving at the same time. The pattern suggested was that the better the driver's visual acuity, the less likely he or she will have any difficulty in performing these two driving tasks simultaneously. See Figure 4 for a display of all correlations of hearing with driving variables.

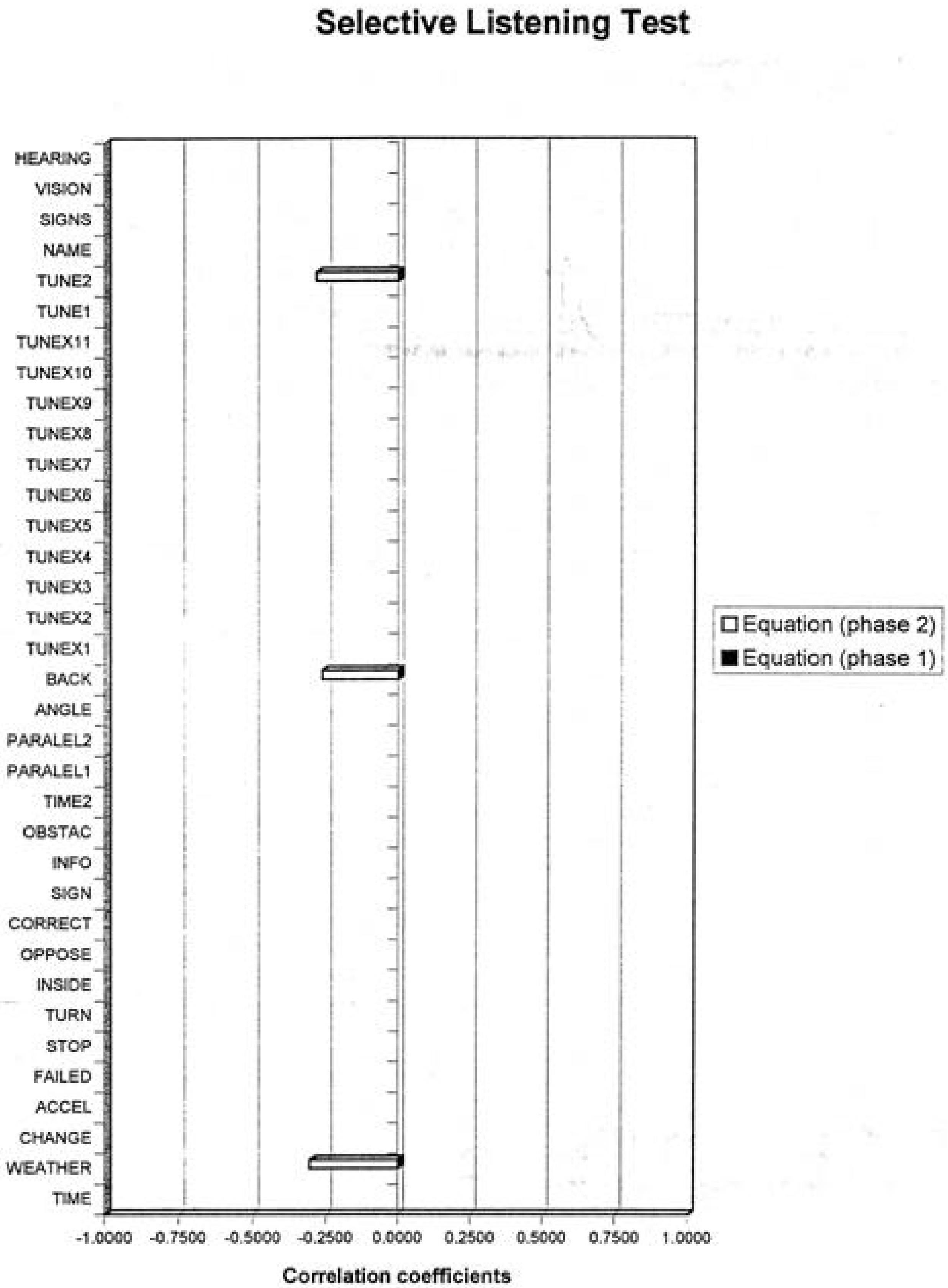

Figure 4. Correlations between selected listening scores and driving scores.

