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Comparing Real-World Behaviors of Drivers With High versus Low Rates of Crashes and Near-Crashes

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16. Abstract

In-depth analyses were conducted examining both quantitative and qualitative differences between drivers who were involved in a high number of crashes and near-crashes (mean of 1,438.1 per MVMT) versus drivers who were involved in far fewer crashes and near-crashes (mean of 195.4 per MVMT). These two groups of drivers were labeled as safe and unsafe, respectively.

Primary findings indicated that unsafe drivers exhibited more hard deceleration, acceleration, and swerve maneuvers during baseline driving than did the safe drivers. Results also indicated that risky driving behaviors such as traveling at inappropriate speeds and improper braking may increase drivers' relative crash risk above that of normal driving. Exploratory analyses were also conducted to assess engagement in risky driving behavior during a variety of environmental and roadway conditions. The results from this analysis indicated that all drivers were willing to engage in risky behaviors during moderately high traffic densities when their speed was impeded than during very low traffic densities when speed selection was not impeded. The results from analyses with questionnaire data also indicated that seven questionnaire/survey/performance-based tests demonstrated that safe drivers could be differentiated from the unsafe drivers. These types of tests have never been compared to actual crash/near-crash involvement prior to these analyses. The results presented in this report are the first to evaluate general driving behavior in relation to the driver's actual crash/near-crash involvement during one year of driving. The results point to a variety of driving behaviors that are associated with higher crash risk. This is important information as it supports the development of driver monitoring systems for teens or older drivers in that it provides further evidence that specific kinematic and driver behaviors can potentially be monitored, and if feedback reduced these behaviors, those drivers would lower their risk of being involved in crashes or near-crash.

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EXECUTIVE SUMMARY

Individual variability among drivers has long been an interest in transportation research and industry. The National Highway Traffic Safety Administration crash rate statistics have long cited wide variability in crash involvement based upon driver age, gender, geographic locations, and other factors (NHTSA Traffic Safety Facts, 2002). Younger and older drivers are generally over-represented in crashes than are middle-aged drivers. Licensed male drivers tend to be over-represented in crashes as compared to licensed female drivers. Also, urban areas generally have higher crash rates than do rural areas. Given that over 40,000 people die on U.S. highways each year, these high-risk categories of drivers are of particular interest to government and transportation safety professionals.

Risky driving behaviors (speeding, tailgating, etc.) have also been well-researched in the transportation community (Boyce & Geller, 2002; Evans & Wasielewski, 1984). Previous studies have used a variety of methods to assess both risky driving habits and crash involvement. Some of these methods include traffic observation techniques, Department of Motor Vehicle records, self-reported crashes or traffic violations, and driving performance in a simulator, test-track, or instrumented vehicle. There are several limitations with this type of research. Neither crash involvement nor engaging in risky driving behavior is accurately reported by drivers. Participants' ability to remember or assess the frequency of these behaviors over periods of time is not a reliable estimate of either crash involvement or risky driving behavior engagement. Drivers may either be too embarrassed or fear their insurance rates will go up if they admit to being in minor collisions. Drivers also may not assess their driving habits as particularly risky if they have not been involved in any crashes.

The 100-Car Naturalistic Driving Study (Dingus et al., 2006) database provides a unique opportunity to compare those drivers who were excessively involved in crashes/near-crashes with those drivers who were not involved in any type of traffic conflict. The drivers in the 100-Car Study demonstrated high variability in driving performance and crash involvement. It should be noted that a crash in the 100-Car Study was operationally defined as any physical contact with a vehicle, object, or pedestrian, which also included high-*g* tire strikes (hitting a curb while traveling over 35 mph). The results indicated that 7 percent of the drivers were not involved in any crashes, near-crashes, or incidents, while the worst 7 percent of drivers were involved in at least three crashes or minor collisions within a 12-month data collection period.

Four research objectives were analyzed in this report.

Objective One: (1) Determine the differences in demographic data, test battery results, and performance-based measures between safe and unsafe drivers. (2) Analyze the crash rate involvement and violations prior to the study for safe and unsafe drivers, noting that drivers may not be honest in reporting their driving history information.

Drivers were categorized into the "safe" and "unsafe" categories as well as safe, moderately safe, and unsafe categories based on their crash/near-crash involvement rates per mile traveled. The results of these analyses indicated that seven of the scores from the survey, questionnaire, and performance-based tests demonstrated that unsafe and safe drivers could be differentiated.

Driver age and experience were significant in that unsafe drivers tended to be younger and have less driving experience than safe drivers. Two of the subscales from the Dula Dangerous Driving Inventory (Dula & Ballard, 2003) demonstrated statistical differences when the drivers were divided into three levels of crash/near-crash involvement. Only one of the NEO Five-Factor Inventory Scales demonstrated statistical differences between drivers with differing crash/near-crash involvement.

A regression analysis was conducted to determine if any of the tests with significant results could be used to predict driver involvement in crashes and near-crashes. The results indicated that both years of driving experience and the NEO-FFI Agreeableness subscale demonstrated some predictive abilities when considering involvement in crashes and near-crashes. The results also suggest that there is a slight inverse relationship: as a driver's experience or Agreeableness score increases, the probability of involvement in high numbers of crashes and near-crashes decreases. This regression equation did not demonstrate a strong relationship, and some caution is urged if using these scales to predict high involvement in crashes and near-crashes.

Objective Two: Determine the relationship between various risky driving behaviors and the presence of environmental conditions among the safe, moderately safe, and unsafe drivers.

Using a modified version of the Virginia State Police accident report Form 16, groups of risky driving behaviors were recorded for each event. The results of this analysis indicated that hard braking, driving inattention, and driving in close proximity to other vehicles were the three most prevalent types of risky behavior among drivers. Other risky driving behaviors were analyzed, but demonstrated low frequency of occurrence; therefore, it was decided to focus this report on only the top three risky driving behaviors.

Unsafe and moderately safe drivers engaged in all three risky driving behaviors far more frequently than the safe drivers, both in general and during differing environmental conditions. Safe drivers engaged in risky behaviors during moderate traffic flows relative to other conditions; however, the frequency was still lower relative to the unsafe and moderately safe driver groups.

Seat belt use was observed, on average, for 79 percent of all drivers, which is similar to the national average (Glassbrenner, 2005). However, the results showed a 10-percent decrease in seat belt compliance for the unsafe drivers (mean age of 27) relative to the safe drivers (who were significantly older with a mean age of 39); this is most likely an artifact of age.

Objective Three: Analyze potential patterns in the driving performance-based measures among the safe, moderately safe, and unsafe drivers.

This analysis is the first investigating driving performance differences between those drivers who are excessively involved in crashes/near-crashes and those drivers who were rarely, if ever, involved in crashes during a year of data collection. Crash/near-crash involvement and normal driving were both collected over the same period. The results of this analysis indicate that during baseline driving, unsafe drivers turned their vehicles at greater than 0.30 *g*, decelerated greater than 0.30 *g*, and swerved greater than 3 ft/s significantly more frequently than either the moderately safe or safe drivers. These behaviors are potentially leading to the unsafe drivers' increased rates of crash and near-crash involvement.

Objective Four: Analyze drivers' involvement in crashes, near-crashes, and incidents and the drivers' behaviors that contributed to their involvement.

The above results suggest that risky driving behaviors such as improper braking and inappropriate speeds increase drivers' relative crash risk above that of normal driving. While relative risk calculations were not conducted, the high frequency of occurrence in association with crashes and near-crashes and the low frequency of occurrence during baseline epochs would indicate that these relative crash risks are higher than for normal driving. This corroborates results found in Klauer, Sudweeks, Hickman, and Neale (2006).

The results investigating the presence of multiple risky behaviors indicated that engagement in multiple risky behaviors is present for both crashes and near-crashes, whereas only one or two risky behaviors are present for incidents, and zero or one risky behavior for baselines. Given that the number of risky behaviors present for baseline epochs is vastly different from crashes and near-crashes, engaging in multiple risky behaviors may increase crash risk.

Seat belt use results for events and baseline epochs indicated an increasing trend with event severity, in that observed seat belt use was approximately 50 percent for crashes and increased up to 78 percent for baseline epochs (Figure 1). This may be due to the fact that younger driver seat belt compliance is generally lower than for older adults, and that younger drivers were excessively involved in crashes and near-crashes by a factor of four for some age groups. Unfortunately, it also means that the drivers who are at highest risk of crash involvement are also the drivers least likely to be wearing seat belts.

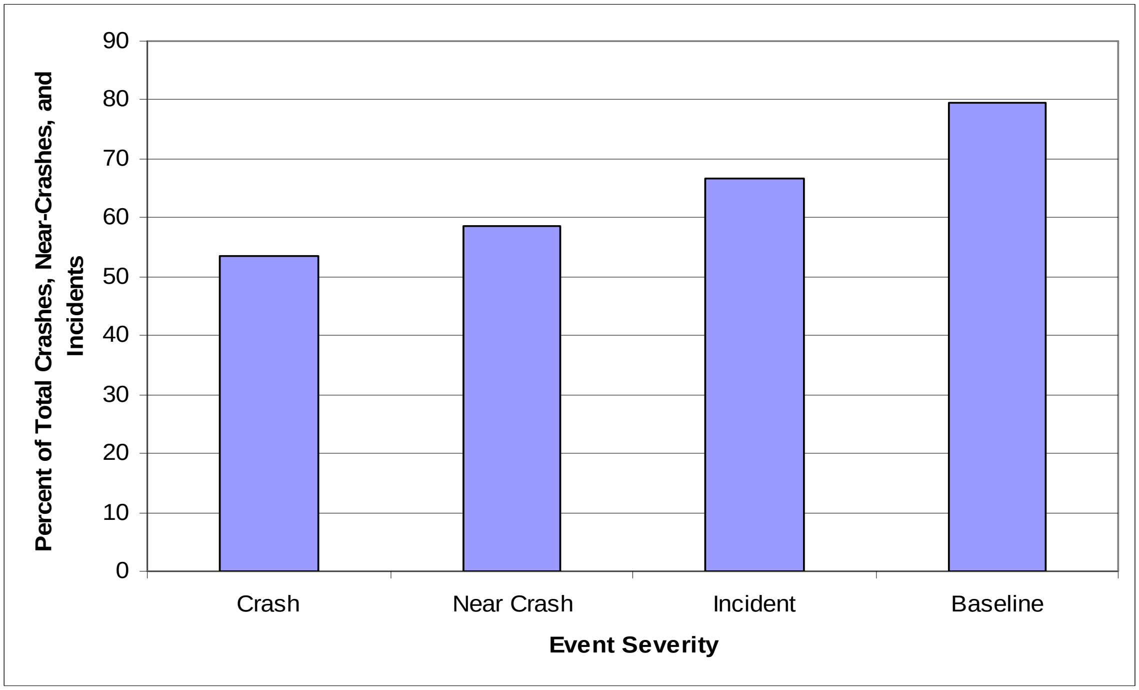

Figure 1. Percentage of Drivers Wearing Seat Belts for Event Severities

GLOSSARY OF TERMS AND ACRONYMS

ANOVA – Analysis of Variance

Additional Driver – Family or friends of the primary driver who drove the subject's vehicle and were not involved with the in-processing.

Associative Factor – Any environmental or vehicular factor where direct causation to crashes, near-crashes, or incidents is not possible to attain but correlation may be determined.

At-Fault – If a behavior is observed by the subject or the driver of another vehicle that contributes to the occurrence of an event, that driver is deemed to be at-fault. If both drivers are observed exhibiting behaviors that contribute to the occurrence of the event, then the event is deemed to have partial fault among the drivers involved.

Backing Crash – A crash that occurs while the driver's vehicle is in reverse gear.

Chase Vehicle – Vehicle designated for locating (through GPS or other means) and downloading data from subject vehicles.

Contributing Factor – Any circumstance that leads up to or affects the outcome of the event. This term encompasses driver proficiency, willful behavior, roadway infrastructure, distraction, vehicle contributing factors, and visual obstructions.

Crash – Any contact with an object, either moving or fixed, at any speed in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, miscellaneous objects on or off of the roadway, pedestrians, cyclists, or animals.

Crash-Relevant Event – Any circumstance that requires a crash avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive maneuver (as defined above), but greater in severity than a "normal maneuver" to avoid a crash. A crash avoidance response can include braking, steering, accelerating, or any combination of control inputs. A "normal maneuver" for the subject vehicle is defined as a control input that falls outside of the 95 percent confidence limit for control input as measured for the same subject. *Note that crash-relevant conflicts and proximity conflicts were combined to form "incidents" as used in this report.*

Conflict Type – All crashes, near-crashes, crash-relevant conflicts, and proximity conflicts were categorized based on the initial conflict that led to the crash that occurred or would have occurred in the case of near-crashes and incidents (crash-relevant conflicts and proximity conflicts were combined to form *incidents*, as used in this report). There were 20 types of conflicts used that are as follows: conflict with lead vehicle, following vehicle, oncoming traffic, vehicle in adjacent lane, merging vehicle, vehicle turning across subject vehicle path (same direction), vehicle turning across subject vehicle path (opposite direction), vehicle turning into subject vehicle path (same direction), vehicle turning into subject vehicle path (opposite direction), vehicle moving across subject vehicle path (through intersection), parked vehicle, pedestrian, pedalcyclist, animal, obstacle/object in roadway, single-vehicle conflict, other, no known conflict, unknown conflict. This list was primarily made up of National Automotive Sampling System: General Estimates System (NASS GES) Accident Types.

DAS – Data Acquisition System

Data Reduction – Process used by which trained Virginia Tech Transportation Institute (VTTI) employees reviewed segments of driving video and recorded a taxonomy of variables that provided information regarding the sequence of events leading up to the crash, near-crash, incident, environmental variables, roadway variables, and driver behavior variables.

Driver Impairment – The driver's behavior, judgment or driving ability is altered or hindered. Includes fatigue, use of drugs or alcohol, illness, lack of or incorrect use of medication, or disability.

Driver Proficiency – Whether the individual's driving skills, abilities, or knowledge are inadequate. This specifically refers to whether the driver appeared to be aware of specific traffic laws (i.e., no U-turn), whether the driver was not competent enough to safely perform a driving maneuver (i.e., check for traffic before pulling out on a roadway), was unaware of the vehicle's turning radius, or performed driving maneuvers under the incorrect assumption that it was safe, (i.e., drives over a concrete median).

Driver-Related Inattention to the Forward Roadway – Inattention due to a necessary and acceptable driving task where the subject is required to shift attention away from the forward roadway (e.g., checking blind spots, center mirror, or instrument panel).

Driver Reaction – The evasive maneuver performed in response to the precipitating event.

Driver Seat Belt Use – Variable indicating if the subject is wearing a seat belt during an event.

EDR – Electronic Data Recorder

Epoch – Typically, a 90-second period of time around one or more triggers in the data; can include one or more events.

Events – a term referring to all crashes, near-crashes, and incidents. The "event" begins at the onset of the precipitating factor and ends after the evasive maneuver.

Event Nature – Classification of the type of conflict occurring in the event (e.g., conflict with lead vehicle, conflict with vehicle in adjacent lane).

Event Severity – Classification of the level of harm or damage resulting from an event. The five levels were crash, near-crash, crash-relevant, proximity, non-conflict.

FARS – Fatality Analysis Reporting System

FOV – Field of View

FV – Following Vehicle

GPS – Global Positioning System **–** used by data reductionists to locate participant vehicle for information on an event.

Improper Braking – The subject brakes suddenly or in an improper manner that could put the subject or other vehicles at risk (late braking, hard braking).

Inattention Event – Any event where fatigue, driver-related inattention to the forward roadway, driver secondary tasks, or non-specific eyeglance away from the forward roadway were identified as contributing factors to the event.

Incident – Encompasses the event severities of crash-relevant conflicts and proximity-conflicts.

IVI – Intelligent Vehicle Initiative

IR LEDs – Infrared Light-Emitting Diodes

Invalid Trigger – Any instance where a pre-specified signature in the driving performance data stream is observed but no safety-relevant event is present.

LV – Lead Vehicle

MVMT – Million Vehicle Miles Traveled

NHTSA – National Highway Traffic Safety Administration

Naturalistic – Unobtrusive observation; observation of behavior taking place in its natural setting.

Near-Crash – Any circumstance that requires a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal in order to avoid a crash. A rapid, evasive maneuver is defined as steering, braking, or accelerating, or any combination of control inputs that approaches the limits of the vehicle capabilities.

Non-Conflict – Any incident that increases the level of risk associated with driving, but does not result in a crash, near-crash, or incident as defined above. Examples include driver control error without proximal hazards being present, driver judgment error such as unsafe tailgating or excessive speed, or cases in which drivers are visually distracted to an unsafe level.

Non-Subject Conflict – Any incident that gets captured on video (crash-relevant, near-crash, or crash) that does not involve the subject driver. Labeled as a non-subject conflict but data reduction was not completed.

Onset of Conflict – Sync number designated to identify the beginning of a conflict; also known as the beginning of the precipitating factor.

ORD – Observer Rating of Drowsiness; measured on a scale from 0 to 100 in increasing severity of drowsiness. Based on Wierwille and Ellsworth, 1994.

Precipitating Factor – The driver behavior or state of the environment that initiated the crash, near-crash, or incident and the subsequent sequence of actions that result in an incident, near-crash, or crash.

Primary Driver –The recruited participant designated as the main the driver of his/her own vehicle or the leased vehicle

Proximity Event – Any circumstance resulting in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the drivers, pedestrians, cyclists or animals, there is no avoidance maneuver or response. Extraordinarily close proximity is defined as a case where the absence of an avoidance maneuver or response is inappropriate for the driving circumstances (including speed, sight distance, etc.). *Note that crash-relevant conflicts and proximity conflicts were combined to form "incidents" as used in this report.*

Pre-Incident Maneuver – The maneuver that the driver was performing immediately prior to an event.

Precipitating Factor –The action of a driver that begins the chain of events leading up to a crash, near-crash, or incident. For example, for a rear-end striking collision, the precipitating factor most likely would be "lead vehicle begins braking" or "lead vehicle brake lights illuminate."

Secondary Task – Task, unrelated to driving, which requires drivers to divert attention from the driving task (e.g., talking on a cell phone, talking to passengers, eating, etc.).

Rear-End Striking – Refers to the subject vehicle striking a lead vehicle.

Rear-End Struck - Refers to the subject vehicle being struck by a following vehicle.

Risky Driving Behavior - When a driver engages in any one or multiple behaviors listed in the "driver behavior" variable, the driver is said to be engaging in risky driving. These behaviors are listed in the Data Reduction Variable list in Appendix C.

Sideswipe – Refers to either a vehicle in the adjacent lane changing lanes into the subject vehicle or the subject vehicle changing lanes into a vehicle in the adjacent lane.

SUV – Sport Utility Vehicle

SV – Subject Vehicle

Trigger/Trigger Criteria – A signature in the data stream that, when exceeded, results in 90 s of video and corresponding driving performance data being copied and saved to a database (60 s prior and 30 s after the data exceedance). Trained data reductionists assess these segments of video and driving performance data to determine whether or not this segment of data contains a safety-relevant conflict (i.e., crash, near-crash, or incident). Examples of triggers include a driver braking at 0.76 *g* longitudinal deceleration or swerving around an obstacle with 0.8 *g* lateral acceleration.

U.S. DOT – United States Department of Transportation

Valid Event or Valid Trigger – Those events where a specific signature in the data stream was identified, viewed by a data reductionist, and deemed to contain a safety-relevant conflict. Data reductionists record all relevant variables and store this data in the 100-Car Database.

Vehicle Run-Off-Road – Describes a situation where the subject vehicle departs the roadway.

VDOT – Virginia Department of Transportation

Virginia Tech Fleet Services – An extension of the Virginia Tech Office of Transportation.

VTTI – Virginia Tech Transportation Institute

Visual Obstruction – This variable refers to glare, weather, or an object obstructing the view of the driver that influences the event in any way.

Willful Behavior – The driver knowingly and purposefully drives in an unsafe or inappropriate manner. Willful behavior includes: aggressive driving, purposeful violation of traffic laws, and use of vehicle for improper purposes (e.g., intimidation).

Yaw Rate – The data collected by the data acquisition system gyro indicating rate of rotation around the vertical axis.

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BACKGROUND

Individual variability among drivers has long been of interest in transportation research and industry. United States Department of Transportation crash rate statistics have long cited large variability in crash involvement based on driver age, gender, and geographic location, among other factors (NHTSA, Traffic Safety Facts, 2002). Younger and older drivers are generally over-represented in crashes as compared to middle-aged drivers. Males tend to be over-represented in crashes as opposed to females. Urban areas generally have a higher crash rate than do rural areas. Given that over 40,000 people die on U.S. highways each year, these high-risk categories of drivers are of particular interest to government and transportation safety professionals.

Risky driving behaviors (speeding, tailgating, etc.) have also been well researched in the transportation community (Boyce & Geller, 2002; Evans & Wasielewski, 1984). Previous studies have used a variety of methods to assess both risky driving habits and crash involvement. These methods have included traffic observation, analysis of Department of Motor Vehicles records, self-reporting of crashes or traffic violations, and examination of driving performance in a simulator, test-track, or instrumented vehicle. There are several problems with this type of research. Neither crash involvement nor the frequency of willingness to engage in risky driving behavior is commonly self-reported. Participants' ability to remember or assess the frequency of these behaviors over specified periods of time do not provide reliable estimates of either crash involvement or risky driving behaviors. Drivers may either be embarrassed or afraid that their insurance rates will go up if they admit to being in minor collisions. Drivers may also not assess their driving habits as particularly risky if they have never been involved in any crashes.

The 100-Car Study database provides a unique opportunity to compare drivers who were excessively involved in crashes with those who were not involved in any type of traffic conflict. The drivers in the 100-Car Study demonstrated high variability in driving performance and crash involvement. It should be noted that crashes were operationally defined in the 100-Car Study as any physical contact with a vehicle, object, or pedestrian, which also includes high-*g* tire strikes (e.g., hitting a curb while traveling over 35 mph). After data was collected, it was found that 7 percent of the drivers were not involved in any crashes, near-crashes, or incidents, while the worst 7 percent were involved in at least three crashes or minor collisions within a 12-month data collection period. The following analyses assessed driving performance and risky driving behaviors during crashes, near-crashes, and incidents, as well as during periods of baseline driving, to answer the following research objectives:

> Objective One: Determine the differences in demographic data, test battery results, and performance-based measures between safe and unsafe drivers. Analyze the crash rate involvement and violations prior to the study for these safe and unsafe drivers, noting that drivers may not be honest in reporting their driving history information.

Objective Two: Determine the relationship between various risky driving behaviors and the presence of environmental conditions among the safe, moderately safe, and unsafe drivers.

Objective Three: Analyze potential patterns in the driving performance-based measures among the safe, moderately safe, and unsafe drivers.

Objective Four: Analyze drivers' involvement in crashes, near-crashes, and incidents and the drivers' behaviors that contributed to their involvement.

Each of these four research objectives is presented in a separate chapter with results from the data analysis and conclusions. The last chapter of the report provides a summary of all key results and conclusions from this analysis and outlines future directions for this research.

For a complete description of the 100-Car Study method, instrumentation and data collection procedure, the reader is referred to the Dingus, Klauer, Neale, et al. (2006a) report.
The following abbreviated description is provided to orient the reader to the study (adapted from Neale, Klauer, Dingus, Sudweeks, & Goodman, 2005).

METHOD

Instrumentation

The 100-Car Study instrumentation package was engineered by the Virginia Tech Transportation Institute to be rugged, durable, expandable, and unobtrusive. It constituted the seventh generation of hardware and software (developed over a 15-year period) that has been deployed for a variety of purposes. The system consisted of a Pentium-based computer that received and stored data from a network of sensors distributed around the vehicle. Data storage was achieved via the systems' hard drives, which was large enough to store data for several weeks of driving before requiring data downloading.

Each of the sensing subsystems in the car was independent, so any failures that occurred were constrained to a single sensor type. Sensors included a vehicle network box that interacted with the vehicle network, an accelerometer that obtained longitudinal and lateral kinematic information, a headway detection system to provide information on leading or following vehicles, side obstacle detection to detect lateral conflicts, an incident box to allow drivers to flag incidents for the research team, a video-based lane-tracking system to measure lane-keeping behavior, and video to validate any sensor-based findings. The video subsystem was particularly important as it provided a continuous window into the happenings in and around the vehicle. This subsystem included five camera views that monitored the driver's face and driver side of the vehicle, the forward view, the rear view, the passenger side of the vehicle, and an over-the-shoulder view for the driver's hands and surrounding areas. An important feature of the video system is that it was digital, with software-controllable video compression capability. This allowed synchronization, simultaneous display, and efficient archiving and retrieval of 100-Car Study data. A frame of compressed 100-Car Study video data is shown in Figure 2. The driver's face (upper left quadrant) is distorted to protect the driver's identity. The lower right quadrant is split with the left-side (top) and the rear (bottom) views.

The modular aspect of the data collection system allowed for integration of instrumentation that was not essential for data collection, but provided the research team with additional important information. These subsystems included automatic collision notification that informed the research team of the possibility of a collision; cellular communications used by the research team to communicate with vehicles on the road to determine system status and position; system initialization equipment that automatically controlled system status; and a GPS subsystem that collected information on vehicle position. The GPS subsystem and the cellular communications were often used in concert to allow for vehicle localization and tracking.

Figure 2. A Compressed Video Image From the 100-Car Study Data

The system included several major components and subsystems that were installed on each vehicle. These included the main Data Acquisition System unit that was mounted under the package shelf for the sedans (Figure 3).

Doppler radar antennas were mounted behind special plastic license plates on the front and rear of the vehicle (Figure 4). The location behind the plates allowed the vehicle instrumentation to remain inconspicuous to other drivers.

Figure 3. The Main DAS Unit Mounted Under the Package Shelf of the Trunk

Figure 4. Doppler Radar Antenna Mounted on the Front of a Vehicle, Covered by a Mock-Up of One of the Plastic License Plates Used for This Study

The final major components in the 100-Car Study hardware installation were mounted above and in front of the center rear-view mirror. These components included an "incident" box that housed an incident pushbutton that the subject could press whenever an unusual event occurred in the driving environment. Also contained in the housing was an unobtrusive miniature camera that provided a view of the driver's face. The camera was invisible to the driver since it was mounted behind a smoked acrylic cover. The forward-view camera and the glare sensor were mounted behind the center mirror (Figure 5). This location was selected to be as unobtrusive as possible and did not occlude any of the driver's normal field of view.

Figure 5. The Incident Pushbutton Box Mounted Above the Rearview Mirror.

Subjects

One hundred drivers who commuted into or out of the Northern Virginia/Washington, DC, metropolitan area were initially recruited as primary drivers for this study. They would either have their vehicles instrumented or receive a leased vehicle for the duration of the study. Drivers were recruited by placing flyers on vehicles, as well as by placing announcements in the classified section of newspapers in that area. Drivers who had their private vehicles instrumented (N = 78) received $125 per month and a bonus at the end of the study ($300) for completing the necessary paperwork. Drivers who received leased vehicles (N = 22) received free use of the vehicles, including standard maintenance, and the same bonus at the end of the study for completing the necessary paperwork. Drivers of leased vehicles were insured under the Commonwealth of Virginia policy.

A few drivers had to be replaced during the course of the study for various reasons (e.g., a move from the study area or repeated crashes in leased vehicles), resulting in 109 primary drivers by the end of the study. Since other family members and friends would occasionally drive the instrumented vehicles, data was also collected on 132 additional drivers.

A goal of this study was to maximize the potential to record crash and near-crash events through the selection of subjects from populations with higher than average crash or near-crash risk exposure. Exposure was manipulated through the selection of a larger sample of drivers below the age of 25, and by the selection of a sample that drove more than the average number of miles. The age by gender distribution of the primary drivers is shown in Table 1. The distribution of miles driven by the subjects during the study appears as Table 2. As presented, the data is somewhat biased compared to the national averages in each case, based on TransStats (2001). Nevertheless, the distribution was generally representative of national averages when viewed across the distribution of mileages within the TransStats data.

One demographic issue with the 100-Car Study data sample is that the data was collected in only one area, the Northern Virginia/Washington, DC, metropolitan area. This area represents primarily urban and suburban driving conditions, often in moderate to heavy traffic. While some data was collected on rural roadways, rural driving as well as differing demographics within the United States are under-represented.

Table 1. Driver Age and Gender Distributions

	Gender		
Age N % of total	**Female**	**Male**	**Grand Total**
18-20	9 8.3%	7 6.4%	16 14.7%
21-24	11 10.1%	10 9.2%	21 19.3%
25-34	7 6.4%	12 11.0%	19 17.4%
35-44	4 3.7%	16 14.7%	20 18.3%
45-54	7 6.4%	13 11.9%	20 18.3%
55+	5 4.6%	8 7.3%	13 11.9%
Total N Total Percent	43 39.4%	66 60.6%	109 100.0%

Table 2. Actual Miles Driven During the Study

Actual Miles Driven	Number of Drivers	Percentage of Drivers
0-9,000	29	26.6%
9,001-12,000	22	20.2%
12,001-15,000	26	23.9%
15,001-18,000	11	10.1%
18,001-21,000	8	7.3%
More than 21,000	13	11.9%

A goal of the recruitment process was to attempt to avoid extreme drivers in either direction (i.e., very safe or very unsafe). Self-reported driving history data indicate that a reasonably diverse distribution of drivers was obtained.

Vehicles

Since over 100 vehicles had to be instrumented with a number of sensors and data collection hardware, and since the complexity of the hardware required a number of custom mounting brackets to be manufactured, the number of vehicle types had to be limited for this study. Six vehicle models were selected based on their prevalence in the Northern Virginia area. These included five sedans (Chevrolet Malibu and Cavalier, Toyota Camry and Corolla, and Ford Taurus) and one SUV (Ford Explorer). The model years were limited to those with common body types and accessible vehicle networks (generally 1995 to 2003). The distribution of these vehicle types was:

- Toyota Camry – 17 percent;
- Toyota Corolla – 18 percent;
- Chevy Cavalier – 17 percent;
- Chevy Malibu – 21 percent;
- Ford Taurus – 12 percent; and
- Ford Explorer – 15 percent.

PROCEDURE FOR DATA REDUCTION: 100-CAR STUDY EVENT DATABASE

Sensitivity Analysis

As described in Dingus, Klauer, Neale, et al. (2006), data was collected continuously onboard the instrumented vehicles. As project resources did not allow for the review of all the data, a sensitivity analysis was conducted to establish post hoc "triggers." A post hoc trigger uses either a single signature (e.g., any lateral acceleration value greater than ±0.6*g*) or multiple signatures (e.g., forward time-to-collision [TTC] value > 3 s plus a longitudinal deceleration value > -0.5 *g*) in the driving performance data stream to identify points in time when it was likely that a driver was involved in an incident, near-crash, or crash.

Figure 6 shows the data reduction plan in a flowchart format. Raw data from each vehicle was saved on the network attached storage (NAS) unit at VTTI until approximately 10 percent of the data was collected. At that time, a sensitivity analysis was performed to establish post hoc trigger criteria.

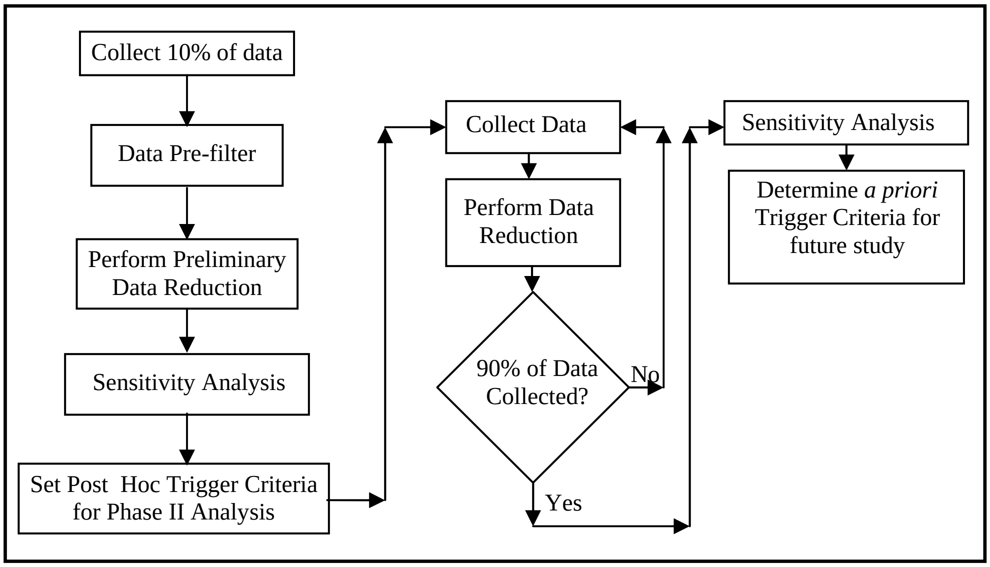

Figure 6. Flow Chart of the Data Reduction Process

The sensitivity analysis was performed by setting the trigger criteria to a very liberal level, ensuring that the chance of a missed valid event was minimal while allowing a high number of invalid events (false alarms) to be identified (see Figure 7). Data reductionists then viewed all of the events produced from the liberal trigger criteria and classified each event as valid or invalid. The number of valid events and invalid events from this baseline setting was recorded.

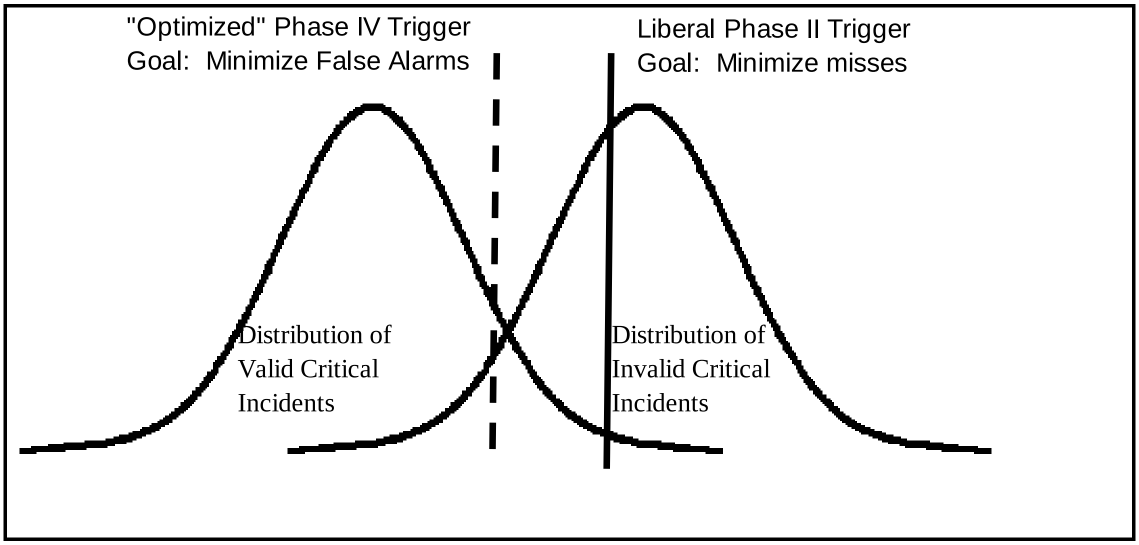

Figure 7. Graphical Depiction of Trigger Criteria Settings for Phase II and Phase IV Using the Distribution of Valid Events

The trigger criteria for each dependent variable were then set to a slightly more conservative level and the resulting number of valid and invalid events was counted and compared to the first frequency count. The trigger criteria were made more and more conservative and the number of valid and invalid triggers counted and compared until an optimal trigger criteria value was determined (a level that results in a minimal amount of valid events lost and a reasonable amount of invalid events identified). The goal in this sensitivity analysis was to obtain a miss rate of less than 10 percent and a false alarm rate of less than 30 percent. Therefore, the data reductionists would be presented with nearly all valid events, but would have to reject fewer than 30 percent of the events that they reviewed. The list of dependent variables ultimately used as triggers is presented in Table 3.

Table 3. Dependent Variables Used as Event Triggers

Trigger Type	Description
1. Lateral Acceleration	• Lateral motion with acceleration equal to or greater than 0.7 *g*.
2. Longitudinal Acceleration	• Acceleration or deceleration equal to or greater than 0.6 *g*. • Acceleration or deceleration equal to or greater than 0.5 *g* coupled with a forward TTC of 4 s or less. • All longitudinal decelerations between 0.4 *g* and 0.5 *g* coupled with a forward TTC value of ≤ 4 s and that the corresponding forward range value at the minimum TTC is not more than 100 ft.
3. Incident Button	• Activated by the driver by pressing a button located on the dashboard when an event occurred that the driver deemed critical.
4. Forward Time-to-Collision (TTC)	• Acceleration or deceleration equal to or greater than 0.5 *g* coupled with a forward TTC of 4 s or less. • All longitudinal decelerations between 0.4 *g* and 0.5 *g* coupled with a forward TTC value of ≤ 4 s and a corresponding forward range value at the minimum TTC of not more than 100 ft.
5. Rear TTC	• Any rear TTC trigger value of 2 s or less that also has a corresponding rear range distance of ≤ 50 ft AND any rear TTC trigger value in which the absolute acceleration of the following vehicle is greater than 0.3 *g*.
6. Yaw Rate	• Any value greater than or equal to a plus AND minus 4-degree change in heading (i.e., vehicle must return to the same general direction of travel) within a 3-second window of time.

Based on data from past VTTI studies, it was originally hypothesized that as many as 26 crashes, 520 near-crashes, and over 25,000 incidents (crash-relevant conflicts and proximity conflicts) would be collected; however, many of these early estimates were based on long-haul truck driving data. It was soon discovered, after the sensitivity analysis process began, that the variability in light-vehicle drivers' braking, acceleration, and steering behavior is much larger than with truck drivers. These differences in variability are primarily due to the differences in vehicle dynamics and the more uniform driving skill of commercial truck drivers. While greater variability was expected, the extent to which this is true was an interesting result.

Given the variability in light-vehicle driving performance, the sensitivity analysis proved to be challenging. VTTI researchers determined that the best option was to accept a very low miss rate while accepting a relatively high false alarm rate to ensure that few valid events were missed. This resulted in viewing over 110,000 triggers in order to validate 10,548 events. The distribution of the total number of reduced events by severity is shown in Table 4.

Table 4. The Total Number of Events Reduced for Each Severity Level

Event Severity	Total Number
Crash	69 (plus 13 without complete data)*
Near-Crash	761
Incidents (Crash-Relevant Conflicts and Proximity Conflicts)	8,295

*Data was missing primarily due to a crash occurring during the DAS system initialization in the first 2 minutes after the vehicle started moving or to the participant tampering with cameras.

Once the trigger criteria were set, data reductionists watched 90-second epochs for each event (60 s prior to and 30 s after), reduced and recorded information concerning the nature of the event, driving behavior prior to the event, the state of the driver, and the surrounding environment, etc. The specific variables recorded in the data reduction process are described in detail in the data reduction software framework section of this chapter.

Recruiting and Training Data Reductionists

Based upon past experience, it was estimated that reductionists would be able to reduce an average of four events per hour. Fourteen data reductionists were trained by a data reduction manager on how to access the data from the server, how to operate the data reduction software, and on all relevant operational and administrative procedures (approximately 4 hours of training). The manager gave the data reductionists data reduction manuals to guide them in learning the software and reduction procedures. All analyst trainees practiced data reduction procedures with another trained analyst prior to reducing data independently. After each trainee felt comfortable with the process, the trainee worked alone under the supervision of the data reduction manager. Once the trainee and manager felt confident of the analyst's abilities, the analyst began working independently, with "spot check" monitoring from the project leader and other reductionists. The data reductionists were responsible for analyzing a minimum number of events per week, and were required to attend weekly data reduction meetings to discuss issues that arose in data reduction.

The data reductionists performed two general tasks while creating the *event database*. On the first 10 to 15 percent of the data, they performed a preliminary data reduction task in which they viewed events to determine whether the event was valid or invalid and, if valid, to determine the severity of the event. After the trigger criteria were set using the results from the sensitivity analysis, the data reductionists then validated the data, determined severity, and performed a full data reduction. For the full data reduction, they recorded all of the required variables (discussed below) for the event type.

Event Database Reduction Software Framework

The data reduction framework for the *event database* was developed to identify various driving behavior and environmental characteristics for four levels of event severity: crashes, near-crashes, crash-relevant conflicts, and proximity conflicts. The operational definitions for these severity levels are presented in Table 5. The variables recorded were selected based on previous instrumented-vehicle studies (Hanowski, Wierwille, Garness & Dingus, 2000; Dingus, Neale, Garness, Hanowski, Lee, Kiesler, et al., 2001), national crash databases (General Estimates System [GES] and Fatality Analysis Reporting System), and questions found on Virginia State Police accident reports. Using this technique, the reduced database can be used to directly compare crash data from GES and FARS to those crashes, near-crashes, and incidents (crash-relevant conflicts and proximity conflicts) identified in this data set.

