

IDENTIFYING FUNCTIONAL RELATIONSHIPS IN DRIVER RISK TAKING:
AN INTELLIGENT TRANSPORTATION ASSESSMENT OF
PROBLEM BEHAVIOR AND DRIVING STYLE

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(ABSTRACT)

Intelligent transportation systems data collected on drivers who presumably participated in a study of cognitive mapping and way-finding were evaluated with two basic procedures for data coding, including analysis of video data based on the occurrence or non-occurrence of a) critical behaviors during consecutive 15 second intervals of a driving trial, and b) the safe alternative when a safe behavior opportunity was available. Methods of data coding were assessed for practical use, reliability, and sensitivity to variation in driving style. A factor analysis of at-risk driving behaviors identified a cluster of correlated driving behaviors that appeared to share a common characteristic identified as aggressive/impatient driving. The relationship between personality and driving style was also assessed. That is, analysis of the demographics and personality variables associated with the occurrence of at-risk driving behaviors revealed that driver Age and Type A personality characteristics were significant predictors of vehicle speed and following distance to the preceding vehicle, p 's < .05. Results are discussed with regard to implications for safe driving interventions and problem behavior theory.

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TABLE OF CONTENTS

Introduction	1
Individual Differences, Problem Behavior Theory, and At-Risk Driving	1
More Recent Evidence for the Relationship between Personality and Driving	3
What is At-Risk Driving?	6
The Relationship between At-Risk Driving and Vehicle Crashes	8
Identifying Risk-Taking Personalities	9
Contributions of the Current Research	12
Operationalizing At-Risk Driving	13
Dependent Measures Investigated in the Present Research	14
Research Hypotheses	15
Method	16
Subjects and Setting	16
Materials	17
Procedure	19
Observation Procedures	22
Results	27
Scoring Predictors	27
Overall Analysis	30
Predicting Driving Style	35
Global Percent Safe Score	39
Defining Clusters of At-Risk Driving Behaviors	39
Self-Reported versus Actual Turn-Signal Use	41
Discussion	41
Age Differences in Driving Behavior	42
Gender Differences in Driving Behavior	46
Understanding the Interaction of Personality and Demographics	48
Implications of the Current Findings for ITS Data and Driving Safety Interventions	51
In Conclusion	54

References	55
Appendices	61
Curriculum Vitae	74

LIST OF TABLES

Table 1. Means and Standard Deviations of Personality Subscale Scores	28
Table 2. Zero-Order Correlations of Personality Variables and Driving Behaviors	29
Table 3. Means and Standard Deviations of Observed Driving Behaviors	31
Table 4. Factors Identified to Predict At-Risk Driving as a Result of Planned Stepwise Regression Procedures	35

LIST OF FIGURES

Figure 1. Data coding sheet used by observers during the partial interval recording procedure	23
Figure 2. Data coding sheet used by observers to record the occurrence of opportunities for turn-signal use and safe following distances	26
Figure 3. Mean speeds and mean following distances for participants in each age group	32
Figure 4. Scatterplot of drivers fitting the “at-risk” speed and following Profile	33
Figure 5. Percentage of time spent on-task and percentage of turn-signal use for participants in each age group	34
Figure 6. A plot of the difference between percentage of actual turn-signal use and percentage of self-reported turn-signal use for males and females in each age group	40

LIST OF APPENDICES

Appendix A. Questionnaire Documents completed by all Participants	61
Appendix B. Information about the Smart Car Performance Measures	72

Introduction

At-risk driving is a tragic problem in contemporary society. Specifically, in 1996, easily modifiable driver behavior led to 41,907 fatalities and 3.5 million serious injuries due to vehicle crashes in the United States. As such, approximately 115 people die each day in a motor vehicle crash. This amounts to one death every 13 minutes (NHTSA, 1998). Ironically, these tragedies occur despite environmental safeguards designed to protect vehicle occupants and mandatory laws to control driving behavior that increases the probability of a crash. In fact, Geller (1991) called the U.S. highways a battleground claiming more lives than any war the United States has ever seen.

Minor changes in driver behavior can prevent injury and save lives. For example, the occurrence of vehicle crashes has been shown to be positively correlated with changes in the national speed limit (Evans, 1991). Moreover, it is estimated that safety-belt use saved 10,414 lives in 1996 and 90,425 lives since 1975 (NHTSA, 1998). In fact, it is predicted that a one percent increase in the use of safety belts nationwide saves 200 lives per year (Nichols, 1998). Given this, it is alarming that nationwide belt use is a low 68% (Nichols, 1998), and many drivers choose to drive in ways that put themselves and others at risk for vehicle crashes and serious injury.

The majority of vehicle crashes can be attributed to driver behavior. Yet some people go their entire lives without experiencing a vehicle crash. Others are involved in multiple crashes throughout the course of their driving lives. Are these people fundamentally different? Proponents of personality psychology argue that some people are more prone than others to taking risks. Some of these risks are likely manifested on the road. Identifying people for propensity to take risks could provide some valuable information relevant to prevention. In particular, risk prone individuals could be intervened upon early in their driving histories, before a habitual problem behavior pattern develops. Furthermore, understanding the characteristics of risky drivers could lead to improved social marketing of intervention strategies (Geller, 1989).

Individual Differences, Problem Behavior Theory, and At-Risk Driving

More than a decade ago, an international symposium on "The Social Psychology of Risky Driving" offered innovative presentations of a person-situation-behavior approach to at-risk driving and vehicle crashes. As summarized by the symposium chairperson, the presentations

showed that "efforts to explain or to prevent the morbidity and mortality associated with driving are unlikely to succeed without psychosocial understanding" (Jessor, 1989, p. iii). Additionally, theoretical formulations and research findings that at-risk driving behaviors (e.g., non-use of safety belts, speeding, and alcohol-impaired driving) are components of a larger risky driving syndrome (e.g., Jessor, 1987) were supported by the data presented at this symposium (Beirness & Simpson, 1988; Donovan Umlauf & Salzberg, 1988; Wilson & Jonah, 1988).

For example, Donovan et al. (1988) identified two clusters of risky drivers--those characterized by impulsivity, sensation seeking, and aggressive acting-out behavior versus those showing high levels of dysphoria, emotional distress, resentment, and an external perception of control. A third cluster evidenced the highest level of aggressiveness, competitive speeding, and driving for tension reduction. In addition, Wilson and Jonah (1988) found that thrill-seeking and aggression, and an environmental variable, peer support, predicted traffic violations on peoples' driving records. They also showed substantial correlations between this measure of risk and self-reports of other problem behaviors (e.g., drug use, preferred vehicle speed, safety-belt non-use, DWI, and charges for non-vehicular offenses). Finally, it was shown that certain social, psychological, and behavioral factors distinguished young drivers (ages 12 to 19) who became involved in vehicle crashes from those who did not (Beirness & Simpson, 1988), and were significant predictors of DWI, driving while using marijuana, and willingness to ride with drinking drivers.

Specifically, youths involved in traffic crashes were more likely to report involvement in a variety of high-risk and health-compromising behaviors such as smoking, drug use, and heavy drinking (Beirness & Simpson, 1988). Furthermore, the self-report of certain undesirable behaviors (e.g., staying out late without permission, shoplifting, and vandalism) were indicative of at-risk driving, while other desirable behaviors (e.g., academic success; participation in religion, sports, and other extracurricular activities) were indicative of taking fewer driving risks. None of this research, however, included observations of actual on-going driving behavior, and thus suffer from weaknesses such as socially desirable responding and other response artifacts that can occur when correlating self-reports with self-reports.

More Recent Evidence for the Relationship between Personality and Driving

Personalities and individual differences have been reliably shown to impact some people's refusal to drive safely, and promote at-risk driving behaviors. For example, Wilson (1990) demonstrated that non-users of safety belts were higher sensation seekers, more impulsive, and accumulated more traffic violations than moderate and consistent users of safety belts. Non-users of safety belts were also more likely to be males, younger, and less educated than safety-belt users. Sensation seeking has also been shown to correlate positively with self-reports of a) driving while intoxicated, b) driving greater than 20 mph above the speed limit, c) racing with another vehicle, and d) illegal passes (Arnett, 1996). Like safety-belt non-users, these behaviors were reported more prevalently by males who also scored higher on the sensation seeking dimension than females.

In a study that distinguished sensation seekers from sensation avoiders, sensation avoiders were shown to prefer larger following distances between their vehicles and the vehicle in front than sensation seekers (Heino, van der Molen, & Wilde, 1996). Heino et al. (1996) reported that when allowed to choose the distance between their vehicle and the car in front of them, persons scoring low on sensation seeking reliably followed at greater distances than those scoring higher. However, neither sensation avoiders nor sensation seekers reported significant differences in the amount of risk they perceived when forced to follow at prescribed distances. As a result, Heino et al. (1996) concluded that although the difference between sensation seekers and sensation avoiders manifested itself at the behavioral level, it did not appear at the cognitive level. However, they claimed that because time headway can be seen as a driving behavior directly related to increases in crash risk (Evans, 1991), one's chosen following distance may be used as a measure of willingness to take risks (Heino et al., 1996).

Additional relationships between personality and driving have been documented by Furnham and Saipie (1993) who reported that drivers convicted of traffic violations such as speeding and reckless driving scored relatively high on psychoticism and low on the neuroticism subscale of Eysenck's Personality Questionnaire (Eysenck, Pearson, Easting, & Allsopp, 1985). They also observed relatively high scores for thrill-seeking and boredom susceptibility among the convicted drivers. However, driving convictions were negatively correlated with age, gender, and years of driving. Indeed, younger drivers have been shown to speed more often

(Wasielewsky, 1984), and follow more closely (Evans, 1991; Evans & Wasielewsky, 1983). Thus, it is noteworthy that younger drivers have also been reported to score higher than older drivers on the aggressiveness subscale of the CPI (Arnett, 1996).

Hansen (1989) identified “general social maladjustment” as a category of personality characteristics (including anger, hostility, and impulsivity) and behaviors that are reliably associated with high crash rates. In addition, Arthur and Graziano (1996) demonstrated a reliable inverse relationship between conscientiousness and involvement in vehicle crashes. Furthermore, when measured as the extent to which people rate themselves as self-disciplined, responsible, reliable and dependable, the conscientiousness construct may reflect a general decision-making model theoretically divergent from aggression. And since it is argued that driving style reflects choices that drivers make (Elander, West, & French, 1993; Evans, 1991), it can then be argued that driving style reflects personality and therefore should predict crash involvement (Arthur & Graziano, 1996). Thus, these personality characteristics may individually help to predict driving style. However, evidence of a systematic relationship between personality and crash involvement is relatively poor. One problem may surround methods of collecting the dependent measures of driving.

The criterion measure of driving performance is typically collected from self-report or archival data (i.e., driving records). It has been claimed that “use of self-reports to measure both personality and accidents limits the study because any [observed] correlation may be a response artifact” (Arthur & Graziano, 1996, p. 599). Furthermore, archival data are deficient because state records may under report the actual number of accidents simply because the drivers involved chose not to report them (Arthur & Graziano, 1996).

Regarding self-reports, Lajunen, Corry, Summala, and Hartley (1997) demonstrated the tendency for participants to engage in impression management and self-deception when completing traffic behavior inventories. These investigators showed that driver impression management correlated negatively with self-reported numbers of crashes, fines, speeding, and incidences of driving aggression. Impression management correlated positively with self-reported compliance with rules of the road.

The veracity of self-reports has been a concern of the behavioral sciences for many years (Baer, Wolf, & Risley, 1968). Failure to collect objective behavioral measures of driving

performance and over-reliance on self-report data are serious short-comings of the traffic safety literature. The author's review of the research literature revealed few non-intervention studies that used behavioral observations of driving performance as the dependent measure. In one exception (Burns & Wilde, 1995), taxi-cab drivers were observed unobtrusively by research assistants using a behavioral checklist and posing as paying taxi-cab passengers in the vehicles of 51 cab drivers. These drivers had originally responded to a series of questionnaires and gave permission to have their driving records examined.

The taxi-cab observations occurred on a route between two popular destinations and included signalized and non-signalized stops, a heavily traveled crosswalk, and a busy parking lot. Data were collected on 20 driving behaviors including: a) following too close, b) average speed at specific check points, c) poor attention, d) turn-signal use, e) exceeding speed limit, and f) changing lanes without caution among others. Risky personalities, identified as drivers who scored high on Zuckerman's Sensation Seeking Scale (SSS) and the Keinan High-Risk Personality Inventory (HRP), drove faster and less carefully (recklessly changing lanes) than those scoring lower (Burns & Wilde, 1995). Additionally, the research found high sensation seekers to be more frequently cited for speeding and other traffic violations.

Although behavioral observations may be more objective than self-reports, as with any observation procedure one must be concerned with the reliability of the observations. Burns and Wilde (1995) did not report interobserver agreement on the data presented in their article. Instead, because of the great number of observations taken, two independent raters used two separate checklists containing different target behaviors. A tally mark was indicated next to the occurrence of an at-risk behavior. Safe driving behaviors were not recorded. Reliability of the observation procedure was established in a different setting by having non-professional drivers stage the at-risk behaviors. Each checklist was used by two independent observers who agreed on the occurrence of 97% of the planned at-risk behaviors. Thus, the checklists and procedures may have been reliable, but one must presume the reliability of observations used in the study.

It is noteworthy, however, that Burns and Wilde derived a general measure of driver risk-taking behavior by performing a factor analysis on the 20 observed behaviors. Following too close, improper steering, sudden acceleration, failure to yield, and sudden braking loaded significantly as Factor 1. Exceeding speed limit and changing lanes without caution loaded

significantly onto Factor 2. Factor 1 was labeled “Competitive Driving” because this driving style might shorten the time on trips, bring in more fares, and ultimately more money for the cab driver. Factor 2 was labeled “Fast and Careless Driving” and thought to be intentionally emitted for the thrill and relief of boredom (Burns & Wilde, 1995). As such, these investigators claimed that identifying sensation seeking personalities may be used to predict repeat traffic offenders in need of behavioral intervention. The current research set out to identify drivers at higher risk for motor vehicle crashes with an observation process that was reliable and unbiased by the potential reactivity of drivers to the presence of an in-vehicle observer.

What is At-Risk Driving?

In his discussion of at-risk driving among teens, Jonah (1986) claimed that risky driving does not necessarily involve a conscious choice to be risky, but rather serves some functional utility. Typically cited desirable outcomes include time savings and fun (Burns & Wilde, 1995). The latter notion is supported by evidence from the literature suggesting that risky drivers score higher on the boredom susceptibility and thrill-seeking subscales of the Zuckerman SSS. High sensation seekers are thought to seek out extra stimulation to achieve an optimal level of physiological arousal (Zuckerman, 1994). Recall that risky driving has been considered part of a larger problem-behavior syndrome (Jessor, 1987) and a general pattern of social maladjustment (Hansen, 1989).

A second perspective of the risky driver has been proposed eloquently by Evans (1991). His perspective involves the distinction between driving performance (skill) and driving behavior (or what the driver does). Implicit in the latter is the conscious choice of behavior. Regardless, Evans (1991) definition of risky driving is any behavior that increases task difficulty. Difficulty increases the probability of a vehicle conflict and thus a crash. According to Evans’ (1991) vehicle crashes occur when the driver is: a) at fault, b) not legally at fault, but could have avoided involvement, or c) unavoidably involved, as in an “act of God.” Accordingly, not using a safety belt is not considered a risky driving behavior, because although it increases the probability of death or serious injury if involved in a crash, it does not increase the probability of the crash. From Evans perspective, crashes only occur as a result of two or more vehicles trying to occupy the same space (Evans, 1991). This is also the essence of the traffic conflict technique (TCT) for categorizing traffic crashes.

The TCT approach to transportation safety is based, in part, on the need for proactive rather than reactive strategies to promote driving safety. It is believed that conflicts or near crashes severe enough to warrant driver avoidance reactions are powerful indicators of crash potential. Specifically, it is presumed that the greater number of near crashes that occur, the greater the probability that a crash will eventually occur (Dingus, 1995; Dingus, McGhee, Hulse, et al., 1995). However, it is also acknowledged that these events may not occur with enough frequency to allow for reliable prediction, and this is a major problem with using archival crash data as a primary dependent measure. As a result, it may be necessary to move further “upstream” and analyze driver errors leading to near crashes.

The current theoretical conceptualization and analysis of driver error was based on Glauz and Miglets’ (1980) definition of a conflict. They write: “A traffic conflict is a traffic event involving two or more road users, in which one user performs some atypical or unusual action, such as a change in direction or speed, that places another user in jeopardy of a collision unless an evasive maneuver is undertaken” (p. 2). It is added that the focus of the current research was to identify at-risk driving behaviors that could potentially lead to conflicts “caused” by our experimental driver.

Thus, from the discussions above, risk may be defined in terms of increasing task difficulty or exceeding one’s driving skill. This likely occurs by decreasing the reaction time necessary to successfully perform an evasive maneuver as when two vehicles are: a) physically too close to each other, or b) the velocity of the vehicle precludes enough time to maneuver safely. From this definition, speeding and close following would be considered at-risk driving behaviors. As Evans (1991) pointed out, vehicle crashes have reliably covaried with increases and decreases in the national speed limit. Speed has also been positively correlated with crashes per distance traveled (Jonah, 1986).

Task difficulty may also be increased by performing unnecessary behaviors or creating a driving environment that occupies attentional resources useful for driving. The result is a possible increase in the time required for the driver to perform normal driving behaviors. Playing the car radio, manipulating vehicle controls, or any of a number of off-task (non-driving) behaviors fall into this category.

Speed variance may also be indicative of poor attention to the roadway environment. However, speed variance is only a risk factor when other vehicles are present (Evans, 1991). Thus, this risk factor is often manifested in traffic as unnecessarily being overtaken (passed) by another vehicle or overtaking another vehicle. Obviously, the probability of being overtaken or overtaking is at a minimum when all vehicles are traveling at average speed (Hauer, 1971).