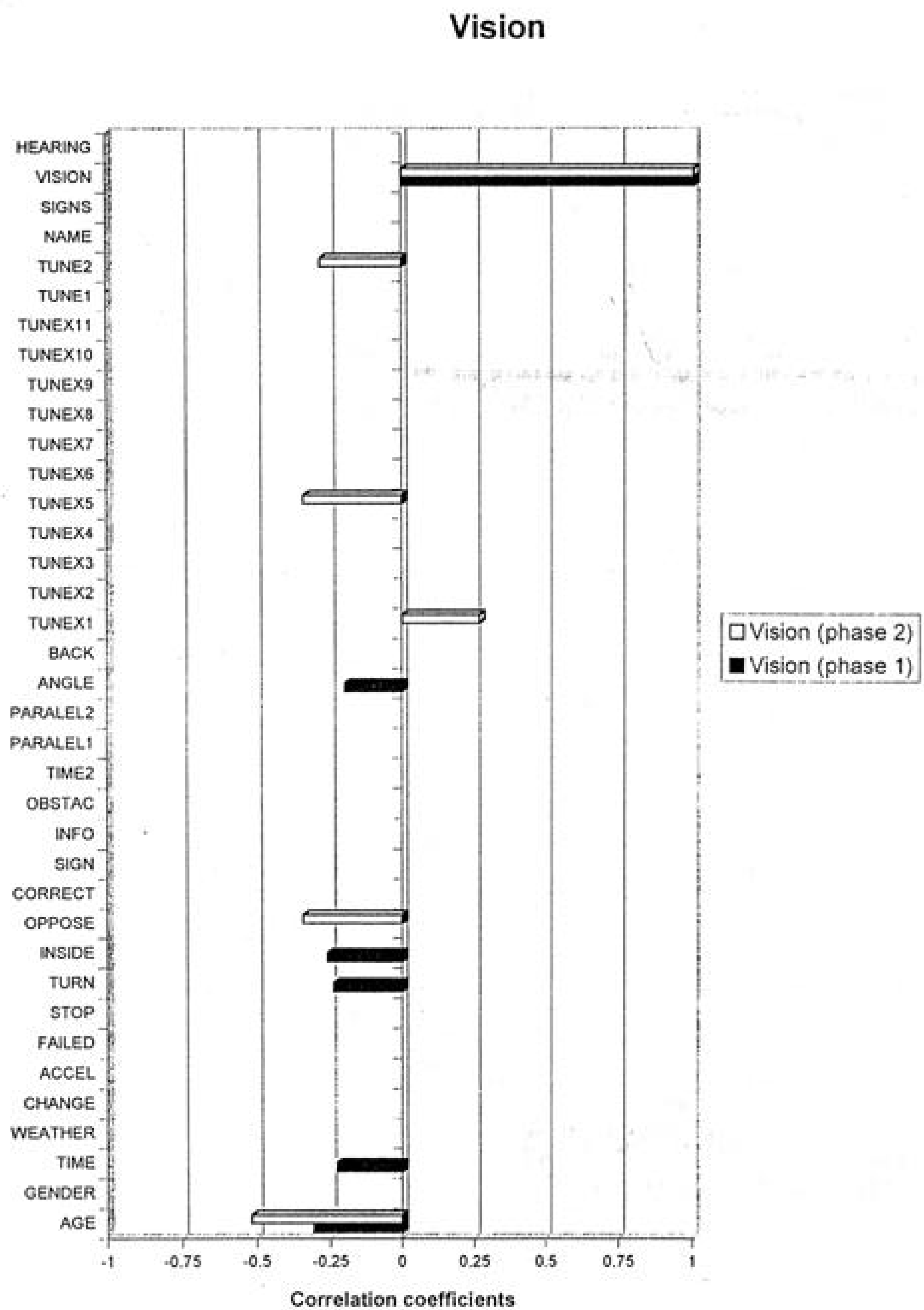

Figure 5. Correlations between vision test scores and driving scores.

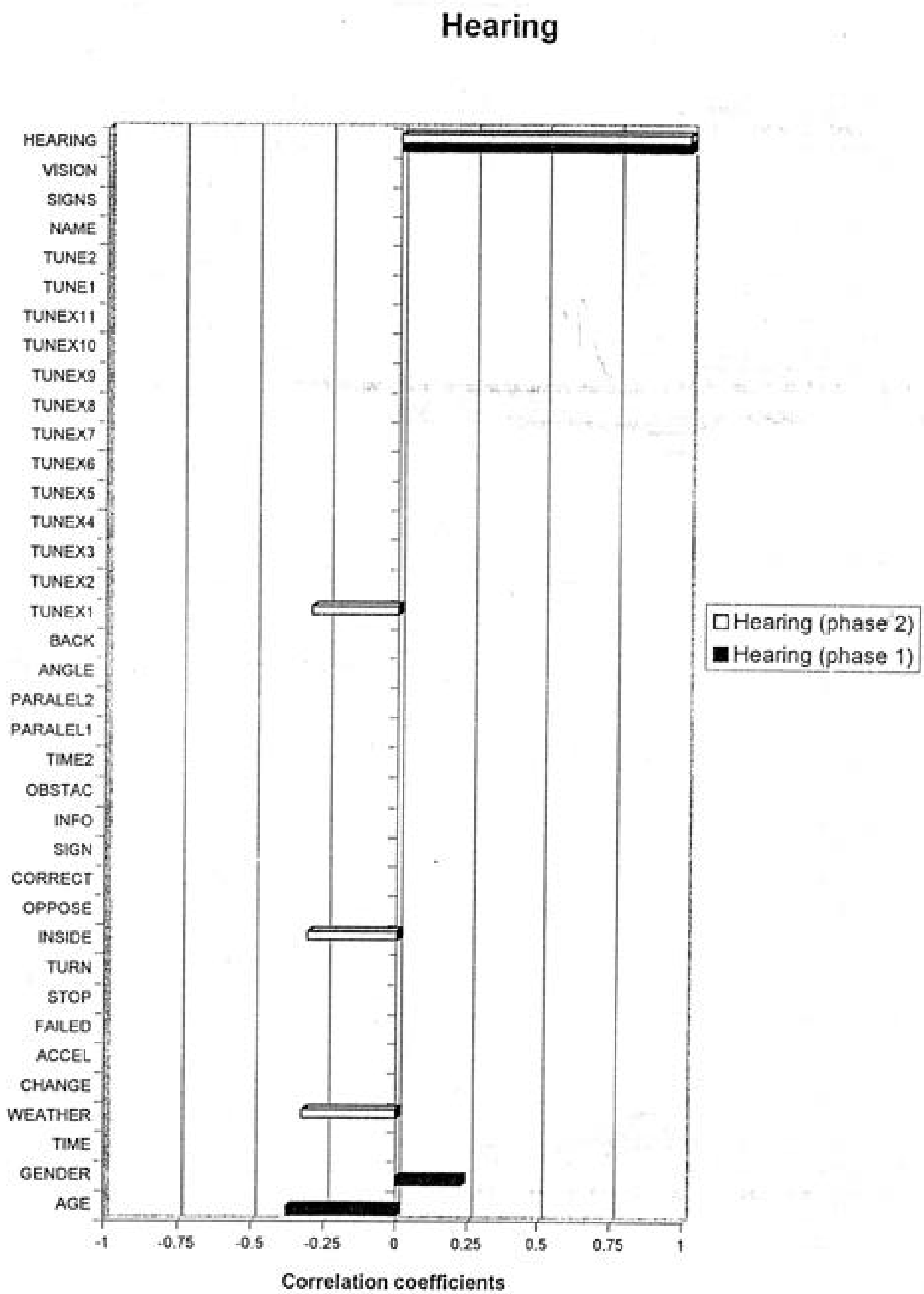

Figure 6. Correlations between hearing scores and driving scores.

Summary

In general, the hypotheses regarding relationships between the cognitive skills and younger drivers performance variables were confirmed. Moreover, the pattern of effects obtained for younger drivers (Phase 2) was somewhat different from that for older drivers (Phase 1). A complete discussion of the project conclusions, including the research hypotheses, is provided in Chapter 7.

CHAPTER 7

SUMMARY AND CONCLUSIONS

General: Demographic

Phase 1 of this project utilized subjects age 65 and older. Although there are many individuals age 90 and older still driving, the oldest driver from that sample population who consented to participate was 84. Though a random selection process was used to produce the list of drivers to be contacted, participants were "self-selected" and younger than the population from which they were randomly chosen. The mean age of participants in Phase 1 was 69.4, while the mean age of "non-participants" (those contacted but did not choose to participate) was 75.5.