Table 5. Operational Definitions for All Event Severity Levels

Severity Level	Operational Definition
Crash	Any contact with an object, either moving or fixed, at any speed in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, objects on or off the roadway, pedestrians, cyclists, or animals.
Near-Crash	Any circumstance that requires a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. A rapid, evasive maneuver is defined as steering, braking, accelerating, or any combination of control inputs that approaches the limits of the vehicle capabilities.
Crash-Relevant Event*	Any circumstance that requires a crash avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive maneuver (as defined above), but greater in severity than a “normal maneuver” to avoid a crash. A crash avoidance response can include braking, steering, accelerating, or any combination of control inputs. A “normal maneuver” for the subject vehicle is defined as a control input that falls outside of the 95 percent confidence limit for control input as measured for the same subject.
Proximity Event*	Any circumstance resulting in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver, pedestrians, cyclists, or animals, there is no avoidance maneuver or response. Extraordinarily close proximity is defined as a clear case where the absence of an avoidance maneuver or response is inappropriate for the driving circumstances (including speed, sight distance, etc.).

*Crash-relevant events and proximity events were combined to form “incidents” as used in the rest of the report.

The general method for data reduction was to have trained data reductionists view the video data and record the battery of variables for all valid events. The data reduction manager and project manager performed all data reduction on the near-crashes and crashes. Varying levels of detail were recorded for each type of event. Crash-relevant conflicts and proximity conflicts have the least amount of information recorded and near-crashes and crashes have the most information recorded. A total of four areas of data reduction were recorded for each event type. These four areas included: vehicle variables, event variables, environmental variables, and driver state variables. Table 6 defines each area of data reduction, provides examples, and describes additional features of the data reduction. The complete list of all variables reduced during data reduction is shown in Appendix C.

Table 6. Areas of Data Reduction, Definition of the Area, and Examples

Area of Data Reduction	Definition	Example
Vehicle Variables	All of the descriptive variables including the vehicle identification number, vehicle type, ownership, and those variables collected specifically for that vehicle, such as vehicle miles traveled (VMT).	Vehicle ID, vehicle type, driver type (leased or private), and VMT.
Event Variables	Description of the sequence of actions involved in each event, list of contributing factors, and safety or legality of these actions.	Nature of event/ crash type, pre-event maneuver, precipitating factors, corrective action/evasive maneuver, contributing factors, types of inattention, driver impairment, etc.
Environmental Variables	General description of the immediate environment, roadway, and any other vehicle at the moment of the incident, near-crash, or crash. Any of these variables may or may not have contributed to the event, near-crash or crash.	Weather, ambient lighting, road type, traffic density, relation to junction, surface condition, traffic flow, etc.
Driver's State	Description of the instrumented-vehicle driver's physical state.	Hands on wheel, seat belt usage, fault assignment, eye glance, PERCLOS, etc.
Driver/Vehicle 2	Description of the vehicle(s) in the general vicinity of the instrumented vehicle and the vehicle's action.	Vehicle 2 body style, maneuver, corrective action attempted, etc.
Narrative	Written description of the entire event.	
Dynamic reconstruction	Creation of an animated depiction of the event.	

Baseline Database Framework

The *baseline database* was comprised of approximately 20,000 6-second segments where the vehicle maintained a velocity greater than 5 mph (referred to as an *epoch*). Kinematic triggers on driving performance data were not used to select these baseline epochs. Rather, these epochs were selected at random throughout the 12- to 13-month data collection period per vehicle. A 6-second segment of time was used as this was the time frame used by data reductionists to ascertain whether a particular secondary task was a contributing factor for each crash, near-crash, and incident. For example, a driver had to take a bite of a sandwich 5 s prior to or 1 s after the onset of the conflict for the activity to be considered a contributing factor to the crash, near-crash, or incident.

Each *baseline epoch* was randomly selected from the 12 months of data collected on each vehicle. However, the number of baseline epochs selected per vehicle was proportioned based upon vehicle involvement in crashes, near-crashes, and incidents. This proportional sampling, based on frequency of crash, near-crash, and incident involvement, was conducted to create a case-control data set in which multiple baseline epochs are present to compare to each crash and near-crash. Case-control designs are optimal for calculating odds ratios (also referred to as relative crash risk) due to the increased power present in a case-control data set. Greenberg, Daniels, Flanders, Eley, and Boring (2001) argue that case-control designs allow for an efficient means to study rare events, such as automobile crashes. These designs provide an efficient means to evaluate the causal relationships that exist by using relatively smaller sample sizes than are used in typical crash database analyses.

The number of baseline epochs was dependent on the number of crashes, near-crashes, and incidents (crash-relevant conflicts and proximity conflicts) collected for each vehicle; therefore, four vehicles that did not have any crashes, near-crashes, or incidents were eliminated from the baseline database. The lack of crashes, near-crashes, and incidents for these vehicles may have been due to either very low mileage (primarily due to driver attrition and/or frequent mechanical malfunctions) or because the drivers exhibited safe driving behavior.

Figure 8 shows the number of events for each vehicle (y-axis) and the corresponding number of baseline epochs for that vehicle (x-axis). Note that vehicles that were involved in multiple crashes, near-crashes, and incidents also had a larger number of baseline epochs.

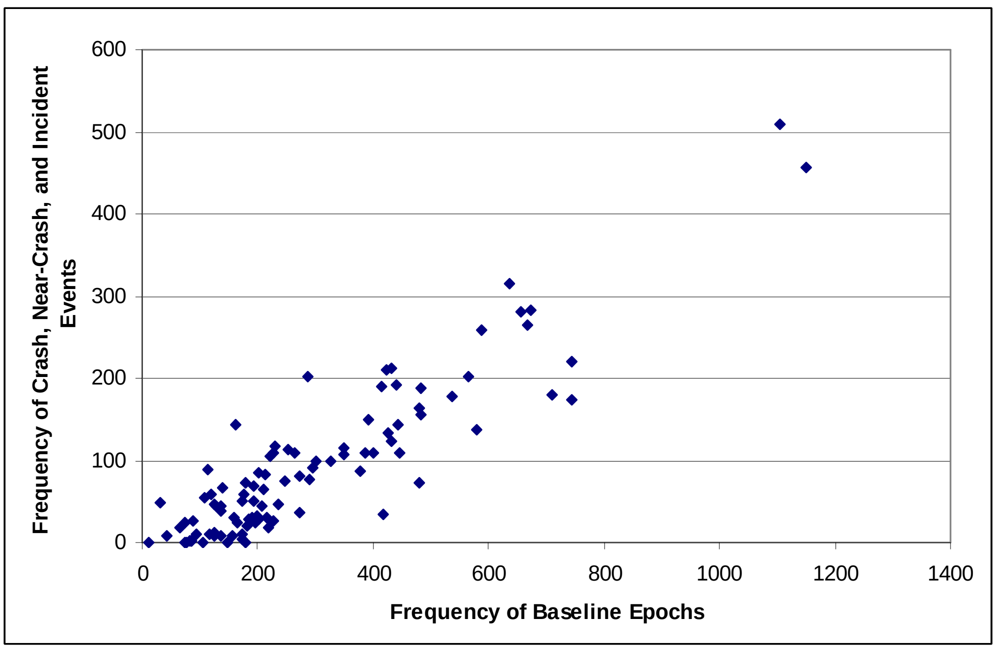

Figure 8. The Frequency of Each Vehicle's Involvement in Crash, Near-Crash, and Incident Events versus the Number of Baseline Epochs Selected for Each Vehicle

The *baseline database* was used to assess the prevalence of various types of inattentive driving, to determine the relative crash risk for each of these types of inattention, and to determine the percentage of crashes and near-crashes in the population that are attributable to these types of inattention. While the reader should keep in mind that the baseline epochs were proportionally sampled, this does not reduce the generalizability of the data analysis for the following reasons:

1) 99 of 103 vehicles are represented in the 20,000 baseline epochs;
2) 101 out of 108 primary drivers are represented in the baseline epochs;
3) Multiple drivers drove each vehicle; and
4) No environmental or driver behavior data were used in the stratification.

The variables recorded for the 20,000 *baseline epochs* included vehicle, environmental, and most driver state variables. In addition, eye-glance analyses were performed for 5,000 randomly selected baseline epochs from the 20,000 baseline epochs. These 5,000 baseline epochs also represent data from all 99 vehicles and 101 primary drivers.

The event variables (Item 2 in Table 6) were not recorded for the baseline epochs as these variables (e.g., precipitating factor, evasive maneuver) were not present unless there was an incident, near-crash, or crash. Table 7 shows the breakdown of the type of data that currently exists as part of the original 100-Car Study *event database* and the *baseline database*.

Table 7. Description of the Databases Created for the Analysis

	100-Car Study Event Database	**Baseline Database (epochs)**
1.	Vehicle variables	Vehicle variables
2.	Event variables	N/A
3.	Environmental variables	Environmental variables
4.	Driver's State variables	Driver's State variables
5.	Eye-glance data (crashes, near-crashes, and incidents)	Eye-glance data on 5,000 randomly selected baseline events.
6.	Observer rating of drowsiness (ORD) for crashes and near-crashes	Fatigue was marked yes/no with "yes" = ORD of 60 or above.
7.	Driver/vehicle 2	N/A
8.	Narrative	N/A

Data Reduction Inter- and Intra-Rater Reliability for the 100-Car Study Event Database

Training procedures were implemented to improve both inter- and intra-rater reliability, given that data reductionists were asked to perform subjective judgments on the video and driving data. Reliability testing was then conducted to measure the resulting inter- and intra-rater reliability.

First, data reduction managers performed spot checks of the reductionists' work, monitoring event validity judgments as well as recording all database variables. Reductionists also performed 30 minutes of spot-checks of their own or other reductionists' work each week. This was done to ensure accuracy, but also to allow reductionists the opportunity to view other reductionists' work. It was anticipated that this would encourage each reductionist to modify his/her own work and to improve consistency in decision-making techniques across all reductionists. Mandatory weekly meetings were held to discuss issues concerning data reduction techniques. Issues were usually identified by the spot-checking activities of the reductionist managers and the reductionists, or due to specific difficult events that the reductionists had encountered. These meetings provided iterative and ongoing reduction training throughout the entire data reduction process.

To determine the success of these techniques, an inter- and intra-rater reliability test was conducted during the last 3 months of data reduction. Three reliability tests were developed (each containing 20 events) for which the reductionist was required to make validity judgments. Three of the 20 events were also completely reduced in that the reductionist recorded information for all reduction variables (i.e., event variables, driver state variables, and environmental variables as opposed to simply marking severity of event). Three of the test events on Test 1 were repeated on Test 2 and three other events were duplicated between Tests 2 and 3 to obtain a measure of intra-rater reliability.

Using the expert reductionist's evaluations of each epoch as a "gold" standard, the proportion of agreement between the expert and each rater was calculated for each test. The measures for each rater for each testing period, along with a composite measure, can be found in Table 8.

Table 8. Percentage Agreement With Expert Reductionists

Rater	**Test 1 (%)**	**Test 2 (%)**	**Test 3 (%)**
1	78.3	87.5	91.3
2	65.2	70.8	78.3
3	100	91.7	95.7
4	100	91.7	87.0
5	100	83.3	87.0
6	95.7	87.5	91.3
7	91.3	87.5	91.3
8	91.3	91.7	91.3
9	95.7	70.8	91.3
10	95.7	91.7	87.0
11	95.7	87.5	100
12	78.3	87.5	87.0
13	87.0	83.3	96.0
14	78.3	83.3	91.3
	Average (across all tests)	88.4	

The Kappa statistic was also used to calculate inter-rater reliability. Although there is controversy surrounding the usefulness of the Kappa statistic, it is viewed by many researchers as the standard for rater assessment (e.g., Cicchetti & Feinstein, 1990). The Kappa coefficient ($K = 0.65$, $p < 0.0001$) indicated that the association among raters is significant. While the coefficient value is somewhat low, given the highly subjective nature of the task, the number of raters involved, and the conservative nature of this statistic, the Kappa calculation probably errs on the low side.

A tetrachoric correlation coefficient is a statistical calculation of inter-rater reliability based on the assumption that the latent trait underlying the rating scale is continuous and normally distributed. Based on this assumption, the tetrachoric correlation coefficient can be interpreted in the same manner as a correlation coefficient calculated on a continuous scale. The average of the pair-wise correlation coefficients for the inter-rater analysis was 0.86. The coefficients for the intra-rater analysis were extremely high, with nine raters achieving a correlation of 1.0 among the three reliability tests, and five raters achieving a correlation of 0.99.

Given these three methods of calculating inter-rater reliability, it appears that the data reduction training coupled with spot-checking and weekly meetings proved to be an effective method for achieving high inter- and intra-rater reliability.

Baseline Database

Inter-rater reliability tests were also conducted for the baseline events. All trained data reductionists were given a random sample of 25 *baseline epochs* to view and record the secondary tasks, driving-related inattention behaviors, and fatigue. The reductionists' responses were then compared to an expert data reductionist's responses. The results indicated an average of 88 percent accuracy among all of the reductionists. Since neither the Kappa coefficient nor the tetrachoric correlation coefficient provided additional information, these tests were not conducted on the baseline inter-rater reliability test.

SURVEYS, QUESTIONNAIRES AND PERFORMANCE-BASED TESTS

As part of the 100-Car Study, the primary drivers were administered questionnaires and performance-based tests either prior to or after data collection (depending on the type of test). Table 9 provides a list and description of each type of questionnaire and performance-based test completed by participants. A copy of all questionnaires and surveys is located in Appendix A.

Table 9. Description of Questionnaire and Computer-Based Tests Used for 100-Car Study

	Name of testing procedure	Type of test	Time test was administered	Brief description
1.	Driver Demographic Information	Paper/pencil	In-processing	General information on driver age, gender, etc.
2.	Driving History	Paper/pencil	In-processing	General information on recent traffic violations and recent collisions.
3.	Health Assessment Questionnaire	Paper/pencil	In-processing	List of illnesses/medical conditions/or any prescriptions that may affect driving performance.
4.	Dula Dangerous Driving Index	Paper/pencil	In-processing	One score that describes driver's tendencies toward aggressive driving.
5.	Sleep Hygiene	Paper/pencil	In-processing	List of questions that provide information about driver's general sleep habits/substance use/sleep disorders.
6.	Driver Stress Inventory	Paper/Pencil	In-processing	One score that describes the perceived stress levels drivers experience during their daily commutes.
7.	Life Stress Inventory	Paper/pencil	In-processing/Out-processing	One score that describes driver's stress levels based upon the occurrence of major life events.
8.	Useful Field-of-View	Computer-based test	In-processing	Assessment of driver's central vision and processing speed, divided and selective attention.
9.	Waypoint	Computer-based test	In-processing	Assessment of the speed of information processing and vigilance.
10.	NEO-FFI	Paper/pencil	In-processing	Personality test.
11.	General Debrief Questionnaire	Paper/pencil	Out-processing	List of questions ranging from seat belt use, driving under the influence, and administration of experiment.

Chapter 2: *Objective 1*: Determine the Differences in Demographic Data, Test Battery Results, and Performance-Based Measures Between Safe and Unsafe Drivers. Analyze the Crash Rate Involvement and Violations Prior to the Study for These Safe and Unsafe Drivers

For this research objective, statistical analyses were conducted using the frequency of drivers' involvement in at-fault crashes and near-crashes to separate participants into safe and unsafe driver groups. Then, these groups were compared using drivers' composite test battery scores and relevant survey responses. For a complete list of test batteries and surveys that were used for data collection, please refer to Table 9.

Data Used in This Analysis

For the analyses in this chapter, the frequency of crashes and near-crashes where the primary driver was at fault was used (incidents were excluded from the analyses). These frequencies were converted to a rate per mile traveled and then normalized to assess a rate of occurrence per million vehicle miles traveled. Only crash and near-crash involvement was used because analyses presented in the 100-Car Study Final Report indicate that the kinematic signatures of these two types of events were nearly identical. On the other hand, the kinematic signatures of incidents were more variable and less comparable to crashes.

Involvement in crashes and near-crashes per MVMT was used since this measure accounts for exposure. For instance, if Driver A was involved in 10 crashes and near-crashes and Driver B was involved in 30 crashes and near-crashes, Driver A might, to a first approximation, be considered a safer driver than Driver B. However if Driver A only drove 5,000 mi/yr and Driver B drove 20,000 mi/yr, Driver A's events per MVMT = 2,000, whereas Driver B's events per MVMT = 1,500, indicating that Driver B may, in fact, be the safer driver. Using VMT as a measure of exposure provided a more accurate measure of driver safety relative to other drivers.

Only those crashes and near-crashes where the primary driver was at fault or where the driver was partially at fault were used in these analyses. At fault or partially at fault was recorded for each of the crashes and near-crashes by a senior researcher and/or expert reductionist. If the senior researcher or expert reductionist observed the participant making an error or performing a behavior that contributed to the crash (i.e., looked away from the forward roadway), then the participant was deemed at fault. If another vehicle was observed braking hard, swerving, or contributing in some way to the occurrence of the event, then the other vehicle was deemed at fault. If both the study participant and the other vehicle exhibited behaviors that contributed to the occurrence of the event, then the reductionist marked "unable to determine," meaning partial fault was assigned to all drivers involved.

Crashes and near-crashes where another driver was at fault were not included in these analyses, because these situations do not directly relate to the participants' safe driving behaviors. However, crashes and near-crashes where fault could not be definitively determined (e.g., because multiple drivers performed unsafe maneuvers) were included in the analyses below. Only primary drivers were used since these were the only drivers who completed the survey and test battery questionnaires.

Assignment of Safety-Level for Drivers

The first step for this research objective was to logically split the drivers into groups of "safe" and "unsafe" drivers based on their crash rates per MVMT. Figure 9 shows the distribution of the crash rates of all of the primary drivers. The median and mean levels are marked on the figure. Note that 18 primary drivers were not involved in any at-fault crashes or near-crashes. The rest of the primary drivers were involved in anywhere from 1 to 3,700 crashes and/or near-crashes per MVMT.

While it is apparent that there are several ways to define various categories of safe drivers, using the mean as a dividing point has been used by many researchers. Given the exploratory nature of these analyses, it provides a fairly conservative measure upon which to divide the drivers, and yet still preserve differences between those drivers who have tendencies for frequent crash and near-crash involvement and those who do not. One issue with only two groups is that there is very little separation between the values. Thus, a second analysis using three groups was conducted. With three groups, some separation between the two tails of the distribution is present so that any differences between the safest and most dangerous drivers are more easily distinguished.

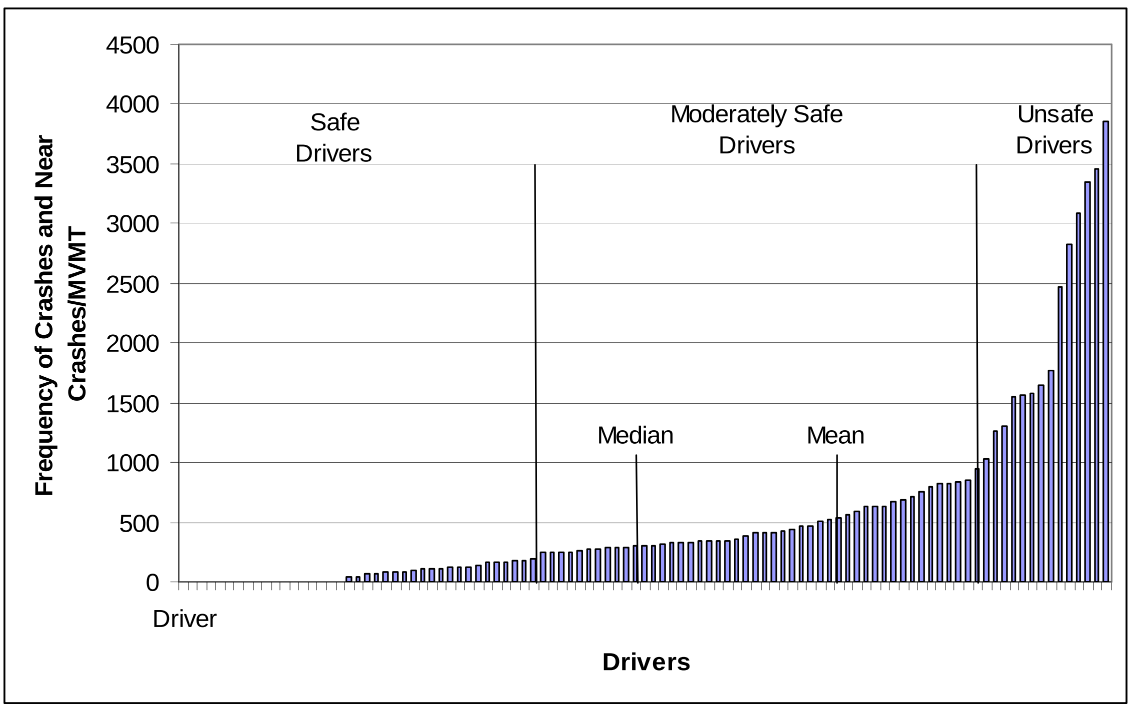

Figure 9. The Frequency of At-fault Crashes and Near-crashes per MVMT by Driver

Therefore, two separate analyses of safe versus unsafe drivers were conducted. The first analysis used the *mean frequency* per MVMT to separate the drivers into two groups: safe and unsafe drivers. Therefore, drivers involved in 552 or fewer crashes and near-crashes per MVMT were labeled as "safe," and drivers involved in more than 552 crashes and near-crashes per MVMT were labeled as "unsafe."

The second analysis separated the drivers into three levels of safe driving: safe, moderately safe, and unsafe. Drivers who were involved in fewer than 200 crashes and near-crashes per MVMT were operationally defined as "safe." "Moderately safe" drivers were involved in 200 to 900 crashes and near-crashes per MVMT, and "unsafe" drivers were involved in more than 900 crashes and near-crashes per MVMT. These groups were created based on observed breaks in the distribution of crash and near-crash involvement per MVMT. Table 10 and Table 11 provide the descriptive statistics for the drivers' respective group divisions.

Table 10. Descriptive Statistics on Drivers Labeled "Safe" and "Unsafe" as Defined by Their Crash/Near-Crash Involvement

Statistic	Safe Drivers	Unsafe Drivers
N (Number of drivers)	72	29
Mean (events per MVMT)	195.4	1,438.1
Median (events per MVMT)	174.1	950.4
Mode (events per MVMT)	0	N/A
Standard Deviation (events per MVMT)	163.3	988.1
Minimum (events per MVMT)	0	567.9
Maximum (events per MVMT)	537.2	3,853.1

Table 11. Descriptive Statistics on Drivers Labeled "Safe," "Moderately Safe," and "Unsafe" as Defined by Their Crash/Near-Crash Involvement

Statistic	Safe Drivers	Moderately Safe Drivers	Unsafe Drivers
N (Number of drivers)	39	47	15
Mean (events per MVMT)	63.1	460.0	2,112.8
Median (events per MVMT)	48.0	411.1	1,650.2
Mode (events per MVMT)	0	339.7	N/A
Standard Deviation (events per MVMT)	67.7	189.9	966.0
Minimum (events per MVMT)	0	240.6	950.4
Maximum (events per MVMT)	191.1	854.7	3,853.1

Analysis One: Analysis for the "Safe and Unsafe" Groups

Demographic Data and Self-Reported Data Analyses

The list of self-reported demographic data and survey data is shown in Table 12. Drivers reported their respective demographic data, driving history (e.g., number of citations received in the past 5 years), health status, and sleep hygiene using four separate surveys. T-tests or Chi-Square Goodness of Fit tests were conducted to determine whether there were any statistical differences between the unsafe and safe drivers.

Table 12. Driver Self-Reported Demographic Data Summary

	Demographic/Survey Data	Information Presented
1.	Driver Demographic Information	▪ Age ▪ Gender ▪ Years of driving experience
2.	Driving History	▪ Number of traffic violations in past 5 yrs ▪ Number of accidents in past 5 yrs
3.	Sleep Hygiene	▪ Daytime sleepiness scale ▪ Number of hours of sleep per night

Driver Age

Figure 10 shows the average age of the safe and unsafe drivers. A T-test was conducted to determine if the differences in age between groups was significantly different. The results revealed significant differences in age between the two groups of drivers: ($t(97) = 5.81$, $p < 0.05$).

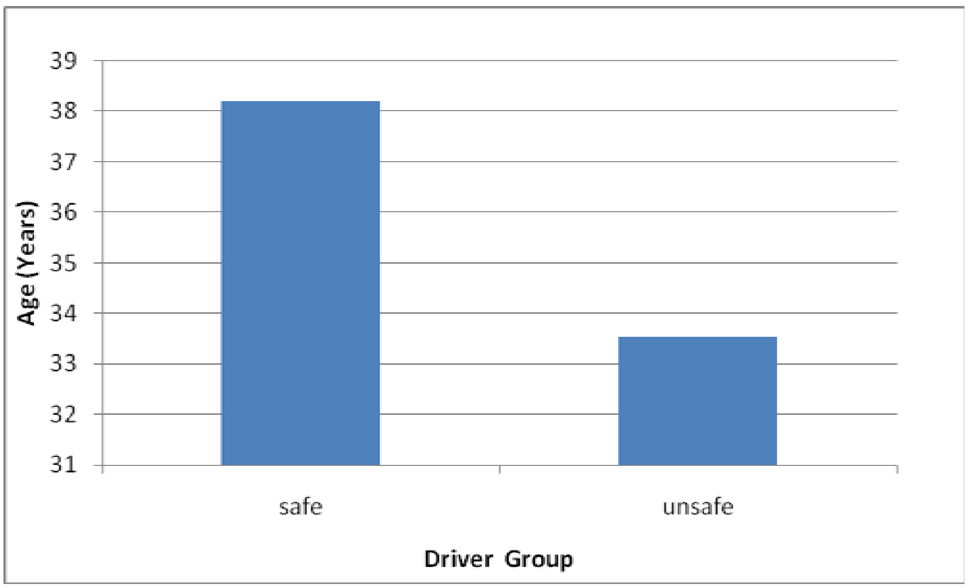

Figure 10. Average Age of Safe (S.D. = 13.1) Versus Unsafe (S.D. = 14.7) Primary Drivers From the 100-Car Study

Years of Driving Experience

An analysis of the number of years of driving experience was also conducted. Figure 11 shows that unsafe drivers had significantly fewer years of driving experience than the safe drivers: $t(94) = 6.72$, $p = 0.01$. Given that drivers in the United States generally receive their driver licenses at 16 years old, this result is highly correlated with driver age ($R = 0.97$, $p > 0.0001$).

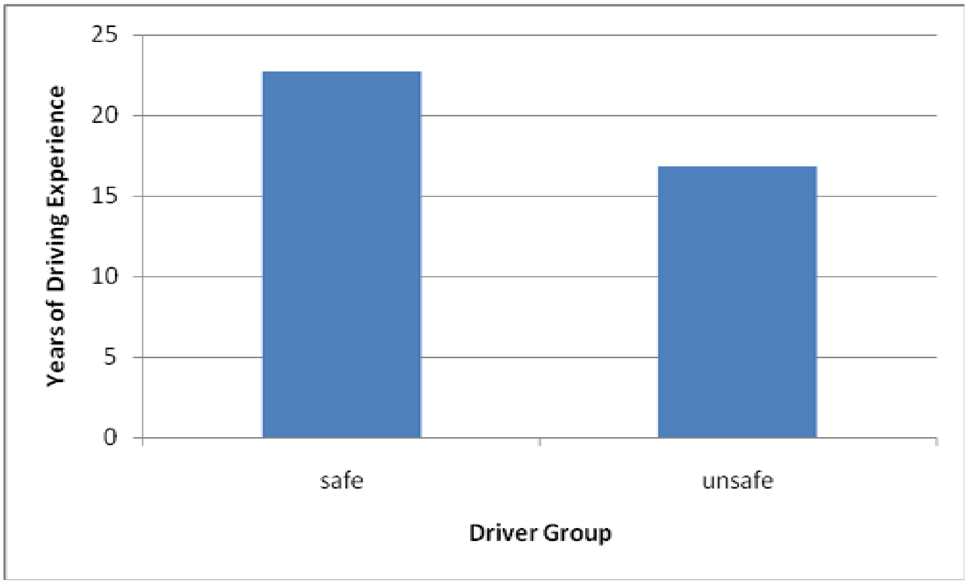

Figure 11. Average Years of Driving Experience of Safe (S.D. = 13.2) Versus Unsafe (S.D. = 14.5) Drivers From the 100-Car Study

Gender

There were 99 primary drivers, 64 of whom were male and 35 of whom were female. Figure 12 presents the frequency of drivers who were safe/female, safe/male, unsafe/female, and unsafe/male. Note that the driver population contained more unsafe female than safe female drivers while the reverse was true for male drivers; there were more safe male drivers than unsafe male drivers. A Chi-Square Goodness of Fit test was conducted on the two female groups and the two male groups. The results indicated that neither of these groups was significantly different from the expected values.

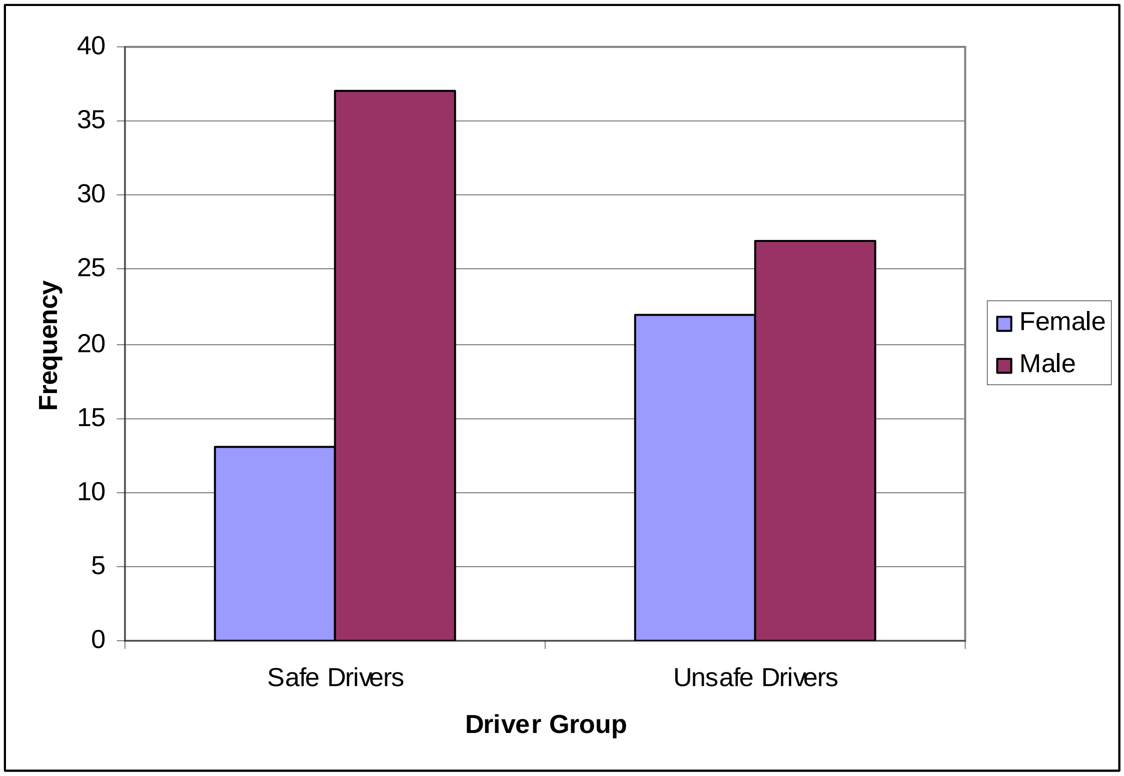

Figure 12. Frequency of Safe and Unsafe Primary Drivers by Gender

Driving History: Traffic Violations

Drivers were asked to report the number of traffic violations received during the past 5 years of driving prior to their participation in the 100-Car Study. T-tests were conducted to determine whether there were differences in the number of violations reported by the safe versus unsafe driver groups. No significant differences were observed. The safe driver group reported an average of 1.4 traffic violations over the past 5 years (S.D. 1.4) and the unsafe drivers reported an average of 2.0 violations (S.D. 3.0).

Driving History: Traffic Accidents

Drivers were also asked to report their number of crashes during the past 5 years of driving prior to their participation in the 100-Car Study. T-tests revealed no statistically significant differences between the safe and unsafe driver groups, with the average number of accidents being 1.2 (S.D. 1.4) and 2.0 (S.D. 3.0), respectively.

These results from the driving history data may suggest either that a driver's past 5 years of driving is not necessarily predictive of driving in the future or, conversely, it may simply indicate that relying upon driver memory or veracity is a limited research approach. Drivers may also not report minor collisions to researchers that were not reported to the police. It would have been beneficial to have known the number of violations and/or collisions in increments of 1 year for the past 5 years, but these data were not collected. Future studies should perhaps request the data in increments of 1 year and/or attempt to secure DMV records to assess the accuracy of these self-reports.

Sleep Hygiene/Fatigue

Drivers were administered an abbreviated version of the Walter Reed Sleep Hygiene Questionnaire to assess their sleep habits. An abbreviated version of the questionnaire with 31 questions was used to reduce the in-processing time required for drivers. This questionnaire was not designed to provide one composite score. Therefore, to explore the relevance of this questionnaire to driving events, two of the questions have been identified as the most representative of the entire questionnaire. These two questions were:

1) "Rank <on a scale of 1(very alert) to 10 (very sleepy)> the extent to which you currently experience daytime sleepiness?"

2) "How many hours do you sleep <per night>?'

<u>Daytime Sleepiness:</u> The average scores of safe and unsafe drivers for daytime sleepiness indicated that both safe and unsafe drivers rated their daytime sleepiness levels nearly the same (unsafe = 4.4, attentive drivers = 4.1). Not surprisingly, this result was not significant.

<u>Hours of Sleep:</u> The safe driver group reported receiving 7.1 hours of sleep per night on average and the unsafe driver group reported receiving slightly less sleep, with a mean of 6.9 hours per night. These differences were also not statistically significant. Given that no significant results were obtained for these two questions, no further analyses of this questionnaire were conducted.

Test Battery Analyses

Table 13 provides a list of the test batteries that were administered to the drivers either prior to the onset of the study or at the completion of the study. Analyses of each of these test batteries then follows.

Table 13. Test Battery Names and Scores

	Test Battery Name	Test Battery Score
1.	Life Stress Inventory	• Life Stress Score
2.	Driver Stress Inventory	• Aggression • Dislike of Driving • Hazard Monitoring • Thrill-Seeking • Fatigue-Proneness
3.	Dula Dangerous Driving Inventory	• DDDI Dangerous Driving Total Score • Negative Emotional Driving Subscore • Aggressive Driving Subscore • Risky Driving Subscore
4.	NEO Five-Factor Inventory	• Neuroticism • Extroversion • Openness to Experience • Agreeableness • Conscientiousness

Life Stress Inventory

The Life Stress Inventory was administered to the drivers after data collection, since the questionnaire instructed drivers to record which life stressors they had experienced during the past 12 months (i.e., the duration of data collection). A composite score was then calculated based upon the type of stressors that each driver experienced, with a possible range of 0-300. Unfortunately, only 60 primary drivers returned after data collection to complete this questionnaire.

T-tests were conducted to determine whether the overall Life Stress Inventory scores were significantly different between the safe and unsafe drivers. No significant differences were observed, as both groups scored in the low stress level category (unsafe = 157.1 and safe =127.8). Other descriptive statistics of the Life Stress Inventory are provided in Table 14.

Table 14. Life Stress Inventory Descriptive Statistics

Statistic	Unsafe Drivers	Safe Drivers
N	26	34
Mean	157.1	127.8
Standard Deviation	117.7	104.3

Driver Stress Inventory

The Driver Stress Inventory was developed by Matthews, Desmond, Joyner, Carcary, and Gilliland (1996) to assess an individual driver's vulnerability to commonplace stress reactions while driving, such as frustration, anxiety, and boredom. The five driver stress factors assessed by the Driver Stress Inventory are: (1) aggression; (2) dislike of driving; (3) hazard monitoring;

(4) thrill seeking; and (5) being prone to fatigue. Composite scores for each driver stress factor are provided. The Driver Stress Inventory was originally validated by correlating responses with a driver's self-reporting of violations and collisions, other driver behavior scales (Driver Coping Questionnaire), and the NEO Five-Factor Inventory. The Driver Stress Inventory has been used widely in transportation research.

T-tests were conducted to determine whether there were significant differences between the unsafe and safe drivers for each of the five driving stress factor scores. None of the T-tests indicated significant differences. One possibility for this result is that these drivers were all urban and may all be fairly uniform on scales such as hazard monitoring and aggressive driving. Descriptive statistics for each of the five driver stress factors are provided in Table 15, Table 16, Table 17, Table 18, and Table 19.

These results show that none of the five Driver Stress Inventory scores were associated with driver involvement in crashes and near-crashes.

Table 15. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Aggression*. Higher Scores Indicate Higher Levels of Aggression.

Statistic	Unsafe Drivers	Safe Drivers
N	28	70
Mean	47.3	46.2
Standard Deviation	14.9	14.5

Table 16. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Dislike of Driving*. Higher Scores Indicate Higher Levels of Dislike for Driving.

Statistic	Unsafe Drivers	Safe Drivers
N	27	70
Mean	30.7	32.4
Standard Deviation	11.0	10.0

Table 17. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Hazard Monitoring*. Higher Scores Indicate Higher Levels of Hazard Monitoring.

Statistic	Unsafe Drivers	Safe Drivers
N	28	70
Mean	67.2	69
Standard Deviation	12.7	11.1

Table 18. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Fatigue Proneness*. Higher Scores Indicate Higher Levels of Proneness to Fatigue.

Statistic	Unsafe Drivers	Safe Drivers
N	27	70
Mean	38.1	36.6
Standard Deviation	15.5	12.5

Table 19. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Thrill-seeking*. Higher Scores Indicate Higher Levels of Thrill-seeking.

Statistic	Unsafe Drivers	Safe Drivers
N	28	69
Mean	26.1	25.3
Standard Deviation	17.2	16.3

Dula Dangerous Driving Inventory

The Dula Dangerous Driving Inventory provides a measure of a driver's likelihood to engage in dangerous behaviors. While the scale exhibited strong internal reliability when it was developed, it was validated using a driving simulator rather than actual driving on a test track or roadways (Dula & Ballard, 2003). This analysis is one of the first analyses of this inventory using driving data on real roadways and in real traffic conditions. The Dula Dangerous Driving Index consists of four measures: (1) Overall Dula Dangerous Driving Index; (2) Negative Emotional Driving Subscale; (3) Aggressive Driving Subscale; and (4) Risky Driving Subscale.

T-tests were conducted on each of the four scales to determine whether unsafe drivers had a significantly different likelihood of engaging in dangerous behavior than did safe drivers. No significant differences on any of the four scales were observed. The descriptive statistics for each scale of the Dula Dangerous Driving Index is presented in Table 20, Table 21, Table 22, and Table 23. Again, a sample of urban drivers may be fairly uniform in their aggressive and risky driving behaviors. None of these subscales of the Dula Dangerous Driving Index demonstrate any association with crash and near-crash involvement for the drivers in this study.

Table 20. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for the *Dula Dangerous Driving Index*. Higher Scores Indicate Higher Propensity for Dangerous Driving.

Statistic	Unsafe Drivers	Safe Drivers
N	28	71
Mean	54.0	51.1
Standard Deviation	12.1	10.5

Table 21. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Negative Emotional Driving Index*. Higher Scores Indicate a Higher Propensity for Experiencing Negative Emotions.

Statistic	**Unsafe Drivers**	**Safe Drivers**
N	28	71
Mean	22.3	21.1
Standard Deviation	5.5	4.4

Table 22. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Aggressive Driving*. Higher Scores Indicate Higher Frequencies of Aggressive Driving Acts.

Statistic	**Unsafe Drivers**	**Safe Drivers**
N	28	70
Mean	11.9	11.4
Standard Deviation	4.2	3.6

Table 23. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Risky Driving.* Higher Scores Indicate Higher Frequencies of Risky Driving Behaviors.

Statistic	**Unsafe Drivers**	**Safe Drivers**
N	28	71
Mean	19.8	18.7
Standard Deviation	4.6	4.2

NEO Personality Inventory -- Revised

The NEO Five-Factor Inventory is a five-factor personality inventory that provides an individual's ranking on the following five scales: (1) neuroticism; (2) extroversion; (3) openness to experience; (4) agreeableness; and (5) conscientiousness.