Finally, in any discussion of at-risk driving, illegal driving behaviors must be considered, even with no specific data to show a relationship with crashes. These behaviors will likely increase the probability of conflict by drivers' failures to indicate their intentions (e.g., not using a turn signal) or in concert with increasing their own task difficulty, increasing the task difficulty of other motorists by creating a situation where they too would have to react more quickly to avoid conflict. Running through stop signs and red lights would also be examples of such at-risk driving behaviors. Since these behaviors reduce travel time, they also meet Jonah's (1986) criterion of functional utility.

The Relationship between At-Risk Driving and Vehicle Crashes

Recent research has demonstrated that at-risk driving is predictive of involvement in fatal vehicle crashes. For example, in the first of two studies, Rajalin (1994) reported that licensed drivers who had been involved in a fatal accident were more likely to have been convicted of a driving offense in a three-year period preceding the fatality than was a control group of randomly selected licensed drivers who had not been involved in a fatal crash. Additionally, these drivers were more often found culpable of the crash than were the control subjects. Furthermore, Rajalin demonstrated that excessive speed, loss of control or driver error typically caused running-off-the-road crashes, while inattention and judgment errors caused intersection crashes. Therefore, running-off-the-road crashes in particular involved at-risk driving behaviors (Rajalin, 1994). Finally, an analysis of demographic variables showed that the fatal-crash drivers were younger and more likely male than were the control drivers.

In a second study, high-risk drivers --those stopped by the police for a violation -- were observed and interviewed by police to obtain behavioral measures of driving (Rajalin, 1994 Study 2). Police in unmarked cars observed speeding, close vehicle following, crossing of no-passing lines, and lane deviations (too close to the centerline). Subjects were 143 drivers stopped

for traffic offenses and 138 control subjects selected from the same traffic flow. Drivers stopped by police were typically cited for speeding.

Results indicated that almost three times more control subjects had no prior traffic offenses in the past three years than did the risky drivers. Also, the high-risk drivers were younger, drove newer cars, more likely drove sports cars, and drove greater distances each year. In fact, the records of the high-risk driver resembled those of the drivers involved in fatal crashes, as evaluated in study 1 (Rajalin, 1994).

Similar findings were reported by Hunter, Stewart, Stutts, and Rodgman (1993) who showed that among residents in North Carolina ($n = 5074$), drivers observed (in a probability sample) not using their safety belts experienced 35% more vehicle incidents and 69% more driving convictions --as indicated by court records and actual accident reports-- than those observed to use their safety belts. Collectively, this research suggests that identifying at-risk behaviors leading to critical incidents and then intervening to prevent them could significantly reduce the number of traffic crashes and fatalities. Such primary prevention would be facilitated if drivers who are more likely to drive at-risk could be identified and targeted for behavior-change intervention.

Identifying Risk-Taking Personalities

The current research attempted to develop a profile of the risky driver by assessing the relationship between driving behavior and personality constructs theoretically related to driver risk-taking. The following discussion briefly describes the personality dimensions used for prediction in the current research. These constructs are discussed in no particular order.

Type A. The type A personality construct is seen as a global personality type encompassing a number of different behaviors. Type A individuals have been said to exhibit characteristics such as competitiveness, aggressiveness, impatience, and negativity; and are achievement-oriented (Friedman & Booth-Kewley, 1988).

Early research on the attributes of Type A individuals showed that the Type A behavioral pattern was a risk factor for coronary heart disease (Friedman & Booth-Kewley, 1988). However, more recent research has suggested that the initial results linking Type A to heart disease may not be accurate (Lee, Ashford, & Jamieson, 1993). Specifically, it is now thought that coronary heart disease is only associated with Type A personality types when these

individuals also exhibit hostility. Thus, the achievement-striving component of the Type A behavior is now associated with positive outcomes (e.g., higher grade point averages), and conversely, the irritability-hostility component of Type A behavior associated with physical symptoms and health problems (Barling & Charbonneau, 1992; Lee et al., 1993).

The hostility component of the Type A personality type is of most interest in understanding risky personalities. Type A personality inventories which are sensitive to the irritability-hostility component are sometimes used as a screening tool to identify individuals with a propensity to respond in an excessively hostile manner to highly stressful situations (Barling & Charbonneau, 1992). Thus, it is likely that Type A people may respond with hostility or aggression in stressful driving situations. Such responses may manifest themselves as risk-taking on the road. Type A was measured in the current research with the Jenkins Activity Survey (Jenkins et al., 1971), which has been shown to have high reliability and acceptable internal consistency, and includes a hostility component (Spence, Helmrich, & Pred, 1987; Yarnold, Mueser, & Lyons, 1988).

Related to the hostility component of Type A is trait anger, which was measured in the current study by the State-Trait Anger Scale which has shown acceptable internal consistency and reliability of .87 (Spielberger, Jacobs, Russell, & Crane, 1983). Additionally, a second measure of hostility, the Buss-Durkee Hostility Inventory (BDHI) was also used in the present research. Spielberger et al. (1983) report reliability estimates of the BDHI to be .82.

Locus of control. Locus of control (Rotter, 1966) has also been studied with regard to safety and at-risk behavior. Specifically, individuals with an internal locus of control (internals) believe they have control over their response outcomes, whereas individuals with an external locus of control (externals) believe factors beyond their control (e.g., luck or fate) determine outcomes. Research has shown that internals are more likely than externals to perform safe behaviors and look out for the safety of others (Geller, 1996; Roberts & Geller, 1995).

By the same token, externals are less likely to perform safely. Because externals tend to attribute events to sheer chance, luck, destiny, and other factors beyond their control, it follows that the risky personality would include this characteristic. The relationship of locus of control to unintentional injury is based on the assumption that externality is related to lack of caution or failure to take precautionary measures to avoid negative outcomes (Nowicki & Strickland, 1973).

Locus of control was measured in the present research with the revised locus of control scale (Nowicki and Duke, 1974), which has shown acceptable reliability estimates of .83 (Nowicki & Strickland, 1973).

Impulsivity. Impulsivity has also been investigated as a predictor of risk taking. This construct is defined as a personality characteristic of people who “act on the spur of the moment without being aware of any risk involved” (p. 404). Clift, Wilkins, and Davidson (1993) investigated the role of impulsiveness in at-risk lifestyles and found that impulsivity was significantly related to at-risk sexual behavior. Logically, impulsiveness (acting without awareness of risk) may be associated with at-risk driving. In fact, Elander et al. (1993) discussed the relationship between hasty (impulsive) decision-making styles and at-risk driving. Nine items from Eysenck et al.’s. (1985) L7 scale were used to assess impulsivity in the current research. This shortened scale has been shown to have acceptable reliability estimates of .77 (Clift et al., 1993).

Venturesomeness. Venturesomeness is a personality characteristic reflected in people who “are well aware of the risks they might run but are prepared to chance it” (Clift et al., 1993, p. 404). Geller (1996, 1998) and others have referred to such acts as calculated risks. Venturesomeness, like impulsiveness, is strongly associated with at-risk sexual behavior (Clift et al., 1993), but according to Clift is distinct from impulsiveness.

Specifically, Clift et al. claimed that individuals high in venturesomeness are aware of the risks they are taking before behaving in a given manner. On the other hand, impulsive individuals are not aware of potential risks in their actions and activities. In fact, Clift et al. (1993) performed a principal components analysis and showed that the impulsiveness and venturesomeness items loaded on two separate factors. Furthermore, they found that men were more venturesome than women, but men and women were equally impulsive. It is possible that these two constructs are also associated with at-risk driving. The venturesomeness items of Eysenck et al.’s. (1985) L7 used in the current research resemble the thrill-seeking items of Zuckerman’s SSS and have shown acceptable reliability of .81 (Clift et al. 1993).

Invulnerability. At-risk behavior may be related to an individual’s perceptions of invulnerability. Broadly, perceptions of invulnerability are associated with unrealistic optimism about future life events (Weinstein, 1984). There is widespread evidence suggesting that most

people believe: a) their future will be better than others; b) good things are more likely to happen to them versus others; and c) negative events are more likely to happen to others (Taylor & Brown, 1988).

While such perceptions affect most people, some individuals have higher perceptions of invulnerability than others. Logically, individuals who have higher perceptions of invulnerability may have been reinforced for risky driving patterns in the past and thus may be more likely to exhibit at-risk driving behaviors. Scales adapted from Weinstein (1980) were used to assess perceptions of invulnerability in the present research and have shown acceptable reliability.

In general, all of these personality variables are believed to be related to at-risk driving behaviors. Accordingly, the present research attempted to predict at-risk driving performance from these personality variables and participant demographics in order to develop a profile of the risky driver. By using objective measures of driving behavior, the current research will advance understanding of the "risky driving syndrome" (Jessor, 1987) as related to driving style.

Contributions of the Current Research

A distinct advantage of the present research over other attempts to study at-risk driving is the use of a "Smart Car." The Smart Car is an instrumented vehicle capable of video-recording and measuring actual on-going driving performance. As reviewed above, previous studies of driving patterns have been plagued with the effects of subject social desirability and reactivity associated with using self-reports or in-vehicle observers to collect dependent measures. Furthermore, attempts to relate driving outcomes and individual differences have used self-reported or agency-obtained crash frequency as the primary criterion variables. Actual crash data are plagued with the problem of infrequency of occurrence and the fact that certain groups of drivers may be over-represented in crash statistics for reasons other than driving behavior (Elander et al., 1993). For example, minor crashes may never be brought to the attention of the recording agencies and thus these records are susceptible to both random and systematic error (Elander et al., 1993).

The Smart Car technology allowed us to take several continuous and discrete driving performance measures simultaneously and unobtrusively. These computer-generated dependent measures, in concert with a real-time video recording of the participants' driving allowed for unprecedented opportunities to perform a behavior analysis of driving performance in the context

of normal driving. Problems associated with truthfulness of self-report, infrequency of occurrence, and error variation were minimized or avoided altogether.

The innovative nature of the Smart Car process required the development of a methodology for transferring videotape and electronic observations to meaningful behavioral indices. In other words, a major challenge of the present research was to evaluate comprehensively the Smart Car data for the most effective method of analyzing driving behavior and defining a profile of driving style. Data were considered from two different perspectives: a) a time sampling or interval approach, and b) a critical event approach. Each of these approaches is described in detail in the procedures section. Thus, a primary purpose of the current research was to define at-risk driving performance and identify the most effective method of using intelligent transportation systems (ITS) data to evaluate this performance.

Furthermore, although some attempts have been made to determine the extent to which driving behaviors covary (e.g., Janssen, 1994; Ludwig & Geller, 1991, 1997), until this point no research paradigm has allowed for comprehensive objective assessment of functionally-related driving behaviors. Another primary purpose of the proposed research was to determine the extent to which at-risk driving behaviors are correlated with one another in distinct classes and its implications for intervention studies.

Finally, although the literature suggests that individual differences in driving style exist and relationships between personality, age, gender, and outcomes due to at-risk driving have been demonstrated (cf. Elander, West, & French, 1993), a comprehensive profile of the risky driver has yet to be developed. Put differently, although some research has demonstrated that males tend to drive more at-risk than females and that young drivers report taking more risks than older drivers (Jonah, 1990), no study reviewed has included collectively age (from adolescents to senior citizens) and gender, nor the present combination of personality measures as predictors of actual driving performance.

Operationalizing At-Risk Driving

From the author's review of the relevant literature, the following definition of at-risk driving was developed and used. At-risk driving behavior is any in-vehicle behavior that increases driving task difficulty by: a) decreasing the reaction time necessary for successful evasive maneuvering, b) diverting attention away from the driving task, or c) increasing response

time to perform typical driving behaviors. At-risk driving may also represent a failure to signal one's intentions to other drivers, thus increasing the probability of vehicle conflict.

Dependent Measures Investigated in the Present Research

The following list represents the behaviors of interest in the current research and describes how they were measured.

Speeding. At-risk speed was measured as the percentage of time the vehicle velocity exceeded the posted speed limit. The percentages were calculated by observing video records of participants' driving trials and recording vehicle velocity as safe or at-risk at the onset of each consecutive 15-sec. interval of the driving trial. Speeds greater than five miles per hour above the legal speed limit were recorded as "at-risk." Observations occurring during a vehicle acceleration or deceleration due to a standard intersection stop or vehicle traffic were not considered in this analysis. A measure of mean speed for the entire driving trial was also obtained.

The experimental vehicle recorded velocity in miles per hour. The vehicle's current speed is clearly displayed on the video record. Additionally, the video record of the roadway environment allowed for clear observation of speed limit signs, and all observers were trained to reliably recognize changes in speed limit along the driving route.

Speed variation. Variation in vehicle speed was calculated as the percentage of times the experimental vehicle passed another vehicle or was passed by another vehicle. The percentage was calculated by observing video records of the entire driving trial and scoring each consecutive 15-sec. interval of the video as safe or at-risk. Observations were scored as at-risk if any vehicle passing occurred during that interval. A distinction was made between passing and being passed. Since the vehicle cruise control had been disabled, changes in vehicle speed by necessity required some input from the driving subject.

Off-task behaviors. Behaviors that focused attention away from the driving task were recorded as the percentage of time a behavior not related to driving occurred during the driving trial. The percent was calculated by observing video records of participants' driving trials and recording each consecutive 15-sec. interval of videotape as safe or at-risk. Observations were scored as at-risk if any non-driving behavior (e.g., manipulating vehicle controls, putting on make-up, combing hair, etc.) occurred during that interval.

Following distance. Distance to the vehicle in front of the experimental vehicle was recorded as the percentage of mean headways of at least two seconds. Headways were sampled each time the driving subjects followed a different vehicle. Observations recorded at or near intersections, and when the vehicle was accelerating, decelerating, or stopped because of normal traffic conditions were omitted from the calculations. At-risk headways were those determined to be less than two seconds, as calculated by dividing the distance and velocity means.

Vehicle headways were recorded in meters by an in-vehicle VORAD system. Each observation was matched to a specific video frame number and an observation of vehicle velocity recorded in miles per hour. Therefore, distance and speed data could be converted to a time measure for each vehicle followed. A distance to time conversion in which the ratio of distance in meters to vehicle speed in mph was .9 or greater indicated a safe following event and each instance was recorded as such. A measure of mean following distance for the entire driving trial as calculated from the VORAD record was also obtained.

Turn-signal use. Percentage of turn-signal use was determined by calculating the number of times the driver used the appropriate vehicle turn signal at intersection turns and when changing lanes and dividing this number by the total number of times a turn signal was called for (i.e., total number of safe plus at-risk behaviors as defined below). Specifically, video frame numbers associated with intersection turns or lane changes were recorded and the participant's data record inspected for turn-signal use. An at-risk observation was recorded if no turn-signal was used or if the wrong direction was signaled.

Every occurrence of left or right turn-signal use was recorded by the experimental vehicle. Each observation was matched to a specific video frame number.

Research Hypotheses

Based on evidence presented in the research literature, the following hypotheses are proposed regarding relationships among at-risk driving behaviors, personality dimensions, and demographics:

Hypothesis 1:

Young drivers will, in general, exhibit more at-risk driving behaviors than middle-aged and older drivers; and these behaviors will be different than those exhibited by older drivers.

Hypothesis 2:

Males will drive more at risk than females and this difference will be greatest for young drivers and lowest for older drivers.

Hypothesis 3:

There will be a positive relationship between measures of impulsivity, invulnerability, hostility, Type A, venturesomeness, and at-risk driving. There will be a positive relationship between external locus of control and at-risk driving.

Hypothesis 4:

At-risk driving behaviors will emerge as patterns of behaviors theoretically related by source of driver error such as inattention versus aggression or thrill-seeking.

Method

Subjects and Setting

Sixty-one licensed drivers (29 males and 32 females) from southwest Virginia participated in the study. Participants ranged in age from 18 to 82 years ($M = 42$) and were recruited through Virginia Polytechnic Institute and State University, advertising in local newspapers, and posted flyers. The flyers specified that participants between the ages of 18 – 25, 35 – 45, and 65+ were needed for a study that involved driving. Participants meeting these age requirements were grouped as younger (10 males, 13 females), middle-aged (10 males, 12 females), and older (9 males, 7 females) drivers, respectively. All were screened for potential health problems, use of prescription medicines, and alcohol use patterns that could potentially influence driving behavior prior to being scheduled for a research appointment. All participants were paid \$10.00 per hour for their participation. Each session took approximately two hours per participant, one hour for assessment of individual differences and one hour for the driving trial.

The current research was conducted as an extension to research funded by the Federal Highway Administration to Virginia Polytechnic Institute and State University's Center for Transportation Research. Specifically, the objectives of the grant research were two-fold. The first purpose was to develop and validate vehicle instrumentation to make the detection of near-miss crash events less labor intensive. This involved the development of a set of computer-collected performance criteria that could be used in statistical analyses to identify events of interest in the data collected by the vehicle instrumentation. A second purpose of the study was to add data to a series of studies (e.g., Dingus et al., 1995) to provide further validation for the

concept of Heinrich's Triangle applied to driving data and therefore support the development of a method to proactively determine safety benefits of Intelligent Transportation Systems (Boyce & Neale, 1998). The research described here went further upstream in data analysis to assess driving behaviors that could potentially increase the probability of a vehicle crash and thus lead to the outcomes assessed for the grant research. The development of a valid a reliable method for coding behavioral data from ITS technology is a unique methodological contribution of the current research.

Materials

Demographic questionnaire. The demographic questionnaire probed subjects for standard personal information including: a) date of birth, b) gender, c) education level, and d) socio-economic status. Additionally, information was asked about the participants' driving history including: a) amount of driving done per year, b) frequency of driving each week, and c) make and model of car driven most often. With the exception of the latter, these questions were presented in a multiple choice, forced response format.

Way-finding questionnaire. The way-finding questionnaire was a deception tool designed to create the illusion that participants were being studied for their map reading and direction-following skills. This instrument asked for "Yes" versus "No" responses regarding the participants' perceptions of their own ability to follow route directions, ask for help when lost, and read maps. The questionnaire included a formal map-reading exercise during which participants were required to use a standard road map obtained from an auto club and navigate a route from their present location in Blacksburg, VA to Athens, GA. To enhance the illusion and increase the exercise difficulty, an unrelated route was highlighted from the location of origin. These data were not analyzed, but were only used in an attempt to maintain the illusion of a way-finding study, originally established in the health-screening interviews and informed consent documents.