While the goal of the Phase 2 study was to test younger drivers and to ensure that they were considerably younger than the respondents in Phase 1 of the study, an additional attempt was made to ensure that they were representative of the population. The 62 respondents taking part in the Phase 2 study were about evenly split between males (30) and females (32). Ages ranged from 22 to 64, with a mean age of 41.5. Drivers age 16-19 were not included in the sample because there was some concern that poor performance on the driving protocol might be due to lack of driving experience. Selection was made randomly from the list of licensed drivers, and an additional caveat in the selection process was to ensure that all age groups in the range were about equally represented. The resulting group of respondents was comprised of slightly less than half age 40 or below and the rest 41 to 64. There were 20 subjects age 32 and younger, 21 age 33 through 47, and 21 age 48 through 64.

There was considerable difference between the two groups in how much they drove. Phase 2 subjects drove more than did the Phase 1 drivers. Nearly three-fourths (71%) drove more than 50 miles each week, compared to slightly more than half (52%) of the older drivers in the Phase 1 study. This may be due to the fact that most of them were employed full-time and commuted to and from work. None of the Phase 2 subjects drove less than 2000 miles annually, while more than an eighth of the Phase 1 drivers reported that they drove that amount or less. Though more of the Phase 2 respondents drove 10,000 miles or more each year than the Phase 1 group, the differences were not great (37% compared to 33%).

As one would expect, this group of individuals rated their health quite highly. All the Phase 2 respondents rated their health as good or excellent, while one-in-eight of the Phase 1 drivers rated their health as fair or poor. And fewer of the Phase 2 subjects took some form of medication (38.7% compared to 57% of Phase 1 respondents).

Because age is a major component of both studies, correlation analysis was used to explore relationships between age and other responses to the questionnaire from the Phase 2 subjects. Significant correlations with age included indications that the oldest drivers were:

- less likely to have ever received driving instructions
- better informed about current health information
- less likely to have their emotions reflected in their driving
- less likely to allow their thoughts to wander when driving
- less likely to get angry over traffic situations
- more likely to wear seat belts

An examination of the significant correlations noted above would suggest that which we have generally assumed to be true, that as drivers get older, they are likely to be safer drivers.

Availability of public transportation in their lives was good, considering the rural nature of the area where the respondents resided. One should note, however, that about three-fourths of the Phase 2 respondents lived in either an urban area or small city, where public transportation was most likely available**.** But 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

One question was whether we would find the same absence of a "Big 5" factor structure in the 37 personality items for the Phase 2 respondents as with the Phase 1 group. Consequently, we used the same factor analytic approach as before. Results, while not identical to those of the Phase 1study, were quite similar. We obtained one of the "Big 5" - - Emotional Instability - - and an amalgam of three of the other four, which was labelled “Competence”. This seems unlikely to be a chance finding, as a similar factor structure was obtained from the undergraduate student pilot study as well; the same results with four different samples.

The near-total lack of relationship between driving performance and personality variables is not surprising, considering the results from the Phase 1 study. One must come back to the explanation 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.

As with the Phase 1 respondents, contributory to the lack of relationship might be having tested a subset of the full range of drivers — the very safe ones. It seems plausible that "bad" drivers would tend not to agree to participate in a driving study, which included a driving test, and our sample did describe themselves through Malfetti-Winter (MW) items as safe drivers.

Cognitive Skills

Expectations again 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. As before, each driver completed a Selective Visual Attention task and an Auditory Attention task.

Spatial Processing. The most important driving task significantly correlated to spatial processing was the task relating to selection of the proper lane to turn into, specifically making a left turn into an opposing lane of traffic (**Oppose**). Two other driving variables were also correlated significantly with spatial processing, both related to tuning the radio while driving — a task added to the Phase 1 protocol to provide dual tasks for the driver to perform.

The problems drivers with lower spatial processing scores had with intersections is not surprising, in view of many researchers who have analyzed accident records. During the driving portion of the study, some drivers in both Phase 1 and Phase 2 had trouble with intersections even knowing that they were on a closed driving course and did not have the additional complicating ingredient of other vehicles on the driving course. A vehicle moving through an 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.

Problems were also associated with backing **(Back)** out of a parking stall for Phase 2 drivers with lower scores in spatial processing. 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. But the problems encountered by drivers with lower scores in spatial processing seem quite logical. Backing out of a parking stall with vehicles on both sides and the possibility of vehicles coming down the street toward the driver requires continuous monitoring of a variety of spatially important relationships. How close are you to the vehicle on the left; on the right? Is there a vehicle coming down the street in the lane that you want to back into? If so, how close, and will you get backed out into the traffic lane before it gets too close at your current progress rate?

The significant correlations between spatial processing and the variables relating to tuning of the radio are noteworthy. The **Tunex4** variable indicates that drivers with lower number correct EFT scores tended to have problems in keeping the vehicle in the lane and the **Tune1** variable indicates that these same drivers are taking much longer to tune the radio, suggesting that they are aware of their problems of wandering over the lane line and will take much longer to tune to the specified radio station, delaying the tuning while they pay closer attention to lane position.

And this was not different from results of the Phase 1 study. Spatial processing scores correlated significantly with both **Oppose** and backing out of an angle parking stall for the Phase 1 subjects as well (note that the radio tuning task was not included in Phase 1). It seems to indicate that this problem is not age related, but cognitive related. Age relationships would logically come into play only if there is a greater likelihood for older drivers to experience an erosion of their spatial processing skills. This was supported in both studies. Spatial processing scores were significantly correlated negatively with age in both studies and both at $p<.05$ - more significant with Phase 2 subjects (with a greater range of age), suggesting that increased age is an important factor in the loss of this cognitive skill.

Visual Attention. Analysis linked visual attention with only one driving task at a significant level and that was parallel parking (**Parallel1**). Its correlation coefficient **was** fairly high (-.37) at p=.003. And, like spatial processing, visual attention correlated signficantly with age, but in this instance, only for the Phase 1 subjects.

Auditory Attention. Two driving task variables were significantly correlated with auditory attention scores, **Back** and **Tune2**. It would be almost possible to repeat the discussion of the relationship of auditory attention and backing out of a parking stall as with spatial processing. Obviously, backing out of a stall with vehicles on either side and the possibility of conflicting moving traffic challenges a driver's ability to "dual process", because they are checking for so much information and must continuously process several elements of information.

The **Tune2** variable refers to problems tuning the radio while making a turn, also consistent with someone having difficulty with dual processing. Correlations approached significance with another tuning variable, **Tunex8**, at p=.097. This variable refers to the propensity to fail to stop at either a stop sign or traffic signal while tuning the radio. And auditory attention correlated significantly with age, but this time it was with the Phase 2 subjects and not the Phase 1 group.