Extensive research has been conducted correlating the personality scales of neuroticism, extroversion, agreeableness, and conscientiousness to crash involvement (Costa & McCrae, 1992; Arthur & Graziano, 1996; Fine, 1963; Loo, 1979; and Shaw & Sichel, 1971). While the hypothesis that drivers with certain personalities would more likely be involved in accidents seems reasonable, the results of this research are mixed. Some of the issues involved with these mixed results are that self-reported driving histories and driving behavior questionnaires have been correlated with personality scales but very little actual driving data has been used. The following analyses represent the first to use observed driving for 12 months and the drivers' responses on these personality scales.

Neuroticism: The neuroticism scale is primarily a scale contrasting emotional stability with severe emotional maladjustment (e.g., depression, borderline hostility). Individuals with scores that are off the scale may indicate a risk for certain kinds of psychiatric problems.

T-tests were conducted comparing the unsafe drivers to safe drivers. These results indicated that there were no significant differences between the safe drivers (mean score of 25.9) and the unsafe drivers (mean score of 23.8). The safe drivers' average score of 25.9 places them in the "High" neuroticism category on a scale from Very High (30-35) to Very Low (0-5). The unsafe drivers' average score also placed them in the category of "High."

Extroversion: The extroversion scale is a scale that measures not only sociability but also assertiveness, general optimism, and cheerfulness. People who score lower on this scale are not pessimists, but rather prefer solitude, are generally more subdued in expressing emotion, and demonstrate higher levels of cynicism.

T-tests conducted on the extroversion scale showed that unsafe drivers rated lower than did the safe drivers; however, the difference was not statistically significant. The unsafe drivers' average score was 34.2, whereas the safe drivers' average score was 37.5.

Openness to Experience: The openness to experience scale is a measure of one's willingness to explore, entertain novel ideas, and accept unconventional values. Those who score lower on this scale uphold more conventional values and are more conservative in action and beliefs. While some intelligence measures are correlated with scoring high on the "openness to experience" scale, this is not necessarily a measure of intelligence.

Results from a T-test on the Openness to Experience scale also revealed no significant differences between the unsafe and safe drivers. The mean scores for both the unsafe and safe drivers placed both groups of drivers on the "High" range of openness to experience (unsafe driver mean = 34.0, **s**afe driver mean = 35.1).

Agreeableness: The Agreeableness scale is a measure of altruistic and sympathetic tendencies versus egocentric and competitive tendencies. Those drivers who scored higher on this scale may be more concerned about the drivers in their near vicinity, while those who scored lower may view driving more as a competition.

The mean scores on the Agreeableness scale for both unsafe and safe drivers, as presented in Figure 13, indicated that the safe drivers scored significantly higher on the Agreeableness scale than did the unsafe drivers: t (97) = 7.05, p = 0.009. The unsafe drivers scored solidly in the middle of the "Average" range while the safe drivers scored in the middle of the "High" range (Figure 13). These results suggest that safe drivers may be more altruistic in nature and thus tend to drive more defensively than the unsafe drivers.

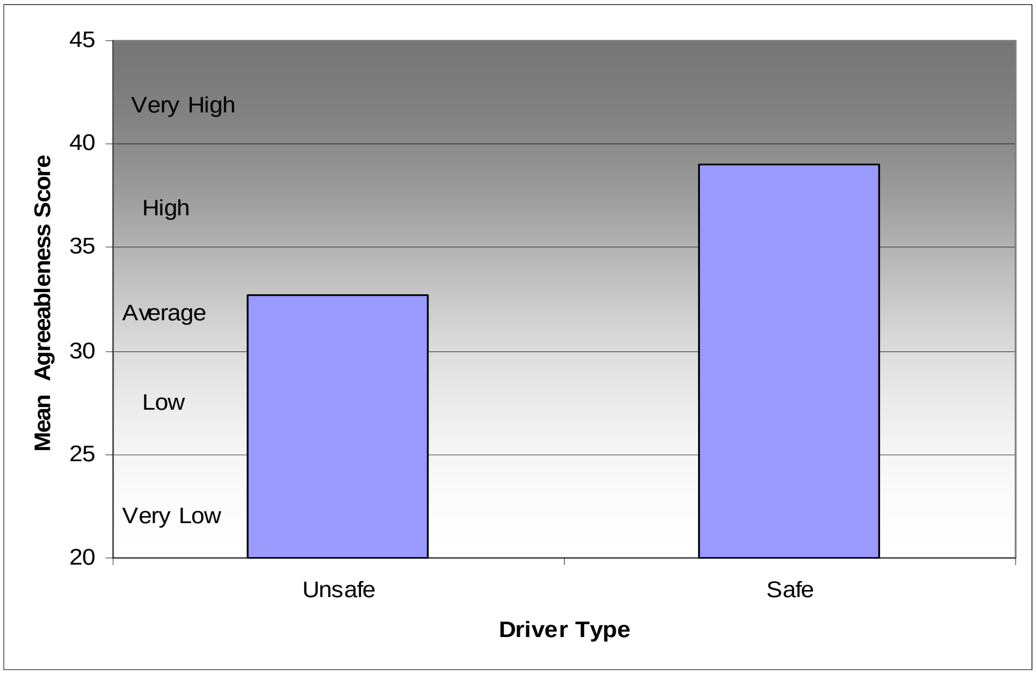

Figure 13. Personality Scores Demonstrating a Significant Difference Between the Unsafe and Safe Drivers on the Agreeableness Score

<u>Conscientiousness:</u> The conscientiousness scale is a measure of individual differences in the tendencies and abilities to plan, organize, and perform tasks. Highly conscientious individuals are purposeful, strong-willed, and highly determined. Highly skilled musicians or athletes are often categorized as Conscientious on this scale. Individuals who score lower on this scale are not as driven to the achievement of goals, and while they may possess goals, they are less likely to maintain schedules and practices that will result in the achievement of these goals.

The mean conscientiousness scores for both unsafe and safe drivers (Figure 14) were not significantly different; however, this analysis approached statistical significance: t (97) = 3.04, p = 0.08. The mean score for the unsafe group indicated that they scored on the high range of "Average" and the safe group scored on the middle range of "High" (Figure 14).

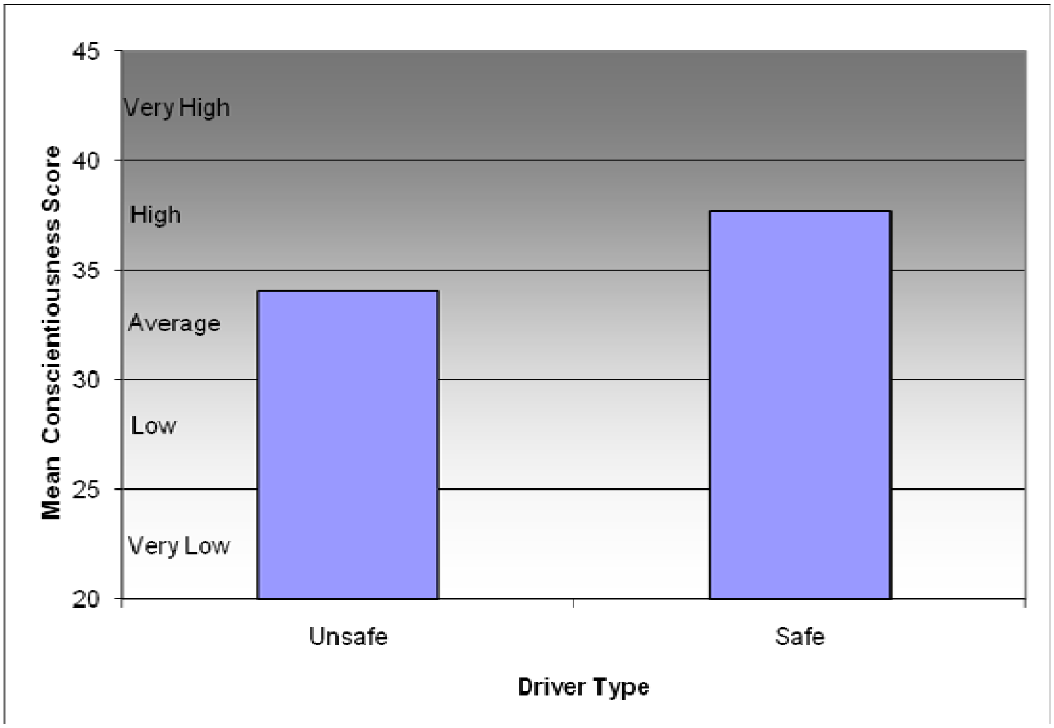

Figure 14. Personality Scores for Unsafe and Safe Drivers

The results of the NEO-FFI found statistically significant differences on only the agreeableness scale. Similar non-significant results were identified on the other scales, where safe drivers scored in the "High" or "Very High" levels of extroversion, openness to experience, agreeableness, and conscientiousness. Unsafe drivers scored either "High" or "Average" on all of these scales, indicating more moderate tendencies in each of these areas of personality. Significant differences were found on the agreeableness scale, which is sensitive to levels of altruism versus competitiveness, and indicates that the safe drivers may be slightly more altruistic in nature than the unsafe drivers.

Performance-Based Test Analyses

Waypoint

The WayPoint computer-based test provides a composite score on four driver characteristics, as follows:

1) Channel capacity: Speed of information processing.
2) Preventable crash risk; ranks a driver on a scale of 1 to 4 from significantly lower than average (odds ratio of 0.4) to greatly above average (odds ratio of 6.2 or higher).
3) The expected number of moving violations in the next 5 years.
4) Expected seat belt use.

Previous testing indicated that this test could identify high-risk drivers 80 percent of the time; however, these results were geared toward older drivers (Janke, 2001). T-tests were conducted to determine whether the unsafe and safe drivers scored significantly differently on any of these four scales. The T-tests for all four scores showed no significant differences between unsafe and safe drivers. The descriptive statistics for each of the four Waypoint scales are presented in Table 24, Table 25, Table 26, and Table 27.

Table 24. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for the *Channel Capacity Score*

Statistic	Unsafe Drivers	Safe Drivers
N	25	59
Mean	5.5	5.2
Standard Deviation	1.9	2.1

Table 25. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Preventable Crash Risk*

Statistic	Unsafe Drivers	Safe Drivers
N	25	59
Mean	1.4	1.5
Standard Deviation	0.6	0.7

Table 26. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Expected Number of Moving Violations*

Statistic	Unsafe Drivers	Safe Drivers
N	25	59
Mean	1.4	1.2
Standard Deviation	0.7	0.6

Table 27. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for *Expected Seat Belt Use*

Statistic	Unsafe Drivers	Safe Drivers
N	25	57
Mean	1.2	1.1
Standard Deviation	0.4	0.4

Useful Field of View

The UFOV test is another computer-based performance test whose score is impacted by an individual's central visual processing speed, and abilities in divided and selective attention. The participant is required to select rapidly presented target objects that are flashed on a computer monitor, while simultaneously attending to other stimuli. Using this test, crash risks are assigned to each individual.

T-tests were conducted using the composite UFOV score to determine whether there were significant differences in the unsafe versus the safe drivers for central visual processing speed, divided attention, and selective attention abilities. While no significant differences between the unsafe and safe drivers were observed, the results did approach significance, t (98) = 3.17, p = 0.08. The descriptive statistics for the UFOV test is presented in Table 28.

Table 28. Descriptive Statistics on the Unsafe and Safe Drivers' Scores on the Driver Stress Factor Scale for UFOV

Statistic	Unsafe Drivers	Safe Drivers
N	28	72
Mean	1.5	2.3
Standard Deviation	1.6	2.2

Analysis Two: ANOVA Statistical Tests for the Safe, Moderately Safe, and Unsafe Driver Groups

Univariate ANOVAs were conducted using the three levels of event involvement per MVMT. All appropriate survey responses and test scores were used as dependent variables. Only those ANOVAS that were significant are reported in the following section. As stated previously, the drivers were grouped into three levels of safety: safe, moderately safe, and unsafe. These groups were based on the number of crashes and near-crashes for each driver per MVMT. Safe drivers refer to those drivers who were involved in fewer than 240 crashes and/or near-crashes per MVMT. The moderately safe driver group was involved in between 240 and 950 crashes or near-crashes per MVMT. The unsafe driver group was involved in more than 950 crashes or near-crashes per MVMT. Therefore, unsafe driver refers to those drivers with high frequency of involvement in crashes and/or near-crashes and safe driver refers to those drivers with low frequency of involvement in crashes and/or near-crashes.

Demographic Data and Self-Reported Data Analyses

Driver Age

An analysis of variance was performed to determine whether the mean age for each of the three groups was significantly different from one another. The ANOVA indicated significance among the three groups: $F(2,96) = 3.61$, $p < 0.05$. A post hoc Tukey test was conducted and the results indicated significant differences between the unsafe and the safe drivers: $t(96) = 2.68$, $p < 0.05$. This suggests that drivers involved in the highest number of crashes and near-crashes were significantly younger than drivers with low involvement (Figure 15).

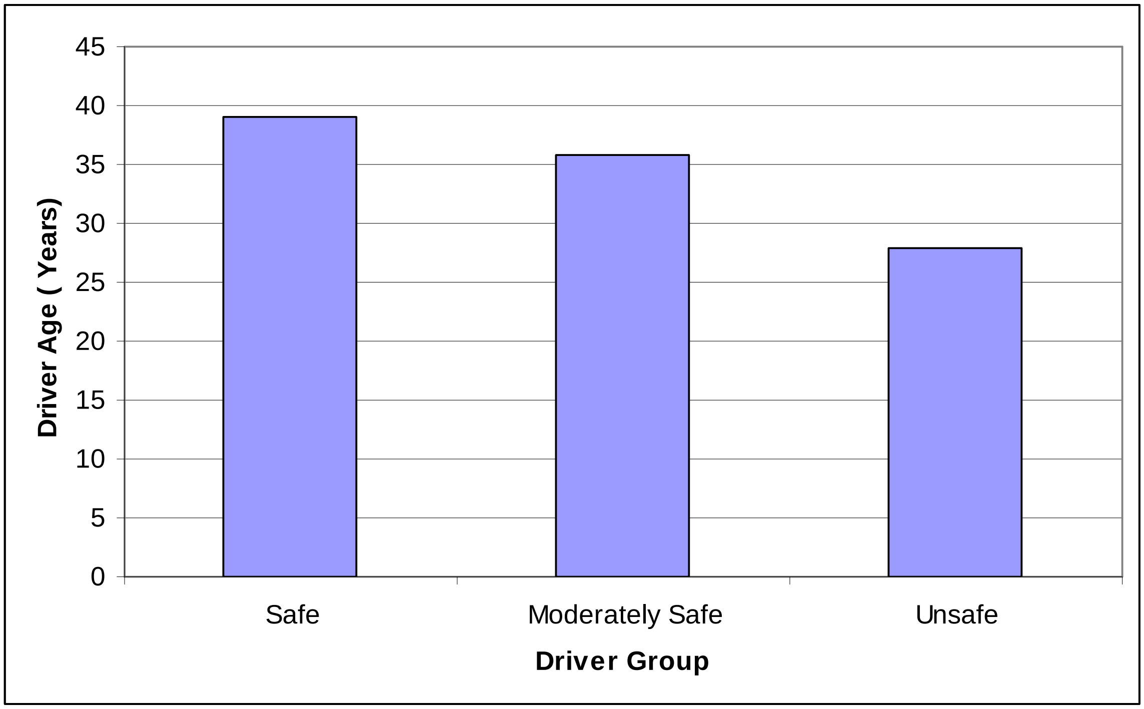

Figure 15. Mean Age of the Drivers in the Safe (N = 39), Moderately Safe (N = 47), and Unsafe (N = 15) Driver Groups

Years of Driving Experience

An analysis of variance was conducted on the number of years of driving experience for the three levels of event involvement. The overall ANOVA indicated significant differences: $F(2, 93) = 5.19$, $p < 0.01$ (Figure 16). Post hoc Tukey test results indicated similar results to Driver Age, with the unsafe drivers having significantly fewer years of driving experience than the safe drivers: $t(93) = 3.21$, $p < 0.01$. This significant finding is not surprising given that the unsafe drivers had an average of 10 years of driving experience while the safe drivers had nearly 25 years of driving experience.

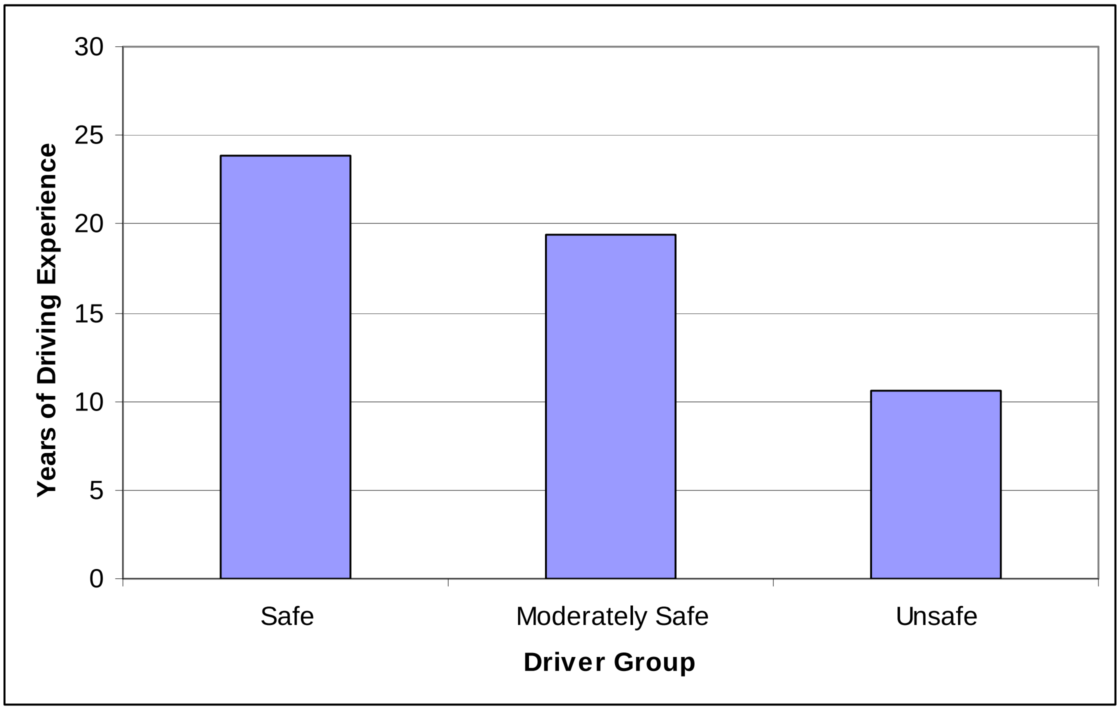

Figure 16. The Mean Years of Driving Experience for the Three Driver Groups, Safe Drivers (N = 39), Moderately Safe, (N = 47), and Unsafe Drivers (N = 15)

Test Battery Analyses

NEO Five Factor Inventory

An ANOVA was conducted on all five scales of the NEO-FFI. Only the agreeableness scores from the NEO-FFI indicated significant differences among the three groups: $F(2,95) = 4.00$, $p < 0.05$. A Tukey post hoc comparison was performed, which indicated that the unsafe driver group scored significantly lower than did the safe driver group: $t(95) = 2.53$, $p = 0.03$. Thus, drivers in the unsafe group scored on average in the middle of the "average agreeableness" scale whereas the safe drivers scored in the "very high agreeableness" category (Figure 17). Recall from previous discussion that the Agreeableness scale measures an individual's altruistic tendencies. Those drivers in the safe categories scored very high on this scale, indicating significantly greater altruistic tendencies than the unsafe drivers.

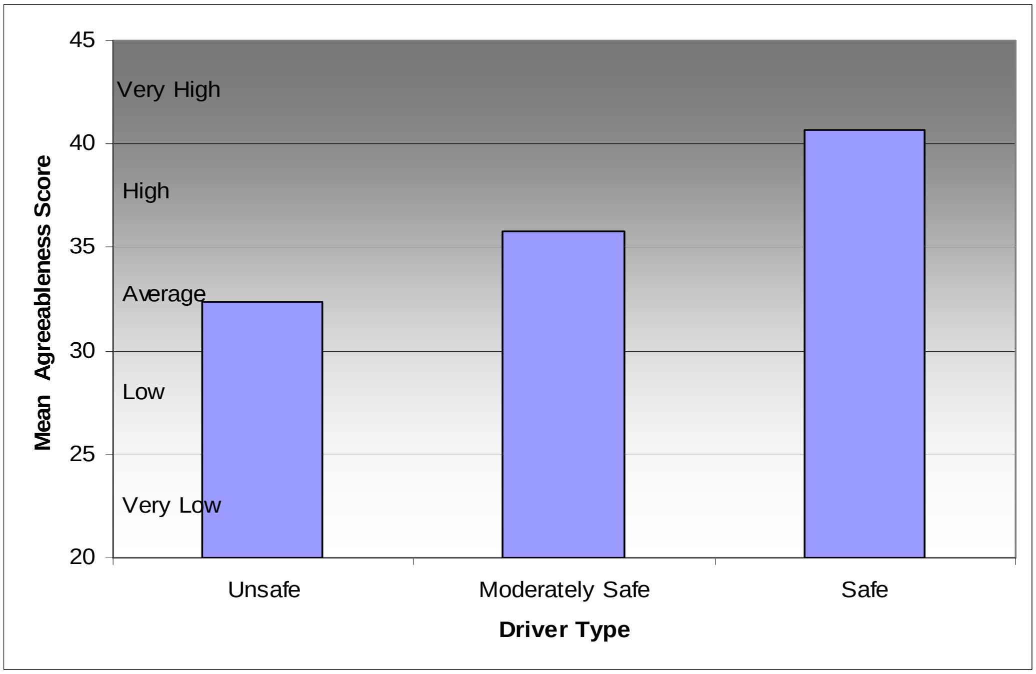

Figure 17. Mean Agreeableness Scores (NEO Five-Factor Inventory) for the Three Driver Groups: Unsafe Drivers (N = 14), Moderately Safe Drivers (N = 45), and Safe Drivers (N = 39).

Dula Dangerous Driving Inventory

Figure 18 and Figure 19 present the results from the ANOVA for the three driver groups and their scores on the Dula Dangerous Driving Inventory. The Dula Dangerous Driving Inventory contains three subscales plus one overall score, the Dula Dangerous Driving Index, as shown in Table 13. A higher rating on any of these scales indicates that the driver rated himself/herself as more of a risk taker. The Risky Driving subscale and the Dula Dangerous Driving Index were found to demonstrate statistical differences among the three groups (Risky Driving: $F(2, 96) = 3.67$, $p = 0.03$; Dula Dangerous Driving Index: $F(2, 96) = 4.40$, $p = 0.02$). Post hoc T-tests revealed that the moderately safe and the unsafe groups were significantly different from one another for both the Risky Driving subscale ($t(96) = 2.71$, $p = 0.02$) and the Dula Dangerous Driving Index ($t(96) = 2.95$, $p = 0.01$). The mean values for each group indicated that the safe drivers rated themselves as nominally more risky than did the moderately safe drivers; however this finding was not statistically significantly. This result does not appear to make intuitive sense, perhaps because this scale was developed and validated with younger drivers. Recall that the drivers in the unsafe group were younger; it is possible that this scale is more sensitive to younger drivers and less sensitive to older drivers. Statistically, the scales suggest that the moderately safe drivers scored significantly lower than the unsafe drivers on both the risky driving scale and the Dula Dangerous Driving Index. This suggests that the unsafe drivers rate themselves as riskier and as more dangerous than do the moderately safe drivers.

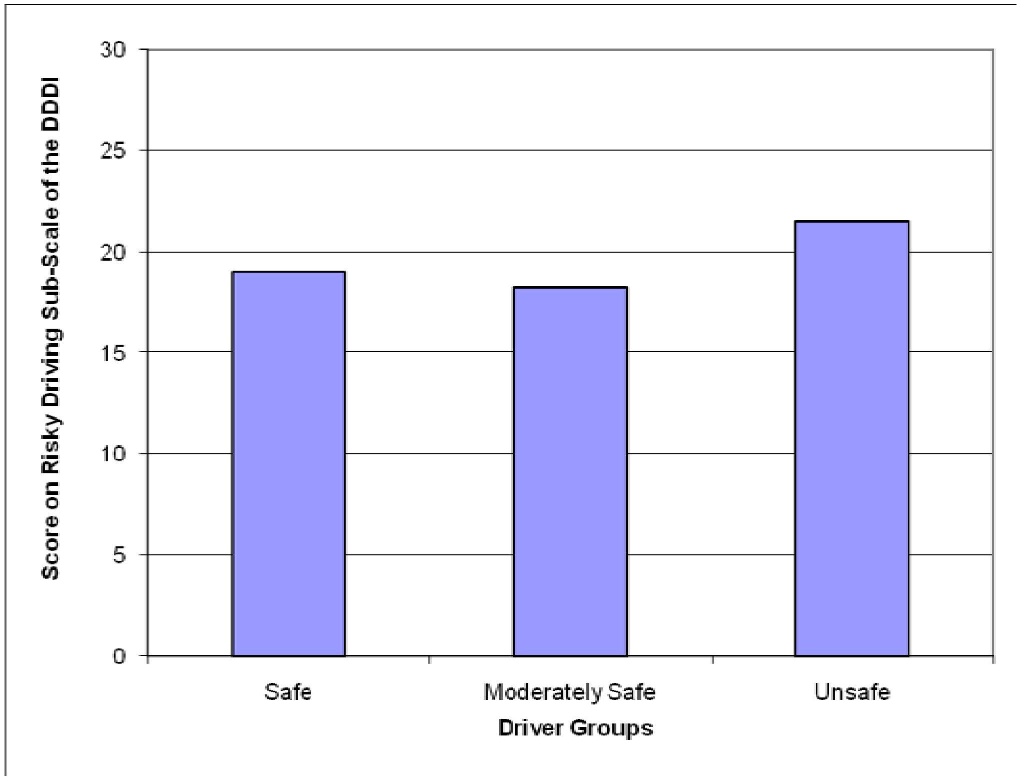

Figure 18. Mean Scores on the Risky Driving Sub-Scale of the Dula Dangerous Driving Inventory by Driver Group: Safe Drivers (N = 39), Moderately Safe Drivers (N = 45), and Unsafe Drivers (N = 15)

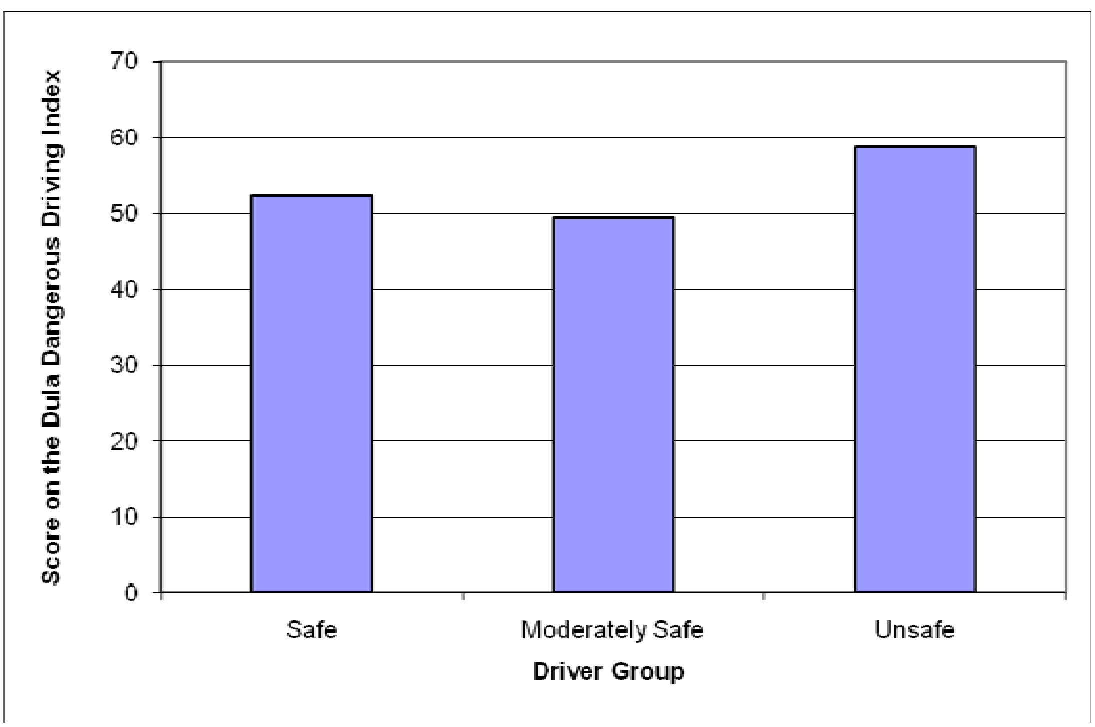

Figure 19. Mean Scores on the Dula Dangerous Driving Index, by Driver Group

Analysis Three: Correlation Analysis

Correlations were performed using the frequency of involvement in crashes and near-crashes per MVMT by driver survey responses or test battery scores. The significant results are shown in Table 29.

While these correlation coefficients were statistically significant, they are deemed to be only modestly significant in behavioral science research (Keppel & Wickens, 2004). Driver age and years of driving experience have slightly stronger correlations. These results, in combination with the significant T-test and F-tests, corroborate a large body of research indicating that driver crash involvement decreases as age increases (up to a point where increasing age tends to result in greater crash risk). The significant correlations with UFOV and Agreeableness to crash and near-crash involvement is somewhat more interesting in that these scales may be measuring a perceptual performance or personality construct that is moderately correlated with crash and near-crash involvement.

Table 29. Correlation Coefficients for All Test Battery Questionnaires

Test Score/Survey Response	Correlation Coefficient	Probability Value
Useful Field of View	-0.19	0.05
Agreeableness	-0.24	0.02
Driver Age	-0.33	0.001
Years of Driving Experience	-0.36	0.0004

Analysis Four: Logistic Regression Using Significant Demographic, Test Battery, and Performance-Based Tests

A logistic regression was conducted to determine whether multiple data sources, all obtained from demographic data, test battery results, and performance-based tests, could be used to predict whether a driver was safe or unsafe. Using the univariate and correlation analyses described above, only the seven test batteries demonstrating significance or approaching significance were used in the analysis. These variables were:

1) Driver Age;
2) Driving Experience;
3) Agreeableness from the NEO-FFI;
4) Conscientiousness from the NEO-FFI;
5) UFOV;
6) the Risky Driving Sub-Scale of the Dula Dangerous Driving Inventory; and
7) the Dula Dangerous Driving Index.

Note that none of the correlation coefficients for any of the above variables or test battery results was greater than ±0.4, which is considered to be a moderate effect size in the behavioral sciences. Nevertheless, these variables were the only ones deemed to be suitable for use in the logistic regression analysis.

A stepwise selection technique was used to first identify those variables that made significant partial contributions to predicting whether a driver is a safe, moderately safe, or unsafe driver.

This procedure produced a logistic regression equation with two variables: Years of Driving Experience and the Agreeableness sub-scale from the NEO Personality Inventory. The resulting regression coefficients and relevant statistics are shown in Table 30. The equation parameters are shown as rows in Table 30.

Table 30. Results from the Stepwise Logistic Regression Analysis

Parameter	DF	Parameter Estimate	Standard Error	Wald ChiSquare	Probability > Chi Square
Intercept 1	1	-2.83	0.85	11.01	0.0009
Intercept 2	1	-0.43	0.80	0.28	0.59
Years of Driving Exp.	1	0.04	0.01	5.57	0.02
Agreeableness Score	1	0.04	0.02	4.30	0.04

A backward selection technique was then used to ensure that each of these variables was making a significant partial contribution to the prediction equation. The results of this test repeated the above regression equation, indicating that Years of Driving Experience and the Agreeableness sub-scale may be predictive of a driver's involvement of crashes and near-crashes. Further analysis would be necessary to test this regression equation's predictive abilities.

The parameter estimates for both Years of Driving Experience and the Agreeableness score were positive numbers, indicating that as drivers gain more Years of Driving Experience or increase their Agreeableness score, the probability that they will be considered a safer driver will also increase. This result suggests that the more experienced drivers and those who score higher on the Agreeableness scale will also be less involved in crashes and near-crashes. Conversely, drivers with less driving experience and who score lower on the Agreeableness scale will be involved in more crashes and near-crashes.

Conclusions

The results of these analyses indicated that seven scores from the survey, questionnaire, and performance-based tests demonstrated that groups of unsafe and safe drivers could be differentiated. Table 31 presents those survey responses and test battery results that demonstrated significant differences for these two analyses. Note that separating the drivers into three groups did improve the results for two of the test batteries. Two of the subscales from the Dula Dangerous Driving Inventory were both significantly different with three groups but not significantly different with two groups of drivers. Only one of the NEO Five-Factor Inventory Scales (Agreeableness) was significant but was significant when separated into either two or three groups.

Table 31. Summary of Tests That found Significant Differences for the Two Analyses Using Either Two or Three Categories of Drivers

	Two-Group Analysis	Three-Group Analysis
1.	Driver Age	Driver Age
2.	Years of Driving Experience	Years of Driving Experience
3.	Agreeableness (Five Factor Personality Inventory)	Agreeableness (Five-Factor Personality Inventory)
4.		Risky Driving Sub-Scale (Dula Dangerous Driving Inventory)
5.		Dula Dangerous Driving Index (Dula Dangerous Driving Inventory)

Recall that the term "safe" was used to simplify discussion of the results and that the drivers in the safe group were not necessarily drivers with no crashes or near-crashes; rather, they were those drivers with fewer crashes and near-crashes (during the year of data collection) than the unsafe drivers. Chapter 3, Objective 2 will provide greater support for the use of the terms *safe* and *unsafe* for these driver groups.

It is interesting to note that driver self-reports of traffic violations or collisions during the past five years were not correlated, nor did these self-reports detect any differences among the driver groups. One explanation for this result could be that the drivers were not honest in these self-reports or they had memory lapses. Another explanation is that younger drivers do not have enough driving history to assess a trend and older drivers' transgressions of five years ago are no longer predictive of their current driving habits. Perhaps the driving history questionnaire should have not requested traffic violations or crash history for five years, but rather only for the past year. Unfortunately, this hypothesis cannot be tested using the demographic questionnaire used for this study.

The unsafe drivers were significantly younger than the safe drivers, with average ages of 30 and 38, respectively. With three groups of drivers, the difference in the average ages for the three groups were still significant (the average ages of the groups were 39 for safe, 36 for moderately safe, and 27 for unsafe). The unsafe drivers had significantly less driving experience than the safe drivers, with an average of 14 versus 22 years of driving experience. When divided into three groups, the unsafe drivers' average Years of Driving Experience was 10 years, while the moderately safe and safe groups were 19 and 24 years, respectively.

Safe drivers scored significantly higher on the personality factor of agreeableness and approached significant for the personality factor of conscientiousness. Please recall that higher values of agreeableness indicate higher levels of altruistic tendencies compared to the unsafe drivers. Higher values of conscientiousness indicate that drivers are more goal-oriented. However, only agreeableness scores remained significant when the drivers were divided into three groups.

For the correlation analysis, driver age, years of driving experience, agreeableness, and UFOV all demonstrated significant correlations of between -0.19 and -0.36. While these correlations indicate only moderate size effects, given the high variability in human performance, these correlation results are useful. These results corroborate other research indicating that age and years of driving experience impact crash involvement. The UFOV has been highly correlated with older driver crash involvement, and the current results show some association with drivers of all ages. The agreeableness scale of the NEO FFI has also demonstrated some association with crash involvement in previous literature, but so have the conscientiousness and extroversion scales. The results from this study suggest that only agreeableness appears to be correlated with crash and near-crash involvement.

The regression analysis indicated that both years of driving experience and agreeableness demonstrated some predictive abilities when considering involvement in crashes and near-crashes. The results also suggest that there is a slight inverse relationship: as a driver's experience or their agreeableness score increases, the probability of involvement in high numbers of crashes and near-crashes decreases. This regression equation did not demonstrate a strong relationship, and thus some caution is urged if using these scales to predict high involvement in crashes and near-crashes.

Chapter 3: *Objective 2*: Determine the Relationship Between Various Risky Driving Behaviors and the Presence of Environmental Conditions Among the Safe, Moderately Safe, and Unsafe Drivers

This analysis focused on frequency distributions of various risky driving behaviors for safe, moderately safe, and unsafe drivers. Risky driving behaviors that were used in this analysis were adapted from a list of driving behaviors originating from the Virginia State Police accident report form. This list was slightly modified for the purposes of this study, but only where the video provided more detail than police officers investigating a crash scene currently have available. For example, hard braking was broken into both improper braking and improper stopping on the roadway.

Drivers were grouped into three categories based on their involvement in crashes and near-crashes per MVMT. Recall the distribution of involvement in crashes and near-crashes per MVMT used in Chapter 2, *Objective 1* as shown below in Figure 20. Note that drivers who were involved in fewer than 200 crashes and near-crashes per MVMT were operationally defined as "safe." "Moderately safe" drivers were those involved in 200 to 900 crashes and near-crashes per MVMT. "Unsafe" drivers were those involved in more than 900 crashes and near-crashes per MVMT. These groups were created based on observed breaks in the distribution of crash and near-crash involvement per MVMT.

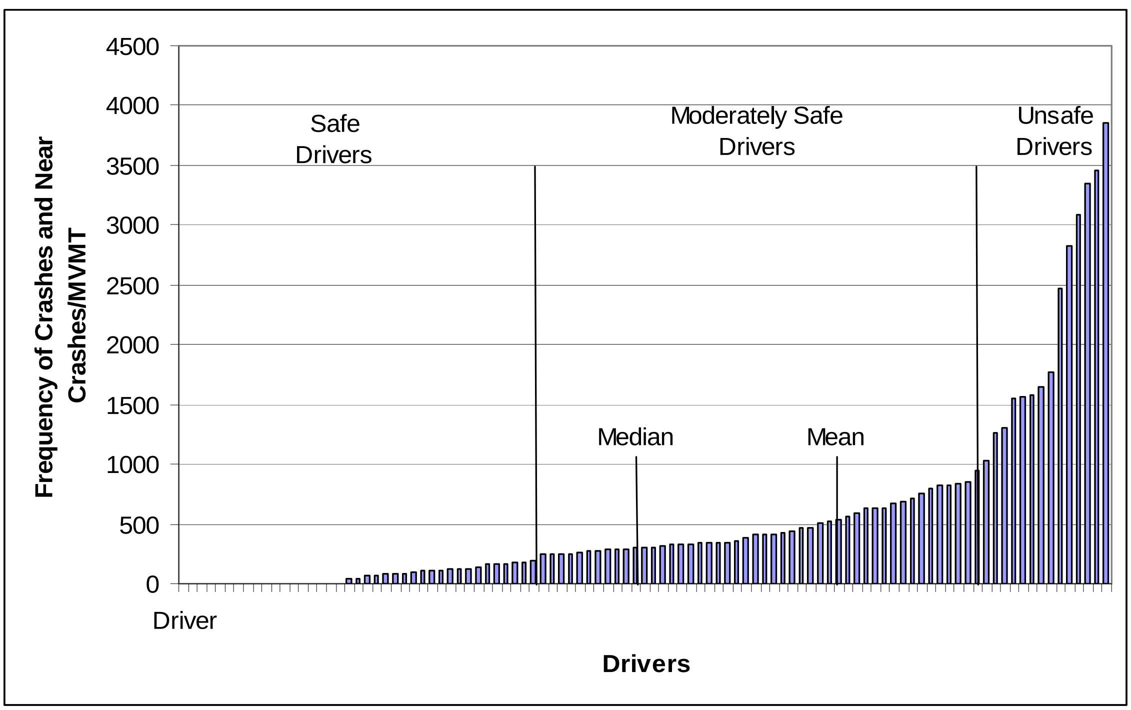

Figure 20. The Frequency of At-fault Crashes and Near-Crashes by Primary Driver in Order From Low Frequency to High Frequency

The descriptive statistics for these three groups are presented in Table 32. Safe drivers were involved in an average of 17 crashes and near-crashes per driver, the moderately safe drivers were involved in an average of 100 crashes and near-crashes per driver, and the unsafe drivers were involved in an average of 197 events per driver.