Personal perception survey. The personal perception survey was presented as a manipulation check. With three open-ended questions, it asked participants to describe: a) what the study was about, b) the primary objectives of the research, and c) what they had learned as a result of their participation. This survey was completed by each subject twice, immediately after the driving trial and at the conclusion of the post-drive testing session.

Risk-taking inventory. The subscales measuring the personality variables theoretically related to risk-taking were presented to subjects as a Cultural Perception Survey. These items were taken directly from the published literature and assessed: a) Venturesomeness (adapted from Eysenck et al., 1985; Clift et al., 1993), b) Impulsivity (adapted from Eysenck et al., 1985; Clift et al., 1993), c) Hostility --Buss-Durkee Hostility Scale (Velicer, Govia, Cherico, & Corriveau, 1985) and Trait Anger (Spielberger et al., 1983) , d) Perceptions of Invulnerability (adapted for Weinstein, 1980), e) Locus of Control (Nowicki & Duke, 1974), and f) Type A personality (Jenkins et al. 1971, Glass, 1977).

Items were scored as the scales were originally designed and included Likert-type, Yes/No, and multiple choice formats. All items were forced choice. Instructions indicating any changes in response format were clearly marked in bold lettering throughout the document. Participants were instructed to respond to all items as if they applied to themselves and to answer each item as quickly as possible. The risk-taking inventory was completed after the driving trial.

Post-drive questionnaire. This questionnaire asked subjects questions about their typical driving behavior, not including the driving trial they had just completed. It asked for a) the frequency of safety-belt use and turn-signal use and b) whether they required passengers in their vehicle to buckle-up. Each question was asked in the form: “Of the last 10 times you drove your car, how many times did you...” Each response was converted to a percentage based on the ratio of the number provided to the criterion of 10. This survey also assessed their familiarity with each portion of the experimental driving course by requesting the number of times in the last year they had driven on a particular section of the driving route. This post-drive questionnaire was completed after the risk-taking inventory. Original copies of all questionnaire documents are included in **Appendix A**.

Smart Car. All driving performance measures were collected in an ITS instrumented vehicle. The Smart Car is capable of video monitoring and recording several driving performance measures simultaneously. The following computer-collected driving data were available : a) driver safety-belt use; b) number of times turn-signal was used --left, right, and emergency flashers; c) vehicle velocity (speed in mph) including average speed, velocity changes, and velocity variance; and d) following distance measured in meters.

The video data included a continuous view of: a) the subject's face and head in order to analyze the amount of time scanning the roadway environment or fixating on a point away from the road and checking mirrors; b) the subject's hands for analyzing position on the steering wheel and unnecessary in-vehicle activity (e.g., adjusting the radio); c) the roadway environment in front of the vehicle, and d) the area directly behind the vehicle. Thus, the video configuration shown continuously on the video monitor allowed for unprecedented study of on-going driver behaviors, as well as the context in which they occurred. A more detailed discussion of the Smart Car, including descriptions and implications of the listed performance measures is given in **Appendix B.**

Procedure

Pre-drive. As soon as participants arrived for their scheduled appointments, they were greeted by the experimenter (the author) or a trained research assistant from the department of psychology and escorted to a pre-test location furnished with a table, chair, and all experimental materials. The experimenter checked the participant's driver's license for expiration date, driving restrictions, and to verify identity. If the driver's license had expired, indicated restricted driving privileges, identity did not match, or if the driver's license was not produced, the subject was paid for his/her time and dismissed. [Only one subject was dismissed due to a restriction on her driver's license and for appearing intoxicated when she arrived.]

Once it was determined that all license information met criteria, participants read and signed informed consent documents which explicitly described the study as an investigation of cognitive mapping, way-finding, and map-reading strategies. General procedural questions were then answered and hearing and vision tests administered. The hearing test consisted of reading six driving-related words to the subject in a normal volume and tone. Subjects were asked to repeat back to the experimenter the words just read. Hearing was determined to be within the normal range if the subject was able to repeat each of the six words correctly.

Vision was tested using a standard Snellen eye chart. Each participant read the chart from a marked distance of 20 feet with both eyes. Vision was determined to be in the normal range if corrected vision was 20/40 or better. If the subject's hearing or vision did not meet criteria, they were thanked, paid for their time, and dismissed. [One older subject, who had not worn his

hearing aids, was dismissed for failing the hearing test. This participant was re-scheduled, and passed the hearing criteria when using his hearing aids.]

After completing the routine health screenings, each participant completed the demographic and way-finding questionnaire, including the map exercise. If a subject persisted for more than 10 minutes at the map exercise, a solution was prompted by the experimenter. Once completed, all pre-test items were collected and the driving course was described.

The route description included verbal instructions, written instructions with obvious route landmarks, and a map with which the participant could follow along. The course was designed to include all possible situations that could be encountered during the course of normal driving. As such, the route included downtown, rural, and highway driving. Once subjects indicated familiarity with the driving course and all their questions were answered, they were escorted to the experimental vehicle which had been set up for data collection during the pre-test session.

Once in the vehicle, the driver-side seat, steering-wheel position, and rear-view and outside mirrors were adjusted for driver comfort and safety. With the experimenter seated in the passenger side of the vehicle, participants were then familiarized with certain features of the car including the operation of: a) safety belts, b) turn signals, c) windshield wipers, d) automatic transmission, e) automatic windows, f) defoggers/defrosters, g) parking brake, and h) the vehicle cellular phone to be used in emergencies.

Participants were asked to buckle-up before leaving the research site and all complied. In addition, they were told that with a driver's side airbag, the safest way to hold the vehicle steering wheel was with both hands, the left at the 9:00 position and the right at the 3:00 position. Final questions were answered and the driving trial was started once it was determined that the subject was buckled, and re-confirmed being comfortable with the operation of the vehicle and the route they were to drive.

Driving trial. The driving course selected included downtown, rural, and highway driving. Participants left the research site and proceeded to the city's Main Street (460 Business at this point) by way of campus roads. Once on Main Street, they proceeded through the business district through downtown and continued through the business district on the other side of town. Once out of town, they experienced approximately 2 miles of two-lane road rural driving until they merged onto a four-lane divided highway (460 west) on which they proceeded 5.2 miles.

This stretch of road required the driver to climb a medium sized mountain and negotiate some tight roadway curves. Although in general the speed limit on this highway is 55 mph., cautionary speed limit changes occur on the curvy portion. Once at their destination, a convenience store off the four-lane highway, subjects had to turn around and retrace the route they had just driven. To initiate this return, the drivers had to negotiate a precarious left-hand turn across the four-lane divided highway.

The route covered 22.3 miles roundtrip, took approximately 45 minutes to complete and included five intersection turns, 30 controlled intersections, 2 miles of suburb driving, 6 miles of business/downtown driving, 4 miles of rural driving, and 10 miles of highway driving. Speed limits were 25, 35, 45, or 55 mph, and were clearly marked with obvious speed limit signs. All driving was done in dry weather during daylight hours.

Post-drive. After approximately 40 minutes, the experimenter watched for the participant to return from the driving trial. Upon arrival, the driver was greeted by the experimenter who asked if he or she experienced any difficulty during the course of the drive. At this time, the participant was escorted to a post-test location furnished with a conference table, chairs and all post-test materials. The map and driving course directions were collected and the post-test session was initiated.

During this session the participant completed the Personal Perception Survey, the Risk-Taking Inventory (presented as the Cultural Perception Survey), and the Post-Drive Questionnaire. After completing all surveys, the subject was again asked the three open-ended questions addressing their perceptions about the purpose of the research (i.e., the Personal Perception Survey).

Participants were provided with verbal instructions to initiate the testing session and were told not to spend too much time on any one item. Response scoring systems (e.g., Likert-type vs. multiple choice) were explained and instructions indicating changes in response requirements were emphasized. Once all questions were answered, subjects were left alone to complete the questionnaire items. To maintain confidentiality and prevent socially desirable responding, no names appeared on any questionnaire document.

During the post-test session, the performance data of the participant collected by the Smart Car were downloaded and the video retrieved. The experimenter made periodic checks

with the subjects to answer any questions and also to ensure their comfort. Once all post-test questionnaires were completed and final questions were answered in an informal debriefing, the subject was asked to provide a mailing address to receive a formal debriefing. Then they were thanked, paid, and escorted from the building.

Observation Procedures

The first aim of the data collection was to define the dependent measures related to at-risk driving, and develop the tool for obtaining this information from the Smart Car data files, which included a videotape of every trip. Two methods of behavior analysis were employed.

Partial interval recording. The video record of each 45-min. driving trial was analyzed for the occurrence of safe versus at-risk vehicle speed, speed variation, and in-vehicle behaviors not relevant to the driving task (off-task behaviors) during each consecutive 15-sec. interval of the driving trial. The percentage of intervals in which off-task behavior occurred was used as a measure of risk due to inattention. Consistent with the traffic conflict technique (TCT) to assess driving hazards, speed variation was measured as the occurrence versus non-occurrence of passing events during each interval. A passing event was determined to occur when: a) a vehicle travelling in the same direction overtook the experimental vehicle and appeared in its entirety on the video monitor, or b) a vehicle travelling in the same direction was overtaken by the experimental vehicle and went completely out of view on the video monitor. Vehicle speed was sampled at the start of each consecutive 15-sec. interval by observing the speed reading in miles per hour that appeared on the video monitor and comparing that observation to the posted speed limit along that portion of the driving route. Speeds in excess of five miles per hour over the posted speed limit were coded as at-risk.

The passage of each interval was indicated with a microcassette tape recorder and tape that announced the number of each new interval as calibrated to a digital stopwatch. Trained research assistants recorded their observations on a data sheet divided into numbered blocks representing each consecutive interval. A portion this data sheet is presented in Figure 1 below.

Interval		1	Stop			2	Stop			3	Stop			4	Stop	
Speed		S	AR			S	AR			S	AR			S	AR	
Extraneous behavior																
With Directions			YES				YES				YES				YES	
Not involving Directions			YES				YES				YES				YES	
Passing Behavior																
We Pass		L	R	Illegal		L	R	Illegal		L	R	Illegal		L	R	Illegal
They Pass		L	R	Illegal		L	R	Illegal		L	R	Illegal		L	R	Illegal
Interval		5	Stop			6	Stop			7	Stop			8	Stop	
Speed		S	AR			S	AR			S	AR			S	AR	
Extraneous behavior																
With Directions			YES				YES				YES				YES	
Not involving Directions			YES				YES				YES				YES	
Passing Behavior																
We Pass		L	R	Illegal		L	R	Illegal		L	R	Illegal		L	R	Illegal
They Pass		L	R	Illegal		L	R	Illegal		L	R	Illegal		L	R	Illegal
Interval		9	Stop			10	Stop			11	Stop			12	Stop	
Speed		S	AR			S	AR			S	AR			S	AR	
Extraneous behavior																
With Directions			YES				YES				YES				YES	
Not involving Directions			YES				YES				YES				YES	
Passing Behavior																
We Pass		L	R	Illegal		L	R	Illegal		L	R	Illegal		L	R	Illegal
They Pass		L	R	Illegal		L	R	Illegal		L	R	Illegal		L	R	Illegal

Figure 1. The data coding sheet used for the partial interval observation procedure

Each block contained a space for descriptors of each target behavior category. Observers circled the appropriate descriptor representing the occurrence of the target behavior during that interval, otherwise it was left blank if the behavior did not occur during that 15-sec. time block. Only speed was coded as safe versus at-risk during each interval, at the time the new interval was identified. However, if the experimental vehicle was stopped due to traffic or a road signal, speed data were not recorded during that interval. Instead the descriptor “stop” was circled and the observations eliminated from any further analysis.

Research assistants were instructed that the interval procedure was an “all or none” method which facilitated the collection of multiple target behaviors. As such, multiple occurrences of a single target behavior during any one interval were not recorded, unless a subsequent occurrence of a behavior represented a different sub-category of the larger behavioral category (e.g., left hand pass, followed by a right hand pass). Observations were not recorded when the experimental vehicle was stopped. Instead, as with speed coding, the descriptor “stop”

was circled in the appropriate interval. Intervals in which a stop was scored were omitted from all subsequent calculations. All research assistants were trained to an 85% reliability criterion for each behavioral category prior to being allowed to make independent observations.

All data coding sessions were conducted in a quiet conference room furnished with a large table and chairs, a 25-inch television set and super VHS videotape recorder with a remote control. Data coding started as the experimental vehicle crossed an obvious stop line at the intersection on which they turned onto the driving route. The videotape was paused at this point and cassette recorder coordinated to start the first interval as the videotape was released from the pause. The session was ended at the close of the interval during which the experimental vehicle crossed the same stop line when turning off the driving route.

All data coded from this interval recording procedure were converted to percent safe scores. With the exception of vehicle speeding which was coded as safe versus at-risk in each interval, the safe response was the absence of behavior in each behavioral category during that interval.

Discrete event recording. Following distance was recorded as a discrete event based on a safe behavior opportunity (SBO) approach (Geller, Lehman, & Kalsher, 1989). Safe behavior opportunities occurred each time the experimental vehicle started following a new car. Each event was coded from the videotape of each participant's driving trial and matched by video frame number to the computer generated measures. Following events were determined to start when a) a car was in front of the experimental vehicle in the same lane, b) the car was no more than five seconds in front of the experimental vehicle, and c) the experimental vehicle was traveling at least 20 mph. The criterion of five seconds was determined by having observers select the first available roadway landmark and counting the number of video frames that passed from the time the back bumper of the preceding vehicle passed the landmark until the time the front bumper of the experimental vehicle passed the same landmark (cf. Evans, 1991; Heino et al., 1996). Each video frame corresponded to one-tenth of a second in time.

Following events were defined as ending when a) the experimental vehicle changed lanes, b) the car being followed turned or changed lanes, c) another vehicle entered in between the vehicle that initiated the following event and the experimental vehicle, d) the experimental vehicle was held up at a stop light while the preceding vehicle made it through, or e) the

preceding vehicle was too far in front of the experimental vehicle to be clearly seen on the video monitor. The video frame number indicating the start and end of each following event was recorded on a data collection sheet by two trained research assistants to ensure reliability.

Average following distances of less than 2 sec. were coded as at-risk. For each event, the time conversion was made by assessing the ratio of average following distance measured in meters and average speed measured in miles per hour and comparing it to a minimum criterion of 0.9. Nine-tenths of a meter was determined to be the criterion for 2 sec. of headway per mph. The mean following distance for the entire driving trial and mean speed were also recorded for analysis.

All following event data corresponding with speeds of less than 20 mph, or when no following distance was recorded by the Smart Car were eliminated from further analysis. This prevented a potential bias in the data created by the context of downtown driving, especially observations recorded when the experimental vehicle was routinely stopped behind other vehicles at an intersection or due to traffic. The percentage of following events during which the experimental subject maintained on average a minimum of 2 sec. following distance was used as the dependent measure (i.e., percent safe).

Turn-signal use was also summarized with an SBO approach. Specifically, trained observers recorded on a data collection sheet the video frame numbers corresponding to the start of an intersection turn or lane change, the type of event, and its direction. The criterion used to determine the start of the SBO was the point at which the driver had committed the experimental vehicle to turn or change lane position (e.g., movement of the car to the center line when changing lanes). Videos could be reviewed such that unintentional lane deviations were not recorded. All observers were trained to a criterion of 85% reliability for determining the start of an SBO for turn-signal use.

Turn-signal SBOs were matched frame by frame to the computer-generated record of driving performance in which left and right turn-signal use, emergency-flasher use, or no-signal use were coded automatically by the Smart Car. If the correct signal was used within 25 frames of the number recorded during video observations (within 2.5 sec. of the point determined to initiate the event), the event was coded as safe. The percentage of safe turn-signal use was used

as the dependent measure. A copy of the data sheet used for coding turn-signal use and following distance is depicted in Figure 2 below.

SBO	Turn-Signal Use				Following Distance			
	Frame #	Beh	Safe	At-Risk	Frame # Begin	Frame # End	Safe	At-Risk
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Figure 2. The data coding sheet used for the discrete event observation procedure

Assessing interobserver agreement. To assess reliability of “Smart Car” data collected from the partial-interval approach, data coding was performed by two independent observers during the same session and evaluated on an interval by interval basis (cf. Kazdin, 1994). We divided the number of intervals in which both observers scored the occurrence or non-occurrence of a behavior (agreements) and divided this total by the number of agreements plus disagreements (the number of intervals in which one observer scored a behavior and the other did not) and multiplying by 100. This procedure was performed separately for each of the time-sampled behaviors, (speed, speed variation, and off-task behaviors).

Reliability for following distance and turn-signal use was assessed as follows. Videos were viewed a second time by independent observers. The data coded during the second viewing were compared frame by frame with data coded during the first viewing. An agreement was scored for a turn-signal use SBO if a) the two events matched within 25 frames, b) the direction of the event (left vs. right) was in agreement, and c) the type of event (lane change versus

intersection turn) corresponded. The reliability estimate was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100.

Following events were scored for agreement a) that the same event was observed based on beginning and ending frame numbers recorded independently by each observer, and b) based on duration of the recorded event. Duration reliability was assessed by dividing the shorter duration by the longer duration and adding these fractions. The sum was divided by the total number of events recorded by both sets of observers and multiplying by 100.

Reliability estimates. Independent observations were made on 43% ($n = 26$) of all interval recording sessions. Interobserver agreement was 93% for vehicle speed, 95% for speed variation, and 91% for off-task behaviors.

Independent observations were made on 30% ($n = 20$) of all event recording sessions. Agreement was 87% for turn-signal use and 85% for following event opportunity. Interobserver agreement for duration of following events was 87%. The majority of the discrepancies for duration of following event occurred as a result of observers recording the start of an event at different points. This likely resulted from the independent observers selecting a different roadway landmark on which to determine if event starting criteria were met. Considering all the conditions that had to be met, reliability of 85% seems commendable.