Study results substantiates our conclusion in the Phase 1 report that it would be premature to dismiss auditory attention as having no relationship to driving safety was valid. It is not difficult to relate low auditory attention scores with difficulty accomplishing dual tasks. However, most drivers are probably not aware of weakness in this cognitive skill and still routinely attempt tasks which conflict with the primary task of driving. This would include not only tuning the radio, the task selected for this study, but use of a cellular telephone, shaving or checking makeup, eating or drinking while driving, or trying to read a road map. And, of course, trying to avoid dual tasks would be difficult to do for parents of small children, riding either in the back or front seat and doing what children do, distracting the parent-driver. It seems likely that the inclusion of any additional dual tasks to the driving protocol would have resulted in additional correlations with auditory attention.

In conclusion, it seems safe to say that the study provides support for our initial hypotheses - that losses in certain cognitive skills can be identified as being related to increasing potential for driving errors and increasingly of a serious nature. Including age in the equation with the cognitive skills confirms the premise of the Phase 2 study: a significant relationship exists between cognitive skills and ability to safely accomplish a variety of driving tasks that are commonplace in any driving experience. That conclusion is independent of age.

The consistent significant correlations of cognitive skills scores with age, however, would support the general finding in cognitive aging literature which is that of inevitable deterioration (of cognitive skills) as aging occurs (Poon, 1985). Without question, the study affirms the opinion of many that one or more cognitive skills tests is needed to provide an appropriate element of information to include in a package of data which can be used in decisions on license renewal.

The research team recommends the use of one of the tests, the test that measures spatial processing in the study. The Embedded Figures Test (EFT) can be adapted for easy use by trained driver examiners, and is a reasonable predictor of driving problems that could have serious consequences. EFT also tests a cognitive skill that has a strong age-related component, in that it significantly correlated with age in both studies.

Other Results

Although not directly related to cognitive scores, another set of significant relationships is 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 variable **Time** was considered to be a dependent variable, but if considered separately from driving tasks, it does correlate significantly with a number of other driving tasks.

The variable **Time** is a metric which is the amount of time that each driver took to complete the driving protocol. Each driver was asked to drive through the course at his or her own speed with no “goal” for time spent. Each driver was expected to drive at speeds with which he or she was comfortable.

However, the correlation analysis results for Phase 2 drivers suggested that some drivers took more time because they were, perhaps subconsciously, compensating for a tendency to make driving mistakes. Correlations were significant when **Time** was considered along with age and gender and a number of driving tasks as well. Included was failing to stop at a traffic signal (**Fail**) and turning incorrectly into a one-way street (**Sign**). The drivers were inclined to make turning movements into the outside lane (instead of the inside lane) and to make turning movements from the wrong lane. For the complete list of significant correlations, see Table 7.

Table 7. Significant relationships with the variable **Time** used to complete the driving protocol and remaining driving task variables.

Correlation of Time with:	Correlation Coefficient
Gender of Respondent	.1705*
Age of Respondent	.5825**
Failed to stop at traffic signal	.2847**
Turned into outside lane on one-way street	.2061*
Turned into **Inside** lane: making a turning movement	.2802**
Turned into **Oppos(e)**ing lane when turning left	.2727**
When going left, turning from **Correct** lane (multilane)	.4372**
Reaction to **Sign** @ intersection w/restricted movement	.2039*
Hit a cone on **Obstac**le course	.2891*
Had difficulty with **Parallel** parking	.2843**
Had spacing problems with **Angle** parking	.2748**
Slowed vehicle noticeably while tuning radio	.3816**
Second trial: tuning radio - relative slowness	.2574*

Key:
- *   Level of Significance: $p<.05$
- **   Level of Significance: $p<.01$

Many of the significant correlations are consistent with results from Phase 1. The logical interpretation is, though taking more time may cause a driver with cognitive skills problems to do better than they might under some time constraints, they still tend to make significantly more errors. This is consistent with other recently completed research results (OECD, 1985; Maleck and Hummer, 1986; Brouwer et al., 1991). It should be noted that care must be taken not to make deceptive assumptions. While both age and gender correlated significantly with time (meaning that women took more time for the driving protocol and that drivers slow down, regardless of age), gender did not correlate significantly with many of the variables that were significant with time. More overlap occurred with age and driving errors than with time and driving errors.

The moral to this story might be that, should you get behind someone who is driving slowly and carefully, perhaps you should assume that he or she would make unsafe driving decisions if driving at a pace more suited to **your** expectations. Yet, that driver may still be a comparatively safe driver, maintaining that all-important mobility and independence. The cautionary note to remember is that a slow, careful driver may make more errors at a higher speed.

Implications

These 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 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 as a potentially unsafe driver to continue driving?

Additional questions remain related to driver age. Would the results of the Phase 1 study 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 the Phase 1 study was that additional research needed to be conducted using younger drivers, using the same methodology, with the thought that results from such a study 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. Phase 2 is such a study and the results appear to confirm the “cognitive related” theory.

Obviously some questions still need to be answered, one of which relates to the political will to explore the issue. Across the country, states are moving toward less exercise of authority, not more, and reducing budgets of most state agencies, including those responsible for driver licensing. Progress should not wait until high profile accidents, specifically those caused by the drivers in the increasing 85 and older population of drivers in many states forcing the issue. It will not be a question of "whether" changes will be made, but a question of "who" will make them?

However, once the decision is made to include a cognitive skills test in any license renewal, the technology involved in cognitive skills testing will not be a problem, once satisfactory answers to the remaining questions are found. The cognitive skills tests administered in these two studies were relatively simple and could, with little effort, be modified to be usable by driver license examiners with minimal additional training.

REFERENCES

Ajzen, I. & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. Journal of Experimental Social Psychology, 22, 453-74.

Avolio, B. J., Kroek, X., & Panek, P. E. (1985). Individual differences in information-processing ability as a predictor of motor vehicle accidents. Human Factors, 26(5), 5770587.

Barrett, G. V., Thornton, C. L., & McCabe, P. A. (1968). Visual functioning and the embedded figures test performance. Perceptual and Motor Skills, 26(6), 40.

Barrett, G. V., Thornton, C. L., & McCabe, P. A. (1969). Relation between embedded figures test performance and simulator behavior. Journal of Applied Psychology, 53, 253-254.