Table 32. Descriptive Statistics for the Three Driver Groups

Statistics for the Number of Crashes and Near-crashes per MVMT	Safe Drivers	Moderately Safe Drivers	Unsafe Drivers
N (# of drivers)	**39 drivers**	**47 drivers**	**15 drivers**
Mean (# of C/NC per MVMT)	**63.1**	**460.0**	**2,112.8**
Median (# of C/NC per MVMT)	**48.0**	**411.1**	**1650.2**
Mode (# of C/NC per MVMT)	**0**	**339.7**	**N/A**
Standard Deviation (# of C/NC per MVMT)	**67.7**	**189.9**	**966.0**
Minimum (# of C/NC per MVMT)	**0**	**240.6**	**950.4**
Maximum Number of Crashes and Near-Crashes per MVMT per Driver	**191.1**	**854.7**	**3,853.1**
Average Number of Events per Driver (not per MVMT)	**16.9**	**97.9**	**196.7**

Data Used in the Following Analyses

The following analyses primarily used frequency counts and percentages based on the number of crashes, near-crashes, and incidents where the drivers were noted to be *at fault* by trained data reductionists. The various risky behaviors were also recorded by trained data reductionists and fell under two primary categories: *driver behavior* and *driver seat belt use*. The list of drivers' behaviors that the reductionists selected from are shown in Table 33 and the variables regarding seat belt use are shown in Table 34. In Table 33, these behaviors would only be recorded as risky by trained data reductionists if the behavior put the subject or other vehicles at risk. For example, improper braking would only have been recorded as a risky behavior if the action of braking hard actually resulted in a safety conflict. If the driver had gradually braked or performed a more appropriate response such as changing lanes, the conflict would never have occurred. See the Appendix B for specific operational definitions of each of these risky behaviors.

Note that reductionists were permitted to note up to three different risky behaviors from the list shown in Table 33 and only one from the list in Table 34. Reductionists were instructed to note the drivers' behaviors in order of importance if more than one risky driving behavior was observed for the event. Thus, the first driver behavior recorded by the reductionists was deemed to have contributed to the occurrence of the crash or near-crash relatively more than any other behavior observed. While this distinction was a relative judgment made by the trained reductionists, it was generally not difficult to assess how one behavior may have been more critical to the outcome of the event than another behavior. For example, if the driver was involved in a rear-end struck near-crash because the driver over-reacted to lead vehicle brake lights while talking to a passenger, hard braking would be the most critical behavior and talking to a passenger would be second. Please note that a senior human factors researcher and an expert data reductionist reduced the crashes and near-crashes, while 14 trained reductionists reduced the incidents and baseline epochs. All of the reductionists spot-checked one another and all were spot-checked by senior researchers to ensure uniformity in these judgments.

Table 33. List of Driving Behaviors as Recorded by Trained Data Reductionists for Both Event and Epoch Databases (Operational Definitions of Each Behavior Are in Appendix B)

Primary Category	**Levels Under Primary Category**
1. Apparent Unfamiliarity	a. Apparent unfamiliarity with roadway b. Apparent unfamiliarity with vehicle; e.g., displays and controls c. Apparent general inexperience driving
2. Inappropriate Avoidance Maneuver	a. Inappropriately avoiding pedestrian b. Inappropriately avoiding other vehicle c. Inappropriately avoiding animal
3. Proximity to Other Vehicles	a. Following too closely b. Cutting in, too close in front of other vehicle c. Cutting in, too close behind other vehicle d. Driving in other vehicle's blind zone
4. Did Not See	a. Did not see other vehicle during lane change/merge
5. Inappropriate Speed	a. Exceeded speed limit b. Exceeded safe speed but not speed limit c. Driving slowly, below speed limit d. Driving slowly in relation to other traffic, not below speed limit e. Speeding in work zone
6. Failure to Signal	a. Failed to signal, or improper signal b. Failure to signal, without other violations or unsafe actions
7. Improper Backing	a. Improper backing, did not see b. Improper backing, other
8. Improper Turn	a. Improper turn: wide right turn b. Improper turn: cut corner on left turn c. Other improper turning
9. Improper Parking	a. Improper start from parked position b. Parking in improper or dangerous location; e.g., shoulder of interstate
10. Improper Passing	a. Illegal passing b. Passing on right c. Other improper or unsafe passing d. Wrong side of road, not overtaking
11. Reckless/Menacing Driving	a. Aggressive driving, specific, directed menacing actions

	b. Aggressive driving, other; i.e., reckless driving without directed menacing actions c. Following too close
12. Traffic Signal Violation	a. Disregarded officer or watchman b. Signal violation, apparently did not see signal c. Signal violation, intentionally ran red light d. Signal violation, tried to beat signal change e. Stop sign violation apparently did not see stop sign f. Stop sign violation intentionally ran stop sign at speed g. Stop sign violation, "rolling stop" h. Other sign (e.g., Yield) violation apparently did not see sign i. Other sign (e.g. ,Yield) violation, intentionally disregarded j. Other sign violation k. Non-signed crossing violation (e.g., driveway entering roadway) l. Right-of-way error in relation to other vehicle, person and apparent decision failure (e.g., did not see other vehicle), m. Right-of-way error in relation to other vehicle or person, apparent decision failure (did see other vehicle or person but misjudged gap) n. Right-of-way error in relation to other vehicle or person, unknown cause.
13. Improper Braking	a. Sudden or improper braking on roadway b. Sudden or improper stopping on roadway c. Use of cruise control contributed to late braking
14. Inattentive	a. Inattentive or distracted
15. Other	a. Failure to dim headlights b. Driving without lights or insufficient lights c. Other risky behaviors

Table 34. List of Seat Belt Use Variables Recorded by Trained Data Reductionists for Both Event and Epoch Databases

1. Lap/Shoulder Belt
2. Only Lap Belt Used
3. Only Shoulder Belt Used
4. None Used
5. Unknown if Used

Only those crashes and near-crashes where the driver was determined to be at fault were used in these analyses, since crashes and near-crashes where another driver was at fault do not directly relate to the participants' safe driving behaviors. Those crashes and near-crashes where the trained reductionist could not determine if the participant was at fault or if the fault was due to multiple drivers performing unsafe maneuvers, *were* included in the analysis below. Please note that the term "*event*" is used for the remainder of this chapter as a general term that encompasses crashes, near-crashes, and incidents.

Analysis One: What Is the Prevalence of Risky Driving Behaviors and the Frequency for Each Type of Risky Driving Behavior?

While there were 9,125 crashes, near-crashes, and incidents identified during the data reduction process, in only 8,210 of these was the primary driver considered to be at fault (or fault was unable to be determined). Reductionists marked the presence of at least one risky driving behavior in 7,351 of the 8,210 events. Thus in 90 percent of all events, reductionists marked a risky driving behavior as a contributing factor.

Figure 21 presents the frequency of occurrence for each of the primary types of risky driving behaviors. The total frequency counts listed below exceed the 7,351 events, since many events had multiple types of risky driving behaviors. Note that *improper braking* was the most frequent type of risky driving behavior observed for these events, followed by *driver inattention* and *proximity to other vehicles*. Please note that the *improper braking* category may be disproportionately high because the data collection system was designed to obtain data on rear-end collisions. Therefore, hard braking/stopping behavior was more easily identified in the data than behaviors such as cutting in front of or behind other vehicles and speeding.

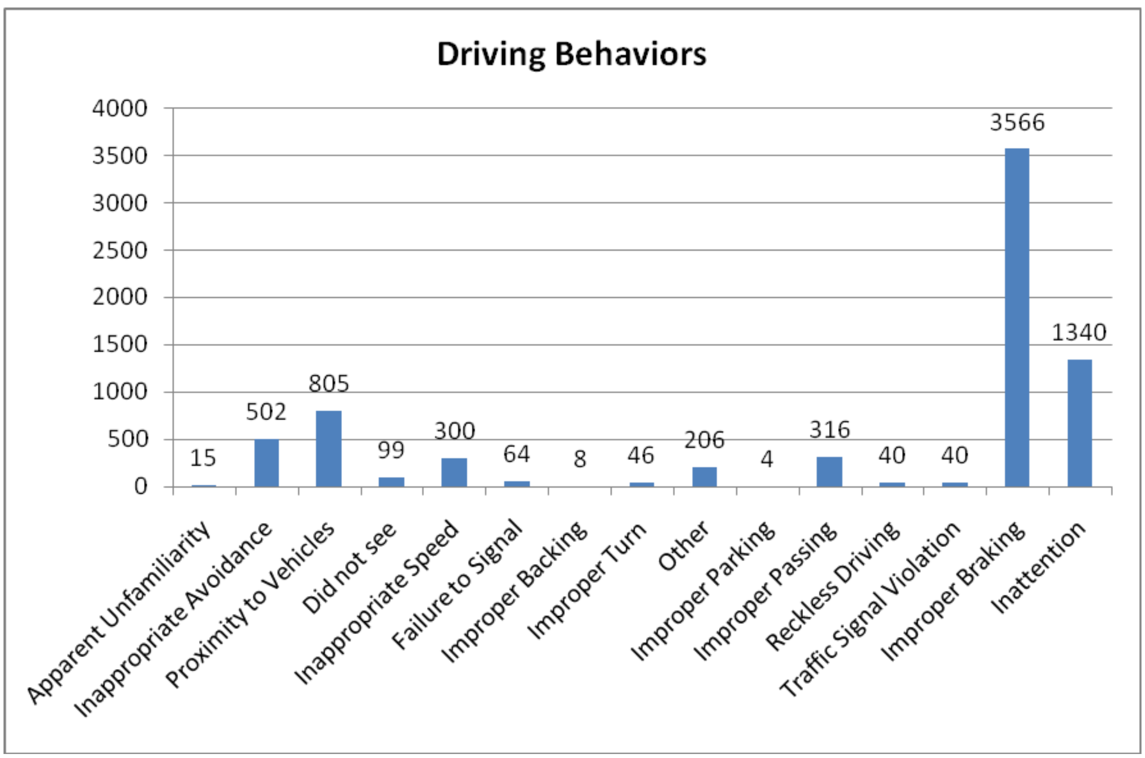

Figure 21. Frequency Counts of the Primary Risky Behavior Categories for Events

Of the 8,210 events where the driver was found to be either at fault or partially at fault, the drivers were clearly wearing their seat belts in 6,013 of these events (73%). This statistic, as well as the frequency of risky driving behaviors, was analyzed per driver group; safe, moderately safe, and unsafe.

Using only the first (most critical) driving behavior that the reductionist recorded for each driver, frequency counts were obtained for each driver group (safe, moderately safe, and unsafe drivers). These frequency counts were divided by the total number of drivers per driver group to obtain an average frequency count per driver. For example, the number of events where the safe drivers were braking improperly was divided by 39 drivers to obtain an average number of improper braking events per safe driver. This was done for each behavior category for the safe drivers, moderately safe drivers, and unsafe drivers and the results are presented in Table 35.

As indicated in previous analyses, improper braking, driving inattention, and proximity to other vehicles were the most frequent types of behaviors observed. Note that the safe drivers had smaller average frequencies for all risky driving behaviors than did the moderately safe and unsafe drivers.

Table 35. List of Average Number of Events Where the Risky Driving Behaviors Were a Primary Contributing Factor

Risky Driving Behavior	Safe Driver	Moderately Safe Driver	Unsafe Driver
Apparent unfamiliarity	0.0	0.2	0.1
Avoiding object	0.0	5.9	5.3
Proximity to other vehicles	0.0	9.9	9.7
Did not see	0.0	1.0	1.5
Speed differential	0.0	2.8	4.6
Failure to signal	0.0	0.9	0.6
Improper backing	0.0	0.0	0.2
Improper turn	0.0	0.5	0.7
Other	0.0	2.6	1.6
Improper parking	0.0	0.0	0.1
Improper passing	4.4	3.3	4.5
Reckless/menacing driving	0.6	0.2	0.9
Traffic signal violation	0.8	0.3	0.7
Improper braking	31.6	47.0	40.6
Inattentive	13.8	14.3	20.1
None	13.9	11.	8.9

Seat belt use for the three driver groups also demonstrated a linear relationship, in that the safe drivers were observed wearing their seat belts for a higher percentage of events than the unsafe drivers, as shown in Figure 22. This represents a 10-percent difference in seat belt use between the safe and unsafe driver groups. This result was expected given that the unsafe group was younger (mean age = 27) than the safe group (mean age = 39), and given that seat belt compliance has been shown to increase with age.

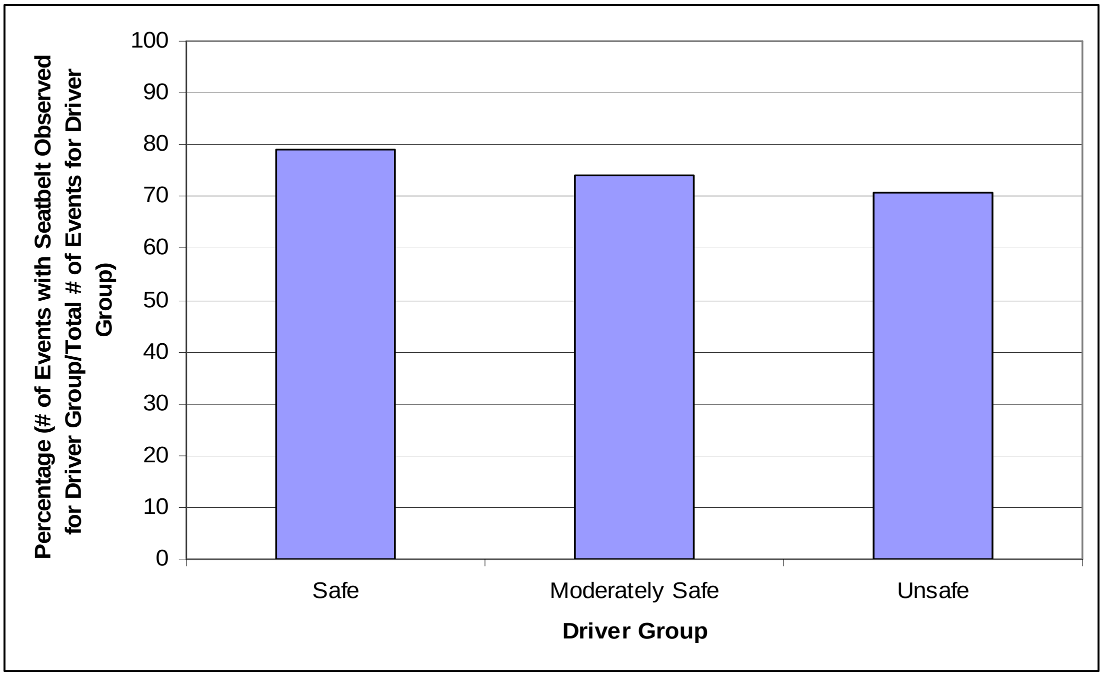

Figure 22. Percentage of Events for Each Driver Group Where a Seat Belt Is in Use By the Driver

Analysis Two: Are There Differences Between the Safe and Unsafe Drivers in Their Engagement in Risky Driving Behaviors During Riskier Environmental Conditions (i.e., Hard Braking on Wet Roadways)?

The following analysis is exploratory in nature and conducted because of the unique nature of the data set being used. While the data set is the largest to date, it has its limitations, especially when dividing the data by driver type, risky behaviors, and environmental conditions. Therefore, caution is urged in the interpretation of these results given that statistical power is low. The purpose of these analyses is to direct future research to those analyses where investigating risky behaviors in the presence of environmental conditions could provide valuable information for safety researchers.

Due to the complexity of the following figures, only the three most frequent risky driving behaviors were plotted in relation to the environmental conditions listed in Table 36. Those three risky driving behaviors are improper braking, inattention, and proximity to other vehicles.

Table 36. Environmental Variables, Levels of Each Variable, and Brief Definition

	Variable Name	Levels of Variable	Definition of Variable
Ambient Light/Weather Conditions			
1.	Lighting	Daylight Darkness, lighted Darkness, non-lighted Dawn Dusk	Ambient lighting levels to denote the time of day.
2.	Weather	Clear Raining Snowing Icy Other	Description of the presence of ambient precipitation and type of precipitation occurring.
Roadway Description			
3.	Road Type	Divided Not divided One-way traffic No lanes	Description of the type of roadway and how traffic is separated.
4.	Road Alignment/Road Profile	Straight, level Straight, grade Curve, level Curve, grade	Description of the road profile at the onset of the conflict.
5.	Traffic Density	Free flow Stable flow, speed restricted Unstable flow, temporary restrictions Unstable flow, temporary stoppages Restricted Flow Forced flow with low speeds and traffic volumes	Level of service definitions (NHTSA) to define six levels of traffic density ranging from free flow to stop-and-go traffic.

To obtain a measure of exposure to each of the environmental conditions, the 20,000 baseline epochs (described in Chapter 1) were analyzed. Please recall that the 20,000 baseline epochs were sampled based on the number of events (crashes, near-crashes, and incidents) observed for each vehicle. Therefore, absolute frequency counts are not important for these analyses; instead, the percent of the total events for each driver group should be compared to the percent of baseline events per environmental condition.

Ambient Light Levels

The percentage of baseline epochs during which drivers experienced each of the following ambient light levels was determined and is presented in Table 37. The results of this analysis indicated that 68 percent of all baseline epochs occurred during daylight hours, 17 percent during darkness but on lighted roadways, 9 percent were in darkness without roadway lighting, 5 percent occurred at dusk, and 1 percent occurred during dawn hours. Note that drivers are in their vehicles four times more frequently during the daytime than at night.

Table 37. The Frequency and Total Percentage of Baseline Epochs That Occurred at Each Ambient Lighting Level

Lighting Level	Frequency of Baseline Epochs	Percent of Baseline Epochs
Darkness-Lighted	3,216	17.0
Darkness- Not Lighted	1,763	9.3
Dawn	49	0.3
Daylight	12,876	68.0
Dusk	1,027	5.4
Total	18,931	100

Figure 23, Figure 24, and Figure 25 present the percentage of baseline epochs that occurred during each ambient lighting condition per driver group. Each figure presents the data for one of the three most frequent risky driving behaviors: 1) inappropriate braking; 2) driver inattention; and 3) close proximity to another vehicle. Please note that between three and six inappropriate behaviors occurred during the daylight for every one inappropriate behavior at night across all three risky driving behaviors. Given that this is generally the relationship for all baseline events (4 daytime:1 nighttime), this result is to be expected (drivers are not engaging in risky behaviors more frequently during the day than at night).

The percentage of hard braking (10%) and inattention events (8%) that safe drivers engage in during *darkness - lighted* conditions is lower than the expected percentage of 17 percent (Table 37). Further analyses would need to be conducted; however, this may indicate that safer drivers do tend to avoid hard braking or engaging in secondary tasks during this ambient lighting condition more so than moderate or unsafe drivers.

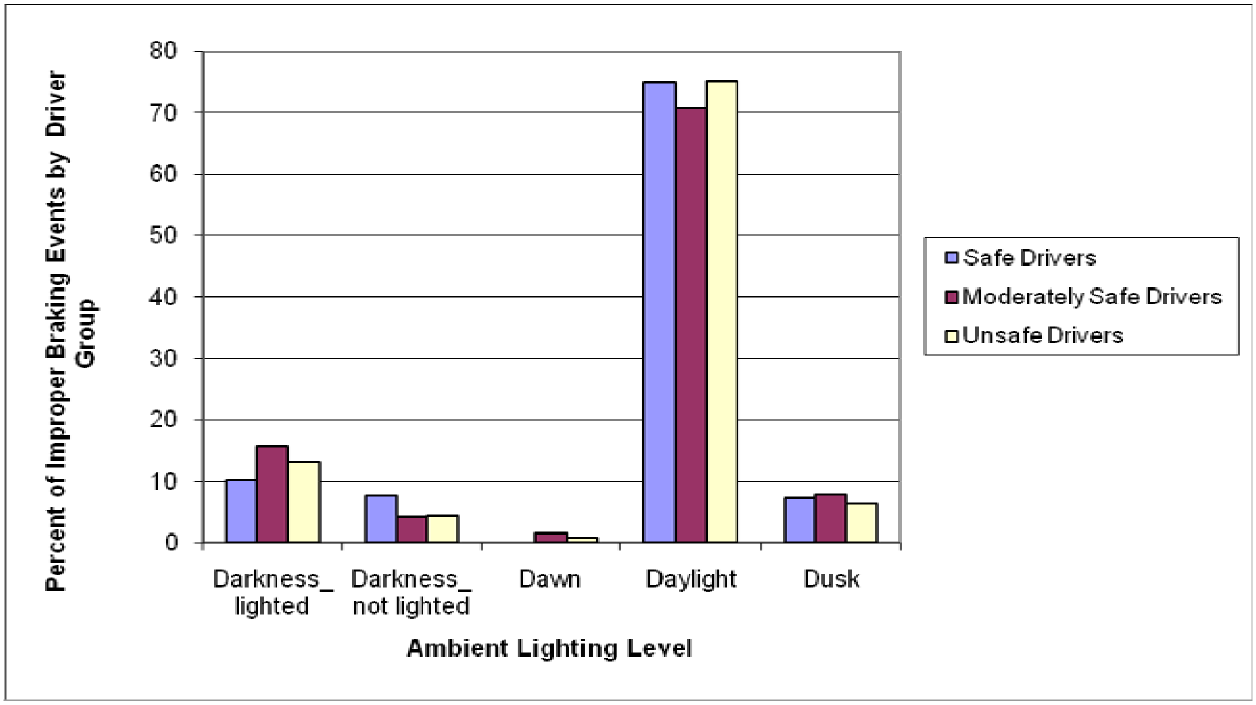

Figure 23. The Average Percentage of Improper Braking Events for the Safe, Moderately Safe, and Unsafe Drivers During the Ambient Lighting Levels

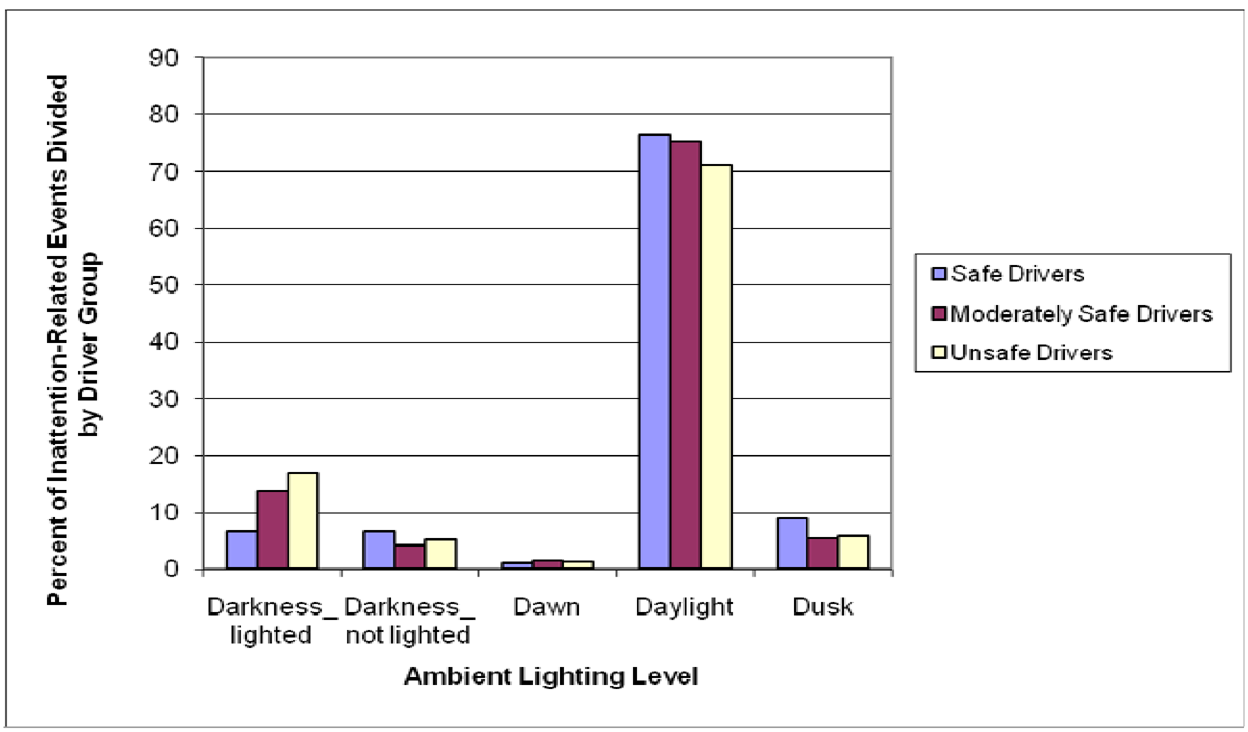

Figure 24. The Percentage of Driver Inattention Events Occurring During the Ambient Lighting Levels for Safe, Moderately Safe, and Unsafe Drivers

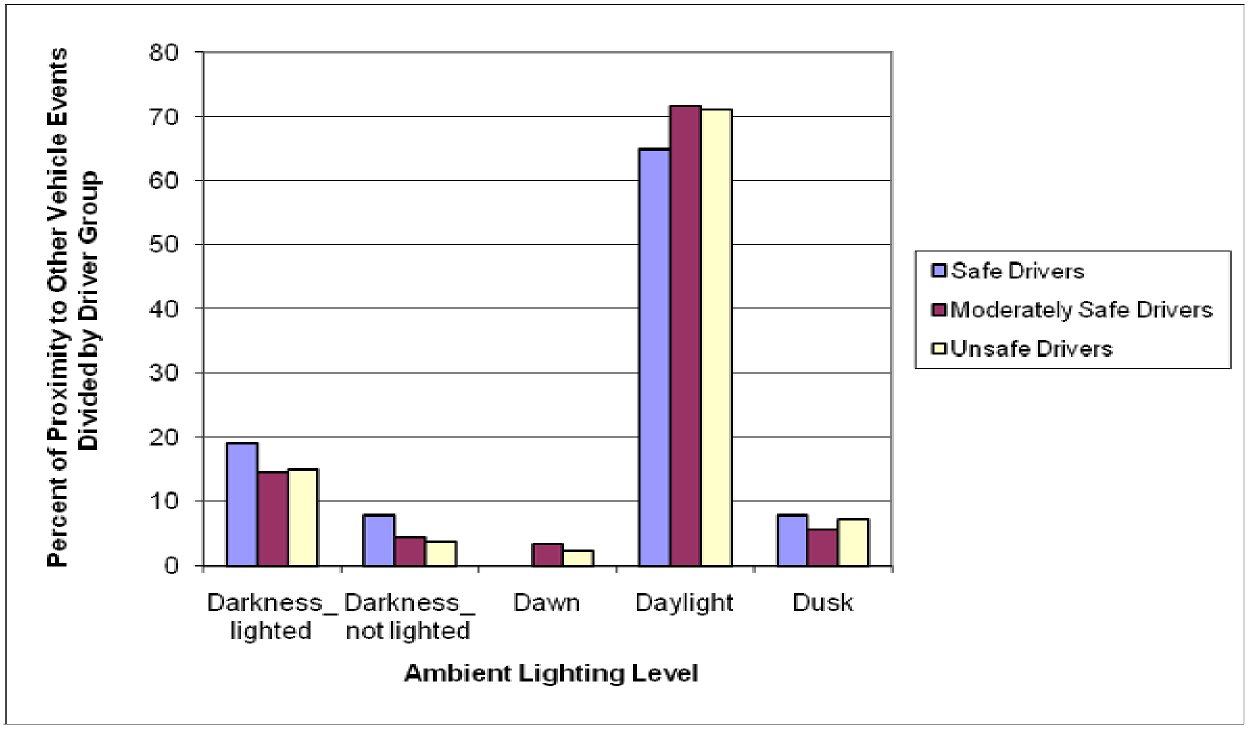

Figure 25. The Percentage of Proximity to Other Vehicle Events Occurring During the Ambient Lighting Levels for Safe, Moderately Safe, and Unsafe Drivers

Weather Conditions

Analyses were conducted using the baseline epochs to determine the percentage of epochs that occurred during the different weather conditions. Eighty-nine percent of all baseline epochs occurred during clear weather, 11 percent occurred during rainy weather, and a negligible number of baseline epochs occurred during sleet, snow, fog, and mist (Table 38). Generally speaking, data were collected in clear versus rainy weather conditions at a ratio of 8:1.

Table 38. The Frequency and Total Percentage of Baseline Epochs That Occurred During Each Weather Condition

Weather Conditions	Frequency of Baseline Epochs	Percent of Baseline Epochs
Clear	16,816	88.8
Rain	1,988	10.5
Sleet	12	0.1
Snow	42	0.2
Fog	32	0.2
Mist	27	0.1
Other	13	0.1
Total	18,930	100

Figure 26, Figure 27, and Figure 28 present the percentage of baseline epochs by driver group where the drivers engaged in the different risky driving behaviors during various weather conditions. Based upon the frequency of baseline events that occurred in foggy, misty, snowy, or sleet conditions, not enough data were collected during these weather conditions. These conditions were thus collapsed under *rainy plus other conditions*. The general relationship of events occurring in clear versus rainy plus other weather is somewhat preserved in that 90 percent of the events occur during clear weather as opposed to rainy weather. The trends of involvement in improper braking, inattention-related events, or frequency of proximity did not differ greatly between the three groups of drivers for clear or rainy conditions. This evidence suggests that drivers are generally engaging in these risky driving behaviors regardless of weather conditions.

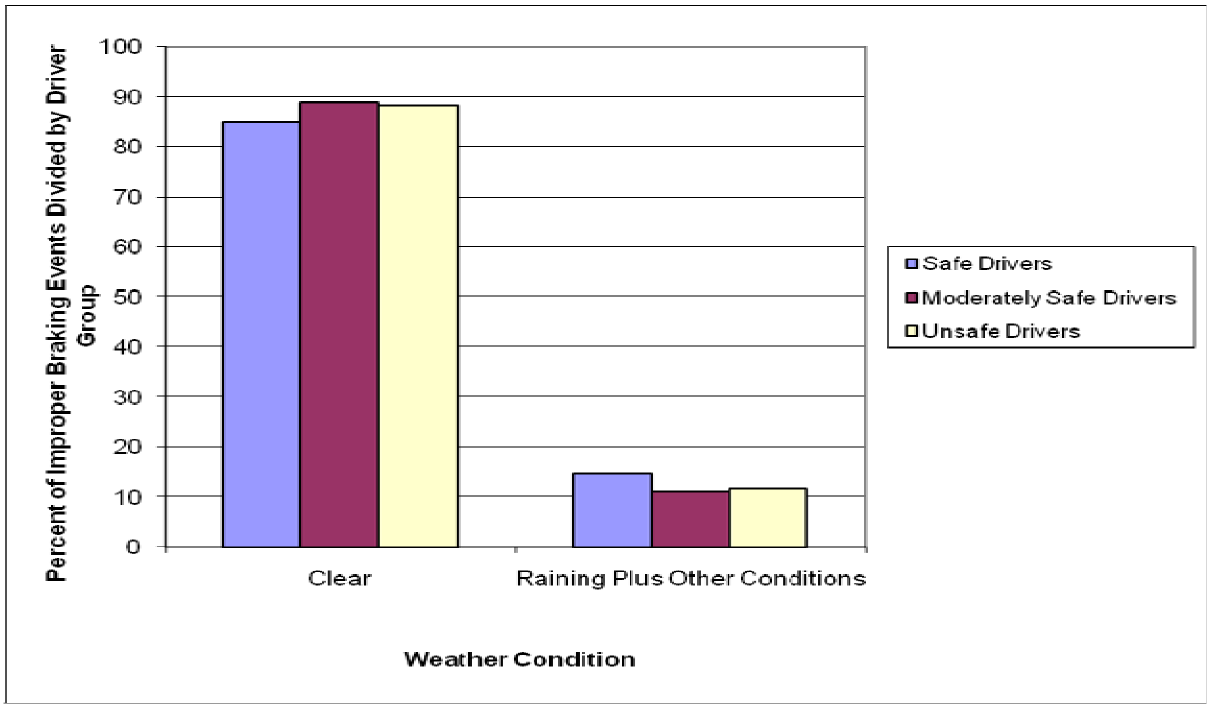

Figure 26. The Percentage of Improper Braking Events Occurring During Various Weather Conditions for Safe, Moderately Safe, and Unsafe Drivers

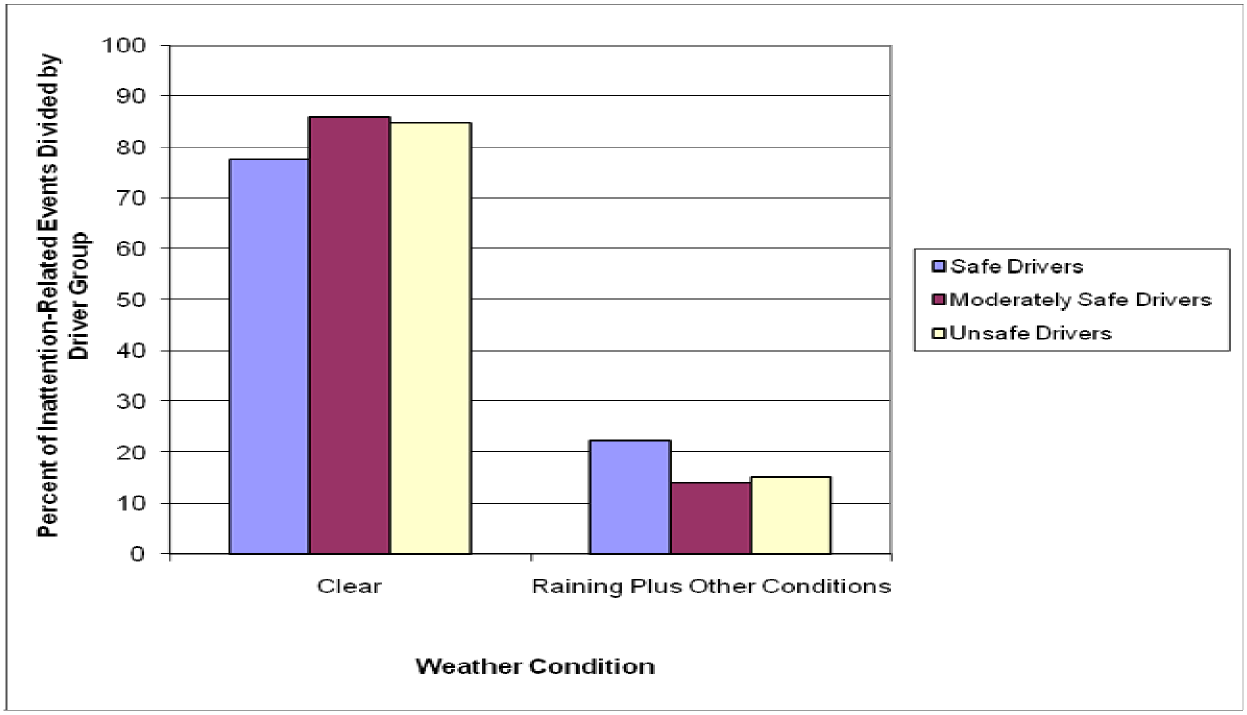

Figure 27. The Percentage of Driver Inattention Events Occurring During Various Weather Conditions for Safe, Moderately Safe, and Unsafe Drivers

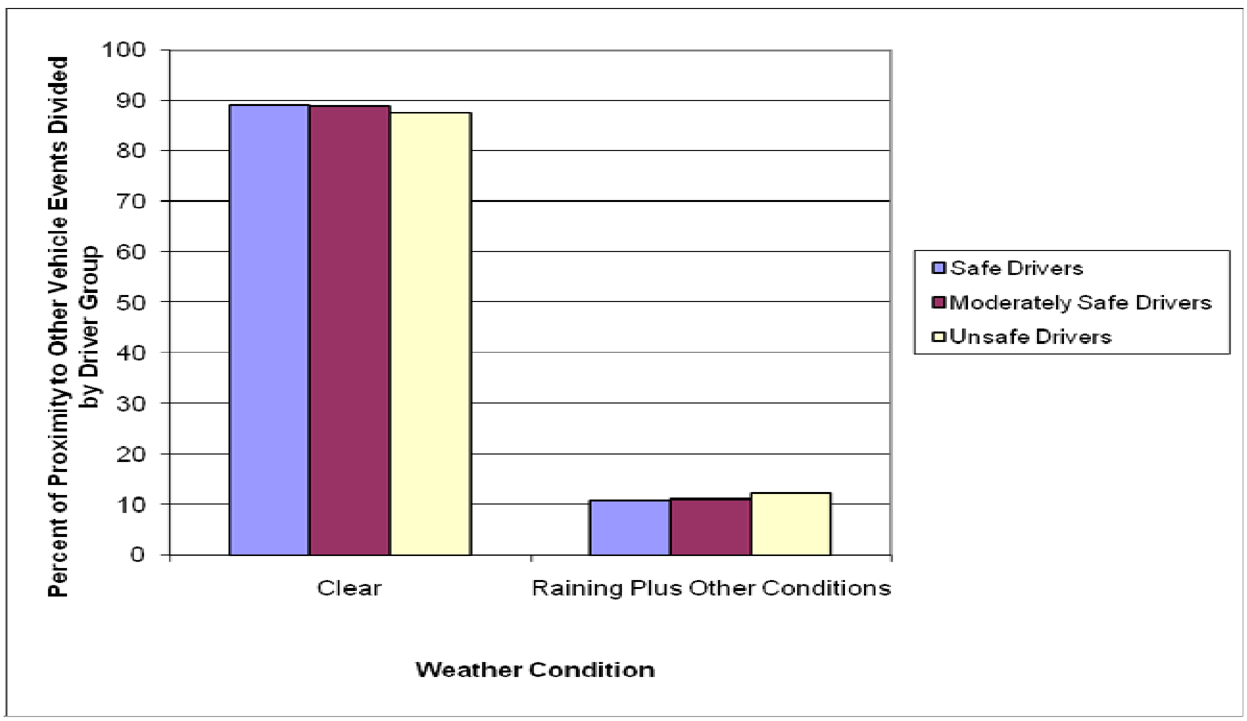

Figure 28. The Percentage of Proximity to Other Vehicle Events Occurring During Various Weather Conditions for Safe, Moderately Safe, and Unsafe Drivers

Road Type (Also Known as Trafficway Flow in the General Estimates System Database)

The analysis of baseline epochs to determine the exposure of the 100-Car Study drivers to the four types of roadways indicated that drivers were on divided roadways during 65 percent of the epochs, undivided roadways for approximately 29 percent of the epochs, and on one-way roads or in parking lots during approximately 6 percent of the epochs.

Given the exposure percentages in Table 39, the percentage of hard braking events and inattention events followed a similar pattern, suggesting that drivers are engaging in these risky behaviors regardless of the type of road that they are traveling (Figure 29 and 30). However, the frequency of being in close proximity to other vehicles increased on the divided roadways in that approximately 75 percent of these risky behaviors were present on divided roadways and only ~22 percent occurred on undivided roadways (Figure 31). Further analyses would be needed; however, this may be an artifact of higher traffic congestion on divided versus undivided roadways. This pattern was observed for all three driver groups.