Results

Scoring Predictors

Subjects ($n = 61$) were assigned to an age and gender category based on information collected from a pre-drive demographic questionnaire. Specifically, males and females aged 18-25 years old were grouped as younger drivers, and those 35-45 as middle-aged drivers. All drivers 65 years of age or older were considered older drivers.

Personality variables were assessed with standard measures of the dimensions of interest. These questionnaire items have been used extensively in the research literature and have demonstrated high internal consistency and reliability (as described earlier). Specifically, hostility (5 items; Spielberger et al., 1983), impulsivity (8 items; Clift et al., 1993), trait anger (10 items; Spielberger et al., 1983), and venturesomeness (9 items; Clift et al., 1993) were all measured on a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). After appropriate items were reversed scored, each participant's score on the different dimensions was

calculated as the average of their responses to the individual items. Higher scores indicated that participants exhibited more of the personality dimensions being measured.

Perceptions of invulnerability (10 items; Weinstein, 1980) were also scored on a 7-point Likert-type scale (1 = very likely, 7 = very unlikely). These questions required subjects to consider the probability of certain life events occurring to themselves versus people their same age and gender. Participants' scores were calculated by taking the average of the difference between their self-ratings and ratings of others. Higher positive scores indicated a stronger systematic bias of perceptions toward invulnerability, and lower negative scores indicated a stronger systematic bias toward vulnerability (Weinstein, 1980).

Locus of control questions (40 items; Nowicki & Duke, 1974) were answered "yes versus no." Responses reflecting an external locus of control were scored a point and then averaged to produce each participant's score. Higher scores were associated with a higher external locus of control.

Table 1

Means and standard deviations of subscale scores for the sample of (n = 61) participants

Personality Variable	Mean Subscale Score	Standard Deviation
Hostility*	3.7	1.3
Impulsivity*	3.7	1.1
Invulnerability**	1.5	1.3
Trait Anger*	3.2	1.1
Venturesomeness*	4.7	1.2
Type A***	3.3	0.3
Locus of Control****	0.25	0.01

*Scored on a 7-point Likert-type scale

**Calculated as the difference between self-ratings and ratings of others

***The Type A response receives a score of 5

****External responses received a score of 1; internal responses a score of 0

The Type A personality (40 items; Jenkins et al., 1971) was assessed in multiple choice format. The number of choices varied from two to four, with the Type A response always

receiving a score of five. If two choices were provided the non-Type A response received a score of 2.5; for three items the least Type A choice was scored 1.67 and the alternate 3.33. For four response items the least Type A response was scored 1.25, the next alternative 2.5, and the final non-Type A choice 3.75 (cf. Spence, Helmreich, & Pred, 1987). Individual items were averaged to produce the participants score on the Type A dimension. Higher scores indicated more Type A characteristics. Descriptive statistics for subjects' scores on the personality variables and the zero-order correlations of the personality dimensions with each dependent measure are provided in Tables 1 and 2, respectively.

Table 2

Zero-order correlations of personality variables with themselves and with the primary dependent measures

	Age	Gender	Host.	Impuls	Invulnr	Anger	Ventur	type A	L of C
Age	1.0								
Gender	-.10	1.0							
Hostility	-.20	*.32	1.0						
Impulsivity	*.29	.14	.03	1.0					
Invulnerability	.02	.11	-.15	-.08	1.0				
Trait Anger	*.38	-.09	*.52	*.44	-.13	1.0			
Venturesome	*.65	-.10	.15	.19	.04	.25	1.0		
Type A	-.12	*.30	.11	-.04	-.06	*.28	.08	1.0	
Locus of Control	-.03	.14	.25	*.26	-.14	.16	-.11	-.01	1.0
Speeding	*.61	-.03	-.13	*.26	.15	-.23	*.40	-.13	-.13
Speed Variation	.04	.08	.03	.06	.02	.12	-.04	.08	-.02
Off-Task	*.48	-.13	-.04	-.26	-.14	-.24	*.25	-.04	-.08
T-Signal Use	*.28	.19	.13	-.01	.09	-.00	.23	.13	.02
Following Distance	*.54	-.22	-.11	-.22	-.03	*.32	*.33	-.24	-.01
Mean Speed	*.59	.15	.17	.19	-.14	.23	*.37	*.33	.07
Mean. Distance	*.50	-.16	-.21	-.18	.08	*.38	*.43	*.30	-.14

* significantly correlated, $p < .05$

Overall Analysis

The effects of Age and Gender on the five primary dependent measures (speeding, speed variation, off-task behaviors, turn-signal use, and following distance) were analyzed with multivariate analysis of variance (MANOVA) procedures with Gender (Male vs. Female) and Age (Younger, Middle-Aged, Older) as the between-subject factors. All dependent measures were calculated as a percent safe score based on observations from the interval or event recording procedures on 60 subjects as described above. Data from one female in the younger group were eliminated from this analysis because a failure of the in-vehicle computer during her driving trial prevented the calculation of the turn-signal use and following distance measures. Multivariate Hotelling-Lawley's trace statistic yielded an overall significant main effect for Age, $F(10, 98) = 1.42, p < .001$. Overall, younger drivers drove more at-risk than middle-aged and older drivers; and middle-aged drivers drove more at-risk than older drivers. Each dependent measure is discussed in turn below. No other overall significant effects were observed.

Speeding. Univariate results indicated a significant Age effect for speeding, $F(2, 54) = 17.71, p < .001$. Fisher's LSD revealed that older drivers (90% safe) maintained a safe vehicle speed significantly more often than younger drivers (62% safe) and middle-aged drivers (81% safe), who were also significantly more safe than younger drivers, p 's $< .05$. In general, men and women were observed speeding equally as often. The percent safe scores for speeding organized by Age and Gender are presented in Table 3 below.

It is noteworthy that percent safe scores for speeding were also analyzed by dividing the roundtrip driving session into two halves: the drive out from versus the drive back to the research site. Repeated measures ANOVA revealed a significant main effect for section of the driving session, $F(1, 55) = 20.28, p < .01$ and a drive by age interaction, $F(2, 55) = 10.78, p < .01$. Fisher's LSD indicated that subjects maintained a safe vehicle speed more often during the first half of their drives (81% safe) than the second half of their drives (74% safe), $p < .05$. Additionally, simple effects tests revealed that younger subjects exhibited the greater decrease in maintaining a safe vehicle speed during the second half of the drive (69% vs. 53% safe) than middle-aged drivers (83% vs. 79% safe) and older drivers (91% safe during both halves of the drive).

Table 3

Means and standard deviations for observed percent safe scores for the five target behaviors, and measures of mean speed and mean following distance

Target Behavior	Younger		Middle-Aged		Older	
	Males (n = 10)	Females (n = 12)	Males (n = 10)	Females (n = 12)	Males (n = 9)	Females (n = 7)
Speeding*	M = 58.5 SD = 14.3	M = 66.1 SD = 16.9	M = 83.1 SD = 15.3	M = 78.8 SD = 20.2	M = 91.4 SD = 3.5	M = 90.0 SD = 6.4
Speed Variation*	M = 81.8 SD = 4.9	M = 86.1 SD = 4.4	M = 84.6 SD = 4.4	M = 85.3 SD = 6.3	M = 86.7 SD = 5.3	M = 82.6 SD = 7.5
On-Task Behavior*	M = 70.6 SD = 20.3	M = 60.8 SD = 22.6	M = 79.4 SD = 11.1	M = 75.9 SD = 18.1	M = 84.2 SD = 8.8	M = 91.1 SD = 6.9
Turn-Signal Use*	M = 89.7 SD = 9.7	M = 92.2 SD = 9.5	M = 79.3 SD = 23.4	M = 82.8 SD = 22.4	M = 72.3 SD = 23.1	M = 87.6 SD = 10.9
Following Distance*	M = 53.2 SD = 25.2	M = 43.9 SD = 23.5	M = 71.5 SD = 26.5	M = 61.7 SD = 19.8	M = 85.7 SD = 8.7	M = 78.4 SD = 22.5
Mean Speed in mph	M = 38.4 SD = 1.8	M = 38.0 SD = 1.9	M = 36.1 SD = 2.6	M = 37.4 SD = 2.2	M = 34.0 SD = 2.0	M = 34.7 SD = 2.1
Mean Following Distance in meters	M = 36.0 SD = 5.7	M = 33.0 SD = 4.5	M = 39.9 SD = 7.4	M = 37.9 SD = 5.2	M = 43.0 SD = 4.3	M = 43.5 SD = 10.6

M = mean, SD = standard deviation

*Score reported as percent safe

Measures of mean speed for the entire driving trial were also calculated and are depicted for each Age group with the corresponding mean following distances in Figure 3.

Following distance. Univariate results indicated a significant Age effect for the percentage of following events that drivers maintained on average at least 2-sec. of time between the experimental and preceding vehicle, $F(2, 54) = 10.86, p < .001$. Specifically, LSD procedures revealed that older drivers (82% safe) maintained a safe following distance more often than younger drivers (49% safe) and middle-aged drivers (67% safe), who were also more safe than younger drivers, p 's $< .05$. Although not statistically significant ($p < .10$), when

collapsed across Age, males (70% safe) followed a minimum of 2 sec. behind the car in front of them more frequently than females (59% safe).

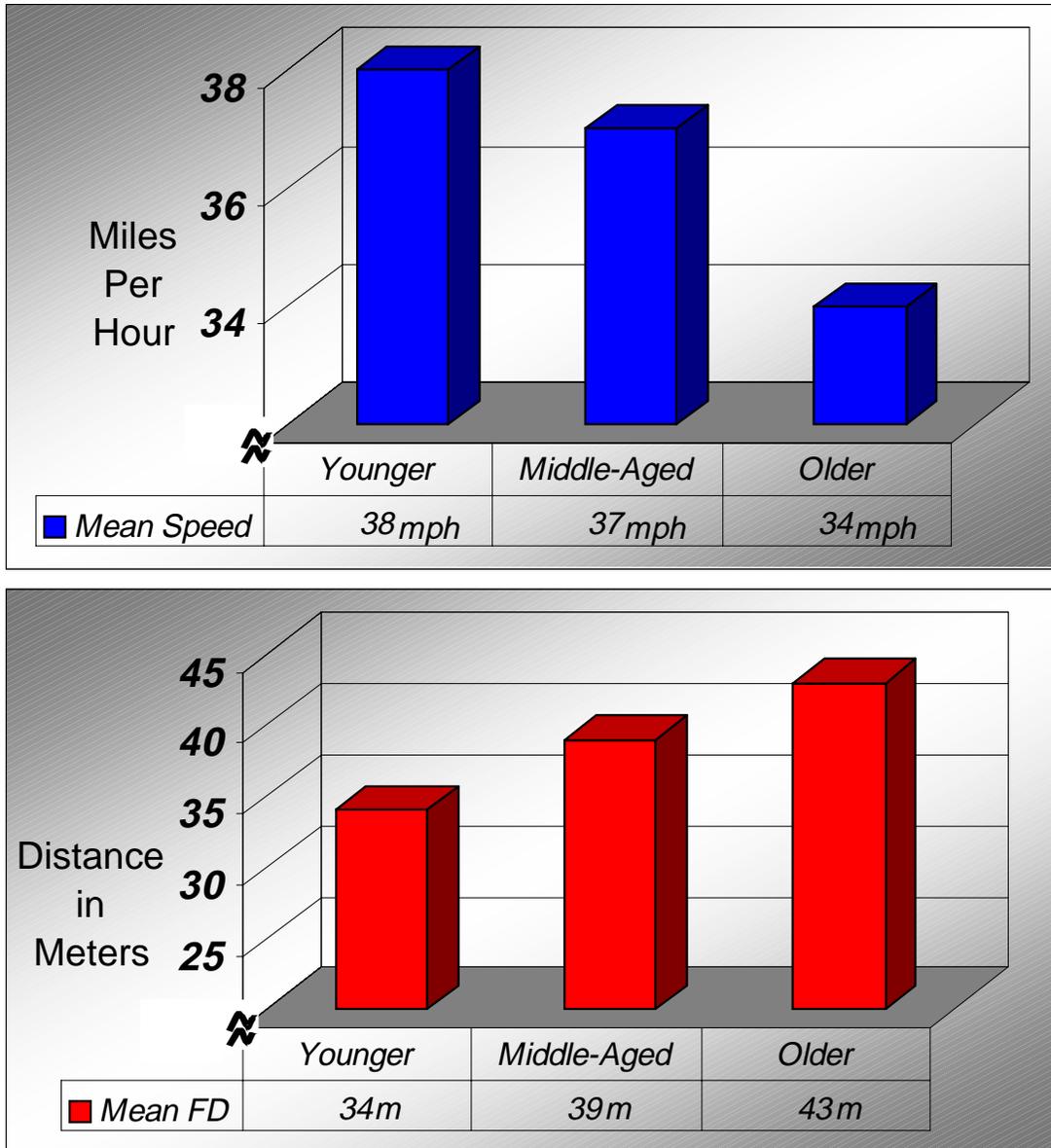


Figure 3. Mean speed in mph and mean following distance in meters for the entire driving session as a function of age group.

The percent safe scores for following distance organized by age and gender are presented in Table 3. As described above, Figure 3 contains a plot of mean following distance for the entire driving trial for each Age group, and their mean speed. Figure 4 below depicts this

relationship in a scatterplot, thus revealing how many drivers in each demographic category fit the at-risk pattern.

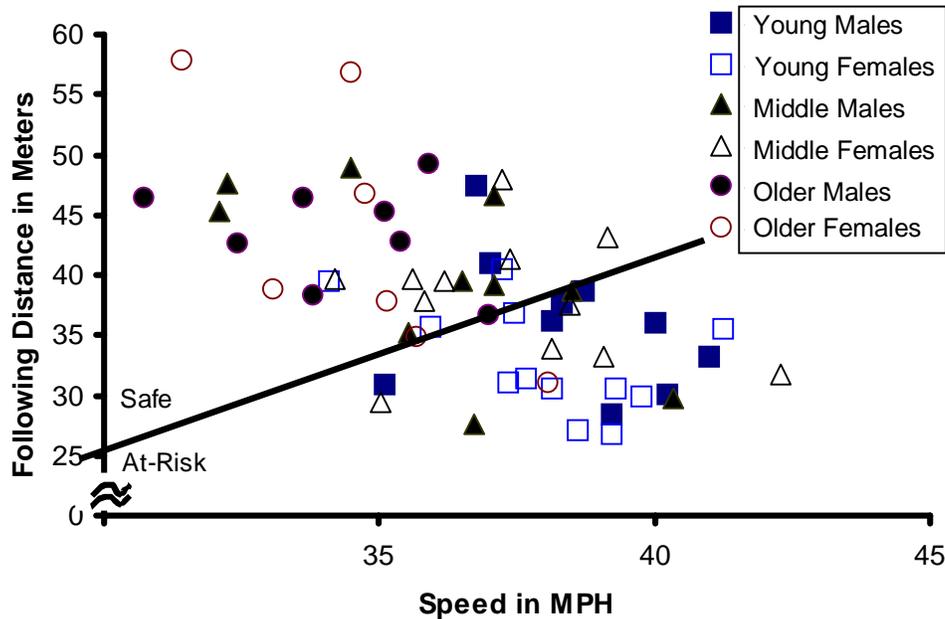


Figure 4. A scatterplot of drivers meeting the at-risk speed and following distance profile

Off-task behavior. Univariate results indicated a significant Age effect for the occurrence of off-task behaviors, $F(2, 54) = 8.20, p < .01$. Specifically, LSD procedures showed that older drivers (88% safe) and middle-aged drivers (78% safe) were significantly safer than younger drivers (66% safe), p 's $< .05$, but did not differ significantly from each other with regard to the amount of off-task behavior they exhibited during the driving trial, $p > .05$. The only gender difference was that young females (61% safe) exhibited substantially more off-task behaviors than their male counterparts (71% safe), $p < .10$. The percent safe scores for off-task behavior organized by Age and Gender are presented in Table 3. Figure 5 depicts these percent safe scores (i.e., percent of time on task) for each age group as well as the percentage of time the appropriate turn signal was used.

Turn-signal use. Univariate results indicated that the effect of Age on the proportion of turn-signal use per opportunity approached significance, $F(2, 54) = 2.42, p < .10$. Although not statistically significant, LSD procedures revealed that younger drivers (91% safe) used their turn-

signal more than middle-aged (81% safe) or older drivers (80% safe), p 's < .10, who did not differ from each other. The percent safe scores for turn-signal use organized by Age and Gender are presented in Table 3. Additionally, the percentage of turn-signal use for each Age group is plotted along with the percentage of time spent on task in Figure 5.