Botwinick, J. (1978). Aging and Behavior. (2nd ed.). New York: Springer.

Brouwer, W. H., Waterink, W., VanWolffelaar, P. C., & Rothengatter, T. (1991). Divided attention in experienced young and older driver in a dynamic driving simulator. Human Factors, 33, 573-582.

Carp, F. M. (1988). Significance of mobility for the well-being of the elderly. Transportation Research Board Special Report 218, Transportation in and Aging Society, 1-20.

Charness, N. (1985). Aging and Human Performance. New York: John Wiley and Sons.

Costa, P. T., Jr., & McCrae, R. R. (1992). Four ways five factors are basic. Personality and Individual Differences, 13, 653-665.

Dewing, W. L., Johnson, S. M., & Stackhouse, S. P. (1995). The interaction of non-driving tasks with driving. Report prepared for Minnesota Department of Transportation.

Digman, J. M. (1989). Personality structure: Emergence of the five-factor model. (Vol. 41). Palo Alto, CA: Annual Reviews.

Dubinsky, R. M., Gray, C., & Husted, H., et al. (1991). Driving in Parkinson’s disease. Neurology, 41, 517-520.

Elander, J., West, R., & French, D. (1993). Behavioral correlates of individual differences in road-traffic risk: An examination of methods and findings. Psychological Bulletin, 113, 279-294.

Evans, D. A., Finkenstein, A. H., Albert, A., et al. (1989). Prevelance of Alzheimer's disease in a community population of older persons: Higher than previously reported. Journal of American Medical Association, 262, 2551-2556.

Evans, D. W., & Ginsberg, A. P. (1985). Contrast sensitivity predicts age-related differences in highway-sign discriminability. Human Factors, 27, 637-42.

Goldberg, L.R. (1992). The development of markers for the Big-5 factor structure. Psychological Assessment , 4, 26-42.

Goldberg, L. R. (1993). The structure of phenotypic personality traits. American Psychologist, 48, 26-34.

Goldberg, L. R. (1990). Standard markers of the Big-five factor structure. Eugene, OR: University of Oregon and Oregon Research Institute.

Harano, R. M. (1970). Relationship of field dependence and motor vehicle accident involvement. Perceptual and Motor Skills, 31, 272-274.

Henderson, R. L., & Burg, A. (1974). Vision and audition in driving (Report No. NTIS PB-238-278). Washington, D. C.: Department of Transportation.

Hill, G. W., & Mershon, D. H. (1985). Age related changes in distance judements. Proceeding of the Human Factors Society, 29th Annual Meeting. 711-714.

Hills, B. J., & Burg, A. (1977). A Re-analysis of California driver vision data (768). Crowthorne, England.

Jordan, T. C., & Rabbitt, P. M. A. (1977). Response times to stimuli of increasing complexity as a function of aging. British Journal of Psychology, 68, 189-201.

Judd, C. M., Jessor, R., & Donovan, J. E. (1987). Structural equation models and personality research. Journal of Personality, 54, 149-98.

Kahneman, D., Ben-Ishari, R., & Lotan, M. (1975). Relation of a test of attention to road accidents. Journal of Applied Psychology, 58, 113-115.

Kausler, D. H. (1982). Experimental Psychology and Human Aging. New York: John Wiley and Sons.

Kline, D. (1986). Visual aging and driving performance. Presented at Invitational Conference on Work, Aging, and Vision, Committee on Vision, National Research Council, Washington, D.C.

Koltnow, P. G. (1985). Improving safety and mobility for older people. Transportation Research News(September-October), 20-23.

Maleck, T., & Hummer, J. (1986). Driver age and highway safety. Transportation Research Record No. 1059: 6-12. National Research Council, Transportation Research Board. Washington, D.C.

Malfetti, J. L., & Winter, D. J. (1986). Development of the older driver self assessment inventory : Teachers College Columbia University.

McCoy, P. T., Tarawneh, R. B., & Ashman, B. F. (1993). Evaluation of countermeasures for improving driving performance of older drivers. Transportation Research Record, 1404, 72-
80.

McGuire, F. L. (1976). Personality factors in highway accidents. Human Factors, 18, 433-442.

McKelvey, F. X., & Stamatiadis, N. (1989). Highway accident patterns in Michigan related to older drivers., 68th Annual Meeting of Transportation Research Board . Washington, D. C.

McKnight, A. J. (1988). Driver and pedestrian training. Transportation in an Aging Society(Transportation Research Board Special Report 218), 101-133.

Mercier, C. M., Mercier, J. M., O'Boyle, M., & Strahan, R. S. (1994).Assessing the independence, mobility, and safety of older drivers. Project report submitted to the Midwest Transportation Center.

Michon, J. A. (1985). A critical view of driver behaviour models: What do we know, what should we do. In L. Evans & R. Schwing (eds.), Human Behaviour and Traffic Safety. pp.487-525. New York: Plenium.

Mihal, W., & Barrett, G. (1976). Individual differences in perceptual information processing and their relation to automobile accident involvement. Journal of Applied Psychology, 61(2), 229-233.

OECD, (Organization for Economic Cooperation and Development). (1985). Traffic safety of elderly road users. Paris.

Olson, P. L., & Sivak, M. (1986). Perception response time to unexpected roadway hazards. Human Factors, 28(1), 91-96.

O'Neill, D. (1996). The older driver. Reviews in Clinical Gerontology, 6, 00.

Owsley, C., Ball, K., Sloane, M., & Roenker, D. (1991). Visual/cognitive correlates of vehicle accidents in older drivers. Psychology and Aging, 6, 403-415.

Parker, D., Reason, J. T., Manstead, A. S. R., & Stradling, S. G. (1995). Driving errors, driving violations, and accident involvement. Ergonomics, 38, 1036-1048.

Poon, L. W. (1985). Differences in human memory with aging: Nature, causes, and implications. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the Psychology of Aging (Second ed.,). New York: Van Nostrand Reinhold Company.

Rabbitt, P. M. A. (1968). Age and the use of structure in transmitted information. In G. A. Talland (Ed.), Human Aging and Behavior . New York: Academic Press.

Rabbitt, P. M. A. (1979). How old and young subjects monitor and control responses for accuracy and speed. British Journal of Psychology, 70, 305-311.

Rackoff, N. J. (1974). An Investigation of age related changes in driver's visual search patterns and driving performance and the ralation to tests of basic functional capacities. Unpublished Dissertation, Ohio State University, Columbus, Ohio.