Table 39. The Frequency and Total Percentage of Baseline Epochs That Occurred for Each Road Type

Road Type	Frequency of Baseline Epochs	Percent of Baseline Epochs
Divided	12,222	64.6
Undivided	5,527	29.2
One-Way	576	3.0
No Lanes	606	3.2
Total	18,931	100

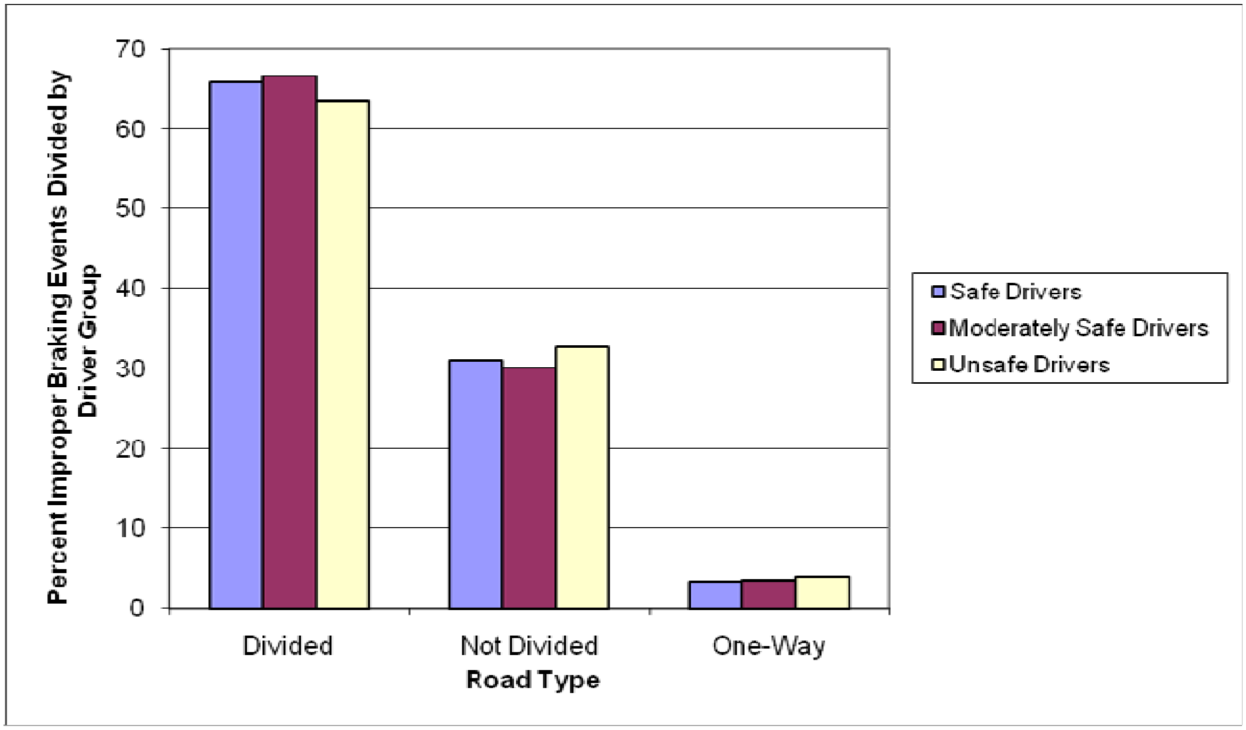

Figure 29. The Percentage of Improper Braking Events on Selected Road Types for Safe, Moderately Safe, and Unsafe Drivers

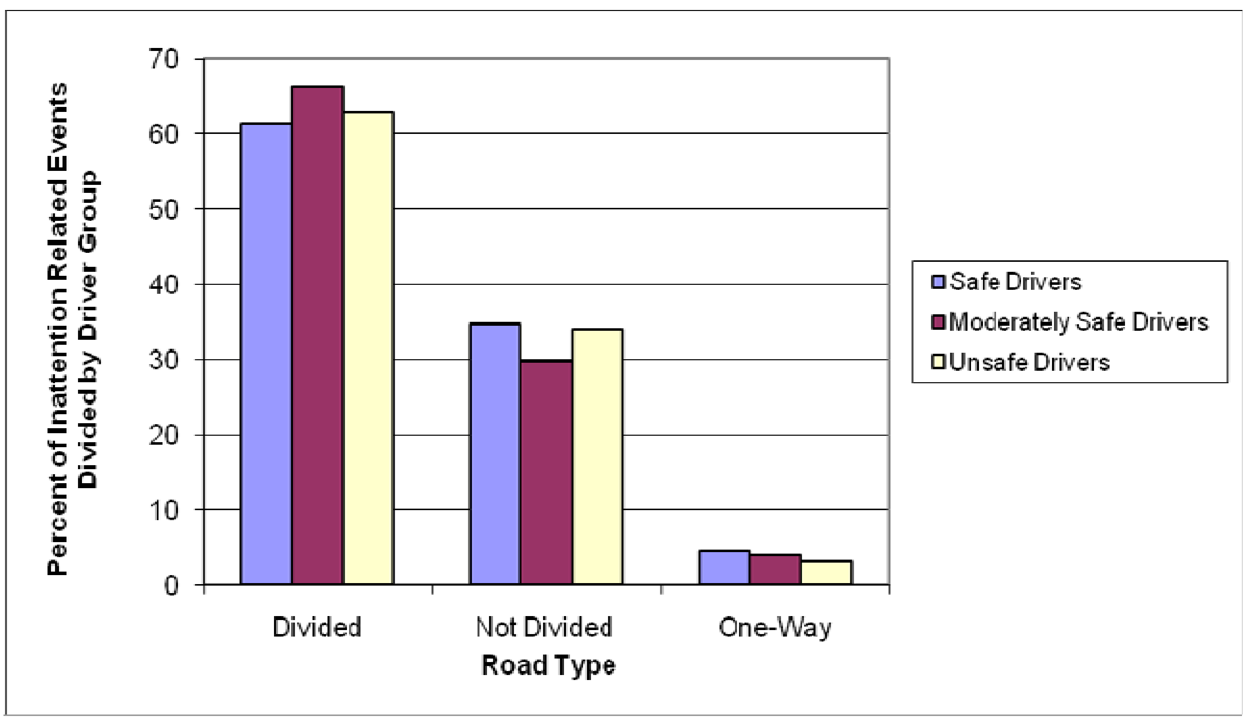

Figure 30. The Percentage of Driver Inattention Events on Selected Road Types for Safe, Moderately Safe, and Unsafe Drivers

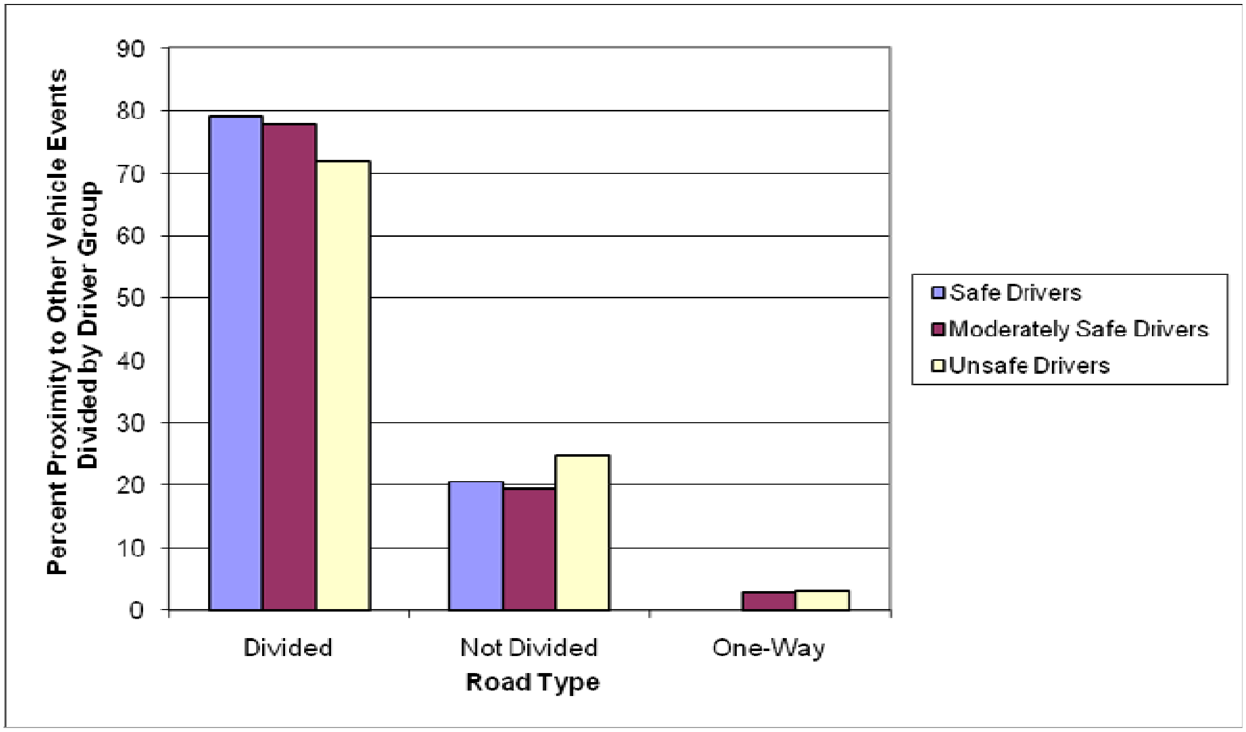

Figure 31. The Percentage of Proximity to Other Vehicle Events on Selected Road Types for Safe, Moderately Safe, and Unsafe Drivers

Road Alignment

Eighty-eight percent of all baseline epochs occurred on straight level roadways with an additional 10 percent occurring on curved, level roadways (Table 40). While this is clearly an artifact of the geographic location of the data collection area, the exposure levels are important to understand when interpreting the following results.

Table 40. The Frequency and Total Percentage of Baseline Epochs That Occurred for Each Type of Roadway Alignment

Type of Roadway Alignment	Frequency of Baseline Epochs	Percent of Baseline Epochs
Curve Grade	148	0.8
Curve Level	1,791	9.5
Curve Hillcrest	2	0.01
Straight Grade	414	2.2
Straight Level	16,571	87.6
Straight Hillcrest	1	0.01
Other	1	0.01
Total	18,928	100

Due to low frequency counts, only straight level and curve level are presented in Figure 32, Figure 33, and Figure 34. Given the overwhelming percentage of baseline epochs on straight, level roadways and the modest percentage on curved, level roadways, the following figures generally all appear to uphold this relationship. Generally, drivers did not appear to choose to engage in risky driving behaviors depending on the type of roadway that they were driving. All three driver groups displayed tendencies to be in closer proximity to vehicles on straight, level roadways than curved, level roadways.

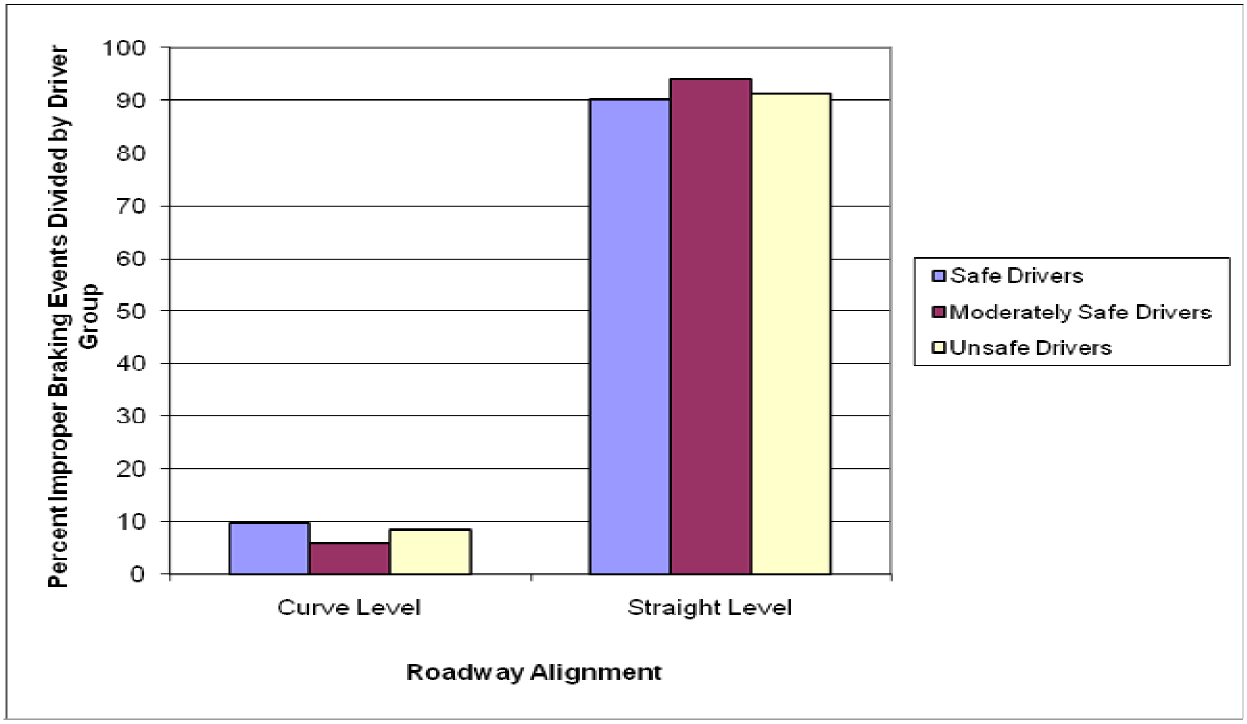

Figure 32. The Percentage of Improper Braking Events on Various Roadway Alignments for Safe, Moderately Safe, and Unsafe Drivers

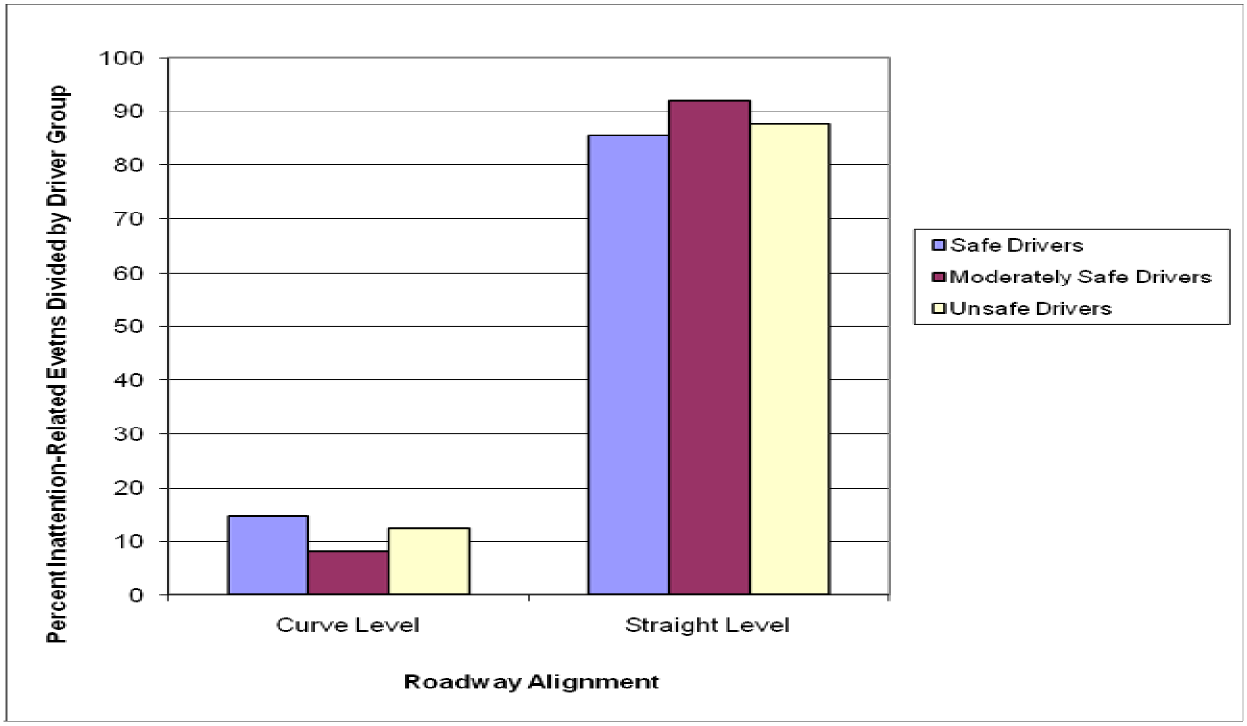

Figure 33. The Percentage of Driver Inattention Events on Various Roadway Alignments for Safe, Moderately Safe, and Unsafe Drivers

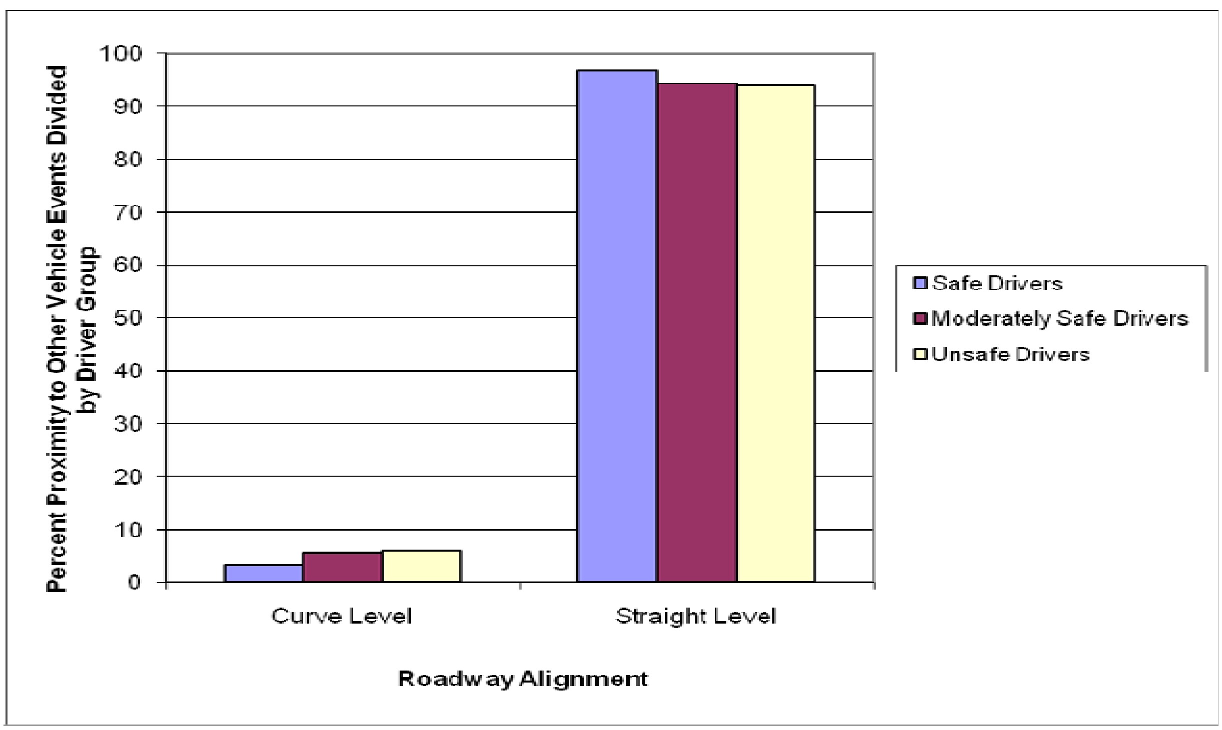

Figure 34. The Percentage of Proximity of Other Vehicle Events on Various Roadway Alignments for Safe, Moderately Safe, and Unsafe Drivers

Traffic Density

Traffic density was determined using the Transportation Research Board's Level of Service Definitions (TRB, 2000). The LOS is a scale (from 1 to 6) of increasing traffic density with 1 being free-flow traffic and 6 being stop-and-go traffic with extended stoppages. An analysis of the percentage of baseline epochs observed for each type of traffic density indicated that nearly 50 percent of all baseline epochs occurred during free flow traffic, 38 percent occurred during free flow with restrictions, and another 10 percent occurred during stable traffic flow (Table 41). Very few epochs were observed at the highest traffic density levels.

Table 41. The Frequency and Total Percentage of Baseline Epochs That Occurred for Each Type of Traffic Density

Traffic Density Type	Frequency of Baseline Epochs	Percent of Baseline Epochs
LOS A: Free Flow	9,333	49.3
LOS B: Flow with Restrictions	7,183	37.9
LOS C: Stable Flow	1,721	9.1
LOS D: Unstable Flow	389	2.1
LOS E: Flow Is Unstable	178	0.9
LOS F: Forced Traffic Flow	126	0.7
Total	18,930	100

Figure 35, Figure 36, and Figure 37 present the percent of events for each level of traffic density. Each figure presents the data for each driver group: safe drivers, moderately safe drivers, and unsafe drivers. The most interesting result is that the occurrence of events for each of these types of traffic density is not the same pattern as observed for the baseline epochs (estimate of exposure to each type of traffic density). Rather, more risky behavior-related events occurred during higher traffic densities, even though drivers spent less time during these traffic densities. This result suggests that the unsafe and moderately safe drivers were more frequently engaging in improper braking and inattention tasks during *flow is unstable, and unstable flow* traffic than were the safe drivers. This may have contributed to their higher rates of crashes, near-crashes, and incidents.

While it is not surprising to observe a higher frequency of improper braking or driving in closer proximity during heavier traffic densities, it is interesting to note that driver inattention is also higher than average for these same levels of traffic density. This may indicate that the unsafe and moderately safe drivers are still choosing to engage in these activities even though they are in more dangerous traffic situations. The safe drivers tended not to engage in inattention-related activities during the three most dense traffic situations.

A final result of interest is that the safe drivers did not engage in driving in close proximity during lighter traffic conditions. The moderately safe and unsafe drivers did choose, though with low percentages, to engage in driving in close proximity during free flow and free flow with some restrictions. This result may suggest that these drivers do, in fact, drive more aggressively regardless of traffic conditions.

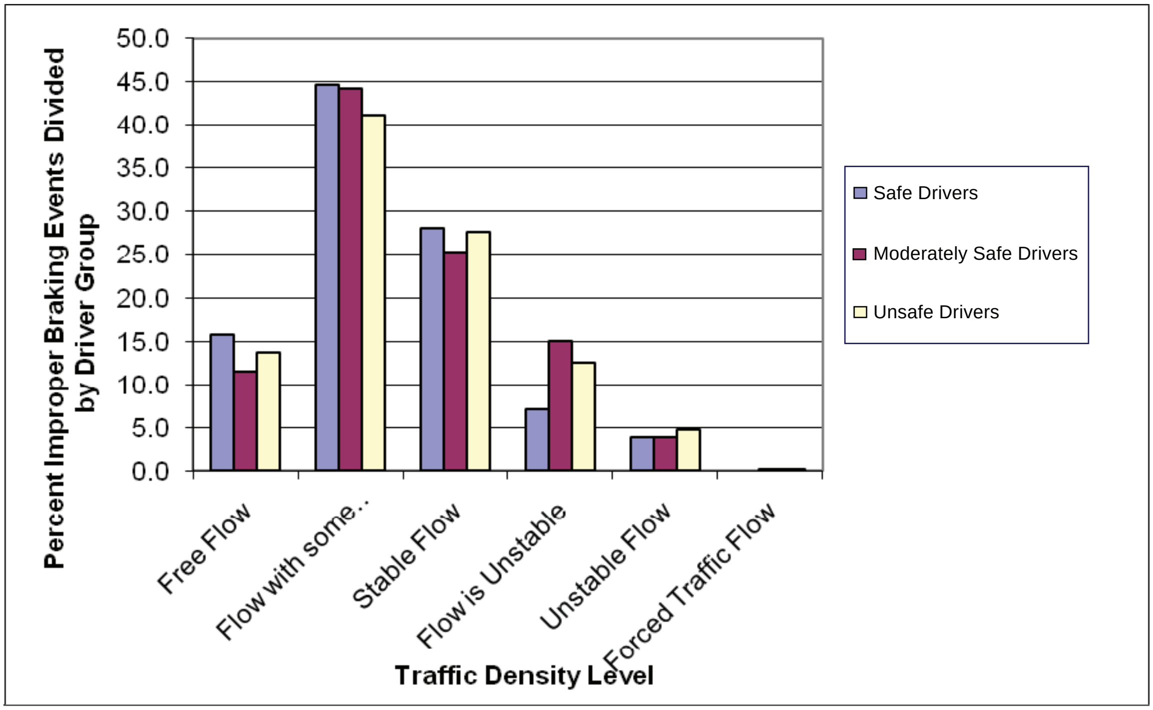

Figure 35. The Percentage of Improper Braking Events Occurring During Different Traffic Densities for Safe, Moderately Safe, and Unsafe Drivers

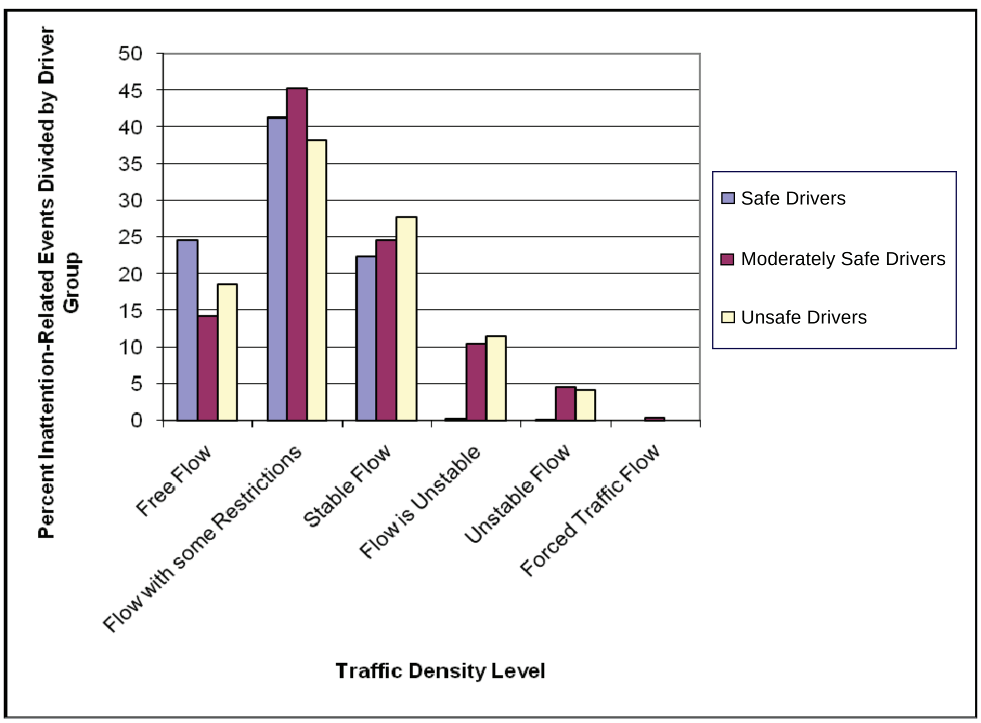

Figure 36. The Percentage of Driver Inattention Events Occurring During Different Traffic Densities for Safe, Moderately Safe, and Unsafe Drivers

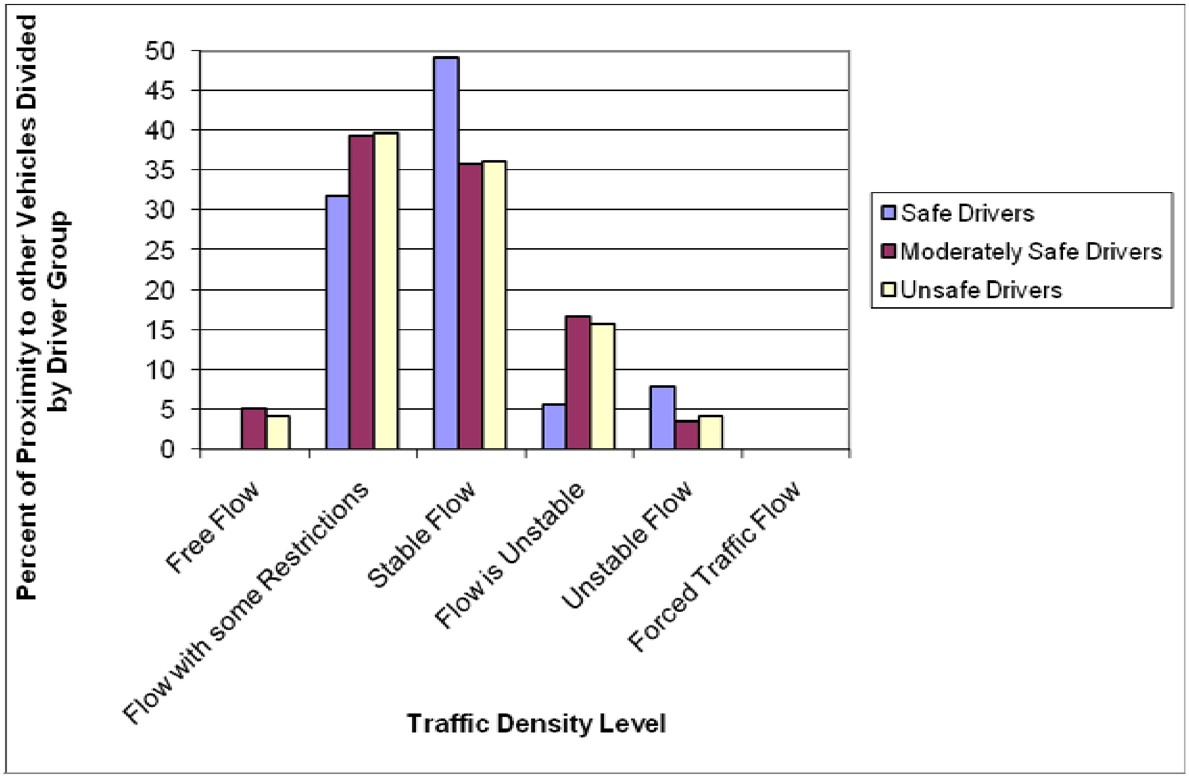

Figure 37. The Percentage of Close Proximity to Other Vehicle Events Occurring During Different Traffic Densities for Safe, Moderately Safe, and Unsafe Drivers

Conclusions

While over 16 primary groups of risky driving behaviors were recorded, improper braking, driving inattention, and proximity to other vehicles were the three most prevalent types. As was discussed earlier, improper braking behavior was easily captured by the data collection system. This may have disproportionately increased the prevalence of improper braking being recorded as a risky behavior. Other risky behaviors such as cutting too closely in front of or behind a vehicle were more difficult to obtain from the data collection system, and thus were perhaps recorded less frequently than they actually occurred. Other risky driving behaviors were also analyzed, but the numbers were infrequent; therefore, it was decided to focus this report on only the top three risky driving behaviors.

Risky behavior-related events occurred more frequently during higher traffic densities, even though drivers spent less time at these higher traffic densities. This result suggests that the unsafe and moderately safe drivers were more frequently engaging in improper braking, inattention tasks, and driving in close proximity to other vehicles during *stable flow, flow is unstable, and unstable flow* traffic than were the safe drivers. Also of interest is the fact that safe drivers did not engage in driving in close proximity during lighter traffic conditions. The moderately safe and unsafe drivers did choose, though with low percentages, to engage in driving in close proximity during free flow and free flow with some restrictions. This result may suggest that these drivers do in fact drive more aggressively regardless of traffic conditions.

Seat belt use was observed on average for 79 percent of all drivers, which is similar to the national average for seat belt use compliance (Glassbrenner, 2005). Seat belt compliance increases with age, which may be why there was a 10-percent difference in seat belt compliance for the unsafe drivers (mean age of 27), since the safe drivers were significantly older (mean age of 39).

The results of this analysis should be used to direct future research, as more analyses are required for validation. The 100-Car Study data set, while extensive, has some limitations. One such limitation is very low frequency counts when parsing the data by driver group, risky behaviors, and specific environmental conditions. These low frequency counts do not allow for statistical testing; thus, any differences observed could be due to random error. The baseline epochs more frequently sampled the unsafe drivers than the safe drivers, so a straight frequency count of these data is not appropriate. Percentages were used to determine general patterns in the data and compare these percentages to the overall exposure that drivers obtained for each environmental condition. Future analyses could be conducted using baseline data that samples more uniformly from each driver/vehicle.

Incidents and baseline epochs were included in these analyses to obtain the most useful numbers for infrequent environmental conditions such as foggy or snowy weather. Unfortunately, the inclusion of incidents did not provide significantly more information, as there were many environmental conditions with fewer than two events (i.e., foggy weather). Perhaps a larger scale naturalistic driving study would be able to shed more light on these more infrequent events (e.g., collecting data in a more northern climate where drivers spend a greater percentage of driving time in snowy conditions).

Chapter 4: *Objective Three*: Analyze Potential Patterns in the Driving Performance-Based Measures Among the Safe, Moderately Safe, and Unsafe Drivers

The following analysis used a subset of the driving performance data from the baseline database (described in Chapter 1) to assess the frequency with which safe, moderately safe, and unsafe drivers engage in lateral accelerations, longitudinal accelerations, longitudinal decelerations, and swerving behaviors of various magnitudes. Analyses of variance were conducted to assess whether the driver groups differ in these behaviors per MVMT.

Data Included in the Analyses

The baseline database consisted of 20,000 6-second epochs, randomly selected from the entire data set. These 6-second epochs were obtained from approximately 15,406 trip files. The trip file was initiated when the driver started the ignition of the vehicle and ended when the ignition was turned off. For the following analyses, the entire duration of these trip files was used as a subset of continuous data to assess the frequency of occurrence of peak lateral accelerations, peak longitudinal accelerations, peak longitudinal decelerations, and peak yaw rates for the safe, moderately safe, and unsafe drivers.

Software was developed to scan the longitudinal acceleration, lateral acceleration, and yaw rate data to assess the frequency with which drivers turned the vehicle, braked, accelerated, or swerved within the ranges of values shown in Table 42. These frequency counts were divided by the number of miles that each driver traveled for the sampled trips and then normalized to attain a value of frequency per MVMT. Analyses of variance were conducted on these values and the results are presented below.

Table 42. The Seven Independent Variable Levels of Lateral Acceleration, Longitudinal Acceleration, Longitudinal Deceleration, and Yaw Rate

	Peak Lateral Acceleration (*g*)	**Peak Longitudinal Acceleration (*g*)**	**Peak Longitudinal Deceleration (*g*)**	**Min/Max Yaw Rate (Swerve)**
1.	0.30-0.39	0.30-0.39	0.30-0.39	4’-4’11”/s
2.	0.40-0.49	0.40-0.49	0.40-0.49	5’-5’11”/s
3.	0.50-0.59	0.50-0.59	0.50-0.59	6’ – 6’11”/s
4.	0.60-0.69	0.60-0.69	0.60-0.69	7’ – 7’11”/s
5.	0.70-0.79	0.70-0.79	0.70-0.79	8’ – 8’11”/s
6.	0.80-0.89	0.80-0.89	0.80-0.89	9’ – 9’11”/s
7.	0.90-0.99	0.90-0.99	0.90-0.99	10’ – 10’11”/ s

Data Analysis

Repeated-measures ANOVAs were conducted to assess the frequency per MVMT of drivers achieving peak driving performance values. A 3 x 7 mixed-subject design was used, with the safe, moderately safe, and unsafe drivers treated as a between-subjects variable and the seven levels of peak lateral acceleration, peak longitudinal deceleration, peak longitudinal acceleration or yaw rate treated as within-subjects variables. Thus, four separate 3x7 repeated measures analyses of variance were conducted:

1) **3** (safe, moderately safe, and unsafe driver group) **x 7** (Level 1 through Level 7 of Lateral Acceleration);
2) **3** (safe, moderately safe, and unsafe driver group) **x 7** (Level 1 through Level 7 of Longitudinal Acceleration);
3) **3** (safe, moderately safe, and unsafe driver group) **x 7** (Level 1 through Level 7 of Longitudinal Deceleration); and
4) **3** (safe, moderately safe, and unsafe driver group) **x 7** (Level 1 through Level 7 of Min/Max Yaw Rate).

Frequency counts per MVMT were calculated for each subject by each range of peak lateral acceleration, peak longitudinal acceleration, peak longitudinal deceleration, and peak yaw rate to assess the frequencies of occurrence. For example, the frequency per MVMT of safe drivers achieving a longitudinal deceleration of 0.3 *g* was calculated and compared to the frequency of unsafe drivers achieving a longitudinal deceleration of 0.3 *g* per MVMT in order to assess whether unsafe drivers engaged in braking behaviors at this level more frequently than did the safe drivers during periods of baseline driving.

Lateral Acceleration

Lateral acceleration is measured in *g*-force (gravitational force) caused by lateral motion (turning the steering wheel) of the vehicle. Figure 38 and Figure 39 present the frequency counts for each of the seven ranges of peak lateral acceleration per MVMT for the three driver groups. The values between the frequency counts at 0.30-0.39 *g* up to 0.90-0.99 *g* ranged from 200,000 occurrences per MVMT to 14 occurrences per MVMT. Therefore, the lowest three *g*-force levels are presented in Figure 38 and the four highest *g*-force levels are presented in Figure 39. The interaction of driver group and lateral acceleration level was statistically significant ($F(12,564) = 10.21$, $p = 0.0001$), as were the main effects of driver safety group ($F(2,94) = 9.91$, $p < 0.0001$) and lateral acceleration ($F(6, 564) = 255.6$, $p < 0.0001$). Post hoc Tukey tests indicated that the safe drivers engaged in lateral accelerations between 0.3 and 0.9 *g* significantly less frequently than did either the moderately safe drivers ($t(94) = 2.54$, $P < 0.05$) or the unsafe drivers ($t(94) = 4.38$, $P < 0.05$). The moderately safe drivers also engaged in lateral accelerations between 0.3 and 0.9 *g* significantly less frequently than did the unsafe drivers ($t(94) = 2.66$, $P < 0.05$).

Tukey tests also indicated that all drivers engaged in lateral accelerations for the two lowest *g*-force levels (0.30-0.39 and 0.40-0.49) significantly more frequently than for the four other levels of lateral acceleration. However, the four highest *g*-force levels (0.60-0.69, 0.70-0.79, 0.80-0.89, and 0.90-0.99) were not significantly different from one another, as shown in Table 45 in Appendix D.

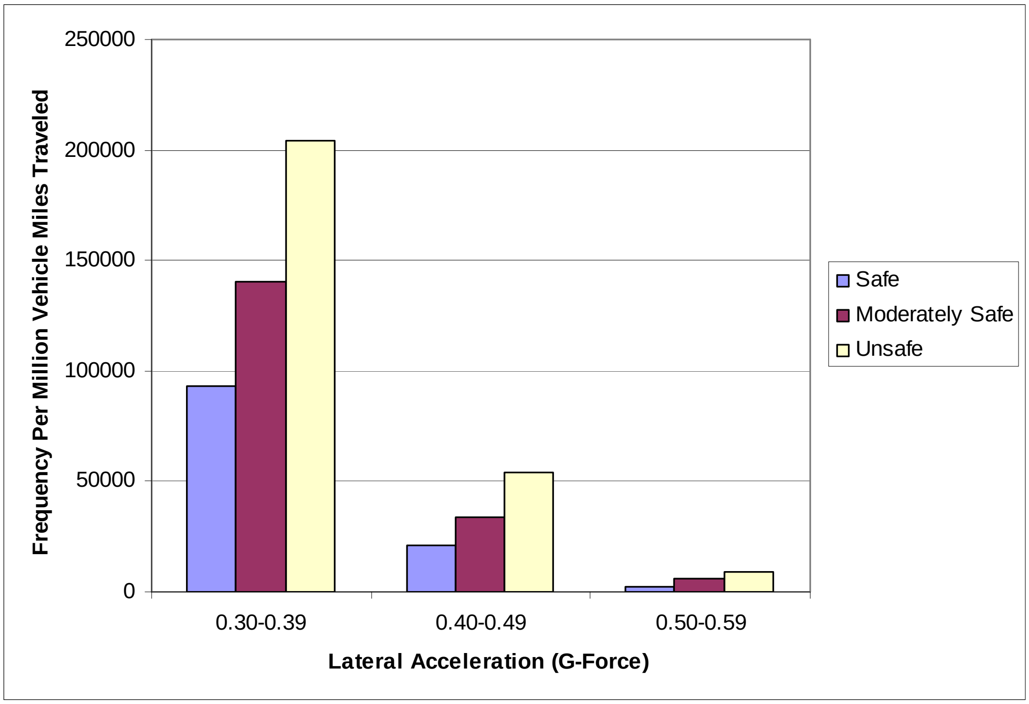

Figure 38. The Rate of Occurrence of Peak Lateral Acceleration Values (0.30 *g* up to 0.59 *g*) per MVMT for the Safe, Moderately Safe, and Unsafe Drivers During Baseline Driving

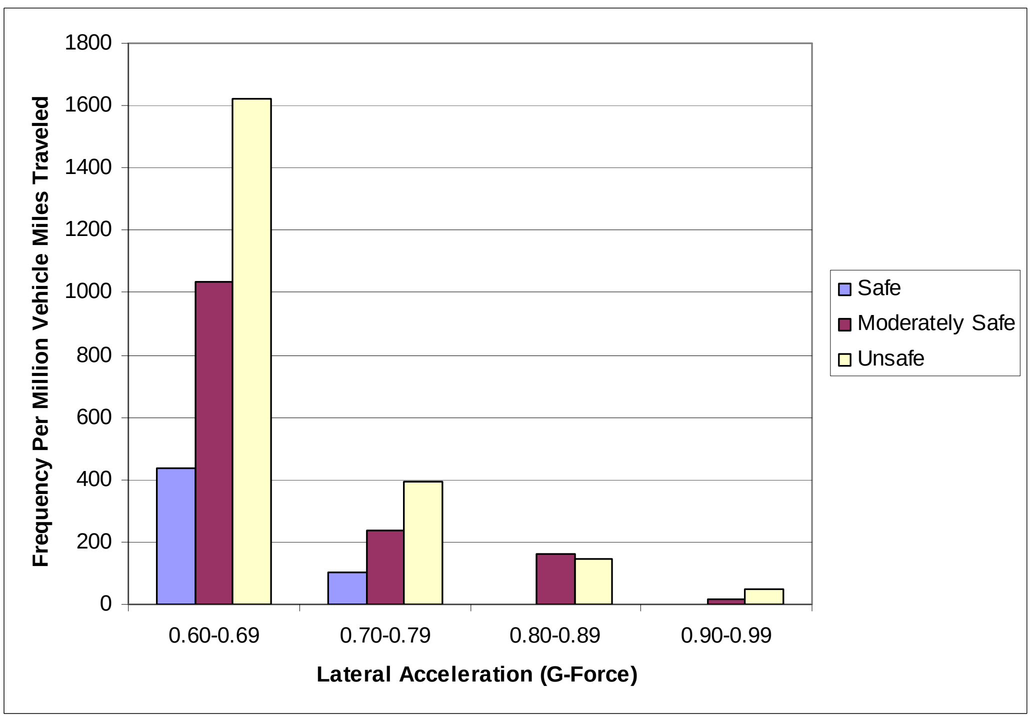

Figure 39. The Rate of the Peak Lateral Acceleration Ranges (0.60 *g* up to 0.99 *g*) per MVMT for the Safe, Moderately Safe, and Unsafe Drivers During Normal Driving

These results suggest that the unsafe drivers turned their vehicles at between 0.30 - 0.59 *g* significantly more frequently than did the safe and moderately safe drivers. Lateral accelerations of greater than 0.60 *g* were so infrequent that differences among these groups of drivers could not be determined. In general, the unsafe drivers engaged in hard steering-wheel turns at all levels more frequently than did the moderately safe or safe drivers. Although further research is needed, this finding may be indicative of more aggressive driving behavior with the unsafe drivers, who choose to negotiate turns and curves at higher rates of speed and with tighter turning radii than the moderately safe or safe drivers. This may also contribute to the unsafe drivers' higher involvement in crashes and near-crashes.