Speed variation. No significant Gender or Age differences were obtained in speed

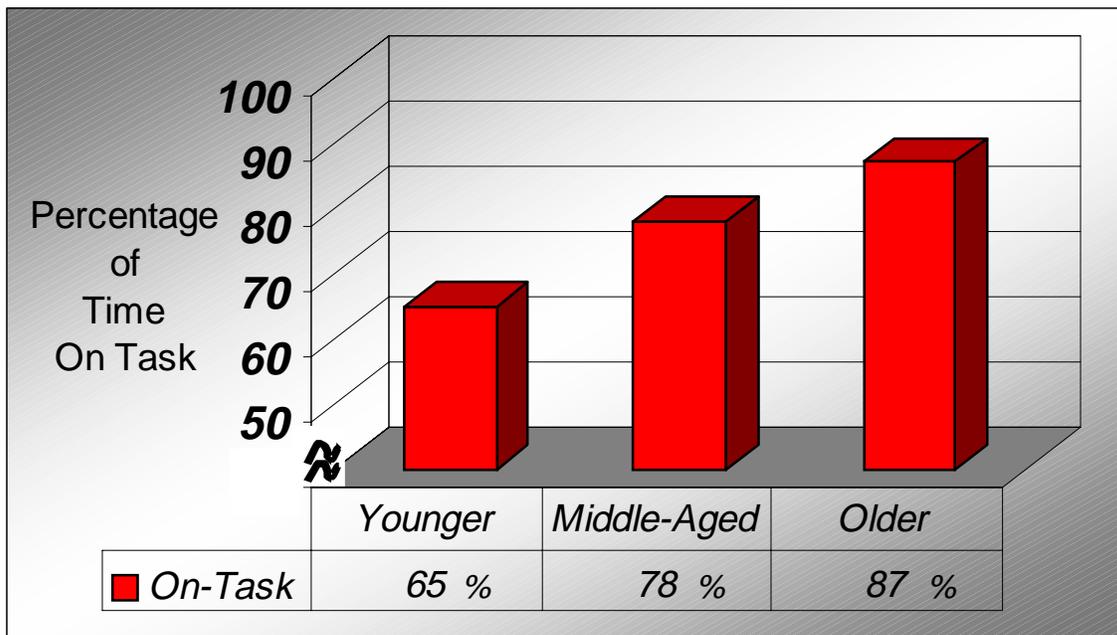
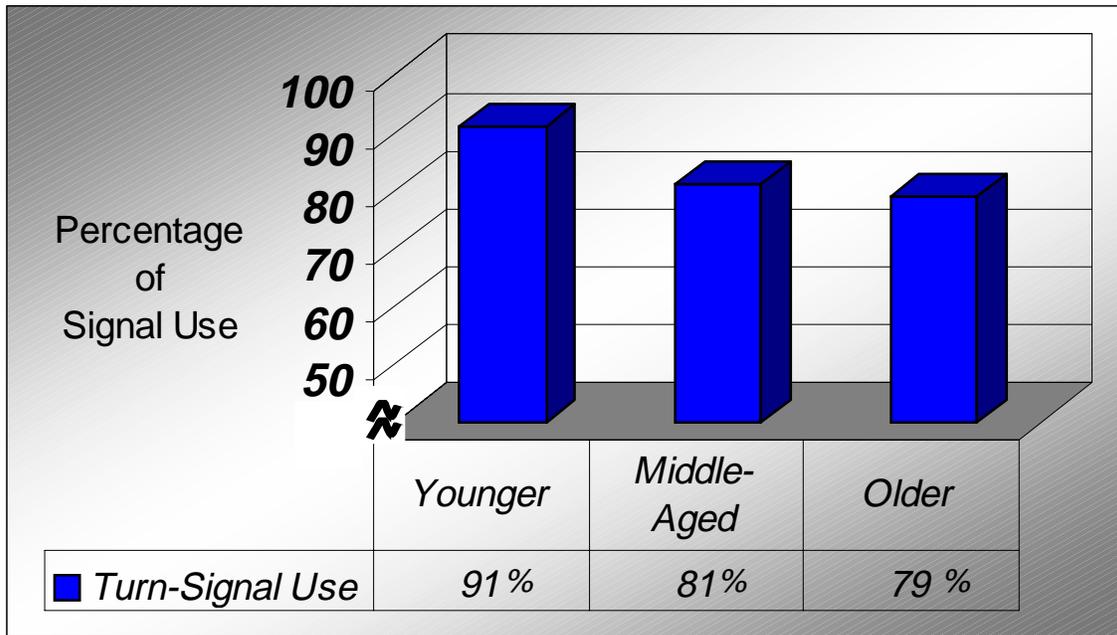


Figure 5. A plot of percentage of time spent on-task and percentage of turn-signal use for participants in each age group.

variation operationalized as the occurrence of passing events observed during the interval recording procedure.

Predicting Driving Style

Statistical regression procedures were used to study relationships between different individual factors and at-risk driving. A summary of significant results from planned stepwise multiple regression procedures performed on the entire sample of drivers is presented in Table 4.

Table 4

Planned stepwise regression of demographics and personality variables on the primary measures of at-risk driving

Predictors	R	R²	ΔR²	r
Speeding				
Age	.61	.38	.38	.61
Mean Speed				
Age	.59	.35	.35	-.59
Type A	.65	.42	.07	.33
Speed Variation				
	--	--	--	--
Speed Variation-Us				
Age	.39	.15	.15	.39
Invulnerability	.46	.21	.06	.25
Extraneous Behavior				
Age	.48	.24	.24	.48
Turn-Signal Use				
Age	.28	.08	.08	-.28
Following Distance				
Age	.54	.29	.29	.54
Mean Following Distance				
Age	.50	.25	.25	.50
Type A	.56	.31	.06	-.30

However, because of the robust Age effect obtained in the omnibus test described above, moderated regression procedures (Aguinas & Stone-Romero, 1997; Kowalski, 1995) were also performed in which interaction terms were calculated as the product of age category and each individual personality dimension. Products were calculated using dummy variables for age such that each was orthogonal (Pedhazur & Schmelkin, 1991). The moderated regression procedure is equivalent to ANOVA for mixed factorial experimental designs, and is recommended when an interaction is suspected and dichotomization of continuous variables is not desirable (Kowalski, 1995).

The moderated regression procedure was performed as follows. First, all predictors were forced into the model as a block with an enter command. Second, all interaction terms were entered as a separate block using stepwise procedures in which predictors compete among themselves for entry into the regression equation above those entered in block one. Moderated regression procedures yielding significant interaction terms allow one to explore the specific contribution of each interacting variable on a specific subsample of data (Kowalski, 1995).

If an interaction term entered significantly at $p < .05$, then a final model was produced in a single separate analysis by splitting the data set by the moderator (age), forcing all significant variables from block one into the equation, and then entering the predictors moderated by age in a second block in a stepwise fashion. This reveals the contribution of the interacting predictor into the regression equation while controlling for all other significant factors. Thus, the test is a conservative evaluation of the influence of any additional predictor.

Criterion variables were derived from the various methods of data collection described above. As such, regression analyses were run separately for criterion measures defined as “percent safe:” a) speeding, b) speed variation, c) following distance, d) turn-signal use, and e) off-task behaviors. As mentioned above, the data of one driver were not available for measures of turn-signal use and following distance.

Speeding. Moderated regression procedures revealed no significant interaction terms. However, when all predictors were entered into the regression equation in a stepwise fashion, Age entered significantly, $p < .001$, accounting for 38% of the variance. Specifically, age correlated positively with percent safe speed, $r = .61$, $p < .01$.

Because the experimental vehicle was capable of recording the mean speed for the driving trial, regression procedures were also performed on this measure of speeding. To calculate the criterion, all velocity observations recorded when the experimental vehicle was stopped were deleted from the data set. Moderated regression procedures revealed no significant interaction terms. However, when all predictors were entered in a stepwise fashion, Age and Type A entered the regression equation, $p < .05$. Age was negatively correlated with mean speed ($r = -.59, p < .01$) and Type A was positively correlated with mean speed ($r = .33, p < .01$). The model Age plus Type A accounted for 42% of the total variance in mean vehicle speed for the driving trial.

Following distance. Moderated regression analysis revealed no significant interactions with age. In fact, only age was significantly correlated with percent safe following distance ($r = .54, p < .01$) indicating that older drivers followed at safe distances more often than younger drivers.

Because the experimental vehicle was capable of recording the mean following distance for the entire driving trial, this measure was subjected to regression analyses. Specifically, stepwise regression analysis was performed on mean following distance in meters as calculated for all observations of following distance when the experimental vehicle was traveling at least 20 mph. Age and Type A entered the regression equation, $p < .05$. Age was positively correlated with mean following distance ($r = .50$) and accounted for 25% of the variance. In contrast, Type A was negatively correlated with mean following distance ($r = -.30$) accounting for an additional 6% of the variance across all subjects.

Because of the significant Age effect, moderated regression procedures were performed and revealed that an Age by Impulsivity interaction entered the regression equation, $p < .05$, accounting for 6% of the variance in mean following distance. As a result of this interaction the sample was split by Age and a single analysis performed on each group separately. After controlling for the influence of Type A, this analysis revealed that Impulsivity correlated positively with mean following distance ($r = .48, p < .01$) for older drivers, but negatively correlated with mean following distance among younger drivers, $r = -.38, p < .05$. This result indicates that, on average, older drivers followed at greater distances when they were more

impulsive, and conversely, younger drivers followed at greater distances when they were less impulsive.

Off-task behaviors. Moderated regression procedures revealed no significant interaction terms. However, when all predictors were entered into the regression equation in a stepwise fashion, Age entered significantly ($p < .05$) accounting for 24% of the total sample variance. Less off-task behavior correlated positively with Age, $r = .48$, $p < .05$. Specifically, this result indicated that older drivers were more likely to stay on task, thus minimizing the amount of in-vehicle behavior that was irrelevant to driving.

Turn-signal use. Analyses revealed no significant interactions terms for use of turn signals. Only Age was significantly correlated (negatively) with percent safe turn-signal use ($r = -.28$, $p < .05$) accounting for 8% of the variance in turn-signal use. This indicated that younger drivers used their turn-signals more often than older drivers.

Speed variation. Speed variation, operationalized as the occurrence of vehicle passing events, was not predicted by either Age or Gender nor by any of the personality variables in the initial analysis. However, because speed variation was operationalized as the occurrence of vehicle passing events, these events were broken down into occurrences of the experimental subject passing other vehicles versus being passed, and analyses were run on these measures separately.

Moderated regression procedures for the experimental subjects' passing indicated that none of the interaction terms were significant, but that Age entered the regression equation significantly, $p < .01$, and accounted for 15% of the variance in passing behavior. Perceptions of Invulnerability also entered significantly, $p < .05$, and accounted for an additional 6% of the variance. Thus, Age plus Invulnerability accounted for 21% of the total variance in the number of times experimental subjects passed another vehicle. Fewer passing correlated positively with Age, $r = .39$, $p < .01$ and Perceptions of Invulnerability, $r = .25$, $p < .05$.

Similar analyses were performed on the occurrence of other cars passing the experimental vehicle. Both Locus of Control and Perceptions of Invulnerability interacted significantly with Age, $p < .05$, accounting for 6% and 5% of the variance, respectively. Thus, the sample was split by the age categories, and procedures were performed on each subsample of data to determine the influence of Locus of Control and Perceptions of Invulnerability on each. This analysis revealed

Locus of Control (31% of the variance) and Perceptions of Invulnerability (22% of the variance) entered the regression equation significantly only for older drivers, $p < .05$. For this analysis, Locus of Control plus Perceptions of Invulnerability accounted for 54% of the total variance in the number of times older drivers were passed by another vehicle during their driving trials. Inspection of the data indicated that both Locus of Control and Perceptions of Invulnerability were negatively correlated with percent safe passing (being passed less often) for older drivers ($r = -.56$ and $-.34$, respectively, p 's $< .05$). In other words, older drivers exhibiting an external Locus of Control and higher Perceptions of Invulnerability were passed more often than the older drivers exhibiting tendencies for an internal locus of control and lower perceptions of invulnerability.

Global Percent Safe Score

To summarize all of the data presented above, the five primary dependent measures (speeding, speed variation, off-task behaviors, turn-signal use, and following distance), calculated as a percent safe scores, were averaged to generate an overall percent safe score for each participant. This criterion was not predicted by any of the personality dimensions nor any of the interaction terms. Thus, these data were analyzed with a 2 Gender (Male vs. Female) by 3 Age (Younger, Middle-Aged, Older) ANOVA and revealed a significant main effect for Age, $F(2, 55) = 4.17$, $p < .05$. Specifically, younger drivers (73% safe) drove less safe than older drivers (83% safe). Middle-Aged drivers (78% safe) did not differ significantly from either older or younger drivers. Neither the Gender main effect nor the interaction term were significant. These findings are consistent with the results of the MANOVA reported above. Finally, stability of driving performance over time was assessed by repeated measures ANOVA of the driving trial divided into the first and second halves of the roundtrip. With the exception of the speed data noted above, percent safe scores for all dependent measures did not differ significantly from the first to the second half of the drive.

Defining Clusters of At-Risk Driving Behaviors

Because driver risk-taking may vary on different dimensions, behaviors collected from evaluation of video data were subjected to an exploratory factor analysis to define categories of at-risk driving performance. Specifically, a maximum likelihood factor extraction was used to identify factors such as errors due to "attention/distraction" or "aggressive driving" that were

correlated with one another, but independent of other factors and behaviors. The maximum likelihood method calculates factor loadings that maximize the probability of sampling the observed correlation matrix from the population (Tabachnick & Fidell, 1989). Because of the strong age effect and similar findings across all dependent measures of driving, this factor analysis could reveal relationships among observed driving behaviors and perhaps contribute to understanding processes underlying at-risk driving among our sample of participants.

With 60 subjects, and five primary dependent measures, it is possible the factor analysis may over- or under-estimate the number of factors in the data set (Tabachnick & Fidell, 1989). Thus, the factor analysis was entered into with caution. The maximum likelihood factor extraction method is recommended when the correlation matrix is not singular and the number of variables is fewer than 60 (Tabachnick & Fidell, 1989).

The factor analysis was performed on the five primary dependent measures defined as

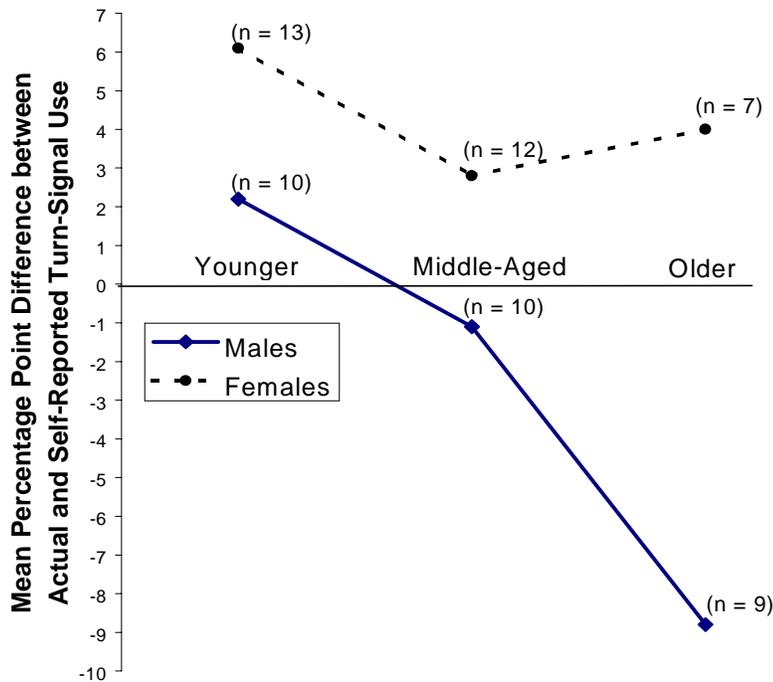


Figure 6. A plot of the difference between percentage of actual turn-signal use and percentage of self-reported turn-signal use for males and females in each age group.

percent safe scores as defined above. The maximum likelihood extraction with a varimax rotation extracted two factors. Bartlett's test for goodness of fit indicated that the two factor model was appropriate, $\chi^2(8) = 17.44$, $p < .05$. Inspection of the rotated correlation matrix revealed that speeding, speed variation, off-task behavior, and following distance loaded significantly onto Factor 1, while turn-signal use loaded significantly onto Factor 2. The two factors accounted for 53% of the variance in driving style, 40% and 13%, respectively.

Self-Reported versus Actual Turn-Signal Use

A planned analysis involved assessing the integrity of each driver's self-report of driving behaviors on the post-drive questionnaire. This was done by comparing the reported proportions of turn-signal use independent of the driving trial with the proportions of opportunities on which turn signals were actually used by participants during their driving trials. Larger difference scores indicated a greater discrepancy between self-reported turn-signal use and actual use. More specifically, negative scores indicated a bias to over report a safe driving practice, and positive scores a bias to under report safe driving.

This integrity score was used as the dependent measure in a 2 Gender (Male, Female) by 3 Age (Younger, Middle-aged, Older) ANOVA, which revealed no significant main effects or interactions, all p 's $> .10$. However, it is noteworthy that males had the tendency to over report their safe driving behavior, and females to under report their safe driving behavior. Specifically, only 3 males reported their level of turn-signal use perfectly, whereas 58% ($n = 15$) of the remaining males followed a pattern of over-reporting. In contrast, five females reported their turn-signal use perfectly, and 60% ($n = 16$) of the remaining females under-reported their actual turn-signal use. The relationship between actual turn-signal use and self-reported turn-signal use for males and females in each age group is depicted in Figure 6.

Discussion

The two primary aims of this research were to a) develop a process for collecting reliable observations of driving practices from intelligent transportation systems data, and b) explore relationships among age, gender, personality, and driving style. As expected, age was a primary predictor of at-risk driving; but contrary to previous research, robust gender differences were not obtained. In addition, the contribution of different personality types to predict at-risk driving were not straightforward. Finally, measures of interobserver agreement among our observations

indicated that partial interval and discrete event observation approaches can be used effectively to collect reliable data from comprehensive video and computer records obtained from Smart Car technology.

Age Differences in Driving Behavior

As predicted younger drivers drove more at-risk than middle-aged or older drivers. This result was obtained from multivariate analysis of variance across all behaviors taken separately, and from analysis of variance procedures on a composite percent safe score derived by combining the scores from each individual target behavior into a single dependent measure of driving. Additionally, univariate analyses performed as part of the omnibus test demonstrated that younger drivers were more at-risk on each behavior measured with one noteworthy exception: younger drivers used their turn-signals more often than older drivers or middle-aged drivers who used their turn-signals equally as often as older drivers.

This is an interesting result in light of the direct negative relationship between age and the percentage of time a participant was observed following the speed limit, and the percentage of opportunities a safe following distance was maintained. It could be claimed that younger drivers were compensating for their at-risk speeding and following by using their turn-signals more often. In other words, from theories of risk compensation (Peltzman, 1975) and risk homeostasis (Wilde, 1982, 1994), it would be presumed that the younger drivers were willing to accept a certain level of risk when driving, and when this level of risk was exceeded, they reduced their perceived risk by using their turn-signals.

When broken down to lane changes, and right versus left turns, the age difference in turn-signal use manifested itself in all turning events equally often. That is, younger drivers used their turn-signals during each of these events approximately 90% of the time, while middle-aged and older drivers signaled on these occasions less than 80% of the time. Finally, older drivers were least likely to use their turn-signals when changing lanes (75%).