Reff, M. E., & Schneider, E. L. (1982). Biological markers of aging (NIH Publication No. 82-2221). Washington, D. C.: U. S. Department of Health and Human Services.

Rosenbloom, S. (1988). The mobility needs of the elderly. Transportation Research Board 218, Transportation in an Aging Society, 218, 21-71.

Salthouse, T. A. (1982). Adult Cognition: An Experimental Psychology of Human Aging. New York: Springer-Verlag.

Sanders, A. F. (1970). Swome aspects of the selective process in the functional field of view. Ergonomics, 13, 101-117.

Shaw, L., & Sichel, H. S. (1971). Accident Proneness: Research in the Occurrence, Causation, and Prevention of Road Accidents. Oxford: Pergamon Press.

Shinar, D. (1977). Driver visual limitations: Diagnosis and treatment (DOT-HS-5-1275). Washington, D. C.: Department of Transportation.

Sivak, M., Olson, P. L., & Pastalan, L. A. (1981). Effect of driver's age on nighttime legibility of highway signs. Human Factors, 23, 59-64.

Sloane, M. E., Owsley, C., & Alvarez, S. L. (1988). Aging, senile meiosis and spatial contrast sensitivity at low luminance. Vision Research, 28(11), 1235-1246.

Smith, E. E. (1968). Choice Reaction Time: An analysis of the major theoretical positions. Psychological Bulletin, 69, 77-100.

Somberg, B. L., & Salthouse, T. A. (1982). Divided attention abilities in young and old adults. Journal of Experimental Psychology: Human Perception and Performance, 8, 651-663.

Staplin, L. et al. (1987). Age related diminished capabilities and driver performance. Working paper FHWA, U.S. Department of Transportation.

Tolliver, L. M. (1984). Testimony by Lennie Marie Tolliver, Commissioner, Administration on Aging, U. S. Department of Health and Human Services, before the National Highway Safety Advisory Committee and the Subcommittee on Driver Related Issues, Washington, D.C., April 12, 1984.

Temple, L. L. (1989). Perceptual and cognitive factors affecting driving ability of young and old drivers . Washington, D. C.: AARP, Andrus Foundation.

Tsuang, M. T., Boor, M., & Fleming, J. A. (1985). Psychiatric aspects of traffic accidents. The American Journal of Psychiatry, 142, 538-46.

Waller, P. F., Trobe, J. D., & Olson, P. L. (1993). Crash characteristics associated with early Alzheimers disease. Presented at the 37th annual proceedings, Association for the Advancement of Automotive Medicine, San Antonio, TX. 157-172.

Waller, P. F., House, E. G., & Stewart, J. R. (1977). An analysis of accidents by age. . Washington, D. C.: Annual Meeting of Transportation Research Board.

Welford, A. T. (1981). Signal, Noise, Performance and Age. Human Factors, 23, 97-109.

Wilson, R., & Greensmith, J. (1983). Multivariate analysis of the relationships between drivometer variables and drivers' accident, sex, and exposure status. Human Factors, 25, 303-312.

Witkin, H. A., Oltman, P., K., Raskin, E., & Karp, S. A. (1971). A Manual for the Embedded Figures Tests. Palo Alto, CA: Consulting Psychologists Press, Inc.

Yanik, A. J. (1985). What accident data reveal about elderly drivers. SAE Paper 851688, Society of Automotive Engineers.

Ysander, L., & Hernes, B. (1976). The traffic behavior of elderly drivers in Gothenburg, Sweden. Accident Analysis and Prevention, 8, 81-86.

APPENDIX A
DRIVER EVALUATION FORM

DRIVER EVALUATION - CHECK CORRECT SPACE Time: ____ to ____#______
Weather: ______________

* 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, before making right turn:
- a. gets into right lane, stops & makes the right turn correctly __
- b. fails to get to correct lane before turn, but stops & 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 __

9) Between B and D, while the driver tunes the radio,
a. The vehicle stays nicely in the lane __
b. The vehicle wobbles in the lane __

* Allow driver thru D,E,F,G and H. Instruct to turn left at H.
10) At H, driver:
a. Turns into correct lane __
b. Turns into opposing traffic lane __

11). 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 __

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

* Signal changes: AMBER to RED while vehicle approaches "M".
14). At "M". Driver: Trial # 1 2 3
a. Stops comfortably __ __ __
b. Accelerates and go through "M" __ __ __
c. Does a panic stop __ __ __

* Complete F to G,H,I,J,B. Instruct: go to Gold City. Between B & D, tell driver; left at D, adjust radio.

15). Approaching intersection D, driver:
a. Stays well in lane __
b. Wobbles in lane as radio is adjusted __

16). Before coming to intersection D to turn left driver:
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 __

17) At M, Driver:

a. Reacts correctly to signal __

b. Doesn't react correctly to signal __

18). Obstacle course

# of missed spaces ___ # of cones struck ___ Drove too cautiously

Time in seconds: ___

19) Parallel park 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 __

20). Angle park to right Driver:

a. Parked well spaced between lines __

b. Between lines, but not spaced properly __

c. Crossed the lines (could have struck parked vehicle) __

21). Angle park to left Driver:

a. Parked well spaced between lines __

b. Between lines, but not properly spaced __

c. Crossed lines (could have struck parked vehicle) __

22). Right angle parking Driver:

a. Parked well spaced between lines __

b. Between lines, but not spaced properly __

c. Crossed the lines (could have struck parked vehicle) __

APPENDIX B
DRIVING COURSE EVALUATION FORM

DRIVING COURSE EVALUATION SUMMARY SHEET

0. COL. 1-3 RESPONDENT NUMBER ___
00. COL. 4-5 Time for driving the course (TIME) ___
000. COL. 6 Weather, light conditions ___

1. Reacted to traffic signal properly: changing from green to red. COL. 7 (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. Accelerated thru on amber when going straight ahead (1=Y,2=N) COL 8(ACCEL) __

3. Failed to stop at red light COL. 9 (FAILED)
    1. Never ___
    2. Once ___
    3. Twice ___

4. Reaction to stop signs COL. 10 (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 ___

5. When turning onto a one-way street, COL. 11 (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 ___

6. When making a turning movement COL. 12 (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 ___

7. Turning into an opposing lane COL. 13 (OPPOSE)
    1. Did not turn into opposing lane ___
    2. Turned into opposing lane once ___
    3. Turned into opposing lane more than once ___

8. When in a multilane situation and making a turn, COL. 14 (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 ___

9. When approaching an intersection w/restricted turning movements, COL. 15 (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 ___