Longitudinal Acceleration

Longitudinal acceleration is also measured in *g*-force and is the gravitational force on the vehicle during both acceleration (driver depressing the accelerator pedal) and deceleration (driver depressing the brake pedal). A 3 x 7 repeated-measures ANOVA was conducted to determine whether unsafe drivers engaged in sharp longitudinal accelerations more frequently than did the safe drivers (Table 43). While the interaction was significant between driver group and the levels of longitudinal acceleration, there was not a significant main effect for driver group. The post hoc Tukey test indicated that there were significant differences between the three driver groups at the 0.3- 0.39 level of acceleration. This result suggests that unsafe drivers engage in these higher levels of acceleration more frequently than do the moderately safe or safe drivers (Table 46 in Appendix D).

Table 43. Frequency Counts of Occurrences of Peak Longitudinal Acceleration Values During Normal Driving

	0.30-0.39	**0.40-0.49**	**0.50-0.59**	**0.60-0.69**	**0.70-0.79**	**0.80-0.89**	**0.90-0.99**
Safe Drivers	39,369	8,050	2,094	135	11	0	0
Moderately Safe Drivers	28,590	2,269	237	73	24	0	0
Unsafe Drivers	72,825	6,762	395	9	0	12	0

Figure 40 presents the mean values for each level of longitudinal acceleration. Note that these patterns are what would be expected from normal driving in a metropolitan area.

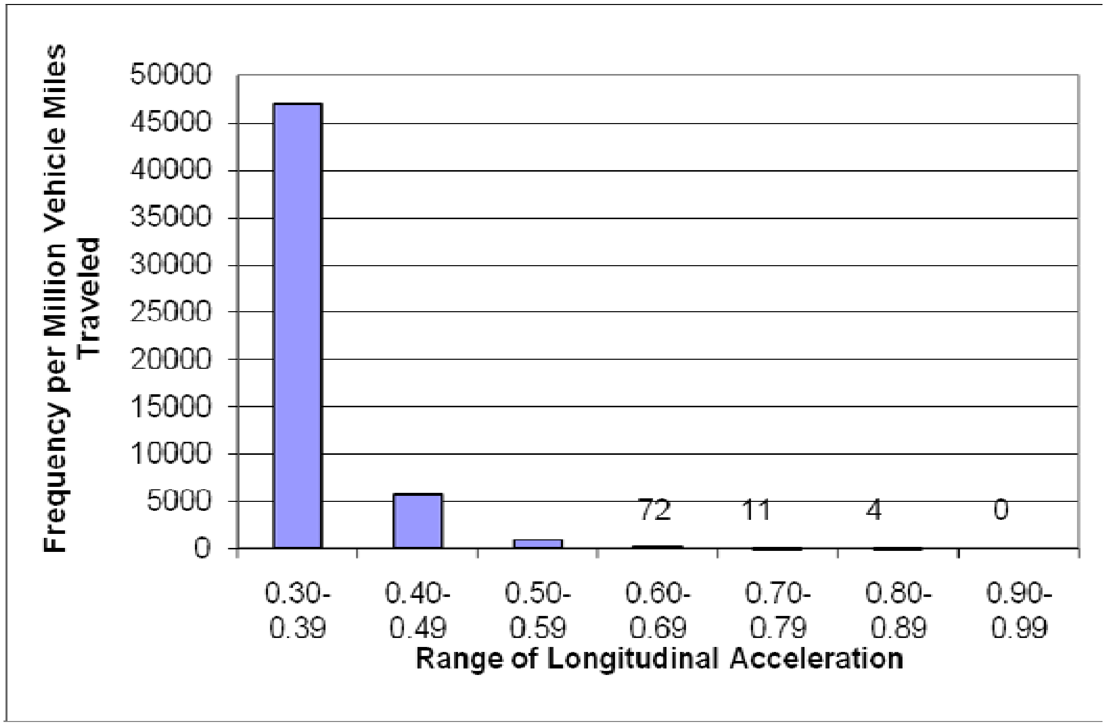

Figure 40. Rate of Longitudinal Accelerations Observed in Normal Driving Behavior for All Drivers

These results indicate that unsafe drivers are engaging in longitudinal accelerations at the 0.30 to 0.39 *g* levels more frequently than are the safe or moderately safe drivers. Lower acceleration levels of 0.1 to 0.3 were not assessed primarily because these acceleration levels are widely considered normal levels of acceleration. Thus, these results demonstrated some discrimination among the unsafe, moderate, and safe driver groups.

Longitudinal Deceleration

The frequencies of peak longitudinal decelerations for the seven levels of longitudinal deceleration per MVMT are presented in Figure 41 and Figure 42. Two figures again were used to best present the wide range of frequency values that exist between the lowest and highest *g*-force levels. The ANOVA indicated that the two-way interaction was significant ($F(12,564) = 12.06$, $p < 0.001$), as were the main effects for driver group ($F(2, 94) = 15.63$, $p < 0.001$), and longitudinal deceleration ($F(6,564) = 97.8$, $p < 0.001$). Post hoc Tukey tests indicated that the safe drivers did not brake as frequently at any braking level as either the moderately safe ($t(94) = 3.64$, $p < 0.001$) or the unsafe drivers ($t(94) = 5.39$, $p < 0.001$). The moderately safe and unsafe drivers' braking frequencies were also significantly different from one another ($t(94) = 2.88$, $p < 0.01$).

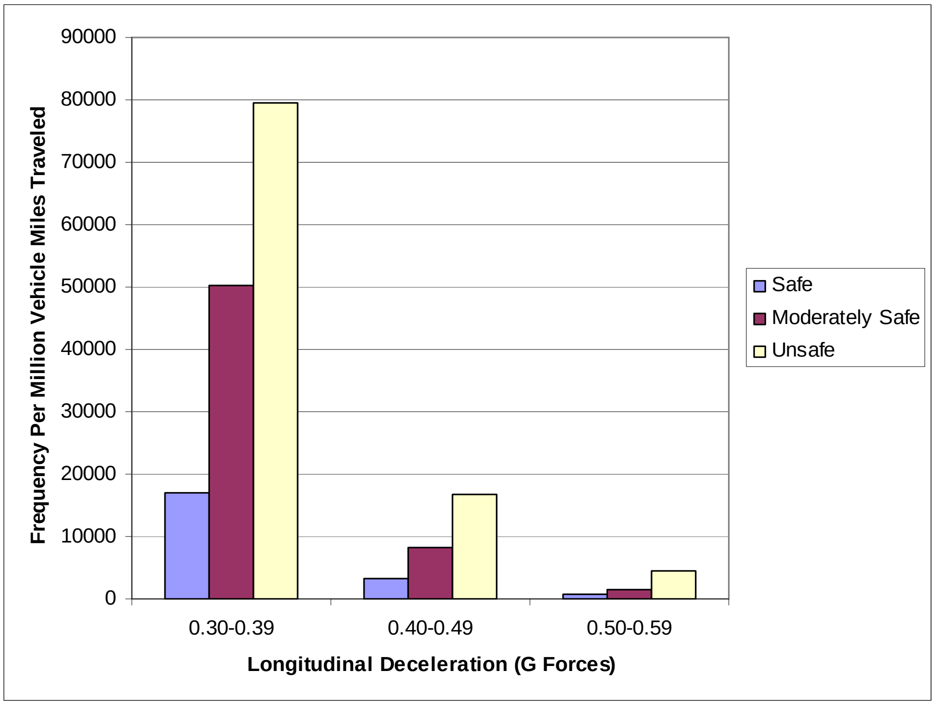

Figure 41. The Rate of the Lower *g*-force Peak Longitudinal Deceleration Ranges per MVMT for the Safe, Moderately Safe, and Unsafe Drivers During Normal Driving

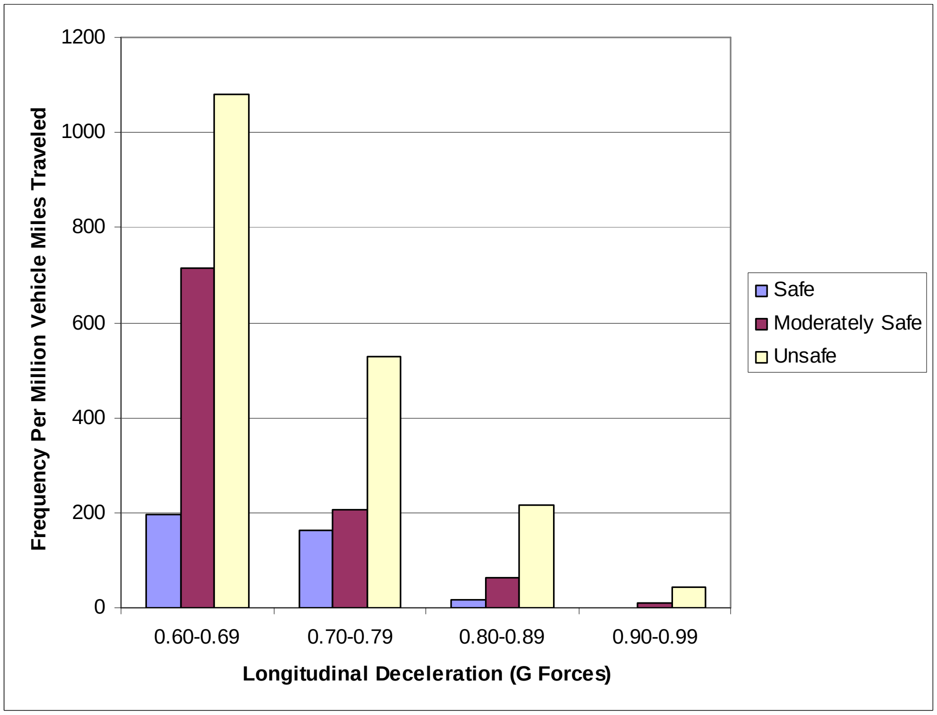

Figure 42. The Rate of the Higher *g*-force Peak Longitudinal Deceleration Ranges per MVMT for the Safe, Moderately Safe, and Unsafe Drivers During Normal Driving

The post hoc Tukey T-tests for the levels of longitudinal deceleration indicated that the average frequency counts for the lowest longitudinal deceleration range, 0.30-0.39 *g*, were significantly different from the average frequency counts for the six other longitudinal deceleration ranges. Also, the average frequency counts obtained in the second lowest *g*-force level of braking (0.40-0.49) were significantly different from the average frequency counts at the four highest levels of braking. The T-values and probability levels are listed in Table 47 in Appendix D.

These combined results suggest that there were significant differences in braking frequencies for the lower *g*-force levels of 0.3, 0.4, and 0.5, but as the *g*-force levels increase to 0.7, 0.8 and 0.9, then the significant differences are no longer present among the safe, moderately safe, and unsafe drivers. On average, the safe drivers brake at these levels significantly less often than do the moderately safe or the unsafe drivers. The moderately safe drivers also brake at these levels significantly less frequently than do the unsafe drivers.

It is also interesting to note that drivers in general tend not to brake harder than 0.6 very frequently. This has been found in other transportation research studies (Lee, Perez, Doerzaph, Stone, Brown, Neale, Knipling, & Holbrook; 2007) where drivers, even in emergency situations, do not brake as hard as they potentially could to stop the vehicle. This information is important to auto manufacturers working on redesigning rear-lights/brake lights for vehicles. Any new lighting configuration that only occurs at very high-*g* decelerations will not be activated very frequently.

Yaw Rate (i.e., Swerve)

Yaw rate is measured in degrees per second and is an indication of the rate of the vehicle's rotation around the vertical axis. Yaw rate best measures a driver's swerving behaviors. The frequency counts per range of yaw rate values per MVMT are presented in Figure 43. The mixed ANOVA indicated that the interaction between driver group and range of yaw rates was significant: $F(12,564) = 7.39$, $p < 0.001$. The main effects were also significant for driver group ($F(2, 94) = 12.71$, $p < 0.001$), and yaw rate level ($F(6, 564) = 84.35$, $p < 0.001$).

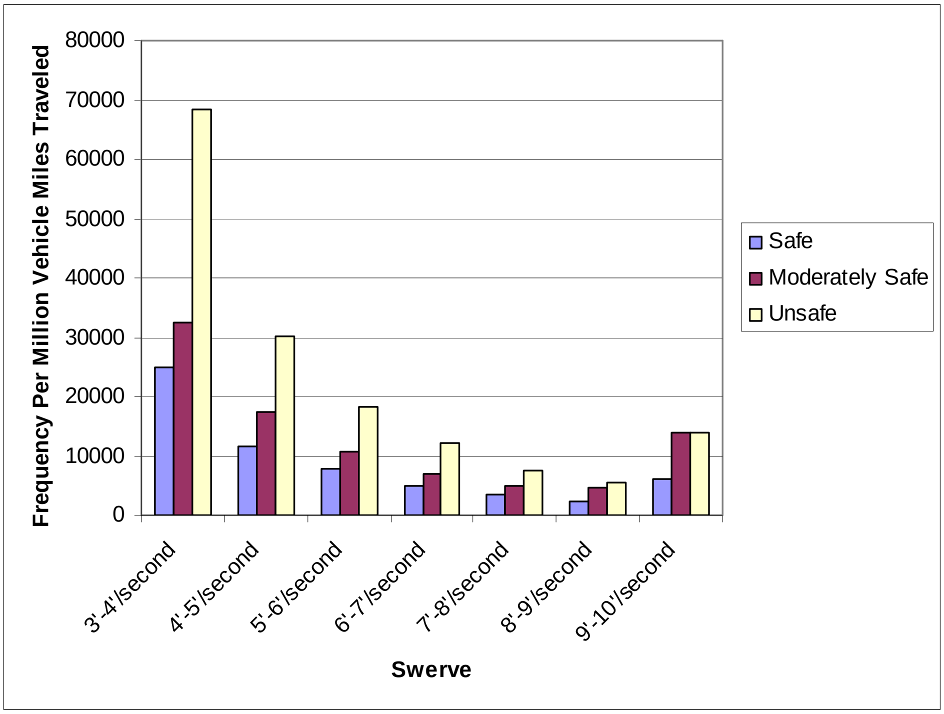

Figure 43. Rate of Swerving per MVMT for the Safe, Moderately Safe, and Unsafe Drivers During Normal Driving

The post hoc Tukey tests indicated that the unsafe driver group swerved between 3 and 10 ft/s significantly more frequently than the safe driver group ($t(94) = 5.04$, $p < 0.0001$) or the moderately safe driver group ($t(94) = 3.63$, $p = 0.001$). The safe driver group did not swerve differently than the moderately safe group.

Post hoc Tukey tests also indicated that all drivers swerved more frequently at the two smallest swerve ranges than any of the larger swerve ranges (Table 48 in Appendix D). The results also indicated that drivers swerved at the highest swerve range (9 to 10 ft/s) significantly more frequently than the two least frequent ranges of swerving (7 to 8 ft/s and 8 to 9 ft/s).

The slight inverted-U shape of the frequency of swerve maneuvers is an interesting finding in that all three driver groups had higher frequencies of 9 ft/s or greater swerve maneuvers than 7 or 8 ft/s swerve maneuvers. This is puzzling but may reflect vehicle widths ranging 6-8 ft, and vehicles are the most common roadway obstruction (drivers do in fact more commonly swerve greater than 9 ft to get around other vehicles). Further analyses are required to better understand the reasons why drivers are swerving as depicted on Figure 43. These swerves could be related to inattention or geographically specific road issues such as extensive pot holes in the roadway.

Conclusions

This analysis is one of the first to investigate driving performance differences between those drivers who are over-involved in crashes and those drivers who were rarely, if ever, involved in a crash during baseline or normal, non-event driving. Event involvement and normal driving data were both collected over the same period; this is a unique feature provided by the 100-Car Study and provides unprecedented statistical power. The results of this analysis indicate that unsafe drivers turn their vehicles at greater than 0.30 *g*, decelerate greater than 0.30 *g*, and swerve greater than 3 ft/s, significantly more frequently than do either the moderately safe or safe drivers.

These results also indicated that unsafe drivers engaged in extremes of driving performance more frequently than did the safe drivers during normal driving for all dependent variables. While previous research and analyses have been focused on driving performance during crashes and near-crashes, this is the first analysis indicating that the unsafe drivers are engaging in these behaviors more frequently during baseline driving than are safe drivers.

Future research should assess the relative crash risks of habitually braking or turning a vehicle at these higher *g* levels. These data are available and these analyses could be performed in a future analysis. The strength of the above analyses of variance suggest that real differences exist in the frequencies of occurrence for peak lateral acceleration, peak longitudinal deceleration, and peak yaw rates for the safe, moderately safe, and unsafe drivers. Longitudinal accelerations demonstrated significant differences at the 0.30-0.39 *g* level only.

These analyses also demonstrate general driver characteristics in that drivers tend not to brake, accelerate, or swerve their vehicles at extreme values very frequently, if ever. This information is important to auto manufacturers working on redesigning rear-lights/brake lights for vehicles. Any new lighting configuration that only occurs at very high-*g* decelerations will not be activated very frequently.

Chapter 5: *Objective 4*: Analyze Drivers' Involvement in Crashes, Near-Crashes, and Incidents and the Drivers' Behaviors That Contributed to Their Involvement

The following analyses are different than the previous analyses in this report, in that they are focused on the frequency of risky driving behaviors in relation to the occurrence of crashes, near-crashes, incidents, and baseline epochs.

Data Used in the Following Analyses

The following analyses primarily used frequency counts and percentages based on the number of events for which the drivers were found to be at fault or partially at fault. The various risky behaviors were also recorded by trained data reductionists and fell into two primary categories: *driver behavior* and *driver seat belt use*. The list of driver behaviors that the reductionists could select from were shown in Table 33 and the variables regarding seat belt use that reductionists could select from were shown in Table 34. As previously discussed in Chapter 3, reductionists were permitted to record up to three different risky behaviors from the list shown in Table 33 and only one from the list in Table 34. Reductionists were instructed to note the drivers' behaviors in order of importance if more than one risky driving behavior was observed for the event. Thus, the first driver behavior recorded by the reductionists was deemed to have contributed to the occurrence of the crash or near-crash relatively more than any other behavior observed. Please note that a senior human factors researcher and an expert data reductionist reduced the crashes and near-crashes while 14 trained reductionists reduced the incidents and baseline epochs. All of the reductionists spot-checked one another and all were spot-checked by senior researchers to ensure uniformity in these judgments. For more detail, please refer to Chapter 3 of this report.

Only those crashes and near-crashes where the driver was at fault or partially at fault were used in these analyses. Situations where another driver was at fault do not directly relate to the participants' safety-relevant behaviors. The term *event* is used for the remainder of this chapter as a general term encompassing crashes, near-crashes, and incidents.

Question 1. What Is the Prevalence of Risky Driving Behaviors That Contribute to Crashes, Near-Crashes, and Incidents?

The number of events and baseline epochs where a risky driving behavior was noted is presented in Figure 44. Note that risky driving behaviors were recorded as a contributing factor in at least 85 percent of all types of events. The same frequency count was conducted on the 20,000 baseline epochs to determine the prevalence of risky driving behavior when drivers are not involved in a serious safety-related conflict. The result indicated that risky driving behaviors were present in 27 percent of all baseline epochs.

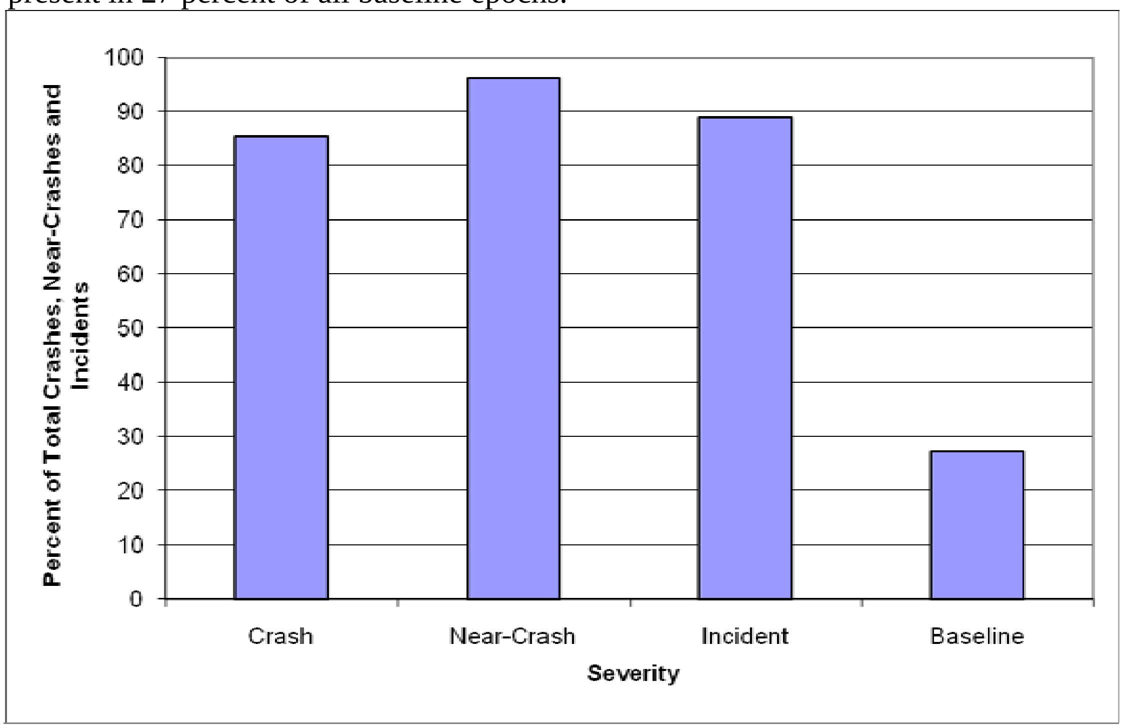

Figure 44. The Percentage of Crashes, Near-Crashes, Incidents, and Baseline Epochs Where a Risky Driving Behavior Was Observed

A second comparison was conducted to determine the frequency with which data reductionists observed multiple risky driving behaviors for events and baseline epochs (Figure 45). These percentages were calculated based on the total number of events. Therefore, for the data point labeled "One Risky Driving Behavior," the number of crashes that had only one risky driving behavior recorded was divided by the total number of crashes where data were collected. The process was repeated for each level of severity and for each level of "Number of Risky Driving Behaviors." The percentages in the table add to the total percentage of events as shown in

Figure 44. Note that the percent of incidents and baseline epochs demonstrate a linear decrease across as the number of risky behaviors observed, whereas the crashes and near-crashes both demonstrate an increase from zero behavior to two risky behaviors and then decrease for three risky behaviors.

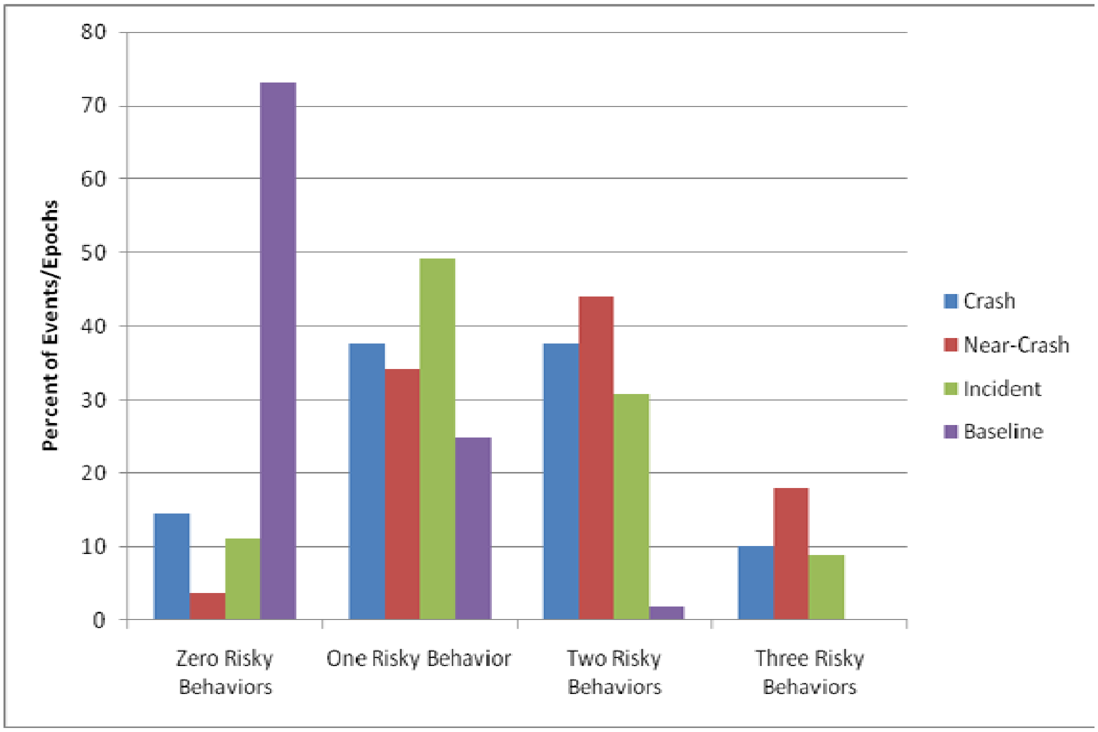

Figure 45. The Percentage of Total Crashes (N = 69), Total Near-crashes (N = 761), Total Incidents (N = 8,295), and Total Baseline Epochs (N = 19,646) Where Risky Driving Behaviors Were Observed

An analysis of seat belt use for events and baseline epochs was conducted by taking the frequency of crashes in which a seat belt was observed in use and dividing by the total number of crashes where data were collected (Figure 46). The same process was repeated for the rest of the events and baseline epochs. The results demonstrate an increasing linear trend in that drivers were wearing their seat belts in a fewer percentage of crashes than for near-crashes, incidents, or baseline epochs. This could be due to an artifact of younger driver over-representation in crash and near-crash occurrence, since younger drivers tend to wear their seat belts less frequently than older drivers.

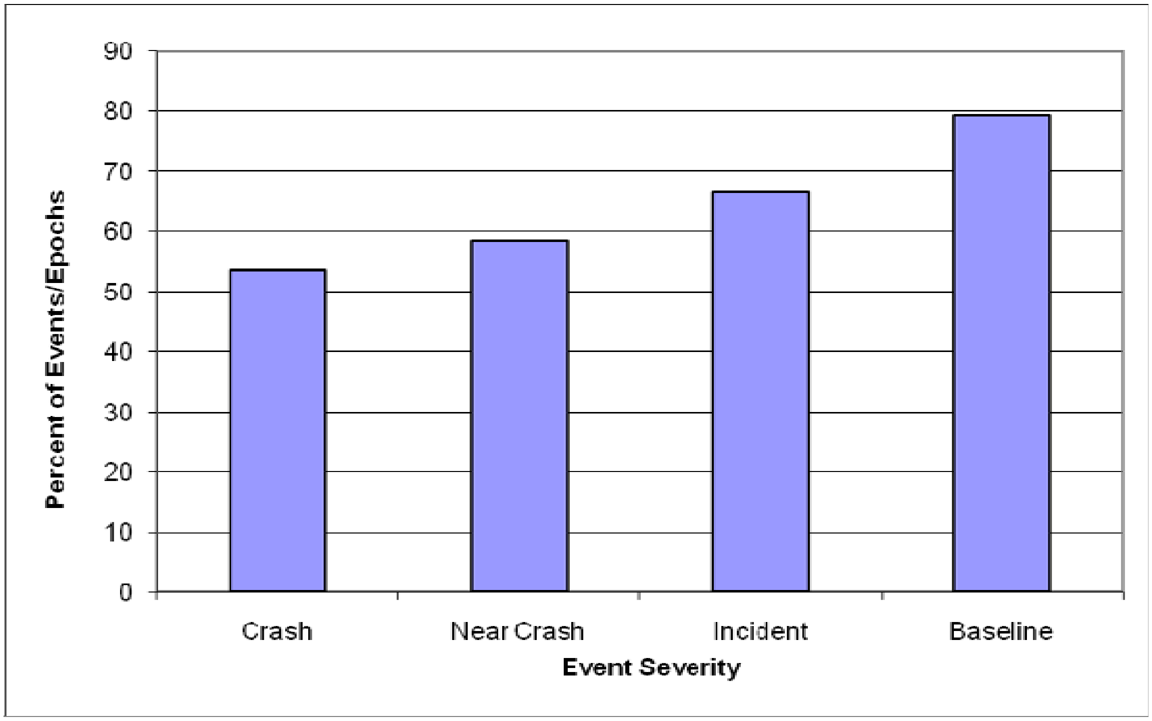

Figure 46. Percentage of Drivers Wearing Seat Belts by Event Severity

Question 2. What Is the Prevalence of Specific Risky Driving Behaviors as They Relate to Events and Baseline Epochs?

The frequencies of each type of risky driving behavior recorded as a contributing factor for events and baseline epochs are presented in Figure 47. To better compare across events and baseline epochs, all risky behaviors (up to three for each event type and baseline epoch) for each event/epoch was counted and a percentage for each event type/epoch was calculated. Those behaviors that resulted in less than 5 percent of the data for events *and* baselines were excluded from the figure.

The top three most frequent risky driving behaviors are slightly different for each event severity. The most frequent risky behaviors for crashes are secondary task engagement, other, and inappropriate speed. The three most frequent risky behaviors for near-crashes are improper braking, secondary task engagement, and avoiding an obstacle. While crashes are relatively simple to identify in the data stream (a spike in acceleration data), near-crashes are not quite as easily identified. Also, the data collection system was designed to identify rear-end events; therefore, hard braking and swerving were important components to the data collection system. Also note that hard braking and avoidance maneuvers more easily identified the occurrence of a near-crash. Therefore, further analyses are required to truly understand the differences between crashes and near-crashes and drivers' risky behaviors.

The top risky driving behaviors for incidents are similar to near-crashes with the addition of proximity to other vehicles. For baseline epochs, secondary task engagement and proximity to vehicles emerge as very frequent driver behaviors.

The common thread between events was secondary task engagement. An analysis of eye glance behavior is critical to distinguishing differences among event severity and the risky driving behavior of inattention. This analysis was conducted for a separate report (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006a). Secondary task engagement is of particular interest given the high frequency of occurrence in baseline driving as well as for events. Please note that Klauer et al. (2006a) used the 100-Car Study data set and found that several types of secondary tasks increased crash risk (e.g., dialing a cell phone, putting on make-up, reaching for a moving object), whereas other types of secondary tasks did not (adjusting the radio, eating, talking to a passenger). The analysis in this chapter does not differentiate types of secondary tasks or eye glance behavior and therefore is too broad in scope to hypothesize further. For more details, readers are encouraged to go to the Klauer et al. (2006a) report.

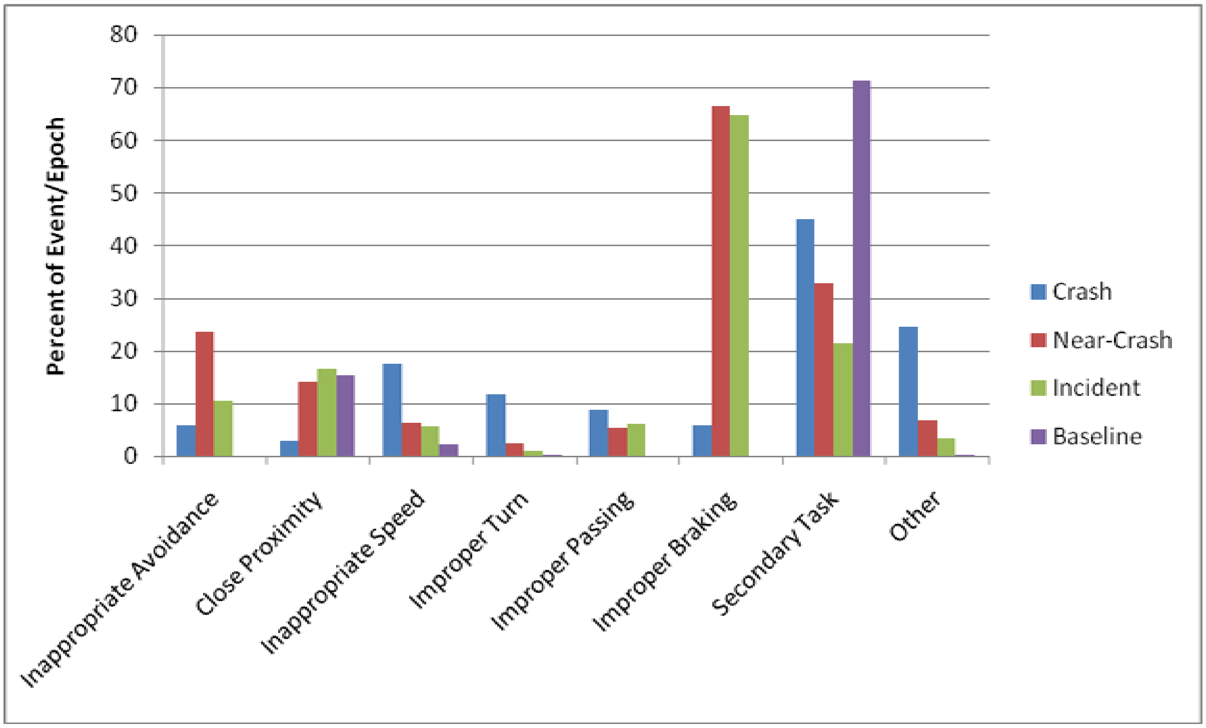

Figure 47. Percent of Events/Epochs Where Each Risky Driving Behavior Was Observed

Conclusions

The above results suggest that risky driving behaviors such as improper braking and inappropriate speeds increase drivers' relative crash risk above that of normal driving. While relative risk calculations were not conducted, the high frequency of occurrence in association with crashes and near-crashes and the low frequency of occurrence during baseline epochs would indicate that these relative crash risks are higher than for normal driving. This corroborates results found in Klauer, Sudweeks, Hickman, and Neale (2006b).

Further analyses should be conducted to evaluate how the number of risky driving behaviors a driver is willing to engage in is associated with crash/near-crash involvement. The results presented here indicated that engagement in multiple risky behaviors are present for both crashes and near-crashes, whereas only one or two risky behaviors are present for incidents, and zero or one risky behavior for baselines. Given that the number of risky behaviors present for baseline epochs is vastly different from crashes and near-crashes, engaging in multiple risky behaviors may increase crash risk.

Relative crash risks were not calculated for two primary reasons. First, the high occurrence of improper braking behavior, in relation to other types of risky driving behaviors, may be disproportionately elevated since the data collection system was designed specifically to identify rear-end collisions and/or conflicts. Therefore, improper braking was easily distinguished by reductionists, whereas other risky driving behaviors such as “did not see” and “improper turn” were more difficult to detect in the data stream and/or video. Second, relative crash risk calculations were conducted for driver inattention in Klauer, Dingus, Neale, Sudweeks, and Ramsey (2006a).

The analysis investigating the types of risky behaviors that occur most frequently for crashes and near-crashes indicated that avoidance and hard-braking maneuvers contributed most frequently to near-crashes but not to crashes. While further research needs to be conducted, as stated in the previous paragraph, this is most likely due to an artifact of the data collection system. Crashes of all kinds were easy to identify in the data stream due to spikes in the longitudinal acceleration plots, whereas near-crashes were more difficult to identify. Hard braking and hard avoidance maneuvers happen to be types of near-crashes that were easier to identify in the data stream and therefore, resulted in higher frequencies in the data set.

Seatbelt use results for events and baseline epochs indicated an increasing trend in that observed seat belt use was approximately 50 percent for crashes and increased up to 78 percent for baseline epochs. This may be because younger driver seat belt compliance is generally lower than for older adults, and younger drivers were excessively involved in crashes and near-crashes by a factor of four for some age groups.

The high frequency of *close proximity to other vehicle* for incidents, near-crashes, and baseline epochs indicates that drivers engage in this behavior frequently and are rarely involved in a crash while doing so. This suggests that being in close proximity to another vehicle (i.e., tailgating) may not actually increase crash risk or be as dangerous as commonly believed. This may be both because drivers who are in close proximity to other vehicles are more alert and because collisions are fairly rare events.

The ranking of risky behaviors by criticality to event occurrence was a subjective judgment made by trained reductionists. While these judgments were spot-checked by one another and by expert data reductionists, other transportation researchers may find one behavior or another to be more critical to particular events.

Chapter 6: General Conclusions

The analyses detailed in this report are the first analyses to be conducted investigating the variability of driving performance and driver behavior using the 100-Car Study database. This database provides a powerful tool to assess the variability among drivers and to associate this variability with observed crash and near-crash involvement. This is the first report of its kind in that most research is dependent upon either self-reported crash involvement or self-reported risky driving behavior engagement. These analyses were conducted on the behaviors observed in the seconds prior to crash and near-crash involvement.

Drivers who were operationally defined (i.e., based upon frequency of crash and near-crash involvement/MVMT) as “unsafe” or “moderately safe” engaged in all types of risky driving behaviors far more frequently than those defined as “safe” drivers. This was true during all types of environmental conditions, including clear, dry roadways and dark, wet roadways. Risky behavior-related events occurred more frequently during higher traffic densities, even though drivers spent less time at these higher traffic densities. The unsafe and moderately safe drivers more frequently engaged in improper braking, inattention tasks, and driving in closer proximity to other vehicles during *stable flow, flow is unstable, and unstable flow* traffic than did the safe drivers.

Safe drivers did not engage in driving in close proximity during lighter traffic conditions. The moderately safe and unsafe drivers did choose, though in low percentages, to engage in driving in close proximity during light traffic conditions. This result may suggest that these drivers do in fact drive more aggressively regardless of traffic conditions. While some results indicated slightly stronger frequencies of engagement in risky behaviors on undivided roadways, curved roadways, and lighted roadways at night, drivers did not generally select to engage or not engage in risky behaviors based on present environmental conditions.

The results of a baseline (i.e., no crash or near-crash events) driving analysis investigating safe, moderately safe, and unsafe drivers indicated that unsafe drivers steer their vehicles in turns at greater than 0.30 *g*, decelerate greater than 0.30 *g*, and swerve greater than 3 ft/s significantly more frequently than do either the moderately safe or safe drivers. While previous research has been focused on driving performance during crashes and near-crashes, this is the first analysis indicating that the unsafe drivers are engaging in these behaviors more frequently during baseline driving as well, which may be contributing to their increased crash and near-crash involvement.

The above results may suggest that risky driving behaviors such as improper braking and inappropriate speeds increase drivers’ relative crash risk above that of normal driving. While relative risk calculations were not conducted, the high frequency of occurrence in association with crashes and near-crashes and the low frequency of occurrence for baseline epochs would indicate that these relative crash risks are higher than for normal driving.

The high frequency of close proximity to other vehicles for both *incidents and baseline epochs*, and, perhaps more importantly, the much lower frequency of close proximity contributing to *crash and near-crash* events indicates that drivers engage in this behavior frequently but that it rarely results in crash or near-crash involvement. This suggests that being in close proximity to another vehicle (i.e., tailgating) may not actually increase crash risk or be as dangerous as commonly believed. This may be because drivers who are in close proximity to other vehicles are more alert. High frequencies of close proximity to other vehicles may also be an artifact of collecting data in a metropolitan area where drivers are commuting in heavy traffic on a regular basis.