Although age did not predict speed variation defined as the occurrence of passing events, younger drivers did spend more time off-task than middle-aged or older drivers. However, middle-aged and older drivers exhibited these off-task behaviors to the same degree. Figure 4 shows the relationship between the percentage of time spent on task in general, and a specific safe driving behavior, turn-signal use. The figure provides a nice portrait of the negative

relationship between on-task behaviors and turn-signal use and demonstrates the risk compensation effect referred to above.

The dramatic age differences in the percentage of time younger drivers attended specifically to the driving task exacerbates the risk created by driving faster and following too closely. In fact from the current definition of at-risk driving, all would increase the probability of a vehicle crash through creating a driving context in which it is likely the driver would be unable to respond quickly enough even to routine driving events. This suggests that time spent on task when driving may be a behavior worthy of special intervention. Geller (1996) has discussed how safety is a fight against human nature because of the naturally reinforcing consequences provided by the at-risk alternative. The amount of off-task behavior exhibited by drivers does not seem to provide these traditional benefits such as fun or arriving at your destination more quickly (as when speeding), and therefore may be particularly amenable to behavioral intervention.

That drivers take fewer risks on the road as they get older is the most robust and common individual-difference finding in the research literature on driving safety (Elander et al., 1993; Evans, 1991). In fact, Elander et al. report that crash involvement is a negatively decelerating curve when plotted against age. They concluded that 17 year old drivers have a 50% greater probability of a crash than do 25-year-olds who in turn have a 35% greater probability than 50-year-olds. These authors conceded, however, that some of the literature suggests the probability of crash increases after age 65.

To explain age differences in driving behavior, Jonah and Dawson (1987) reported that younger drivers perceived less risk in most driving situations than older drivers. Additionally, it has been suggested that older drivers take a longer time to get accustomed to novel driving situations. This concept was manifested in the current behavioral data by greater decreases in safe driving during the second half of the driving session by younger drivers than older or middle-aged drivers. As a specific example, although younger drivers maintained a safe vehicle speed less often during both halves of the driving session than older or middle-aged drivers, this difference was greater during the second half of the drive. It could be argued that the younger drivers adapted to the novel in-vehicle environment more quickly than drivers older than themselves. Thus, it is intuitive that younger drivers would report greater perceptions of invulnerability and take more calculated risks on the road. Surprisingly, this explanation was not

supported by the current research. In fact, the measure of invulnerability (Weinstein, 1980) only predicted how often a subject passed another car; and this correlation was opposite to expectation. Perhaps, drivers who passed vehicles less often exhibited greater perceptions of invulnerability because they were doing the safe thing. In other words, it could be claimed from the theory of cognitive dissonance that drivers who drove more safely reported greater perceptions of invulnerability thus maintaining a consistency between their behaviors and beliefs. Congruent with this argument is the finding that drivers typically rate driving situations in which they have control as the least likely to result in a vehicle crash (Holland, 1993).

Other relationships between personality, age, and driving deserve mention. In the current research venturesomeness was negatively correlated with age $r = -.65$, $p < .01$. In other words, higher scores for the venturesomeness dimension were observed among younger subjects, and as age increased, venturesomeness scores decreased. This result is consistent with findings regarding the relationship between age and sensation seeking (a similar construct) in the literature. In fact, the relationships between age, gender, sensation seeking, and driving have been so robust, that studies with sensation seeking as the primary variable of interest control for gender and age (e.g., Heino et al., 1996). Thus, the robust age effect obtained in the current study may have masked the influence of the venturesomeness personality dimension on at-risk driving.

Inspection of the zero-order correlations in Table 2 reveals that venturesomeness correlated negatively with percent safe measures of speeding, on-task behavior, and following distance. Furthermore, venturesomeness correlated negatively with mean following distance, and positively with mean speed. All of these relationships are in the expected direction, and are consistent with the research literature (e.g., Arnett, 1996; Heino et al., 1996). However, venturesomeness shared a lot of variance with the age variable, and thus did not predict enough unique variance beyond that already predicted by age. A discussion of venturesomeness and driving risk as measured by vehicle following distance is worthy of further discussion.

Venturesomeness is a measure similar to the thrill-seeking component of the more common sensation seeking construct, and sensation seekers have been shown to follow cars more closely than sensation avoiders (Heino et al., 1996). Moreover, younger drivers reliably score higher than older drivers on sensation seeking measures. In the present research, younger drivers followed a safe distance behind the car they were following on significantly fewer following

occasions than middle-aged or older drivers; and middle-aged drivers followed safely more often than older drivers. Younger drivers also followed a closer distance for their entire driving trial. Furthermore, as mentioned above, younger drivers scored higher on venturesomeness measures (5.6 out of 7) than middle-aged drivers (4.4) who scored higher than older drivers (3.7). This result is consistent with the research literature and demonstrates the significant negative correlation between venturesomeness (willingness to take calculated risks) and age, on a behavior (following distance) particularly relevant to risk taking.

Following distance in relation to vehicle speed is a crucial measure of risk because it provides multiple sources of information and continuous feedback to a driver regarding probability of a crash. Specifically, following events typically occur for some duration and result from continuous judgements. That is, changes in distance to the car in front, and changes in vehicle speed provide visual stimuli by which a driver can potentially judge risk. As such, individuals can increase or decrease their own level of perceived risk by following more closely or farther back or by driving faster or slower.

When allowed to choose a desired following distance, Heino et al. (1996) reported that sensation avoiders reliably followed further behind the car in front at all speeds than did sensation seekers. They concluded that although differences in sensation seeking manifested itself most prominently at the behavioral level, it may have been rooted at the perceptual and physiological levels. One could argue that the sensation seekers take greater calculated risks, and that these risks are reinforced by the stimulation provided by vehicle speed and proximity to the vehicle in front.

The fact that in the current research younger drivers drove faster and maintained riskier following distances is particularly alarming. High speeds and close following distances are good predictors of a vehicle crash (Evans, 1991). Exacerbating this dangerous relationship is the finding that younger drivers also exhibit more inattention to driving as measured by the occurrence of off-task behaviors.

Recall that behaviors making the driving task more difficult increase driving risk (Evans, 1991). As such, it can be seen that younger drivers are particularly prone to a vehicle crash on several dimensions. This result was supported by the factor analysis which demonstrated the relationship between speeding, close following, and off-task behaviors. These findings have

important implications for the design of driver education programs, and interventions to improve driving as discussed below.

In light of the aforementioned risk factors among younger drivers, it is ironic that they were the drivers who used their turn-signals most often. Thus, it is noteworthy that of all behaviors measured, turn-signal use was the only dimension that did not directly increase the probability of a vehicle conflict as a result of increasing driving task difficulty. In other words, turn-signal use currently defined as a means of signaling one's driving intentions was important only in the presence of other traffic. Our measure of turn-signal use did not include traffic present as a dimension. As a result, it can be speculated that turn-signal use among younger participants may have been rule-governed as a result having experienced driver training in the not so distant past. In contrast, for older drivers turn-signal use appeared to be controlled by the natural contingencies of traffic and thus were used only when necessary. As a result, it becomes noteworthy that turn-signal use was the only target behavior measured in this research that loaded significantly onto a separate factor and was not correlated with the other four observed behaviors (that were correlated with one another).

Gender Differences in Driving Behavior

It has been shown consistently that males report driving more at-risk than females. This was reported by Wilson (1990) for safety-belt use, and Arnett (1996) for speeding, illegal passes, and driving while intoxicated. Moreover, Evans (1991) documented the overrepresentation of males in national accident statistics and Jonah (1990) reported more pronounced age differences in driving risk for males than females. These findings were supported by the review by Elander et al. (1993) who reported that after controlling for driving exposure, females were less likely to be involved in a vehicle crash than males, and that this difference was greatest among young and inexperienced drivers. While such findings are common, the results of the present research do not support these data nor the hypothesis that males in general tend to take more risks on the road than females (Elander et al., 1993; Jessor, 1987).

Regarding an explanation for the failure to observe gender differences with the current measures of driving behavior, one may need only to look at a primary weakness of typical driving studies. Specifically, the data reported in studies of driving performance were usually obtained from self-reported surveys. That is, subjects in these studies typically expressed in writing the

frequency they engaged in specific at-risk driving behaviors such as speeding and following too close. For example, the Driving Behaviour Questionnaire (cf. Burns & Wilde, 1995) is a measurement tool commonly used to assess driving behavior. As such, a certain response artifact could have contributed to significant measurement error (Arthur & Graziano, 1996; Lajunen et al., 1997). More specifically, it is possible that findings associating females with less risk when driving resulted from a greater social desirability bias among females than males; or conversely that males are more willing to admit to their at-risk driving behavior. For example, in their review of individual differences related to vehicle crash risk, Elander et al. (1993) reported that males consistently expressed a greater willingness to commit driving violations than females.

The current study did attempt to assess accuracy of self-reported driving by comparing self-reported turn-signal use with observed turn-signal use, but no significant gender differences were found. The failure to obtain significant differences in “truth scores” for males versus females may have resulted from highly variable responding on self-reported turn-signal use, and no significant gender differences in actual turn-signal use. However, when over-reporting safe driving, males did so to a greater degree than females, and females under-reported safe driving to a greater degree than males. Thus, it is likely that response patterns were a function of memory rather than an effort to deceive. Additionally, limiting the accuracy measure to only turn-signal use may not have allowed us to obtain enough information to detect a systematic pattern in people’s tendencies when self-reporting driving behavior. An investigation of discrepancies between self-reported driving behavior and actual driving behavior would be a useful line of research for future studies using ITS data.

More importantly, our behavioral data showed that males and females drive with relatively the same amount of risk. This was true for all ages and across all dependent measures. The only two exceptions were that younger females exhibited more off-task behaviors than younger males, and older and middle-aged males followed at a safe distance behind the preceding vehicle a greater proportion of the time than did older and middle-aged females.

An explanation for the gender differences in off-task behaviors among younger drivers comes about anecdotally. The current definition of off-task behavior allowed any behavior not necessary for driving to be recorded as at-risk. This was typically a movement of the hand for a purpose other than operating the vehicle. Both males and females manipulated the radio controls

equally often, and both looked at themselves in the rearview mirror frequently. However, when looking at themselves in the mirror, the younger females were more likely than males to groom themselves. Specifically, they frequently straightened their hair, adjusted make-up, and performed other off-task behaviors related to physical appearance.

The literature is replete with evidence that males tend to seek out more stimulation than females (cf. Zuckerman, 1994) and are reliably higher sensation seekers. This “sensation seeking” has been reflected as risk-taking on the road (Arnett, 1996) and more convictions for driving violations (Furnham & Saipe, 1993). Thus, it could be speculated that younger females did not derive as much stimulation as males from the driving task and therefore took the opportunity to perform extra off-task behaviors.

Understanding the Interaction of Personality and Demographics

The literature has shown reliable positive relationships between driving risk and a) sensation seeking (Arnett, 1996; Burns & Wilde, 1995; Furnham & Saipe, 1993), b) aggressiveness (Arnett, 1996; Arthur & Graziano, 1996), c) impulsivity (Stanford, Greve, Boudreaux, & Mathias, 1996; Wilson, 1990), d) external locus of control (Nowicki & Strickland, 1973), and e) patterns of other psychosocial influences associated with problem behavior (Jessor, 1987). Unfortunately the relationships between these individual differences and the at-risk driving assessed in the current research were not so clear. It is possible this inconsistency is due to the fact the majority of previous research relied on self-report or archival data to measure driving. The following discussion presents results from the present research regarding the relationship between driving and personality supporting findings from the research literature.

Type A. The Type A dimension was a significant predictor of mean speed and mean following distance. However, the positive correlation with mean speed was modest, accounting for only 7% of the sample variance above the age variable which entered the regression equation first. That people exhibiting Type A characteristics drove relatively fast is no surprise. This is consistent with the profile of the Type A personality who exhibits impatience and is competitive (Spence et al., 1987). In fact, the items on the survey used to assess Type A probed specifically for a preference for a fast-paced lifestyle (Spence et al., 1987). Although we are not aware of a direct demonstration of the relationship between Type A and driving, the present results appear

to support findings in the research literature between the impatience and achievement strivings components of Type A and “at-risk” lifestyle choices and behaviors (Spence et al., 1987).

Arnett (1996) showed significant positive relationships between aggressiveness and several reckless driving behaviors. The current research did not investigate aggressiveness, but the Type A measure likely taps some of the same dimensions, including a hostility dimension. As such, the negative correlation between Type A and mean vehicle following distance and positive correlation between Type A and mean speed support the research literature. In particular, close following has received much attention as a hostile or aggressive driving behavior. People often tailgate the car in front of them in acts of anger (Evans, 1991), putting both drivers at greater risk for a vehicle crash. Type A as a predictor of aggressive driving styles is worthy of further research.

The relationships between the Type A personality and both speeding and following distance did not occur when the behaviors were measured as a percent safe score. Two possible explanations are offered. First, our measure of percent safe speeding coded all observations of greater than five mph above the speed limit as at-risk. Therefore, this measure was not sensitive to the degree to which drivers were travelling above the speed limit, only that they were more than 5 mph above the speed limit when vehicle speed was sampled. Second, our measure of safe following distance only required subjects to maintain a minimum following distance (i.e., two seconds) to be safe, and thus this measure, like the discrete coding of speed, was not sensitive to variations in following distance. Future research may want to regard these continuous measures with regard to degree of risk, such that observations of speeding 5 to 10 mph above the speed limit are scored differently than those 11 to 20 mph above, etc. And a weighted scoring system might also be used to score longer safe or shorter at-risk following distance events. It is possible a more sensitive percent safe measure may then reveal similar relationships of Type A as observed with the continuous measures of speed and following distance.

Because of the significant correlations between gender, hostility, and Type A, this relationship was explored further. In an exploratory analysis, an interesting Gender by Type A interaction was revealed with regard to the off-task behaviors. Specifically, Type A males scored higher percent safe scores for off-task behaviors (i.e., exhibited fewer behaviors irrelevant to driving) than non-Type A males. However, this relationship was reversed for females. That is,

Type A females exhibited more off-task behaviors than non-Type A females. Recall, the majority of the off-task behavior for females resulted from grooming and secondarily manipulating the radio controls, whereas males in particular manipulated the radio controls. Thus, with the knowledge that Type A personalities like to take on more than one task at a time, it is not surprising that Type A females (who may not have been as engaged in the driving task), in addition to manipulating the radio, took the time to groom themselves during the driving trial. This is as predicted by the impatience characteristic of the Type A personality.

Perceptions of invulnerability. Measured as unrealistic optimism (Weinstein, 1980), perceptions of invulnerability correlated significantly with the percent safe score for speed variation ($r = .25$) measured as the proportion of time the experimental subject passed another vehicle during the driving trial. This variable accounted for a modest 6% of the total sample variance above the contribution of the age variable which entered the regression equation first. More specifically, the non-occurrence of a vehicle passing event was scored as safe. A positive score on the current measure of invulnerability indicated unrealistic optimism. Therefore, the positive correlation between perceptions of invulnerability and percent safe in this case indicated that those participants reporting unrealistic optimism passed other vehicles significantly less often than those who did not show this optimistic bias. As such, this relationship was opposite to that expected.

Although Zimbardo, Keough, and Boyd (1997) demonstrated a significant negative relationship between a future-oriented time perspective (regardless of positive or negative outcome expectations), the literature on invulnerability (e.g., Weinstein, 1980, 1984), suggests that individuals with greater perceptions of invulnerability would pass more often because of their beliefs that bad things won't happen to them. Inspection of individual scores on this personality measure revealed that only three subjects scored in a negative direction, reflecting a negative or pessimistic bias to their beliefs. Failure of scores to depart from zero in both directions may have prevented enough variation to both sides of the optimism scale to show the expected negative relationship between optimism (high perceptions of invulnerability) and this measure of speed variation. Table 1 depicts the positive bias in perceptions of invulnerability as reflected in the positive mean score. Scores could have ranged from -7 for the lowest

perceptions of invulnerability to + 7 for the highest perceptions of invulnerability. As a result, it is possible that some other factor, such as time orientation, was operating in the current context.

Apart from the response artifact explanation, it is also possible that the positive relationship between perceptions of invulnerability and speed variation may reflect subjects' unfamiliarity or discomfort with driving the experimental vehicle. That is, although high perceptions of invulnerability were reported by the experimental subjects, it is possible these were not manifested at the behavioral level because of the novel driving stimulus (i.e., the experimental vehicle). In fact, Wilde (1982) and others have demonstrated that perceptions of risk are highly malleable, and thus the driving subjects in the current research may have perceived more risk than normal on the road as a result of fear of damaging a very expensive test vehicle.

In other words, participants may have compensated for their general willingness to take risks by passing other vehicles because of the additional perceived risk of damaging a vehicle that was not their own. As described above, the risk compensation (Peltzman, 1975) explanation presumes that people will adjust their behavior to match their perceived risk with a general level of risk they are willing to accept. Although in the present research we took time to familiarize experimental subjects with the Smart Car and driving route, and they indicated their comfort with both, future research using ITS technology should consider giving participants more experience with the experimental vehicle (i.e., multiple driving trials).

Implications of the Current Findings for ITS Data and Driving Safety Interventions

Consistent with the research literature, the present research found a robust age effect for driving style. Significant relationships between Type A personality, perceptions of invulnerability, and drivers' actual risk-taking were also found. The relationship to driving of a commonly assessed personality dimension, locus of control, was not clear. Therefore consistent with previous findings, a clear and systematic relationship of multiple personality variables to predict driving risk was not obtained. It is possible the robust age effect across all dependent measures masked the discovery of a risky driver profile.

Inspection of Table 2 reveals that age shared much variance with many of the personality dimensions, indicating that respondents in the current study may have responded the way they did on the personality inventories because of their age. For example, Heino et al. demonstrated

that standard measures of sensation seeking ask questions that may reflect age differences rather than true sensation seeking propensities. It could be speculated that the same type of responding occurred in the present study. This is a weakness of self-reported data.