10. Responding to information signs on destination. COL. 16 (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 more times without additional directions ___

11. Obstacle course COL. 17 (OBSTAC)
   1. No cones hit, ___
   2. Hit one cone ___

12. Time through the obstacle course COL. 18-21 (TIME2) ___

13. Parallel parking COL. 22 (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 ___

14. Parallel parking COL. 23 (PARALLEL2)
   1. hit no cones ___
   2. nudged cones front ___
   3. nudged cones rear ___
   4. knocked over cones

15. Angle parking COL. 24 (ANGLE)
   1. Parked well-spaced between lines always ___
   2. Between lines, but not spaced properly, once ___
   3. Between lines, but not spaced properly twice ___

16. Angle parking, backing COL. 25 (BACK)
   1. Backed out OK each time ___
   2. Parked OK, but would have backed into parked vehicle ___

17. Tuning radio problems (can use more than 1) COL. 26-36 (TUNE)
   1. Had no problems tuning ___
   2. Trial #2 - did better than #1 (learning curve) ___
   3. Slowed vehicle noticeably while tuning ___
   4. Wandered over lane line while tuning ___
   5. Stopped vehicle while finishing tuning ___

6. Missed some instructions while tuning ___
7. Nearly struck obstacle while tuning ___
8. Failed to stop at stop sign (or red signal) ___
9. Purposely avoided dual task while tuning (straight away only) ___
10. Needed station number repeated ___
11. Had difficulty finding correct control ___

18. Tuning radio - Trial #1 - driving straight ahead. COL 37 (TUNE1)
    1. Completed by Position D ___
    2. Completed by Position F ___
    3. Completed by Position H ___
    4. Completed by Position M ___
    5. Never completed correctly (never tuned to correct station) ___
    6. Never completed (includes when driving past M to complete) ___

19. Tuning radio - Trial #2 - dialing while making turn. COL 38 (TUNE2)
    1. Completed by Position D ___
    2. Completed by Position M (at signal light) ___
    3. Completed by Position H ___
    4. Completed by Position J ___
    5. Completed by Position I ___
    6. Never completed correctly (wrong station) ___
    7. Never completed (includes when driving past I to complete) ___

Lists for correct responses to items 20 and 21 are found at the end of the form.

20. Naming of cities on destination signs COL 39 (NAME)
    1. Named all four cities correctly ___
    2. Named three cities correctly ___
    3. Named two cities correctly ___
    4. Named one city correctly ___
    5. Did not name any city correctly ___

21. Naming of regulatory signs on closed driving course COL 40 (SIGNS)
    1. Named all five regulatory signs correctly ___
    2. Named four regulatory signs correctly ___
    3. Named three regulatory signs correctly ___
    4. Named two regulatory signs correctly ___
    5. Named one regulatory sign correctly ___
    6. Did not name any regulatory sign correctly ___

Regulatory Signs: give credit to these only
STOP, YIELD, NO RIGHT TURN, DO NOT ENTER, ONE-WAY
Weather:
1. Clear
2. Partly Cloudy (partly sunny)
3. Cloudy
4. Light Rain

5. Moderate to Heavy Rain

Destination Cities:

Gold City, Story City, Red City, Gravity

APPENDIX C
DRIVER QUESTIONNAIRE

DRIVING QUESTIONNAIRE **M** **F**

Directions: Below are a number of questions relating more or less directly to automobile driving behavior. 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 2. Less than a year 3. 1-2 years 4. 2-5 years 5. Over 5 yrs

4. Please indicate your age in years. _________

5. Please indicate your marital status.
   1. Married 2. Widowed 3. Divorced 4. Separated 5. Never been married

6. With whom do you live?
   1. Spouse 2. Children 3. Other relative(s) 4. Friend(s) 5. Live Alone

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. Great increase   3. No change
2. Increase   4. Decrease   5. 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)   2. Large town (2500-9999)
3. Small city (10,000-49,999)   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   2. Fair   3. Good   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. 1 2

25. I am currently taking medication for arthritis. 1 2

26. I am currently taking medication for diabetes. 1 2

27. I am currently taking medication for a heart condition. 1 2

28. I am currently taking medication for anxiety. 1 2

29. I am not currently taking any medication. 1 2

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. 1 2

31. I have considered stopping driving because I have had recent accidents. 1 2

32. I have considered stopping driving because of my age. 1 2

33. I have considered stopping driving because of my family members. 1 2

34. I have considered stopping driving because I do not have a license. 1 2

35. I have considered stopping driving because I have no insurance. 1 2

36. I have considered stopping driving because my vision is poor. 1 2

37. I have not considered stopping driving. 1 2

For questions 38 to 42 the response choices are these:
1. Hardly ever 2. Several times a year 3. Monthly 4. More often

38. How often do you drive to the grocery store, pharmacy, or shopping malls? 1 2 3 4

39. How often do you drive to movies, restaurants, or other entertainment? 1 2 3 4

40. How often do you drive to the doctor or dentist's office or hospital? 1 2 3 4

41. How often do you drive to friends or relatives homes in the local area? 1 2 3 4

42. How often do you drive to your local church or senior center? 1 2 3 4

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.	1	2
47.	I consciously choose to drive less often on busy streets.	1	2
48.	I often feel I need someone with me to provide directions.	1	2
49.	I am increasingly bothered by headlight glare.	1	2
50.	I have difficulty deciding when to merge into traffic.	1	2
51.	I drive closer to the centerline so I can see it better.	1	2
52.	I have difficulty seeing signs by the roadway at night.	1	2
53.	I have never received formal driving instruction.	1	2
54.	I am interested in receiving formal driving instruction.	1	2
55.	I rarely drive when there is snow or ice on the pavement.	1	2
56.	I regularly have difficulty in turning my head.	1	2
57.	Sometimes I think my headlights are not on when they are.	1	2
58.	I have great difficulty in seeing yellow or white markings on the pavement at night.	1	2
59.	Glare from street lights and/or highway intersection lights really affects my ability to see at night.	1	2
60.	Sometimes my fingers are so stiff I have difficulty gripping a steering wheel.	1	2
61.	I have particular difficulty reading signs with red background.	1	2
62.	I have particular difficulty reading signs with white background.	1	2
63.	I have particular difficulty reading signs with yellow background.	1	2