The results of the questionnaire analyses indicated that seven scores from the survey, questionnaire, and performance-based tests allowed groups of unsafe and safe drivers to be differentiated, when comparing either two groups of drivers (safe versus unsafe) or three groups of drivers (safe, moderately safe, and unsafe). Table 44 presents those survey responses and test battery results that demonstrated significant differences for these two analyses. Note that separating the drivers into three groups did improve the results for two of the test batteries. Two of the subscales from the Dula Dangerous Driving Inventory were significantly different with three groups and not significantly different with two groups of drivers. Only one of the NEO FFI Scales (Conscientiousness) was no longer significant when separated into three groups.

Table 44. Summary of Those Tests That Found Significant Differences for the Two Analyses Using Two Levels of Attentiveness and Three Levels of Attentiveness

	Two-Group Analysis	***Three-Group Analysis***
1.	Driver Age	Driver Age
2.	Years of Driving Experience	Years of Driving Experience
3.	Agreeableness (NEO Five-Factor Personality Inventory)	Agreeableness (NEO Five-Factor Personality Inventory)
4.		Risky Driving Sub-Scale (Dula Dangerous Driving Inventory)
5.		Dula Dangerous Driving Index (Dula Dangerous Driving Inventory)

It is interesting to note that drivers' self-reports of traffic violations or collisions during the past five years were not correlated nor did these self-reports detect any differences among the driver groups. One explanation for this result could be that the drivers were not honest in these self-reports or had memory lapses. Other explanations are that younger drivers do not have enough driving history to assess a trend, and that older drivers' transgressions from five years ago are no longer predictive of their current driving habits. Perhaps the driving history questionnaire should not have requested traffic violations or crash history for five years, but rather only for the past year. Unfortunately, this hypothesis cannot be tested using the demographic questionnaire used for this study.

A regression analysis was conducted to determine whether any of the tests with significant results could be used to predict driver involvement in crashes and near-crashes. The results indicated that both Years of Driving Experience and Agreeableness demonstrated some predictive abilities when considering involvement in crashes and near-crashes. The results also suggest that there is a slight inverse relationship: as a driver's experience or Agreeableness score increases, the probability of involvement in high numbers of crashes and near-crashes decreases.

This regression equation did not demonstrate a strong relationship, and some caution is urged if using these scales to predict high involvement in crashes and near-crashes.

Seat belt use was observed for 79 percent of all drivers, which is similar to the national average for seat belt use compliance (Glassbrenner, 2005). Seat belt compliance increases with age, which is why the 10-percent decrease in seat belt compliance for the unsafe drivers (mean age of 27) was not surprising, since the safe drivers were significantly older (mean age of 39). Unfortunately, this result means that the drivers who are at highest risk of crash involvement are also the drivers least likely to be wearing seat belts.

Based on the results from Chapter 4, a possible application of these findings is that driver monitoring systems (e.g., for teen, elderly, or commercial drivers) that focus on kinematic near-crash detection may have promise for identifying dangerous drivers among the population prior to involvement in a serious crash. These results corroborate findings from a teen-driver monitoring study that also used kinematic signatures to alert teens when they were driving unsafely (McGehee, Raby, Carney, Lee, & Reyes, 2007).

This analysis of risky driving behaviors using the 100-Car Study data is similar to another risky driving behavior analysis that was funded by the AAA Foundation for Traffic Safety (Klauer, Sudweeks, Hickman, & Neale, 2006b). The similarities are primarily that risky driving behaviors were evaluated in both studies. However, in the AAA-FTS study, multivariate analyses were conducted to assess the relationships between/among risky driving behaviors; relative risks of each type of risky behavior were also calculated. The current analysis was a first step or overview of the prevalence of risky driving behaviors and concentrated on the association of risky driving behavior and crash and near-crash involvement. While there are pros and cons to both studies, this study used the entire data set, whereas the AAA-FTS study was unable to use the entire data set due to the complexity of the multivariate analyses. Therefore, frequency tables that are presented here cannot be compared with nor will they match the frequency tables published in the AAA-FTS report. Interesting commonalities between the reports are that the AAA report found that inattention and speed differentials were among the riskiest behaviors for drivers and that close proximity did not result in a significant increase in crash/near-crash risk. The results presented here are consistent with these results.

Crashes were operationally defined for this study as any physical contact with a vehicle, object, or pedestrian, which also includes high-*g* tire strikes (e.g., hitting a curb while traveling over 35 mph). The results from this study indicated that 7 percent of the drivers were not involved in any crashes, near-crashes, or incidents, while the worst 7 percent of drivers were involved in at least three crashes or minor collisions within the 12-month data collection period. The definition of crashes used in this report includes a higher proportion of non-police reported crashes than other analyses in the literature. Few other studies have had access to non-police reported crash data, and all crashes in the current report refer to a loss of control of the vehicle. Given these differences, some caution is urged when comparing the results from this study to other crash studies.

While data were collected on 109 vehicles continuously for a 12- to 13-month period, it should be noted that in the analysis of crashes and even near-crashes, this time period is relatively short to assess differences in driver behaviors. While the inclusion of the near-crashes helps (since near-crashes occur at a rate of 10 near-crashes to every crash), when the number of events is divided by the number of drivers, power is reduced. This should be considered in future studies, where more data per driver will allow for more powerful and precise driver variability analyses.

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Appendix A: Questionnaires and Surveys

Visual Acuity Test

Snellen Eye Chart:

Right Eye: ____________________

Left Eye: ____________________

Ishihara's Test for Colour Deficiency:

Plate 1: __________

Plate 2: __________

Plate 3: __________

Plate 4: __________

Plate 5: __________

Plate 6: __________

Plate 7: __________

Plate 8: __________

Plate 9: __________

Plate 10: _________

Plate 11: _________

Plate 12: _________

Plate 13: _________

Plate 14: _________

Comments:____

____

____

Contrast Sensitivity Test:

Left Eye:

Row A: ________________

Row B: ________________

Row C: ________________

Row D: ________________

Row E: ________________

Right Eye:

Row A: ________________

Row B: ________________

Row C: ________________

Row D: ________________

Row E: ________________

Comments:____

____

____

Audiogram Air Conduction Test

<u>Check all that apply</u>

____Known hearing loss	____Right	____Left
____Uses hearing aids	____Right	____Left
____History of ear problems	____Right	____Left
____Ear Surgery	____Right	____Left
____Tinnitus (ringing)	____Right	____Left
____Fullness feeling in the ears	____Right	____Left
____Ear wax buildup	____Right	____Left
____Ear pain	____Right	____Left
____Ear drainage problems	____Right	____Left
____Diabetes	____Right	____Left
____Kidney problems	____Right	____Left

____Noise exposure

____work ____military ____hobby ____other

____Vertigo/dizziness

____Head injury/loss of consciousness

____High blood pressure

____Family history of hearing loss

____Family members with hearing loss

Comments:

____

____

____

Hearing Test

Audiometer: Welch Allyn AM 232 Manual Audiometer

Last acoustical calibrations:________________

Tester:_______________

Date of Testing:_______________

BASELINE HEARING TEST

LEFT EAR

125	250	500	750	1000	1500	2000	3000	4000	6000	8000

Comments:____
____
____

RIGHT EAR

125	250	500	750	1000	1500	2000	3000	4000	6000	8000

Comments:____
____
____

Medical Health Assessment

To the Participant: Please note that your responses to the following questions will in no way affect your ability to participate in the study. Your honest answers are appreciated

1. Do you have a history of any of the following?
    - a. Stroke Y N
    - b. Brain tumor Y N
    - c. Head injury Y N
    - d. Epileptic seizures Y N
    - e. Respiratory disorders Y N
    - f. Motion sickness Y N
    - g. Inner ear problems Y N
    - h. Dizziness, vertigo, or other balance problems Y N
    - i. Diabetes Y N
    - j. Migraine, tension headaches Y N
    - k. Depression Y N
    - l. Anxiety Y N
    - m. Other Psychiatric Disorders Y N
    - n. Arthritis Y N
    - o. Auto-immune disorders Y N
    - p. High Blood Pressure Y N
    - q. Heart arrhythmias Y N
    - r. Chronic Fatigue Syndrome Y N
    - s. Chronic Stress Y N

    If yes to any of the above, please explain?

    ____
    ____
    ____
    ____

2. Are you currently taking any medications on a regular basis? Y N
    If yes, please list them.

    ____
    ____
    ____

3. (Females only) Are you currently pregnant? Y N

4. Height __________

5. Weight __________lbs.

Walter Reed Army Institute of Research Preliminary Sleep Questionnaire

Using the following rating scale, to what extent do you currently experience the following?

	None				Moderate					Severe
Daytime sleepiness	1	2	3	4	5	6	7	8	9	10
Snoring	1	2	3	4	5	6	7	8	9	10
Difficulty Falling Asleep	1	2	3	4	5	6	7	8	9	10
Difficulty Staying Asleep	1	2	3	4	5	6	7	8	9	10
Difficulty Waking Up	1	2	3	4	5	6	7	8	9	10
Daytime Sleepiness	1	2	3	4	5	6	7	8	9	10
Obtain too little sleep	1	2	3	4	5	6	7	8	9	10

Read through the following questions carefully, answer each as accurately as possible

1. When you are working:
what time do you go to bed ____:____ am/pm and wake up ____:____ am/pm

2. When you are not working:
what time do you go to bed ____:____ am/pm and wake up ____:____ am/pm

3. Do you keep a fairly regular sleep schedule? Yes_____ No_____

4. How many hours of actual sleep do you usually get? ________

5. Do you consider yourself a light, normal, or heavy sleeper? _______________

6. Do you feel uncomfortably sleepy during the day? Never_____ every day_____
more than once per week_____ once per week _____ a few times a month _____
once a month or less_____

7. Do you ever have an irresistible urge to sleep or find that you fall asleep in unusual/
inappropriate situations? Never_____ every day_____ more than once per week_____
once per week _____ a few times a month _____ once a month or less_____

8. Do you usually nap during the day (or between major sleep periods)?
Yes_____ No_____

9. Do you drink caffeinated beverages (coffee, tea, coca cola, mountain dew, jolt cola)?
Yes_____ No_____

18. If yes, how many cups/glasses per day? __________________

19. How often do you drink alcohol? Never_____ every day_____
more than once per week_____ once per week _____ once a month or less_____

22. Do you smoke cigarettes, cigars, pipe or chew or snuff tobacco? Yes_____ No_____

23. If yes, how often? __________________________

PRIMARY SLEEP DISORDERS

24. Have you ever been diagnosed with or suffer from any of the following sleep disorders?

Narcolepsy	Yes	No
Sleep Apnea	Yes	No
Periodic Limb Movement	Yes	No
Restless Leg Syndrome	Yes	No
Insomnia	Yes	No

Dula Dangerous Driving Index

Please answer each of the following items as honestly as possible. Please read each item carefully and then circle the answer you choose on the form. If none of the choices seem to be your ideal answer, then select the answer that comes closest. THERE ARE NO RIGHT OR WRONG ANSWERS. Select your answers quickly and do not spend too much time analyzing your answers. If you change an answer, erase the first one well.

1. I drive when I am angry or upset.

   A. Never B. Rarely C. Sometimes D. Often E. Always

2. I lose my temper when driving.

   A. Never B. Rarely C. Sometimes D. Often E. Always

3. I consider the actions of other drivers to be inappropriate or "stupid."

   A. Never B. Rarely C. Sometimes D. Often E. Always

4. I flash my headlights when I am annoyed by another driver.

   A. Never B. Rarely C. Sometimes D. Often E. Always

5. I make rude gestures (e.g., giving "the finger"; yelling curse words) toward drivers who annoy me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

6. I verbally insult drivers who annoy me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

7. I deliberately use my car/truck to block drivers who tailgate me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

8. I would tailgate a driver who annoys me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

9. I "drag race" other drivers at stop lights to get out front.

   A. Never B. Rarely C. Sometimes D. Often E. Always

10. I will illegally pass a car/truck that is going too slowly.

    A. Never B. Rarely C. Sometimes D. Often E. Always

11. I feel it is my right to strike back in some way, if I feel another driver has been aggressive toward me.

    A. Never B. Rarely C. Sometimes D. Often E. Always

12. When I get stuck in a traffic jam I get very irritated.

    A. Never B. Rarely C. Sometimes D. Often E. Always

13. I will race a slow moving train to a railroad crossing.

    A. Never B. Rarely C. Sometimes D. Often E. Always

14. I will weave in and out of slower traffic.

A. Never B. Rarely C. Sometimes D. Often E. Always

15. I will drive if I am only mildly intoxicated or buzzed.

A. Never B. Rarely C. Sometimes D. Often E. Always

16. When someone cuts me off, I feel I should punish him/her.

A. Never B. Rarely C. Sometimes D. Often E. Always

17. I get impatient and/or upset when I fall behind schedule when I am driving.

A. Never B. Rarely C. Sometimes D. Often E. Always

18. Passengers in my car/truck tell me to calm down.

A. Never B. Rarely C. Sometimes D. Often E. Always

19. I get irritated when a car/truck in front of me slows down for no reason.

A. Never B. Rarely C. Sometimes D. Often E. Always

20. I will cross double yellow lines to see if I can pass a slow moving car/truck.

A. Never B. Rarely C. Sometimes D. Often E. Always

21. I feel it is my right to get where I need to go as quickly as possible.

A. Never B. Rarely C. Sometimes D. Often E. Always

22. I feel that passive drivers should learn how to drive or stay home.

A. Never B. Rarely C. Sometimes D. Often E. Always

23. I will drive in the shoulder lane or median to get around a traffic jam.

A. Never B. Rarely C. Sometimes D. Often E. Always

24. When passing a car/truck on a 2-lane road, I will barely miss on-coming cars.

A. Never B. Rarely C. Sometimes D. Often E. Always

25. I will drive when I am drunk.

A. Never B. Rarely C. Sometimes D. Often E. Always

26. I feel that I may lose my temper if I have to confront another driver.

A. Never B. Rarely C. Sometimes D. Often E. Always

27. I consider myself to be a risk-taker.

A. Never B. Rarely C. Sometimes D. Often E. Always

28. I feel that most traffic “laws” could be considered as suggestions.

A. Never B. Rarely C. Sometimes D. Often E. Always

Driver Stress Inventory

Please answer the following questions on the basis of your usual or typical feelings about driving. Each question asks you to answer according to how strongly you agree with one of two alternative answers. Please read each of the two alternatives carefully before answering. To answer, circle the number that expresses your answer most accurately.

Example: Are you a confident driver?

1 2 3 4 5 6 7 8 9 10

Not at all ... Very Much

1. Does it worry you to drive in bad weather?

   1 2 3 4 5 6 7 8 9 10

   Very Much ... Not at all

2. I am disturbed by thoughts of having an accident or the car breaking down.

   1 2 3 4 5 6 7 8 9 10

   Very Rarely ... Very Often

3. Do you lose your temper when another driver does something silly?

   1 2 3 4 5 6 7 8 9 10

   Not at all ... Very much

4. Do you think you have enough experience and training to deal with risky situations on the road safely?

   1 2 3 4 5 6 7 8 9 10

   Not at all ... Very much

5. I find myself worrying about my mistakes and the things I do badly when driving.

   1 2 3 4 5 6 7 8 9 10

   Very rarely ... Very often

6. I would like to risk my life as a racing driver.

   1 2 3 4 5 6 7 8 9 10

   Not at all ... Very much

7. My driving would be worse than usual in an unfamiliar rental car.

   1 2 3 4 5 6 7 8 9 10

   Not at all ... Very much

8. I sometimes like to frighten myself a little while driving.

   1 2 3 4 5 6 7 8 9 10

   Very much ... Not at all

9. I get a real thrill out of driving fast.

   1 2 3 4 5 6 7 8 9 10

Very much Not at all

10. I make a point of carefully checking every side road I pass for emerging vehicles.
1 2 3 4 5 6 7 8 9 10
Very Much Not at all

11. Driving brings out the worst in people.
1 2 3 4 5 6 7 8 9 10
Not at all Very much

12. Do you think it is worthwhile taking risks on the road?
1 2 3 4 5 6 7 8 9 10
Very much Not at all

13. At times, I feel like I really dislike other drivers who cause problems for me.
1 2 3 4 5 6 7 8 9 10
Very much Not at all

14. Advice on driving from a passenger is generally:
1 2 3 4 5 6 7 8 9 10
Useful Unnecessary

15. I like to raise my adrenaline levels while driving.
1 2 3 4 5 6 7 8 9 10
Not at all Very much

16. It's important to show other drivers that they can't take advantage of you.
1 2 3 4 5 6 7 8 9 10
Not at all Very much

17. Do you feel confident in your ability to avoid an accident?
1 2 3 4 5 6 7 8 9 10
Not at all Very much

18. Do you usually make an effort to look for potential hazards when driving?
1 2 3 4 5 6 7 8 9 10
Not at all Very much

19. Other drivers are generally to blame for any difficulties I have on the road.
1 2 3 4 5 6 7 8 9 10
Not at all Very much

20. I would enjoy driving a sports car on a road with no speed-limit.
1 2 3 4 5 6 7 8 9 10
Very much Not at all

21. Do you find it difficult to control your temper when driving?

1	2	3	4	5	6	7	8	9	10
Very much									Not at all

22. When driving on an unfamiliar road do you become more tense than usual?

1	2	3	4	5	6	7	8	9	10
Very much									Not at all

23. I make a special effort to be alert even on roads I know well.

1	2	3	4	5	6	7	8	9	10
Very much									Not at all

24. I enjoy the sensation of accelerating rapidly.

1	2	3	4	5	6	7	8	9	10
Not at all									Very much

25. If I make a minor mistake when driving, I feel it's something I should be concerned about

1	2	3	4	5	6	7	8	9	10
Very much									Not at all

26. I always keep an eye on parked cars in case somebody gets out of them, or there are pedestrians behind them.

1	2	3	4	5	6	7	8	9	10
Not at all									Very much

27. I feel more anxious than usual when I have a passenger in the car.

1	2	3	4	5	6	7	8	9	10
Not at all									Very much

28. I become annoyed if another car follows very close behind mine for some distance

1	2	3	4	5	6	7	8	9	10
Very much									Not at all

29. I make an effort to see what's happening on the road a long way ahead of me.

1	2	3	4	5	6	7	8	9	10
Not at all									Very much

30. I try very hard to look out for hazards even when it's not strictly necessary.

1	2	3	4	5	6	7	8	9	10
Not at all									Very much

31. Are you usually patient during the rush hour?

1	2	3	4	5	6	7	8	9	10
Very much									Not at all

32. When you pass another vehicle do you feel in command of the situation?

1	2	3	4	5	6	7	8	9	10

Not at all Very much

33. When you pass another vehicle do you feel tense or nervous?

1	2	3	4	5	6	7	8	9	10

Not at all Very much

34. Does it annoy you to drive behind a slow moving vehicle?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

35. When you're in a hurry, other drivers usually get in your way.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

36. When I come to negotiate a difficult stretch of road, I am on the alert.

1	2	3	4	5	6	7	8	9	10

Very much Not at all

37. Do you feel more anxious than usual when driving in heavy traffic?

1	2	3	4	5	6	7	8	9	10

Not at all Very much

38. I enjoy cornering at high speeds.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

39. Are you annoyed when the traffic lights change to red when you approach them?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

40. Does driving, <u>usually</u> make you feel aggressive?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

41. Think about how you feel when you have to drive for several hours, with few or no breaks from driving. How do your feelings <u>change</u> during the course of the drive?

a) More uncomfortable 1 2 3 4 5 6 7 8 9 10 No change
physically (e.g. headache or muscle pains)

b) More drowsy or sleepy 1 2 3 4 5 6 7 8 9 10 No change

c) Maintain speed of reaction 1 2 3 4 5 6 7 8 9 10 Reactions to
other traffic becomes increasingly slower

d) Maintain attention to road signs 1 2 3 4 5 6 7 8 9 10 Become increasingly inattentive to road-signs

e) Normal vision 1 2 3 4 5 6 7 8 9 10 Vision becomes less clear

f) Increasingly difficult to judge your speed 1 2 3 4 5 6 7 8 9 10 Normal judgment of speed

g) Interest in driving does not change 1 2 3 4 5 6 7 8 9 10 Increasingly bored and fed-up

h) Passing becomes increasingly risky and dangerous 1 2 3 4 5 6 7 8 9 10 No change

Life Stress Inventory

Please read through the following events carefully. Mark each event that occurred within the past year.

____ Death of spouse or parent

____ Divorce

____ Marital separation or separation from living partner

____ Jail term

____ Death of close family member

____ Personal injury or illness

____ Fired from job

____ Marital or relationship reconciliation

____ Retirement

____ Change in health of family member

____ Pregnancy

____ Sex difficulties

____ Gain of new family member

____ Business readjustment

____ Change in financial state

____ Death of close friend

____ Change to different line of work or study

____ Change in number of arguments with spouse or partner

____ Mortgage or loan for major purchase (home, etc.)

____ Foreclosure of mortgage or loan

____ Change in responsibilities at work

____ Son or daughter leaves

____ Trouble with in-laws / partner's family

____ Outstanding personal achievement

____ Mate begins or stops work

____ Change in living conditions

____ Marriage / establishing life partner

____ Change in personal habit

____ Trouble with boss

____ Change in work hours or conditions

____ Change in residence

____ Change in schools

____ Change in church activities

____ Change in recreation

____ Change in social activities

____ Minor loan (car, TV, etc)

____ Change in sleeping habits

____ Change in number of family get-togethers

____ Change in eating habits

____ Vacation

____ Christmas (if approaching)

____ Minor violation of the law

NEO

Five-Factor Inventory

Form S

Paul T. Costa, Jr., Ph.D., and Robert R. McCrae, Ph.D.

Instructions

Write only where indicated in this booklet. Carefully read all of the instructions before beginning. This questionnaire contains 60 statements. Read each statement carefully. For each statement fill in the circle with the response that best represents your opinion. Make sure that your answer is in the correct box.

Fill in (SD) if you *strongly disagree* or the statement is definitely false.

Fill in (D) if you *disagree* or the statement is mostly false.

Fill in (N) if you are *neutral* on the statement, you cannot decide, or the statement is about equally true and false.

Fill in (A) if you *agree* or the statement is mostly true.

Fill in (SA) if you *strongly agree* or the statement is definitely true.

For example, if you *strongly disagree* or believe that a statement is definitely false, you would fill in the (SD) for that statement.

Example
● (D) (N) (A) (SA)

Fill in only one response for each statement. Respond to all of the statements, making sure that you fill in the correct response. DO NOT ERASE! If you need to change an answer, make an "X" through the incorrect response and then fill in the correct response.

Note that the responses are numbered in *rows*. Before responding to the statements, turn to the inside of the booklet and enter your name, age, and sex and the date.

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Name ____ Age ____ Sex ____ Date __________

1. I am not a worrier.
2. I like to have a lot of people around me.
3. I don't like to waste my time daydreaming.
4. I try to be courteous to everyone I meet.
5. I keep my belongings neat and clean.

6. I often feel inferior to others.
7. I laugh easily.
8. Once I find the right way to do something, I stick to it.
9. I often get into arguments with my family and co-workers.
10. I'm pretty good about pacing myself so as to get things done on time.

11. When I'm under a great deal of stress, sometimes I feel like I'm going to pieces.
12. I don't consider myself especially "light-hearted."
13. I am intrigued by the patterns I find in art and nature.
14. Some people think I'm selfish and egotistical.
15. I am not a very methodical person.

16. I rarely feel lonely or blue.
17. I really enjoy talking to people.
18. I believe letting students hear controversial speakers can only confuse and mislead them.
19. I would rather cooperate with others than compete with them.
20. I try to perform all the tasks assigned to me conscientiously.

21. I often feel tense and jittery.
22. I like to be where the action is.
23. Poetry has little or no effect on me.
24. I tend to be cynical and skeptical of others' intentions.
25. I have a clear set of goals and work toward them in an orderly fashion.

26. Sometimes I feel completely worthless.
27. I usually prefer to do things alone.
28. I often try new and foreign foods.
29. I believe that most people will take advantage of you if you let them.
30. I waste a lot of time before settling down to work.

31. I rarely feel fearful or anxious.
32. I often feel as if I'm bursting with energy.
33. I seldom notice the moods or feelings that different environments produce.
34. Most people I know like me.
35. I work hard to accomplish my goals.

36. I often get angry at the way people treat me.
37. I am a cheerful, high-spirited person.
38. I believe we should look to our religious authorities for decisions on moral issues.
39. Some people think of me as cold and calculating.
40. When I make a commitment, I can always be counted on to follow through.

41. Too often, when things go wrong, I get discouraged and feel like giving up.
42. I am not a cheerful optimist.
43. Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement.
44. I'm hard-headed and tough-minded in my attitudes.
45. Sometimes I'm not as dependable or reliable as I should be.

46. I am seldom sad or depressed.
47. My life is fast-paced.
48. I have little interest in speculating on the nature of the universe or the human condition.
49. I generally try to be thoughtful and considerate.
50. I am a productive person who always gets the job done.

51. I often feel helpless and want someone else to solve my problems.
52. I am a very active person.
53. I have a lot of intellectual curiosity.
54. If I don't like people, I let them know it.
55. I never seem to be able to get organized.

56. At times I have been so ashamed I just wanted to hide.
57. I would rather go my own way than be a leader of others.
58. I often enjoy playing with theories or abstract ideas.
59. If necessary, I am willing to manipulate people to get what I want.
60. I strive for excellence in everything I do.

Enter your responses here—remember to enter responses *across the rows*.

SD = *Strongly Disagree*; D = *Disagree*; N = *Neutral*; A = *Agree*; SA = *Strongly Agree*

1 (SD)(D)(N)(A)(SA)	2 (SD)(D)(N)(A)(SA)	3 (SD)(D)(N)(A)(SA)	4 (SD)(D)(N)(A)(SA)	5 (SD)(D)(N)(A)(SA)
6 (SD)(D)(N)(A)(SA)	7 (SD)(D)(N)(A)(SA)	8 (SD)(D)(N)(A)(SA)	9 (SD)(D)(N)(A)(SA)	10 (SD)(D)(N)(A)(SA)
11 (SD)(D)(N)(A)(SA)	12 (SD)(D)(N)(A)(SA)	13 (SD)(D)(N)(A)(SA)	14 (SD)(D)(N)(A)(SA)	15 (SD)(D)(N)(A)(SA)
16 (SD)(D)(N)(A)(SA)	17 (SD)(D)(N)(A)(SA)	18 (SD)(D)(N)(A)(SA)	19 (SD)(D)(N)(A)(SA)	20 (SD)(D)(N)(A)(SA)
21 (SD)(D)(N)(A)(SA)	22 (SD)(D)(N)(A)(SA)	23 (SD)(D)(N)(A)(SA)	24 (SD)(D)(N)(A)(SA)	25 (SD)(D)(N)(A)(SA)
26 (SD)(D)(N)(A)(SA)	27 (SD)(D)(N)(A)(SA)	28 (SD)(D)(N)(A)(SA)	29 (SD)(D)(N)(A)(SA)	30 (SD)(D)(N)(A)(SA)
31 (SD)(D)(N)(A)(SA)	32 (SD)(D)(N)(A)(SA)	33 (SD)(D)(N)(A)(SA)	34 (SD)(D)(N)(A)(SA)	35 (SD)(D)(N)(A)(SA)
36 (SD)(D)(N)(A)(SA)	37 (SD)(D)(N)(A)(SA)	38 (SD)(D)(N)(A)(SA)	39 (SD)(D)(N)(A)(SA)	40 (SD)(D)(N)(A)(SA)
41 (SD)(D)(N)(A)(SA)	42 (SD)(D)(N)(A)(SA)	43 (SD)(D)(N)(A)(SA)	44 (SD)(D)(N)(A)(SA)	45 (SD)(D)(N)(A)(SA)
46 (SD)(D)(N)(A)(SA)	47 (SD)(D)(N)(A)(SA)	48 (SD)(D)(N)(A)(SA)	49 (SD)(D)(N)(A)(SA)	50 (SD)(D)(N)(A)(SA)
51 (SD)(D)(N)(A)(SA)	52 (SD)(D)(N)(A)(SA)	53 (SD)(D)(N)(A)(SA)	54 (SD)(D)(N)(A)(SA)	55 (SD)(D)(N)(A)(SA)
56 (SD)(D)(N)(A)(SA)	57 (SD)(D)(N)(A)(SA)	58 (SD)(D)(N)(A)(SA)	59 (SD)(D)(N)(A)(SA)	60 (SD)(D)(N)(A)(SA)

Have you responded to all of the statements? ______Yes ______No

Have you entered your responses in the correct boxes? ______Yes ______No

Have you responded accurately and honestly? ______Yes ______No

Driver Demographic Information

Subject ID # ___________

Please answer each of the following items.

1. What is your age in years: _________

2. Gender: _____ Male   _____ Female

3. What is your highest level of education?
   a. Didn't complete high school
   b. High school graduate
   c. Some college
   d. 2 year college degree/trade school
   e. 4 year college degree
   f. Masters degree
   g. Professional degree
   h. Doctorate degree

4. What is your occupation: ____________________

5. What group do you identify yourself with
   a. Latino/Latina
   b. African American
   c. Caucasian
   d. Middle Eastern
   e. Pacific Islander
   f. Asian
   g. Other ________________

6. How many years have you been driving? ______________

7. What type of driving do you usually do? (please indicate all that apply)
   a. Around town driving
   b. Commuting on freeways
   c. Commuting on other main roads
   d. Short distance travel (50-200 mile round trip)
   e. Middle distance travel (201-500 mile round trip)
   f. Long distance travel (>500 mile round trip)

WayPoint Test

Test Name: WayPoint

Objective: Used to identify drivers who are at high risk of being in a crash.

Description/Procedure: Measures the speed of information processing and a person's vigilance. The test is done by computer and consists of 4 different levels of sequential "connect the dots" type activities. The subject is required to start at 1 then find A, then 2, then B, and so on. The different levels get consecutively harder, in the last level distracters are add to test the subject's response to a novel situation. The subjects risk level is measured by using their reaction times from the 4 activities to gauge his/her channel capacity and situational awareness level.

Rationale: WayPoint has been administered and used is several validation trials to measure its accuracy rate for over-the-road trucks, transit buses, army enlisted personnel automobile drivers, and teenage drivers. In a study sponsored by NHTSA, WayPoint's predictive value was tested on elderly drivers. The report states that WayPoint's hit rate (identifying high risk drivers) is 62.2% and its false alarm rate (mistakenly identifying low risk drivers as high risk) is 19.9%

Comments: Based on its validity and hit rate, this could be a useful tool during the subject screening or in-processing process.

Useful Field of View Test

Test Name: Useful Field of View (UFOV)

Objective: Used to measure a driver's risk for accident involvement

Description/Procedure: The UFOV is a computer based test that measures central vision and processing speed, divided attention, and selective attention. The participant is required to select rapidly presented target objects that are flesh on the computer screen while simultaneously attending to other stimuli. The program then prints out a report that assigns a crash risk level for the participant.

Rationale: UFOV has been used in many studies of older drivers and has been shown to be a good measure of visual processing and attention. As reported by the NIH, a drivers risk rises 16% for every 10 points of visual reduction in the driver's useful field of view for drivers 55 years and older.

Comments: Most studies using this measure are conducted on those 55 and older, however, this test may be a useful tool to help predict and classify which participants have a higher risk of accident, near crash, and critical incident involvement. Although this test is usually used on the elderly it is also used on those that have concerns about their driving due to multiple accident involvement, head trauma, and memory disorders.

Debriefing Questionnaire

Driver # _________

Please answer the following questions as accurately as possible. You may need to take some time to think about each question for a few minutes. Remember, all responses are completely confidential.

1a. Over the past year, how often were you very or extremely fatigued while driving?

___ Never (if the answer is never, skip to question 2)
___ Once or twice over the year
___ 3 or 4 times over the year
___ Monthly
___ Once per week
___ More than once per week
___ Almost daily or daily

1b. When you drive very or extremely fatigued, is the fatigue due to (select all that apply):
___ Too little sleep the night before
___ A chronic problem of too little sleep
___ Driving after a long day (so that it is late at night)
___ Stress at home or work
___ Illness
___ Drugs/Alcohol/Partying
___ Other (explain) ____

1c. When you drive very or extremely fatigued, how often do have you fallen asleep at the wheel?
___ Once or twice over the year
___ 3 or 4 times over the year
___ Monthly
___ Once per week
___ More than once per week
___ Almost daily or daily

1d. During times you have driven very or extremely fatigued, in **all of your experience** driving, how many times have you had a crash or hit something with your car?
___ 0
___ 1
___ 2
___ 3
___ 4

1e. How many times have you driven very or extremely fatigued **during this study** and had a crash or hit something with your car?
___ 0
___ 1
___ 2
___ 3
___ 4

1f. During times you have driven very or extremely fatigued, in **all of your experience** driving, how many times have you had a **near crash or close call**? For example, running off the road or drifting into an oncoming lane.
___ 0
___ 1
___ 2
___ 3
___ 4

1g. How many times have you driven very or extremely fatigued **during this study** and had a **near crash or close call**?
___ 0
___ 1
___ 2
___ 3
___ 4
___ more

1h. How dangerous or risky would you say it is to drive while very or extremely fatigued?

Not risky		Slightly risky		Moderately risky		Very risky		Extremely risky

2a. Over the past year, how often were you under the influence of drugs or alcohol while driving?
___ Never (if the answer is never, skip to question 3)
___ Once or twice over the year
___ 3 or 4 times over the year
___ Monthly
___ Once per week
___ More than once per week
___ Almost daily or daily

2b. When you drive under the influence of drugs or alcohol, is this due to (select all that apply):

___ You believed that you were still a safe driver
___ You were too intoxicated to know better
___ You did not care
___ You did not have a designated driver and needed to be someplace
___ Other (explain) ____

2c. During times you have driven under the influence, **in all of your experience driving**, how many times have you had a **crash** or hit something with your car?

___ 0
___ 1
___ 2
___ 3
___ 4

2d. How many times have you driven under the influence **during this study** and had a **crash** or hit something with your car?

___ 0
___ 1
___ 2
___ 3
___ 4

2e. During times you have driven under the influence, **in all of your experience driving**, how many times have you had a **near crash or close call**? For example, running off the road or drifting into an oncoming lane.

___ 0
___ 1
___ 2
___ 3
___ 4

2f. How many times have you driven under the influence **during this study** and had a **near crash or close call?**

___ 0
___ 1
___ 2
___ 3
___ 4
___ more

2g. How dangerous or risky would you say it is to drive while under the influence of drugs or alcohol?

Not risky		Slightly risky		Moderately risky		Very risky		Extremely risky

2h. How dangerous or risky would you say it is to drive while using a cell phone? __________

(where Not Risky = 0, Slightly Risky = 1, Moderately Risky = 2, Very Risky = 3, and Extremely Risky = 4)

(if you fall somewhere in between, it is appropriate to respond with a .5 designation following your ranking).

Not risky		Slightly risky		Moderately risky		Very risky		Extremely risky

2i. How many times have you driven while talking on your cell phone?

_____ never
_____ once per month
_____ more than once per month
_____ once per week
_____ more than once per week
_____ almost daily or daily

3a. How often do you wear your seat belt when driving?
___ Never
___ Rarely
___ Occasionally
___ Usually
___ Always, I never drive without my seat belt on

3b. Why do you think this is your pattern of seat belt use?

____
____
____

3c. If your answer was other than always, what do you think it would take to get you to wear your seat belt more often?

____

____

____

3d. Why do you not always wear your seat belt? (Check all that apply)

___ I don't believe it makes me safer
___ I am concerned about getting trapped in a crash
___ It is inconvenient
___ It is uncomfortable
___ I forget to put it on

4a. On average, how much stress did you feel during the last year?

Not stressed		Slightly stressed		Moderately stressed		Very stressed		Extremely stressed
|	|	|	|	|	|	|	|	|

4b. How much is your driving affected by stress?

Not affected		Slightly affected		Moderately affected		Very affected		Extremely affected
|	|	|	|	|	|	|	|	|

5a. To what degree do you think your driving was altered or different because you were participating in this study and your driving was monitored?

Not altered		Slightly altered		Moderately altered		Very altered		Extremely altered
|	|	|	|	|	|	|	|	|

5b. How would you rate how safely you drove in the past year compared to all of your previous years of driving?

Not safe		Slightly safe		Moderately safe		Very safe		Extremely safe
|	|	|	|	|	|	|	|	|

5c. How would you rate your driving compared to other drivers?

Not better		Slightly better		Moderately better		Very better		Extremely better

5d. **For drivers of leased vehicles,** to what degree do you think your driving was altered or different because you were driving a vehicle that was not your own?

Not altered		Slightly altered		Moderately altered		Very altered		Extremely altered

6a. Is there any event or incident that happened in the past year that you would like to report at this time?

Approximate date: ________________________ Approximate time: ______________________

Description:

____

____

____

7a. Is there any event or incident that happened in the past year where you pushed the critical incident button that you would like to tell me about?

Approximate date: ________________________ Approximate time: ______________________

Description:

____

____

____

8a. How favorably would you rate your experience of participating in this study?

Not favorably		Slightly favorably		Moderately favorably		Very favorably		Extremely favorably

8b. Is there anything in particular that you would like to bring to our attention?

____

____

____

____

9a. **For drivers of private vehicles,** how would you rate your experience with Hurleys?

Not favorably		Slightly favorably		Moderately favorably		Very favorably		Extremely favorably

9b. Is there anything in particular that you would like to bring to our attention?