Contrary to previous research, however, the present study used self-report only to assess the personality variables. Actual unobtrusive observations were used to evaluate driving behavior. This in itself is a valuable contribution to the research literature. Specifically, driving behavior in the current research was collected with a computer and a continuous video record of an entire driving trial in the context of normal traffic. Participants drove alone, with only instructions from the experimenter that they should obey all traffic laws during the course of their driving session. As such, confounds of reactivity typically associated with the presence of an in-vehicle observer were avoided. Because it was possible to code continuous video records reliably, this research presented an unprecedented opportunity to observe multiple driving behaviors as they occurred in real time. Thus, it becomes instructive to assess how these behaviors covaried with one another.

It is presumed that phenomena such as risk compensation (Peltzman, 1975) versus response generalization (Bandura, 1969; Falk, 1971) operate as a function of the extent to which behaviors covary in a negative or positive direction, respectively. Furthermore, it is claimed that such knowledge may have great implications for selecting the target behaviors on which to intervene, and that this knowledge may help to increase the ecological validity of behavior change intervention (Ludwig & Geller, 1991, 1997). Uncovering such relationships was a primary purpose of the planned factor analysis.

The five primary dependent measures (percent safe scores for speeding, speed variation, off-task behaviors, turn-signal use, and following distance) were submitted to a maximum-likelihood factor analysis. This analysis revealed that speeding, speed variance, following distance, and off-task behaviors loaded significantly onto one factor, while turn-signal use appeared to be a factor separate from the others. Additionally, inspection of zero-order correlations indicated that the most robust significant positive relationships (p 's < .01) existed between maintaining a safe vehicle speed, percent safe scores for off-task behaviors, and maintaining a safe distance behind the vehicle in front. However, percent safe scores for speed variation also correlated positively with percent safe scores for speeding, p < .05. Furthermore,

the proportion of on-task in-vehicle behaviors correlated positively with maintaining a safe following distance, $p < .01$. Finally, maintaining safe following distances correlated negatively with mean vehicle speed, $p < .01$. And, consistent with the results of the factor analysis, safe use of turn signals did not correlate significantly with any of the other target driving behaviors.

These results have both practical and theoretical implications. Theoretically, these findings offer support for the concept of a problem behavior syndrome within the context of driving (cf. Jessor, 1987; Jonah & Dawson, 1987). That is, it can be concluded that if drivers exhibit one of these at-risk driving behaviors, they are more likely to exhibit others. Therefore, from a practical perspective it can be speculated that intervening to increase the occurrence of the safe alternatives, for example maintaining safe vehicle speed, may have concomitant desirable effects on the other behaviors. This is predicted by response generalization theory. Therefore, it may be instructive to understand the functional utility uniting these driving behaviors.

The independent behavior, turn-signal use, is the only target behavior which does not directly change the probability of a vehicle crash by changing the physical proximity of two vehicles. In contrast, the behaviors observed to covary all affect the position of the experimental vehicle in the context of traffic. Moreover, the choice to speed, change speeds (pass another vehicle), follow too closely, or to engage in off-task behaviors while driving all provide a change in the physical stimulus inputs that impact on judgements of risk. Thus, deciding to engage in one at-risk driving behavior must at some level require an analysis of the potential crash risks they create, and the probable costs versus the benefits for taking the risk. As such, they appear to be united in that they all reflect calculated risk taking.

The Factor 1 behaviors also “impose” the presence of the experimental vehicle on other traffic, either by dictating travel speed through velocity, or minimizing physical boundaries between vehicles by following too closely or changing position when passing. Thus, they all appear to be united by an aggression or impatience component. This notion is supported by the relationship of Type A to vehicle speed and following distance. Thus, all of the related behaviors can be perceived as a socially acceptable way of acting out, with a minimum probability of receiving negative consequences (a traffic crash or driving fine) for doing so, and that such aggressive behavior can be performed relatively anonymously.

In other words, the present research provided the first objective evidence for the existence of a class of driving behaviors that are functionally related to risk taking. These behaviors appear to be united by an aggression component anchored by a behavior defined as vehicle speed. Thus, these findings also lend empirical support for extending problem behavior theory into the domain of driving. As presumed by problem behavior theory, the positive relationship among specific at-risk driving behaviors has implications for designing driver improvement interventions.

Practically, as suggested by response generalization theory, the present results indicate that it may be necessary to change the focus of driving interventions from taking a piecemeal approach to impact multiple driving behaviors to a comprehensive approach to influence a single target (speeding) anchoring a response class of aggressive driving. This knowledge could increase the practicality, cost effectiveness, and social validity of driver education programs and state-sanctioned remedial driving classes for drivers convicted of traffic violations. Specifically, results suggest that if one can increase the proportion of times a driver follows the speed limit, they may also maintain a safer following distance, increase the amount of time spent on-task, and as a result reduce the probability of traffic conflict. It thus becomes noteworthy that speeding was predicted by the Type A personality variable, and therefore these drivers may be worthy of special consideration for early intervention.

In Conclusion

The present research provides the first objective evidence for the relationship of at-risk driving behaviors including vehicle speed, vehicle following distance, and off-task behavior into a response class of behaviors presumed to increase a driver's risk for a vehicle crash. This provides evidence for response generalization theory. It was also demonstrated that a single behavior, turn-signal use, not included in the response class was used to compensate for increased crash risk among younger drivers. This provides evidence for risk compensation theory. Both findings were obtained without the confounds associated with assessing driving behavior via self-report, archival data, and avoided subject reactivity to the presence of an in-vehicle observer. Results also suggest that younger drivers and those who report exhibiting characteristics of the Type A personality may be at greatest risk for a vehicle crash. Finally, it is claimed that this information may be used to design more effective driving safety interventions, and target them to populations of drivers particularly at risk.

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APPENDIX A

Questionnaire Documents Completed by All Participants

DEMOGRAPHIC QUESTIONNAIRE

Instructions: Please answer the following questions to the best of your knowledge. Please be as honest as possible for the sake of the validity of this research.

1) What is your birth date? _____
Month / Day / Year

- 2) Are you:
 Male
 Female

- 3) Approximately how many miles do you drive per year? (Check only one)
 Under 2,000
 2,000 - 7,999
 8,000 - 12,999
 13,000 - 19,999
 20,000 or more

- 4) How often do you drive? (Check only one)
 At least once daily
 At least once weekly
 Less than once weekly

- 5) What type of automobile do you drive most often?
Make (e.g., Ford, Toyota): _____
Model (e.g., Escort, Celica): _____
Year: _____

- 6) What level of education have you reached? (Check only one)
 Some High School
 Completed High School / G.E.D.
 Some College
 College Degree
 Some Graduate Work
 Completed Masters Degree
 Completed Doctorate
 Post-Doctorate Work

RISK PERCEPTION SURVEY

Please answer the following questions to the best of your ability. Use the scale below to indicate how you feel about each question by placing the corresponding number in the bracket next to that question. If a question does not seem to apply directly to you, please place yourself in that situation and answer to the best of your ability.

Strongly Disagree	Disagree	Moderately Disagree	Neutral	Moderately Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

- [] 1) I am an impulsive person.
- [] 2) I have known people who pushed me so far that we came to blows.
- [] 3) I generally do and say things without stopping to think.
- [] 4) I welcome new and exciting experiences and sensations even if they are a little frightening and unconventional.
- [] 5) If somebody hits me first, I let him/her have it.
- [] 6) I have a fiery temper.
- [] 7) I would enjoy the sensation of skiing very fast down a high mountain slope.
- [] 8) I often buy things on impulse.
- [] 9) I get so 'carried away' by new ideas that I never think of possible snags.
- [] 10) I usually think carefully before doing anything.
- [] 11) I get angry when slowed down.
- [] 12) I feel furious when criticized.
- [] 13) I mostly speak before thinking things out.
- [] 14) I fly off the handle.
- [] 15) I am a hotheaded person.
- [] 16) I seldom strike back, even if someone hits me first.
- [] 17) I am quick-tempered
- [] 18) When I'm frustrated I feel like hitting something.
- [] 19) I often do things on the spur of the moment.
- [] 20) When mad, I say nasty things.
- [] 21) If I have to resort to physical violence to defend my rights, I will.
- [] 22) I would like to go scuba diving.
- [] 23) I often get involved in things that I later wish you could get out of.
- [] 24) I find it hard to understand people who risk their necks climbing mountains.
- [] 25) I sometimes like doing things that are a bit frightening.
- [] 26) I get infuriated when received a poor evaluation.

- 27) I would enjoy parachute jumping.
- 28) I quite enjoy taking risks.
- 29) I get annoyed when not given recognition.
- 30) I can think of no good reason for ever hitting anyone.
- 31) I would like to learn to fly an airplane.
- 32) If I have to resort to physical violence to defend my rights, I will.
- 33) I would enjoy water skiing.

Please answer the following questions to the best of your ability. Use the scale below to indicate how you feel about each question by placing the corresponding number in the bracket next to that question.

Very Likely	Likely	Somewhat Likely	Neutral	Somewhat Unlikely	Unlikely	Very Unlikely
1	2	3	4	5	6	7

How likely is it that YOU will experience each of the following events sometime during your life?

- 34) Having a heart attack
- 35) Developing a drug/alcohol addiction
- 36) Contracting a venereal disease
- 37) Getting a divorce
- 38) Attempting suicide
- 39) Being fired from a job
- 40) Getting lung cancer
- 41) Being sterile
- 42) Not finding a job for six months
- 43) Being injured in an auto accident

How likely is it that the AVERAGE INDIVIDUAL of your age and gender will experience each of the following events sometime during their life?

- 44) Having a heart attack
- 45) Developing a drug/alcohol addiction
- 46) Contracting a venereal disease
- 47) Getting a divorce
- 48) Attempting suicide
- 49) Being fired from a job
- 50) Getting lung cancer
- 51) Being sterile

- [] 52) Not finding a job for six months
- [] 53) Being injured in an auto accident

Please answer the following questions to the best of your ability. Answer YES or NO to indicate how you feel about each question. Place a Y or N in the bracket next to that question.

- [] 54) Do you believe that most problems will solve themselves if you just don't fool with them?
- [] 55) Do you believe that you can stop yourself from catching a cold?
- [] 56) Are some people just born lucky?
- [] 57) Most of the time, do you feel that getting good grades meant a great deal to you?
- [] 58) Are you often blamed for things that aren't your fault?
- [] 59) Do you believe that if somebody just studies hard enough, he or she can pass any subject?
- [] 60) Do you feel that most of the time it doesn't pay to try hard because things never turn out right anyway?
- [] 61) Do you feel that if things start out well in the morning, it's going to be a good day no matter what you do?
- [] 62) Do you feel that most of the time parents listen to what their children have to say?
- [] 63) Do you believe that wishing can make good things happen?
- [] 64) When you get punished, does it usually seem it's for no reason at all?
- [] 65) Most of the time, do you find it's hard to change a friend's opinion?
- [] 66) Do you believe that cheering more than luck helps a team to win?
- [] 67) Do you feel that it was nearly impossible to change your parents' minds about anything?
- [] 68) Do you believe that parents should allow children to make most of their own decisions?
- [] 69) Do you feel that when you do something wrong, there's very little you can do to make it right?
- [] 70) Do you believe that most people are just born good at sports?
- [] 71) Are most of the other people your age stronger than you?
- [] 72) Do you feel that one of the best ways to handle most problems is just not to think about them?
- [] 73) Do you feel that you have a lot of choice in deciding who your friends are?
- [] 74) If you find a four-leaf clover, do you believe that it might bring you good luck?
- [] 75) Do you often feel that whether or not you did your homework had much to do with the kind
of grades you got?
- [] 76) Do you feel that when a person your age is angry at you, there's little you can do to stop him or her?

- [] 77) Have you ever had a good luck charm?
- [] 78) Do you believe that whether or not people like you depends on how you act?
- [] 79) Did your parents usually help you if you asked them to?
- [] 81) Have you felt that when people are angry with you it is usually for no reason at all?
- [] 82) Most of the time, do you feel that you can change what might happen tomorrow by what you do today?
- [] 83) Do you believe that when bad things are going to happen, they are just going to happen no matter what you try to do to stop them?
- [] 84) Do you believe that people can get their own way if they just keep trying?
- [] 85) Most of the time, do you find it useless to try and get your own way at home?
- [] 86) Do you feel that when good things happen they happen because of hard work?
- [] 87) Do you feel that when somebody your age wants to be your enemy, there's little you can do to change matters?
- [] 88) Do you feel that it's easy to get friends to do what you want them to do?
- [] 89) Do you usually feel that you have little to say about what you get to eat at home?
- [] 90) Do you feel that when someone doesn't like you there's little you can do about it?
- [] 91) Did you usually feel that it was almost useless to try in school because most other children were just plain smarter than you?
- [] 92) Are you the kind of person that believes that planning ahead makes things turn out better?
- [] 93) Most of the time, do you feel that you have little to say about what your family decides to do?
- [] 94) Do you think it's better to be smart than to be lucky?

Please answer the following questions to the best of your ability. Circle the letter next to the answer that best indicates how YOU feel about each question.

- 95) Do you ever have trouble finding time to get you hair cut or styled?
 - A Never
 - B Occasionally
 - C Almost always
- 96) How often does school “stir you into action”?
 - A Less often than most people
 - B About average
 - C More than most people
- 97) Is your everyday life filled mostly by....
 - A Problems needing a solution?
 - B Challenges needing to be met?
 - C A rather predictable routine of events?
 - D Not enough things to keep me interested and busy?
- 98) When you are under pressure or stress, what do you usually do?

- A Do something about it immediately
 - B Plan carefully before taking any action
- 99) Ordinarily, how rapidly do you eat?
- A I'm usually the first one finished
 - B I eat a little faster than average
 - C I eat about the same speed as most people
 - D I eat more slowly than most people
- 100) Has your spouse or a friend ever told you that you eat too fast?
- A Yes, often
 - B Yes, once or twice
 - C No, never
- 101) How often do you find yourself doing more than one thing at a time, such as working while eating, reading while dressing, or figuring out problems while driving?
- A I do two things at once whenever practical
 - B I do this only when I'm short of time
 - C I rarely or never do more than one thing at a time
- 102) When you listen to someone talking, and this person takes too long to come to the point, how often do you feel like hurrying the person along?
- A Frequently
 - B Occasionally
 - C Almost never
- 103) How often do you actually "put words in the person's mouth" in order to speed things up?
- A Frequently
 - B Occasionally
 - C Almost never
- 104) If you tell your spouse or a friend that you will meet somewhere at a definite time, how often do you arrive late?
- A Once in awhile
 - B Rarely
 - C I am never late
- 105) How often do you find yourself hurrying to get to places even when there is plenty of time?
- A Frequently
 - B Occasionally
 - C Almost never
- 106) Suppose you are to meet someone at a public place (street corner, building lobby, restaurant) and the other person is already 10 minutes late. What will you do?
- A Sit and wait
 - B Walk about while waiting

- C Usually carry some reading paper or writing a paper so I can get something done while waiting
- 107) When you have to “wait in line” at a restaurant, store, or post office, what do you do?
- A Accept it calmly
 - B Feel impatient but not show it
 - C Feel so impatient that someone watching can tell I am restless
 - D Refuse to wait in line, and find ways to avoid such delays
- 108) When you play games with young children about 10 years old (or when you did in the past) how often do you purposely let them win?
- A Most of the time
 - B Half of the time
 - C Occasionally
 - D Never
- 109) When you were younger did most people consider you to be. . .
- A Definitely hard-driving and competitive?
 - B Probably hard-driving and competitive?
 - C Probably more relaxed and easygoing?
 - D Definitely more relaxed and easygoing?
- 110) Nowadays, do you consider yourself to be. . .
- A Definitely hard-driving and competitive?
 - B Probably hard-driving and competitive?
 - C Probably more relaxed and easygoing?
 - D Definitely more relaxed and easygoing?
- 111) Would your spouse (or closest friend) rate you as. . .
- A Definitely hard-driving and competitive?
 - B Probably hard-driving and competitive?
 - C Probably more relaxed and easygoing?
 - D Definitely more relaxed and easygoing?
- 112) Would your spouse (or closest friend) rate your general level of activity as. . .
- A Too slow – should be more active?
 - B About average – busy much of the time?
 - C Too active – should slow down?
- 113) Would people you know all agree that you take school too seriously?
- A Definitely yes
 - B Probably yes
 - C Probably no
 - D Definitely no
- 114) Would people you know well agree that you have less energy than most people?
- A Definitely yes
 - B Probably yes
 - C Probably no

- D** Definitely no
- 115)** Would people you know well agree that you tend to get irritated easily?
- A** Definitely yes
 - B** Probably yes
 - C** Probably no
 - D** Definitely no
- 116)** Would people you know well agree that you tend to do most things in a hurry?
- A** Definitely yes
 - B** Probably yes
 - C** Probably no
 - D** Definitely no
- 117)** Would people you know well agree that you enjoy a “contest” (competition) and try hard to win?
- A** Definitely yes
 - B** Probably yes
 - C** Probably no
 - D** Definitely no
- 118)** How was your temper when you were younger?
- A** Fiery and hard to control
 - B** Strong but controllable
 - C** No problem
 - D** I almost never get angry
- 119)** How is your temper nowadays?
- A** Fiery and hard to control
 - B** Strong but controllable
 - C** No problem
 - D** I almost never get angry
- 120)** When you are in the midst of doing something and someone interrupts you, how do you usually feel inside?
- A** I feel O.K. because I work better after an occasional break
 - B** I feel only mildly annoyed
 - C** I really feel irritated because most such interruptions are unnecessary
- 121)** How often are there deadlines in your courses?
- A** Daily or more often
 - B** Weekly
 - C** Monthly or less often
 - D** Never
- 122)** These deadlines usually carry...
- A** Minor pressure because they are routine in nature
 - B** Considerable pressure, since delay would upset my entire schedule
 - C** Deadlines never occur
- 123)** Do you ever set deadlines or quotas for yourself in courses or other things?