For questions 64 to 75 the response alternatives are: 1. Always or almost always

2. Sometimes
3. Never or almost never

64.	I signal and check to the rear when I change lanes.	1	2	3
65.	I wear a seat belt.	1	2	3
66.	I try to stay informed on changes in driving and highway regulations.	1	2	3
67.	Intersections bother me because there is so much to watch for from all directions.	1	2	3
68.	I find it difficult to decide when to join traffic on a busy interstate highway.	1	2	3
69.	I think I am slower than I used to be in reacting to dangerous driving situations.	1	2	3
70.	When I am really upset I show it in my driving.	1	2	3
71.	My thoughts wander when I am driving.	1	2	3
72.	Traffic situations make me angry.	1	2	3
73.	I get regular eye checks to keep my vision at its sharpest.	1	2	3
74.	I check with my doctor about the effect of my medications on driving ability (if you do not take any medication, skip this question).	1	2	3
75.	I try to stay abreast of current information on health practices and habits.	1	2	3
76.	Family members or friends are concerned about my driving ability.	1	2	3

For questions 7 and 78 the response alternatives are these:

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

77.	How many traffic tickets, warnings, or "discussions" with officers have you had in the past two years?	1	2	3
78.	How many accidents have you had during the past two years?	1	2	3

The next set of questions are more general 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

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

103.	What happens to people is pretty much out of their control.	1	2	3	4	5
104.	It's important to obey rules even if they aren't always the best ones.	1	2	3	4	5
105.	Current events interest me more than history.	1	2	3	4	5
106.	I get flustered easily.	1	2	3	4	5
107.	Literature interests me more than science.	1	2	3	4	5
108.	I enjoy spectator sports.	1	2	3	4	5
109.	I'm a person who likes to get things done.	1	2	3	4	5
110.	I'm pretty satisfied with the way I am.	1	2	3	4	5
111.	Other people view me as a competent person.	1	2	3	4	5
112.	I like activities that call for close attention to detail.	1	2	3	4	5
113.	Small setbacks irritate me more than they should.	1	2	3	4	5
114.	I get impatient when I have to wait.	1	2	3	4	5
115.	I'm a polite, courteous person.	1	2	3	4	5

HOW ACCURATELY CAN YOU DESCRIBE YOURSELF?

On the next page is a list of common traits. Please use this list of common human traits to describe yourself as you see yourself at the present time, not as you wish to be in the future. Describe yourself as you are generally or typically, as compared with other persons you know of the same sex and of roughly your same age.

Before each trait, please write a number indicating how accurately that trait describes you, using the scale noted at the top of the page.

INACCURATE								ACCURATE
Extremely	Very	Quite	Slightly	Neither	Slightly	Quite	Very	Extremely
1	2	3	4	5	6	7	8	9

____ Active	____ Extroverted	____ Negligent	____ Trustful
____ Agreeable	____ Fearful	____ Nervous	____ Unadventurous
____ Anxious	____ Fretful	____ Organized	____ Uncharitable
____ Artistic	____ Generous	____ Philosophical	____ Uncooperative
____ Assertive	____ Haphazard	____ Pleasant	____ Uncreative
____ Bashful	____ Harsh	____ Practical	____ Undemanding
____ Bold	____ Helpful	____ Prompt	____ Undependable
____ Bright	____ High-strung	____ Quiet	____ Unemotional
____ Careful	____ Imaginative	____ Relaxed	____ Unenvious
____ Careless	____ Imperceptive	____ Reserved	____ Unexcitable
____ Cold	____ Imperturbable	____ Rude	____ Unimaginative
____ Complex	____ Impractical	____ Self-pitying	____ Uninquisitive
____ Conscientious	____ Inconsistent	____ Selfish	____ Unintellectual
____ Cooperative	____ Inhibited	____ Shy	____ Unkind
____ Creative	____ Innovative	____ Simple	____ Unreflective
____ Daring	____ Insecure	____ Sloppy	____ Unrestrained
____ Deep	____ Intellectual	____ Steady	____ Unsophisticated
____ Demanding	____ Introspective	____ Sympathetic	____ Unsympathetic
____ Disorganized	____ Introverted	____ Systematic	____ Unsystematic
____ Distrustful	____ Irritable	____ Talkative	____ Untalkative
____ Efficient	____ Jealous	____ Temperamental	____ Verbal
____ Emotional	____ Kind	____ Thorough	____ Vigorous
____ Energetic	____ Moody	____ Timid	____ Warm
____ Envious	____ Neat	____ Touchy	____ Withdrawn

APPENDIX D
SAMPLE LETTER

Date

Name
Address
City, State Zip

Dear _________:

A team of researchers from Iowa State University is conducting Phase 2 of a study of drivers in Iowa. Phase 1 consisted of the collection of data from a group of drivers age 65 and older. Phase 2 will allow us to collect data on a representative sample of younger drivers, those between the ages of 20 through 64.

The study's purpose 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 process of driving.

Your participation in the research project means that you will be involved in several activities on the Iowa State University campus. Each participant will be asked to complete a questionnaire consisting of 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. In the final part of the study, you will go to a closed driving course and participate in a actual driving test. Completion of all components will take about three hours of your time.

Each person participating in the study will be reimbursed for mileage from you home to the Iowa State University campus and return. A light meal will also be provided for you. As an incentive to participate, we will provide an honorarium of $50.00 to compensate you for your time and effort involved as a result of taking part in this research project.

The anticipated dates for this research project are May and June, 1995. We will ask participants schedule a time 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 on campus.

Individual performance results are strictly confidential. Your name will not be associated with the results. Only the researchers will know your individual scores. Your results will not be reported to any official agency. 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 ability. Our goal is to help drivers remain safely on the highways as they grow older. 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. We realize that many of you will have job and other commitments which limit the times you might be available, so part of the purtpose of the call is to determine when you might be free. Your participation is highly significant to the success of the project and we will do what we can to accommodate your schedule.

Sincerely,

Cletus R. Mercier, PhD.
Project Director

ACKNOWLEDGEMENTS

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A debt of gratitude is owed the Office of the Dean of the College of Engineering, and especially Associate Dean William Lord, for support to complete driving course pavement repair.

The researchers appreciate the assistance and counsel of members of the project's advisory committee: Scott Falb (Project Monitor), Office of Driver Services, Iowa DOT; Ronald Beane, Administrator, Operations Division, Iowa Department of Elder Affairs; Betty G. Foster, Assistant Professor, Section of Geriatrics and Gerontology, University of Nebraska Medical Center; and Robert Thompson, Iowa Governor's Traffic Safety Bureau.

A special thank you is owed to the 62 driver participants. Working with them was a pleasure and, without them, this research project would not have been possible.