- A No
 - B Yes, but only occasionally
 - C Yes, once a week or more
- 124) When you have to work against a deadline, what is the quality of your work?
- A Better
 - B Worse
 - C The same (pressure makes no difference)
- 125) At school, do you ever keep two projects moving at the same time by shifting back and forth rapidly from one to the other?
- A No, Never
 - B Yes, but only in emergencies
 - C Yes, regularly
- 126) Do you maintain a regular study schedule during vacations such as Thanksgiving, Christmas, or Easter?
- A Yes
 - B No
 - C Sometimes
- 127) How often do you study materials related to your classes?
- A Rarely or never
 - B Once a week or less
 - C More than once a week
- 128) When you find yourself getting tired at school what do you usually do?
- A Slow down for a while until my strength comes back
 - B Keep pushing my self at the same pace in spite of the tiredness
- 129) When you are in a group, how often do the other people look to you for leadership?
- A Rarely
 - B About as often as they look to others
 - C More often than they look to others

For questions 130-134, compare yourself with the average student in your present position and mark the most accurate description.

- 130) In amount of effort put forth, I give. . .
- A Much more effort
 - B A little more effort
 - C A little less effort
 - D Much less effort
- 131) In sense of responsibility, I am. . .
- A Much more responsible
 - B A little more responsible
 - C A little less responsible
 - D Much less responsible
- 132) I find it necessary to hurry. . .

- A Much more of the time
- B A little more of the time
- C A little less of the time
- D Much less of the time

133) In being precise (careful and detailed), I am. . .

- A Much more precise
- B A little more precise
- C A little less precise
- D Much less precise

134) I approach life in general. . .

- A Much more seriously
- B A little more seriously
- C A little less seriously
- D Much less seriously

POST-DRIVE QUESTIONNAIRE

Instructions: Please read and answer the following questions regarding your driving behavior.

Do not consider your trips in the experimental vehicle when answering these questions.

- 1) In the last year, how many times have you driven a part of the route through downtown Blacksburg? ____
- 2) In the last year, how many times have you driven a part of the route on 460 west to Newport, VA? ____
- 3) Of the last 10 times you drove your car, how many times did you use your safety-belt? ____
- 4) Of the last 10 times you drove your car with a front seat passenger, how many times did you make sure he/she was buckled up? ____
- 5) Of the last 10 times you made a *right hand* turn at an intersection, how many times did you use your turn-signal? ____
- 6) Of the last 10 times you made a *left hand* turn at an intersection, how many times did you use your turn-signal? ____
- 7) Of the last 10 times you changed lanes, how many times did you use your turn-signal? ____

Appendix B
Instrumentation and Capabilities of the Smart Car (provided by the Center for Transportation
Research, Virginia Polytechnic Institute and State University, Blacksburg, VA)

Description of the Instrumented Vehicle

A 1995 Oldsmobile Aurora was used as the experimental vehicle for all participants. The instrumentation in the vehicle provided the means to unobtrusively collect, record, and reduce a number of data items, including measures of attention demand, measures of navigation performance, safety-related incidents, and subjective opinions of the participants.

Camera

There were four video camera images recorded. The forward-view camera served to collect relevant data from the forward scene (e.g., traffic density, signs and markers, and headway). The driver view camera recorded the driver's eye glance information and the driver's reactions. In addition, two lane-tracking cameras recorded highway pavement markings.

Multiplexer and PC-VCR

A quad-multiplexer was used to integrate the four camera views and place a time stamp onto a single videotape record. A PC-VCR received a time stamp from the data collection computer and displayed the time stamp continuously on the multiplexed view of the videotaped record. In addition, the PC-VCR had the capability to read and mark event data provided by the data collection computer and perform high-speed searches for event marks. The PC-VCR operated in an S-VHS format so that each multiplexed camera view would have 200 horizontal lines of resolution.

Data Collection Computer

The data collection computer provided reliable data collection, manipulation, and hard drive storage under conditions present in a vehicle environment. The computer had a 16-channel analog-to-digital capability, standard QWERTY keyboard, and a 9-inch diagonal color monitor. Computer memory and processing capabilities included: 12 megabytes RAM, a 1.2 gigabyte hard drive, and a Pentium processor.

Sensors

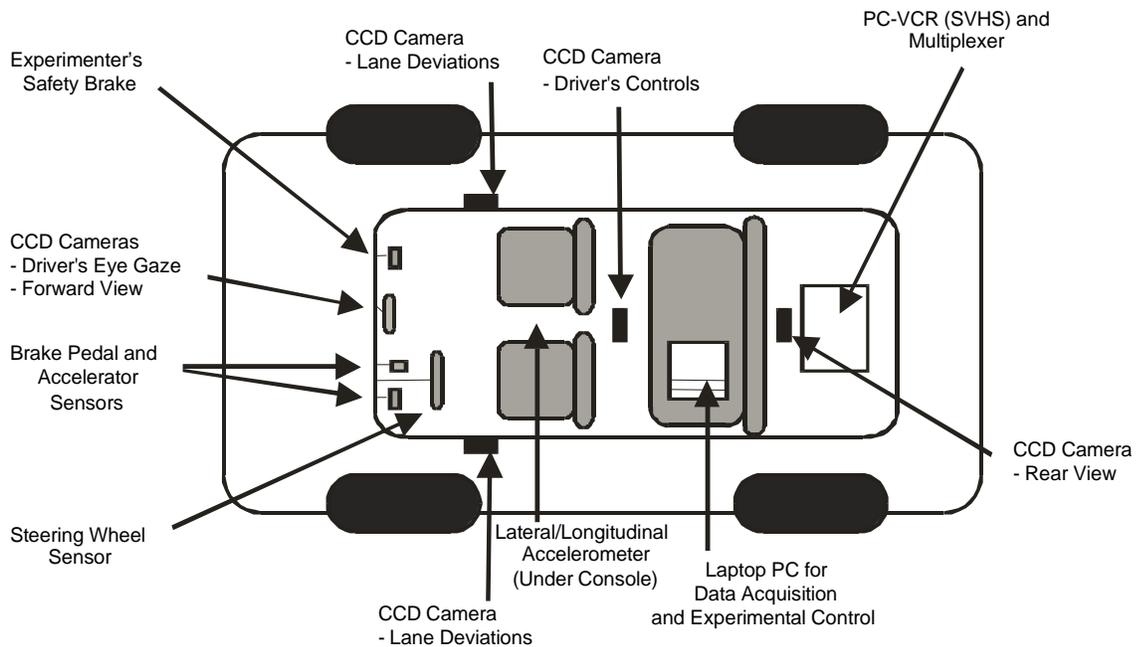
The steering wheel, speedometer, accelerator, and brake were instrumented with sensors that transmitted information about position of the respective control devices. The steering wheel sensor provided steering position data accurate to within +/- 1 degree. The brake and accelerator

sensors provided brake position to within ± 0.1 inch (in). An accelerometer provided acceleration readings in the lateral and longitudinal planes of the vehicle. The accelerometers provided values for vehicle acceleration and deceleration up to and including hard braking behavior, as well as intense turning. These sensors provided signals that were read by the A/D interface at a rate of 10 times per second.

Video/Sensor/Experimenter Control Panel Interface

A custom interface was used to integrate the data from the experimenter control panel, driving performance sensors, event flagger, and speedometer with the data collection computer. In addition, the interface provided a means to accurately read and log the time stamp from the PC-VCR to an accuracy of ± 0.1 second. The time stamp was coded such that a precise location could be synchronized from any of the videotaped records to the computer data record for post-test laboratory reduction and file integration.

Diagram of Instrumented Vehicle



CURRICULUM VITAE

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A. PERSONAL HISTORY:

D.O.B. 03-21-64
New Haven, CT

B. EDUCATIONAL HISTORY:

1. Vanderbilt University, Nashville, TN. 1982
2. Berklee College of Music, Boston, MA 1984-1985

Major: Music Performance, Theory

3. University of Florida, Gainesville, FL

Major: Music in combination with Psychology
Degree: B.M. with Honors 1992

4. Virginia Polytechnic Institute and State University

Major: Applied Experimental Psychology

Degree: M.S. 1995

Masters Thesis:

*Effects of External Contingencies on an Actively Caring Behavior: A Field
Test of Intrinsic Motivation Theory*

Advisor: E. Scott Geller

Ph.D. expected 5/99

Dissertation:

*Identifying Functional Relationships In Driver Risk Taking:
An Intelligent Transportation Assessment of Problem Behavior and Driving
Style*

Advisor: E. Scott Geller

C. HONORS:

Membership in Golden Key National Honor Society
Membership in Phi Kappa Phi National Honor Society

D. PROFESSIONAL AFFILIATIONS:

Association for Behavior Analysis
Florida Association for Behavior Analysis
Southeastern Psychological Association
Virginia Psychological Association
Virginia Academy of Science

E. TEACHING EXPERIENCE:

Fall 1993-Fall 1994, Fall 1996:
Introduction to Psychology: Lab/discussion instructor
Spring 1994-Present:
Research Methods in Psychology: Teaching Assistant
Fall 1994:
Developmental Psychology: Graduate Teaching Assistant
Spring 1995:
Lab in Advanced Social Psychology: Instructor
Fall 1995:
Introduction to Psychology: Lecture Teaching Assistant
Spring 1996:
History and Systems of Psychology: Teaching Assistant
Spring 1997:
Introduction to Psychology: Administrative Assistant
Summer 1998:
Principles of Psychological Research: Instructor
Fall 1998, Spring 1999:
Introduction to Psychology: Guest Lecturer
Spring 1999
Principles of Psychological Research: Instructor

F. PROFESSIONAL POSITIONS

8/93 to Present: Research Associate/Senior Research Associate, Center for Applied Behavior Systems, Department of Psychology, Virginia Tech, Blacksburg, VA.

6/96 to Present: More than 100 hours of experience presenting occupational safety training and workshops.

Professional Positions (continued)

10/97 to Present: Research design and implementation consultant, Center for Transportation Research, Department of Industrial Systems Engineering, Virginia Tech, Blacksburg, VA.

4/98 to Present: National Highway Traffic Safety Administration Safe Communities consultant, West Virginia Department of Motor Vehicles Highway Safety Program

Document Reviews

1997 to 1998: Reviewed manuscripts for: *Journal of Organizational Behavior Management and Environment and Behavior*

1998: Guest reviewer for *Journal of Applied Behavior Analysis*

1998: Reviewed book chapters for Brooks/Cole Publishers

G. GRANT WORK

2/96 to 11/98: Co-author of and Senior Research Associate on a two-year grant from the National Institute for Occupational Safety & Health (grant # 1 R01 OH03374-01)

Title: *Critical Success Factors for Behavior-Based Safety*

PI: E. Scott Geller

Amount funded: **\$291,651; two years**

6/96 to present: Research Assistant on a two-year grant from the National Institute for Occupational Safety & Health (grant # 1 R01 OH03397-01)

Title: *Industry-Based Interventions to Increase Safe Driving*

PI: E. Scott Geller

Amount funded: **\$344,315; two years**

8/97 to 5/98: Project coordinator on a grant from the National Highway Traffic Safety Administration and Virginia Department of Motor Vehicles (project # 208-11-11OC-053-842480-1) to design, implement, and evaluate a community-wide intervention to increase pedestrian safety.

PI: E. Scott Geller

Amount funded: **\$80,000; one year**

10/97 to present: Project manager and research design consultant on a grant from the Federal Highway Administration-Research Centers of Excellence (project# 425341)

Title: *Development of Near-Miss Detection Methodologies for the Prediction of Driving Safety*

PI: Vicki L. Neale

Amount Funded: **\$61,227; one year**

Grant Submissions/Proposals

2/98: Author of Grant Proposal (# R49-CCR-315448) to the Centers for Disease Control and Prevention entitled *Psychology and young drivers: New tools for road safety*.

PI: E. Scott Geller

Status: Priority Score = 235, Amount requested: \$699,704; 3 years

2/98 Co-author of Grant Continuation Proposal (#1 R01 OH03374-01) to the National Institute for Occupational Safety and Health entitled: *Critical Success Factors for Behavior-Based Safety*.

PI: E. Scott Geller

11/98 Author of Grant Continuation Proposal resubmission (# 2 R01 OH03397-03) *Industry-Based Intervention to Increase Safe Driving*

PI: E. Scott Geller

Status: Submitted for review. Amount requested: \$420,002; two years

H. SCHOLARSHIP:

Book Chapters

Boyce, T. E., DePasquale, J. P., Pettinger, C. P., & Williams, J. H. (1998). A process blueprint: Timeline and phases of implementation. In E. S. Geller *Practical behavior-based safety: Step by step methods to improve your workplace* (2nd ed.). Neenah, WI: J. J. Keller & Associates Inc.

Research Articles

Geller, E. S., Boyce, T. E., Williams, J. H., Pettinger, C. B., DePasquale, J. P., & Clarke, S. W. (1998). Researching behavior-based safety: A multi-method assessment and evaluation. Published in the *Proceedings of the American Society of Safety Engineers* (pp. 537-559), Seattle, WA.

Boyce, T. E. & Geller, E. S. (under review). Occupational safety and applied behavior analysis: The challenge of programming response maintenance. *Behavior and Social Issues*.

Boyce, T. E., & Geller, E. S. (under review). Attempts to increase vehicle safety-belt use among industry workers: What can we learn from our failures? *Journal of Organizational Behavior Management*.

Boyce, T. E., & Geller, E. S. (under review). A communitywide intervention to increase pedestrian safety: Guidelines for institutionalizing large-scale behavior change. *Journal of Applied Behavior Analysis*.

Research Articles (cont.)

Boyce, T. E. & Geller, E. S. (under review). Encouraging college students to reinforce prosocial behavior: Effects of direct versus indirect rewards. *Journal of Applied Behavior Analysis*.

Pettinger, C. B., Boyce, T. E., & Geller, E. S. (under review). Behavior-based safety and employee involvement: Differential effects during training versus implementation. *Journal of Safety Research*.

Technical Reports

Glindemann, K. E., Geller, E. S., Fortney, J. N., Pettinger Jr., C. B., DePasquale, J. P., Boyce, T. E., & Clarke, S. W. (1996). *Determinants of alcohol intoxication and social responsibility for DUI-risk at university parties*. Final report submitted to the Alcoholic Beverage Medical Research Foundation.

Geller, E. S., DePasquale, J. P., Williams, J. H., Clarke, S. W. & Boyce, T. E., (1997). *Searching for metrics to assess safety achievement*. Final report submitted to the Monsanto Corporation.

Boyce, T. E., & Neale, V. L. (1998). *Developing near-miss methodologies for the prediction of driving safety*. Final report submitted to the Federal Highway Administration *Research Centers for Excellence*.

Geller, E. S., Boyce, T. E., DePasquale, J. P., Pettinger, C. B., & Williams J. H. (1998). *Critical Success Factors for Behavior-Based Safety*. Final report submitted to the National Institute for Occupational Safety and Health.

Training Manuals

DePasquale, J. P., Pettinger, C. B., Boyce, T. E., Williams, J. H., & Geller, E. S. (June, 1996). *Achieving a total safety culture through employee involvement*. All employee training manual developed for the National Institute for Occupational Safety & Health (for Grant # 1 R01 OH03374-01).

Pettinger, C. B., Boyce, T. E., DePasquale, J. P., Williams, J. H., & E. S. Geller (June, 1996). *Achieving a total safety culture through employee involvement*. Two-day facilitator training manual developed for the National Institute for Occupational Safety & Health (for Grant # 1 R01 OH03374-01).

Boyce, T. E., & Pettinger, C. B. (April, 1997). *Implementing a National Safe Community Agenda for the Promotion of Traffic Safety*. One day workshop developed for the Highway Safety Program of the West Virginia Department of Motor Vehicles (private contract).

Published Abstracts

Boyce, T. E., Fortney, J. N., Rashleigh, C. M., & Newell, M. (1994). A behavioral assessment of the risk compensation hypothesis. In the *Virginia Journal of Science*.

Ramsby, K. L., Maddox, K. L., Jones, III, J. P., Spisak, J., Boyce, T. E. (1994). How self-esteem affects the amount of alcohol university students consume: A field study. In the *Virginia Journal of Science*.

Presentations

Jones, III, J. P., Dorsey, T., Boyce, T. E., Delinocci, C., & Saunders, C. (April, 1994). *An examination of party types: Do students drink more at keg parties or BYOB parties?* Paper presented at the annual meeting of the Virginia Psychological Association, Charlottesville, VA.

Boyce, T. E., Pettinger, Jr., C. B., Maddox, K. L., & Geller, E. S. (May, 1994). *The effects of establishing conditions on risk-taking behavior.* Paper presented at the 20th annual convention of the Association for Behavior Analysis, Atlanta, GA.

Rashleigh, C. M., Ammons, J., Boyce, T. E., Heath, J., & Saunders, C. (May, 1994). *Assessing the validity and reliability of a simple performance task for assessing blood alcohol concentration at parties: The "star tracing" task.* Poster presented at the 20th annual convention of the Association for Behavior Analysis, Atlanta, GA.

Maddox, K. L., Wetzel, B. R., Heath, J. M., & Boyce, T. E. (September, 1994). *The use of social responsibility stations at a fraternity party to influence levels of alcohol consumption.* Paper presented at the 14th annual convention of the Florida Association for Behavior Analysis, Orlando, FL.

Boyce, T. E., Fortney, J. N., Wetzel, B. R., Plemmons, R., & Brown, R. S. (January, 1995). *How persuasive is a Kohnman: The effects of Alfie Kohn's "Punished by Rewards."* Poster presented at the 5th semi-annual convention of the Florida Association for Behavior Analysis/Organizational Behavior Management Network, Clearwater Beach, FL.

Pettinger, Jr., C. B., Fortney, J. N., Boyce, T. E., & Haskell, I. O. (January, 1995). *Activator versus consequence strategies to encourage "buckling-up" behaviors.* Poster presented at the 5th semi-annual convention of the Florida Association for Behavior Analysis/Organizational Behavior Management Network, Clearwater Beach, FL.

Boyce, T. E., Fortney, J., Plemmons, R., Brown, R. C., & Buermeyer, C. M. (May, 1995). *Effects of extrinsic reinforcers on an actively caring behavior: A test of intrinsic motivation.* Paper presented at the 21st annual convention of the Association for Behavior Analysis, Washington, D.C.

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