Driving History – Subject Interview

In the past year, how many moving or traffic violations have you had? ___________

What type of violation was it?
(1). ____________________
(2). ____________________
(3). ____________________
(4). ____________________
(5). ____________________

In the past year, how many accidents have you been in? ________________

For each accident indicate the severity of the crash (select highest)

a. Injury
b. Tow-away (any vehicle)
c. Police-reported
d. Damage (any), but no police report

Using the diagram indicate each of the following: Category, Configuration, Accident type

	Accident 1	**Accident 2**	**Accident 3**	**Accident 4**	**Accident 5**
Accident Severity					
Accident Category					
Accident Configuration					
Accident Type					

Comments: ____
____
____
____

Post-Crash Interview Form

100-Car Crash Variables

Subject No.______________________

Interviewer _______________________

Date ____________

Driver's description of crash:

1. List the most Severe Injury in Crash

0 = No injury (O)
1 = Fatal (K)
2 = Visible signs of injury; e.g., bleeding wound or distorted member, or carried from scene (A).
3 = Other visible injury as bruises, abrasions, swelling, limping, etc. (B)
4 = No visible injury but complaint of pain or momentary unconsciousness (C)

2. What other vehicles/non-motorists were involved

1 = 1 vehicle (Subject vehicle only)
2 = 2 vehicles
3 = 3 vehicles
4 = 4 or more vehicles
5 = Subject vehicle + pedestrian
6 = Subject vehicle + pedalcyclist
7 = Subject vehicle + animal
8 = Other, specify

6. Date of crash

7. Day of Week of crash

8. Time of crash

10. Jurisdiction that crash occurred

1 = Virginia
2 = Maryland
3 = DC
4 = other

11. Traffic control device present?

1 = No traffic control
2 = Officer or watchman
3 = Traffic signal
4 = Stop sign
5 = Slow or warning sign
6 = Traffic lanes marked
7 = No passing signs
8 = Yield sign
9 = One way road or street
10 = Railroad crossing with markings or signs
11 = Railroad crossing with signals
12 = Railroad crossing with gate and signals
13 = Other

12. Alignment of roadway at the scene?
1 = Straight level
2 = Curve level
3 = Grade straight
4 = Grade curve
5 = Hillcrest straight
6 = Hillcrest curve
7 = Dip straight
8 = Up curve [need definition]
9 = Other

13. Weather at the time of crash?
1 = Clear
2 = Cloudy
3 = Fog
4 = Mist
5 = Raining
6 = Snowing
7 = Sleeting
8 = Smoke dust
9 = Other

14. Surface condition of the roadway at the time of crash?
1 = Dry
2 = Wet
3 = Snowy
4 = Icy
5 = Muddy
6 = Oily
7 = Other

15. Light level at the time of the crash?

1 = Dawn
2 = Daylight
3 = Dusk
4 = Darkness, lighted
5 = Darkness, not lighted

16. Kind of locality at the crash scene?

1 = School
2 = Church
3 = Playground
4 = Open Country
5 = Business/industrial
6 = Residential
7 = Interstate
8 = Other
9= *Construction Zone (Added)*

17. Where in relation to a junction did the crash occur?

Non-Interchange Area

00 = Non-Junction
01 = Intersection
02 = Intersection-related
03 = Driveway, alley access, etc.
04 = Entrance/exit ramp
05 = Rail grade crossing
06 = On a bridge
07 = Crossover related
08 = Other, non-interchange area
09 = Unknown, non-interchange
20 = Parking lot [Added]

Interchange Area

10 = Non-Junction
11 = Intersection
12 = Intersection-related
13 = Driveway, alley access, etc.
14 = Entrance/exit ramp
16 = On a bridge
17 = Crossover related
18 = Other location in interchange area
19 = Unknown, interchange area
99 = Unknown if interchange

18. What was the trafficway flow at the time of the crash?

1 = Not divided
2 = Divided (median strip or barrier)

3 = One-way traffic

19. What was the number of travel lanes at the time of the crash?

1 = 1
2 = 2
3 = 3
4 = 4
5 = 5
6 = 6
7 = 7
8 = 8+

21. What was the type of collision?

1 = Rear-end (striking)
1b = Rear-end (struck)
2 = Angle
3 = Head on
4 = Sideswipe, same direction
5 = Sideswipe, opposite direction
6 = Fixed object in road
7 = Train
8 = Non-collision
9 = Fixed object – off road
10 = Deer
11 = Other animal
12 = Pedestrian
13 = Bicyclist
14 = Motorcyclist
15 = Backed into
16 = Other

Driver/Vehicle 1 File

4. How many occupants in your vehicle?

6. What were you (driver) doing prior to the crash?

1 = Going straight ahead, constant speed
2 = Making right turn
3 = Making left turn
4 = Making U-turn
5 = Slowing or stopping
6 = Starting in traffic lane
7 = Starting from parked position
8 = Stopped in traffic lane]
9 = Ran off road right
10 = Ran off road left

11 = Parked
12 = Backing
13a = Passing left
13b = Passing right
14 = Changing lanes
15 = Other
16 = Accelerating in traffic lane
17 = Entering a parked position
18 = Negotiating a curve
19a = Merging left
19b = Merging right

9. What was the action by you or other driver that started the sequence of events leading to the crash? (Most likely filled out by Heather based on the driver's narrative)

This Vehicle Loss of Control Due to:
- 001 = Blow out or flat tire
- 002 = Stalled engine
- 003 = Disabling vehicle failure (e.g. wheel fell off)
- 004 = Minor vehicle failure
- 005 = Poor road conditions (puddle, pothole, ice, etc.)
- 006 = Excessive speed
- 007 = Other or unknown reason
- 008 = Other cause of control loss
- 009 = Unknown cause of control loss

This Vehicle Traveling:
- *XXX = Ahead, stopped on roadway more than 2 seconds*
- *XXX = Ahead, decelerated and stopped on roadway 2 seconds or less*
- *XXX = Ahead, traveling in same direction and decelerating*
- *XXX = Ahead, traveling in same direction and accelerating*
- *XXX = Ahead, traveling in same direction with slower constant speed*
- *XXX = Behind, traveling in same direction and accelerating*
- *XXX = Behind, traveling in same direction with higher constant speed*
- *XXX = Behind, stopped on roadway*
- 010 = Over the lane line on the left side of travel lane
- 011 = Over the lane line on right side of travel lane
- 012 = Over left edge of roadway
- 013 = Over right edge of roadway
- 014 = Unknown which edge
- 015 = End departure
- 016 = Turning left at intersection
- 017 = Turning right at intersection
- 018 = Crossing over (passing through) intersection
- 018 = This vehicle decelerating
- 019 = Unknown travel direction

020a = From adjacent lane (same direction), over left lane line behind lead vehicle, rear-end crash threat
020b = From adjacent lane (same direction), over right lane line behind lead vehicle, rear-end crash threat

Other Vehicle in Lane:

030 = Ahead, stopped on roadway more than 2 seconds
031 = Ahead, decelerated and stopped on roadway 2 seconds or less
032 = Ahead, traveling in same direction and decelerating
033 = Ahead, traveling in same direction and accelerating
034 = Ahead, traveling in same direction with slower constant speed
035 = Behind, traveling in same direction and accelerating
036 = Behind, traveling in same direction with higher constant speed
037 = Behind, stopped on roadway
050 = Stopped on roadway
051 = Traveling in same direction with lower steady speed
052 = Traveling in same direction while decelerating
053 = Traveling in same direction with higher speed
054 = Traveling in opposite direction
055 = In crossover
056 = Backing
057 = Unknown travel direction of the other motor vehicle

Another Vehicle Encroaching into This Vehicle's Lane:

060a = From adjacent lane (same direction), over left lane line in front of this vehicle, rear-end crash threat
060b = From adjacent lane (same direction), over left lane line behind this vehicle, rear-end crash threat
060c = From adjacent lane (same direction), over left lane line, sideswipe threat
060d = From adjacent lane (same direction), over right lane line, sideswipe threat
060e = From adjacent lane (same direction), other
061a = From adjacent lane (same direction), over right lane line in front of this vehicle, rear-end crash threat
061b = From adjacent lane (same direction), over right lane line behind this vehicle, rear-end crash threat
061c = From adjacent lane (same direction), other
062 = From opposite direction over left lane line.
063 = From opposite direction over right lane line
064 = From parallel/diagonal parking lane
065 = Entering intersection—turning in same direction
066 = Entering intersection—straight across path
067 = Entering intersection – turning into opposite direction
068 = Entering intersection—intended path unknown
070 = From driveway, alley access, etc – turning into same direction
071 = From driveway, alley access, etc – straight across path
072 = From driveway, alley access, etc – turning into opposite direction
073 = From driveway, alley access, etc – intended path unknown
074 = From entrance to limited access highway

078 = Encroaching details unknown

Pedestrian, Pedalcyclist, or other Non-Motorist:

080 = Pedestrian in roadway
081 = Pedestrian approaching roadway
082 = Pedestrian in unknown location
083 = Pedalcyclist/other non-motorist in roadway
084 = Pedalcyclist/other non-motorist approaching roadway
085 = Pedalcyclist/or other non-motorist unknown location
086 = Pedestrian/pedalcyclist/other non-motorist—unknown location

Object or Animal:

087 = Animal in roadway
088 = Animal approaching roadway
089 = Animal unknown location
090 = Object in roadway
091 = Object approaching roadway
092 = Object unknown location

Other:

098 = Other event/not applicable
099 = Unknown critical event

10. What corrective action did you attempt to make prior to the crash?

0 = No driver present
1 = No avoidance maneuver
2 = Braking (no lockup)
3 = Braking (lockup)
4 = Braking (lockup unknown)
5 = Releasing brakes
6 = Steered to left
7 = Steered to right
8 = Braked and steered to left
9 = Braked and steered to right
10 = Accelerated
11 = Accelerated and steered to left
12 = Accelerated and steered to right
98 = Other actions
99 = Unknown if driver attempted any corrective action

Did your vehicle successfully respond to this corrective action or was this vehicular control maintained?

0 = No driver present
1 = Vehicle control maintained after corrective action
2 = Vehicle rotated (yawed) clockwise
3 = Vehicle rotated (yawed) counter-clockwise
4 = Vehicle slid/skid longitudinally – no rotation
5 = Vehicle slid/skid laterally – no rotation

9 = Vehicle rotated (yawed) unknown direction
20 = Combination of 2-9
94 = More than two vehicles involved
98 = Other or unknown type of vehicle control was lost after corrective action
99 = Unknown if vehicle control was lost after corrective action.

14. Were you physically or mentally impaired?

0 = None apparent
1 = Drowsy, sleepy, asleep, fatigued
2 = Ill, blackout
3a = Angry
3b = Other emotional state
4a = Drugs-medication
4b = Drugs-Alcohol
5 = Other drugs (marijuana, cocaine, etc.)
6 = Restricted to wheelchair
7 = Impaired due to previous injury
8 = Deaf
50 = Hit-and-run vehicle
97 = Physical/mental impairment – no details
98 = Other physical/mental impairment
99 = Unknown physical/mental condition

21. Did you (driver) consume any alcohol prior to crash?

0 = None
1 = In vehicle without overt effects on driving
2 = In vehicle with overt effects on driving
3 = Reported by police
4 = Use not observed or reported, but suspected based on driver behavior.

22. Was your vision obscured by any obstacle prior to the crash?

0 = No obstruction
1 = Rain, snow, fog, smoke, sand, dust
2a = Reflected glare
2b = Sunlight
2c = Headlights
3 = Curve or hill
4 = Building, billboard, or other design features (includes signs, embankment)
5 = Trees, crops, vegetation
6 = Moving vehicle (including load)
7 = Parked vehicle
8 = Splash or spray of passing vehicle [any other vehicle]
9 = Inadequate defrost or defog system
10 = Inadequate lighting system
11 = Obstruction interior to vehicle
12 = Mirrors

13 = Head restraints
14 = Broken or improperly cleaned windshield
15 = Fog
50 = Hit & run vehicle
95 = No driver present
96 = Not reported
97 = Vision obscured – no details
98 = Other obstruction
99 = Unknown whether vision was obstructed

23. Were you distracted?

1) Cognitive distraction
    a. Lost in thought
    b. Looked but did not see
2) Passenger in vehicle
    a. Passenger in adjacent seat
    b. Passenger in rear seat
    c. Child in adjacent seat
    d. Child in rear seat
3) Object/Animal/Insect in Vehicle
    a. Moving object in vehicle (i.e. object fell off seat when driver stopped hard at a traffic light)
    b. Insect in vehicle
    c. Pet in vehicle
    d. Object dropped by driver
    e. Reaching for object in vehicle (not cell phone)
4) Cell phone operations
    a. Locating/reaching/answering cell phone
    b. Dialing hand-held cell phone
    c. Dialing hand-held cell phone using quick keys
    d. Dialing hands-free cell phone using voice activated software
    e. Talking/listening
5) PDA operations
    a. Locating/reaching PDA
    b. Operating PDA
    c. Viewing PDA
6) In-vehicle system operations
    a. Adjusting climate control
    b. Adjusting the radio
    c. Inserting/retrieving cassette
    d. Inserting/retrieving CD
    e. Adjusting other devices integral to vehicle (unknown which device)
    f. Adjusting other known in-vehicle devices (text box to specify)
7) Dining
    a. Eating
    b. Drinking

8) Smoking
    a. Reaching for cigar/cigarette
    b. Lighting cigar/cigarette
    c. Smoking cigar/cigarette
    d. Extinguishing cigar/cigarette
9) External Distraction
    a. Looking at previous crash or highway incident
    b. Pedestrian located outside the vehicle
    c. Animal located outside the vehicle
    d. Object located outside the vehicle
    e. Construction zone

24. Were you engaging any unsafe driving behaviors that may have contributed to the crash?

Note: Analyst may code up to 3, in order of importance.
0 = None
1 = Exceeded speed limit
2= Inattentive or distracted
3 = Exceeded safe speed but not speed limit
4 = Driving slowly; below speed limit
5 = Driving slowly in relation to other traffic; not below speed limit
6 = Illegal passing (i.e., across double line) 2 = Inattentive or distracted (coded in previous variable)
7 = Passing on right
8 = Other improper or unsafe passing
9 = Cutting in, too close in front of other vehicle
10 = Cutting in, too close behind other vehicle
11 = Making turn from wrong lane (e.g., across lanes)
12 = Did not see other vehicle during lane change or merge
13 = Driving in other vehicle's blind zone
14 = Aggressive driving, specific, directed menacing actions
15 = Aggressive driving, other; i.e., reckless driving without directed menacing actions
16 = Wrong side of road, not overtaking
17 = Following too close
18 = Failed to signal, or improper signal
19 = Improper turn: wide right turn
20 = Improper turn: cut corner on left turn
21 = Other improper turning
22 = Improper backing, did not see
23 = Improper backing, other
24 = Improper start from parked position
25 = Disregarded officer or watchman
26 = Signal violation, apparently did not see signal
27 = Signal violation, intentionally ran red light
28 = Signal violation, tried to beat signal change
29 = Stop sign violation, apparently did not see stop sign

30 = Stop sign violation, intentionally ran stop sign at speed
31 = Stop sign violation, “rolling stop”
32 = Other sign (e.g., Yield) violation, apparently did not see sign
33 = Other sign (e.g., Yield) violation, intentionally disregarded
34 = Other sign violation
35 = Non-signed crossing violation (e.g., driveway entering roadway)
36 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
37 = Right-of-way error in relation to other vehicle or person, apparent decision failure (i.e., did see other vehicle prior to action but misjudged gap)
38 = Right-of-way error in relation to other vehicle or person, other or unknown cause
39 = Sudden or improper stopping on roadway
40 = Parking in improper or dangerous location; e.g., shoulder of Interstate
41 = Failure to signal with other violations or unsafe actions
42 = Failure to signal, without other violations or unsafe actions
43 = Speeding or other unsafe actions in work zone
44 = Failure to dim headlights
45 = Driving without lights or insufficient lights
46 = Avoiding pedestrian
47 = Avoiding other vehicle
48 = Avoiding animal
49 = Apparent unfamiliarity with roadway
50 = Apparent unfamiliarity with vehicle; e.g., displays and controls
51 = Apparent general inexperience driving
52 = Use of cruise control contributed to late braking
53 = Other, specify

25. Were there any vehicle malfunctions that contributed to the crash?

0 = None
1 = Tires
2 = Brake system
3 = Steering system
4 = Suspension
5 = Power train
6 = Exhaust system
7 = Headlights
8 = Signal lights
9 = Other lights
10 = Wipers
11 = Wheels
12 = Mirrors
13 = Driver seating and controls
14 = Body, doors
15 = Trailer hitch
50 = Hit and run vehicle
97 = Vehicle contributing factors, no details

98 = Other vehicle contributing factors
99 = Unknown if vehicle had contributing factors

26. Did you have a reason for avoiding, swerving, sliding?

0 = Not avoiding, swerving, or sliding
1 = Severe crosswind
2 = Wind from passing truck
3 = Slippery or loose surface
4 = Tire blow-out or flat
5 = Debris or objects in road
6 = Ruts, holes, bumps in road
7 = Animals in road
8 = Vehicle in road
9 = Phantom vehicle
10 = Pedestrian, pedalcyclist, or other non-motorist in road
11 = Water, snow, oil slick in road
50 = Hit and run vehicle
97 = Avoiding, swerving, or sliding, no details
98 = Other environmental contributing factor
99 = Unknown action

35. Were you using your cruise control? What speed?

0 = Cruise control off
1-97 = Set speed of cruise control, if activated.
98 = Cruise control activated, unknown set speed
99 = Unknown if cruise control is activated.

36. What was the duration of the latest principal sleep period?

37. How long have you been awake since this principal sleep period?

38. Did you take a nap prior to crash? What was the duration of nap prior to collision?

39. How long have you been awake since your nap?

V1 Occupant File

Information on occupants – number, seating position, injuries, etc. – will be available only for crashes. In-vehicle cameras will not show occupants other than the driver, and thus no information regarding these other occupants will be available for near-crashes, incidents, and baseline epochs.

2. What were the occupant seating position(s)?

3. V1 Occupant Sex(C)

1 = Male
2 = Female
3 = Unknown

4. V1 Occupant Age (C)

5. V1 Occupant Safety Belt Usage (C)

1 = Lap/shoulder belt
2 = Child safety/booster seat with safety belt
3 = Child safety/booster seat without safety belt
4 = Other safety belt used (describe)
5 = None used
99 = Unknown if used.

6. V1 Occupant Injury Severity (C)

0 = No injury (O)
1 = Fatal (K)
2 = Visible signs of injury; e.g., bleeding wound or distorted member, or carried from scene (A).
3 = Other visible injury as bruises, abrasions, swelling, limping, etc. (B)
4 = No visible injury but complaint of pain or momentary unconsciousness (C)

7. V1 Occupant Injury Narrative (C)

Driver/Vehicle 2 File

1. What other type of vehicles were involved in the crash?

1 = Automobile
2 = Van (minivan or standard van)
3 = Pickup truck
4 = Bus (transit or motor coach)
5 = School bus
6 = Single-unit straight truck
7 = Tractor-trailer
8 = Motorcycle or moped
9 = Emergency vehicle (police, fire, EMS) in service
10 = Other vehicle type
11 = Pedestrian
12 = Cyclist
13 = Animal

99 = Unknown vehicle type

2. What was the other driver(s) gender?

1 = Male
2 = Female
3 = Unknown

3. What were the other driver/pedestrian age(s)?

4. What was Vehicle 2 doing prior to the collision? (Repeat for each other vehicle listed by participant)

1 = Going straight ahead
2 = Making right turn
3 = Making left turn
4 = Making U-turn
5 = Slowing or stopping
6 = Starting in traffic lane
7 = Starting from parked position
8 = Stopped in traffic lane]
9 = Ran off road right
10 = Ran off road left
11 = Parked
12 = Backing
13 = Passing
14 = Changing lanes
15 = Other
16 = Accelerating in traffic lane
17 = Entering a parked position
18 = Negotiating a curve
19 = Merging

7. What corrective action was taken by Vehicle 2? (Repeat for all other vehicles)

0 = No driver present
1 = No avoidance maneuver
2 = Braking (no lockup)
3 = Braking (lockup)
4 = Braking (lockup unknown)
5 = Releasing brakes
6 = Steered to left
7 = Steered to right
8 = Braked and steered to left
9 = Braked and steered to right
10 = Accelerated
11 = Accelerated and steered to left
12 = Accelerated and steered to right
98 = Other actions

99 = Unknown if driver attempted any corrective action

8. Did you believe that driver 2 was mentally or physically impaired? (Repeat for other vehicle drivers)

0 = None apparent
1 = Drowsy, sleepy, asleep, fatigued
2 = Ill, blackout
3a = Angry
3b = Other emotional state
4 = Drugs-medication
5 = Other drugs (marijuana, cocaine, etc.)
6 = Restricted to wheelchair
7 = Impaired due to previous injury
8 = Deaf
50 = Hit-and-run vehicle
97 = Physical/mental impairment – no details
98 = Other physical/mental impairment
99 = Unknown physical/mental condition

9. Do you believe or suspect alchohol use?

0 = None known
1 = Observed or reported by police
2 = Purported (e.g., by Subject Driver)

10. Do you believe that driver 2's vision was obscured? By what?

0 = No obstruction
1 = Rain, snow, fog, smoke, sand, dust
2a = Reflected glare
2b = Sunlight
2c = Headlights
3 = Curve or hill
4 = Building, billboard, or other design features (includes signs, embankment)
5 = Trees, crops, vegetation
6 = Moving vehicle (including load)
7 = Parked vehicle\
8 = Splash or spray of passing vehicle [any other vehicle]
9 = Inadequate defrost or defog system
10 = Inadequate lighting system
11 = Obstruction interior to vehicle
12 = Mirrors
13 = Head restraints
14 = Broken or improperly cleaned windshield
15 = Fog
50 = Hit & run vehicle
95 = No driver present
96 = Not reported

97 = Vision obscured – no details
98 = Other obstruction
99 = Unknown whether vision was obstructed

11. Do you believe driver 2 was distracted?

0 = Not distracted
1 = Looked but did not see
2 = NOT USED [for consistency with GES]
3 = By other occupants
4 = By moving object in vehicle
5 = While talking or listening to phone
6 = While dialing phone
7 = While adjusting climate control
8a = While adjusting radio
8b = While adjusting cassette or CD
9 = While using other devices integral to vehicle
10 = While using or reaching for other devices
11 = Drowsy, sleepy, asleep, fatigued
12a = Previous crash or highway incident
12b = Other outside person or object
13a = Eating
13b = Drinking
14 = Smoking related
95 = No driver present
96 = Not reported
97 = Inattentive or lost in thought
98 = Other distraction or inattention
99 = Unknown if distracted

12. Do you believe that Driver 2 was exhibiting any unsafe actions?

Note: Analyst may code up to 3, in order of importance.
0 = None
1 = Exceeded speed limit
2 = Inattentive or distracted (coded in previous variable)
3 = Exceeded safe speed but not speed limit
4 = Driving slowly; below speed limit
5 = Driving slowly in relation to other traffic; not below speed limit
6 = Illegal passing (i.e., across double line)
7 = Passing on right
8 = Other improper or unsafe passing
9 = Cutting in, too close in front of other vehicle
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11 = Making turn from wrong lane (e.g., across lanes)
12 = Did not see other vehicle during lane change or merge
13 = Driving in other vehicle's blind zone
14 = Aggressive driving, specific, directed menacing actions

15 = Aggressive driving, other; i.e., reckless driving without directed menacing actions
16 = Wrong side of road, not overtaking
17 = Following too close
18 = Failed to signal, or improper signal
19 = Improper turn: wide right turn
20 = Improper turn: cut corner on left turn
21 = Other improper turning
22 = Improper backing, did not see
23 = Improper backing, other
24 = Improper start from parked position
25 = Disregarded officer or watchman
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27 = Signal violation, intentionally ran red light
28 = Signal violation, tried to beat signal change
29 = Stop sign violation, apparently did not see stop sign
30 = Stop sign violation, intentionally ran stop sign at speed
31 = Stop sign violation, "rolling stop"
32 = Other sign (e.g., Yield) violation, apparently did not see sign
33 = Other sign (e.g., Yield) violation, intentionally disregarded
34 = Other sign violation
35 = Non-signed crossing violation (e.g., driveway entering roadway)
36 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
37 = Right-of-way error in relation to other vehicle or person, apparent decision failure (i.e., did see other vehicle prior to action but misjudged gap)
38 = Right-of-way error in relation to other vehicle or person, other or unknown cause
39 = Sudden or improper stopping on roadway
40 = Parking in improper or dangerous location; e.g., shoulder of Interstate
41 = Failure to signal with other violations or unsafe actions
42 = Failure to signal, without other violations or unsafe actions
43 = Speeding or other unsafe actions in work zone
44 = Failure to dim headlights
45 = Driving without lights or insufficient lights
46 = Avoiding pedestrian
47 = Avoiding other vehicle
48 = Avoiding animal
49 = Apparent unfamiliarity with roadway
50 = Apparent unfamiliarity with vehicle; e.g., displays and controls
51 = Apparent general inexperience driving
52 = Use of cruise control contributed to late braking
53 = Other, specify

13. Do you believe that there were any vehicle malfunctions on Vehicle 2 that contributed to the crash?

0 = None
1 = Tires

2 = Brake system
3 = Steering system
4 = Suspension
5 = Power train
6 = Exhaust system
7 = Headlights
8 = Signal lights
9 = Other lights
10 = Wipers
11 = Wheels
12 = Mirrors
13 = Driver seating and controls
14 = Body, doors
15 = Trailer hitch
50 = Hit and run vehicle
97 = Vehicle contributing factors, no details
98 = Other vehicle contributing factors
99 = Unknown if vehicle had contributing factors

14. Do you believe that Driver 2 was avoiding, swerving, or sliding for a specific reason?

0 = Not avoiding, swerving, or sliding
1 = Severe crosswind
2 = Wind from passing truck
3 = Slippery or loose surface
4 = Tire blow-out or flat
5 = Debris or objects in road
6 = Ruts, holes, bumps in road
7 = Animals in road
8 = Vehicle in road
9 = Phantom vehicle
10 = Pedestrian, pedalcyclist, or other non-motorist in road
11 = Water, snow, oil slick in road
50 = Hit and run vehicle
97 = Avoiding, swerving, or sliding, no details
98 = Other environmental contributing factor
99 = Unknown action

V2 Occupant File

Information on V2 occupants – number, seating position, injuries, etc. – will be available only for crashes. Subject vehicle cameras will not show occupants of the other vehicle, and thus no information regarding these other occupants will be available for near-crashes, incidents, and baseline epochs. Crash PARs, and comparable data collected for non-police-reported crashes, will be the source of occupant information.

1. How many occupants in vehicle 2? (Repeat for each vehicle involved)

2. Where were the occupant seating position(s)?

3. What were the occupant(s) gender?

4. What was the approximate or specific age of these occupants?

5. Were the occupants using a seat belt?

1 = Lap/shoulder belt
2 = Child safety/booster seat with safety belt
3 = Child safety/booster seat without safety belt
4 = Other safety belt used (describe)
5 = None used
99 = Unknown if used.

6. Were the occupants injured?

0 = No injury (O)
1 = Fatal (K)
2 = Visible signs of injury; e.g., bleeding wound or distorted member, or carried from scene (A).
3 = Other visible injury as bruises, abrasions, swelling, limping, etc. (B)
4 = No visible injury but complaint of pain or momentary unconsciousness (C)

Air Bag Deployment

1. At the time of the accident, what was your body/head position? Were you leaning forward, back on the head rest, etc.???

2. Did you have radio on? What was the general volume, could you hold a conversation with it on?

3. Were the windows up or down?

Seatbelt Questionnaire

1) In general, how often do you use your seatbelt?
    a. Always use my seatbelt
    b. Typically use my seatbelt, with a few exceptions
    c. Occasionally use my seatbelt
    d. Rarely use my seatbelt
    e. Never use my seatbelt
    f. Don't know

    If you answered a or b, please continue with Question 2-4.
    If you answered c, d, or e, please skip to Question 5.

2) For how long have you been wearing a seatbelt regularly?
    a. Started within the last month
    b. One to six months
    c. Six months to a year
    d. 1-3 years
    e. More than 3 years
    f. Don't know

3) Was there a particular event that caused you to wear your belt more?
    a. No
    b. Yes, I had an accident
    c. Yes, I was stopped by police for not wearing a belt
    d. Yes, I received a lot of pressure from family/friends to do so
    e. Yes, other (please specify): ________________________________
    f. Don't know

4) Since you started wearing your seatbelt more often, do passengers wear theirs more when they ride with you?
    a. Yes, because I ask them
    b. Yes, they seem to buckle up when I do
    c. No
    d. About the same as before
    e. Don't know/haven't paid attention

        (full-time/majority users are now finished with seatbelt questions)

5) When you don't use your seatbelt why don't you? (Circle all that apply)
   a. Forget
   b. Uncomfortable/doesn't fit properly
   c. Messes clothing
   d. Only needed on certain road types
   e. Just a short trip
   f. No safety benefit/won't do any good
   g. Hassle/annoying to use
   h. Hazardous/more dangerous than not wearing belt
   i. Not using is my choice/doesn't affect anyone else
   j. When it's my time to go, it won't matter whether I have my belt on
   k. Other (please specify) ____
   l. Don't know

6) Below are some ways of encouraging people to wear their seatbelts more. Which would be effective in getting you to wear your seatbelt?
   a. Primary law, where police can pull you over just for not wearing a seatbelt
   b. Advanced seatbelt reminders, which would include lights and/or a sound and stay on up to one minute after starting the vehicle or you fastened your belt
   c. Advanced seatbelt reminders, which would include lights and/or a sound and stay on until you fasten your belt
   d. Other (please specify): ____
   e. Nothing would get me to wear my belt more
   f. Don't know

7) Of those you chose in Question 6, which would be most effective? a b c d

INFORMED CONSENT FOR DRIVERS OF LEASED VEHICLES

INFORMED CONSENT FOR PARTICIPANTS IN RESEARCH PROJECTS INVOLVING HUMAN SUBJECTS

Title of Project: Naturalistic Driving Study

Research Conducted by: Virginia Tech Transportation Institute (VTT)

Research Sponsored by: National Highway Traffic Safety Administration (NHTSA)

Investigators: Dr. Tom Dingus, Dr. Vicki Neale, Ms. Sheila Klauer, Dr. Ron Knipling, Ms. Heather Foster

I. PURPOSE OF THIS RESEARCH PROJECT

The objective of this study is to collect data on driving behavior. There are no special tasks for the driver to perform; instead, the driver is requested to merely drive as they regularly would to their normal destinations. This instrumentation is designed such that it will in no way interfere with the driving performance of the vehicle and will not obstruct the driver in any way. Due to the number of vehicles that are being instrumented and the time period involved, it is likely that crashes and the events leading up to them will be recorded.

One hundred high-mileage drivers are being recruited to participate in this research. All age groups and both men and women are being asked to participate. To participate, drivers must have a valid drivers' license and own a vehicle of which they are the primary driver for the experimental period of one year.

II. PROCEDURES AND SUBJECT RESPONSIBILITIES

The following describes procedures for the study and participant responsibilities:

Preparation for study:

1. Review entire study information package.
2. Read this informed consent form carefully; make a note of any questions. You may call Ms. Heather Foster of VTTI (703-538-8447) to discuss any questions.
3. Sign and date this form.
4. Ensure that any person likely to drive the instrumented vehicle has signed this consent form. (If you wish to add another driver at a later time, an informed consent form cal be obtained from VTTI.)
5. Provide close-up pictures (head-shots) of all consenting drivers.

In-processing (requires two hours):

6. Call Ms. Heather Foster of VTTI at 703-538-8447 to schedule an appointment for in-processing. In-processing will ordinarily be scheduled for 8-10am or 4-6pm on selected weekdays, and 9-11 am on Saturdays, at the VT Northern Virginia Center, 7054Haycock

Road, Falls Church, VA 22043. (Parking is available in the Visitors Parking Lot.)

7. Bring the following to the subject in-processing:
   - Signed informed consent form (this document)
   - Valid driver's license
   - Social Security Number
   - Two forms of identification
8. Listen to a short overview orientation to the study, and "Q&A" discussion. Sign remaining administrative forms; a copy of all signed forms will be provided to you for your records.
9. Review insurance protocol for the leased vehicle.
10. Take a vision exam.
11. Take a hearing exam. (Note: a free hearing exam is available for all prospective drivers, family members, and other frequent passengers, provided they agree to the re-testing in the event of an airbag deployment.)
12. Complete surveys regarding your health, sleep hygiene, stress levels, overall personality, and driving behaviors and practices.
13. Take one or more brief performance tests.
14. Schedule VTTI delivery of the leased vehicle to your home or workplace.

<u>Data collection during driving:</u>

15. Wear your seatbelt at all times.
16. Drive your vehicle as you normally would.
17. Do not wear sunglasses unless absolutely necessary.
18. In the event of a safety-related incident, [i.e. a crash, near-crash, driving error, or unsafe condition involving you vehicle or adjacent vehicles], press the red incident button located above the rear-view mirror after the incident as soon as it is safe to do so. For one minute, a microphone (directed toward the driver) will be activated; during this time, please briefly describe what happened, and why. In particular, what was the driving error that caused the incident?

<u>Data downloading:</u>

Note: the location of your vehicle will be known to VTTI researchers via a radio transmitter providing Global Positioning System (GPS) coordinates. This information will be used to locate vehicles for data downloading.

19. Permit VTTI researchers to access the vehicle (at your home or work location) every 1-4 weeks to download data. Most data downloads will require a data line to be plugged into a data port near the vehicle's rear license plate on the outside of the vehicle. (No access to the inside of the vehicle is required.) Subject to your approval, data downloads will be completed between 7am and 11pm.

<u>Equipment and vehicle maintenance:</u>

20. In the event of equipment malfunction or damage, notify VTTI as soon as possible.
21. Permit a service call at your home or office for repairs (if preferred, vehicle may be brought to Hurley's). If repairs cannot be made in a service call, bring the vehicle to Hurley's for repairs. VTTI will provide $10 to cover Metro fare or other transportation needs.

22. Buy regular, unleaded gasoline for the vehicle. Perform regular safety checks; e.g., once monthly, check tire pressure, oil level, and other fluids. Have oil changes and other preventive maintenance performed per a schedule and instructions provided to you by VTTI.

<u>In the event of a crash: Study Procedures (applies to all collisions, regardless of severity);</u>

23. Contact VTTI as soon as possible after the crash. (Accident reporting instructions and phone numbers will be left in the glove box of the leased vehicle.)
24. Participate in a short phone interview with VTTI about the crash. In addition, since you are driving a vehicle owned by the State of Virginia, there are two reporting requirements following accidents, one for this study and one for the state (Virginia Tech Motor Pool), which will be explained to you during in-processing.
25. Schedule an appointment for hearing re-testing, to be conducted **as soon as possible** after the crash. Re-testing is conducted at Professional Hearing Services (6231Leesburg Pike Suite 512 Falls Church, VA 22044 Phone 703-536-1666). Re-testing results will be provided to you and to VTTI.
26. Encourage all passengers whose hearing has been tested to schedule this re-testing.
27. If the crash is police reported, request a copy of the Police Accident Report from the police, and provide a copy to VTTI. VTTI will remove all personal identifiers to ensure confidentiality. "Personal identifiers" include names, addresses, phone numbers, and license plate numbers.
28. Request and provide copies of medical report(s) associated with your crash injuries and treatment. For some crashes, crash and injury information may already be available to NHTSA, and thus to this study, in conjunction with other NHTSA-sponsored studies in the Northern Virginia area.
29. Permit VTTI and/or Hurley's to check and test the vehicle instrumentation.

<u>In the event of a crash: Virginia Tech Motor Pool Procedures</u>

30. Follow the instructions in the glove compartment.
31. Contact VTTI as soon as possible, we will assist you in filing the Virginia Tech Motor Pool accident report.

<u>In the event of an airbag deployment:</u>

32. Permit a Special Crash Investigation team from NHTSA to inspect the vehicle.
33. Participate in an in-person interview with the Crash Investigation team.

<u>Vehicle Return:</u>

VTTI will contact you at the end of the 12-month study, to schedule out-processing and return of the leased vehicle.

34. Bring your leased vehicle to the VT North Virginia Center to return. VTTI will provide $10 to cover Metro fare or other transportation.

<u>Out-processing/study completion (requires one hour):</u>

35. Complete out-processing administrative paperwork.
36. Complete short questionnaires regarding stress levels, driving behavior and performance over the past year, and study evaluation.

Equipment Installation and Data Collection

You are being asked to drive with the instrumentation for approximately one year. The data on the vehicle will be downloaded via a data port located behind the rear license plate or via short range wireless communication (if there is no access to the vehicle). Once the data is downloaded, it will be stored on a project specific data server that will be accessed only by research staff affiliated with the project.

The data collection system is designed to require no maintenance and will not require you to perform any maintenance. However, if a diagnostic check of the data confirms a disruption of the data collection, a hardware engineer will be assigned to correct the problem. To perform the maintenance, VTTI or Hurley's will contact you to receive permission to work on the vehicle and schedule the repair. We will try to avoid interfering with your commuting schedule.

Automobile Insurance

In the Commonwealth of Virginia, responsibility for automobile insurance resides with the owner of the vehicle.
In the event of an accident or injury in a Virginia Tech automobile, the University will provide automobile liability coverage for property damage and personal injury. The total policy amount per occurrence is $2,000,000. This coverage (unless the other party was at fault, which would mean all expense would go to the insurer of the other party's vehicle) would apply in case of an accident for all volunteers and would cover medical expenses up to the policy limit. In the event of an accident, you must notify the police and the VT Motor Pool (contact information will be left in the glove compartment of the leased vehicle).

VT also carries as a part of its automobile liability insurance a "Med Pay" endorsement that will pay up to $5,000 in medical expenses, until fault in an accident is determined, at which time all medical expenses would go to the insurer of the vehicle at fault.

If you are working as an employee for another company, you may be deemed to be driving in the course of your employment, and your employer's worker's compensation provisions may apply in lieu of the Virginia Tech and Commonwealth of Virginia insurance provisions, in case of an accident. The particular circumstances under which worker's compensation would apply are specified in Virginia law. If worker's compensation provisions do not apply in a particular situation, then Virginia Tech and Commonwealth of Virginia insurance will provide coverage.

Medical Insurance

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation; under Commonwealth of Virginia law, workers compensation does not apply to volunteers; therefore, if not in an automobile, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

If you should become injured in an accident, whether in or out of an automobile, the medical treatment available to you would be that provided to any person by emergency medical services in the vicinity where the accident occurs.

A Virginia Tech automobile accident report form is located in the glove compartment of the vehicle you will be driving and outlines what you should do if you become involved in an accident and are not incapacitated.

Automatic Collision Notification

The vehicle will also be equipped with an automatic collision notification system, triggered by collision impacts. The system is intended to notify VTTI in the event of a collision impact. When serious impacts are detected by VTTI staff, they will notify local emergency services. However, VTTI cannot guarantee continuous 24-hour coverage or coverage of all vehicle locations. Therefore, in the event of a crash, you should not expect an emergency response based on this system. Notify police and emergency services as you otherwise would following a crash. However, this automatic collision notification system may enable emergency service to be dispatched to you faster after a crash.

III. RISKS

The risk to you is no more than you would normally incur while driving. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard in any foreseeable way. None of the data collection equipment will interfere with any part of your normal field of view. The addition of the data collection systems to the vehicle will in no way affect the operating or handling characteristics of the vehicle.

Please note that you are being asked not to wear sunglasses unless absolutely necessary; however, if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and your surrounding environment, sunglasses are recommended.

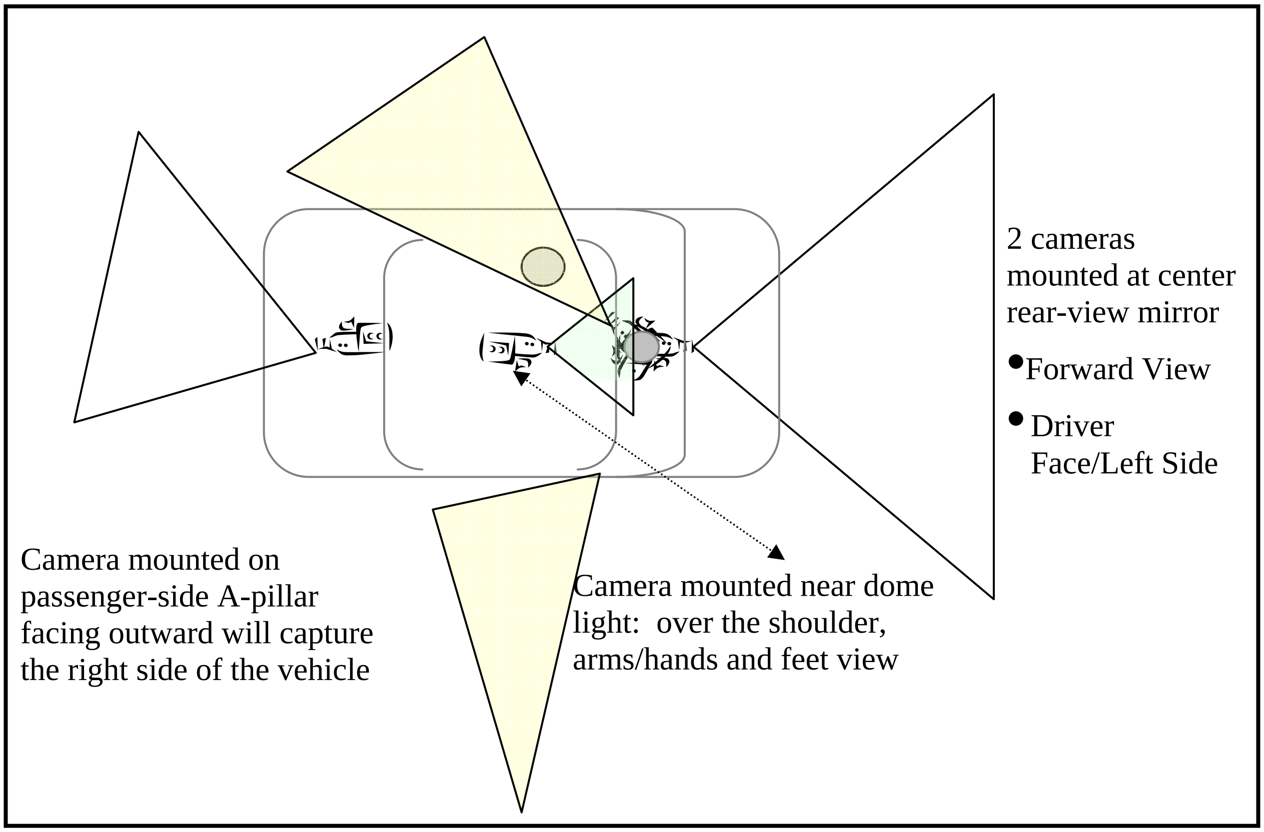
IV. BENEFITS

While there are no direct benefits to you from this research, you may find the experiment interesting. No promise or guarantee of benefits is being made to encourage participation. Your participation will help to improve the body of knowledge regarding driving behavior and performance.

V. EXTENT OF ANONYMITY AND CONFIDENTIALITY

Video information will be taken during the course of data collection. The data gathered in this experiment will be treated with confidentiality. Driver names will be separated from the collected data. A coding scheme will be employed to identify the data by subject number only (e.g., Driver No. 3).

While you are driving the vehicle, a camera will record your face and the left exterior side of vehicle, the right exterior side of the vehicle, the forward view, the rear-view, and the instrument panel view. This is shown below. Note that no other passengers in the vehicle will be within the camera view. Also, there is audio recording capability in the vehicle, but it will only record for one minute when you activate the incident push button. Please note that the audio microphone is directional and will only record your voice from the driver's seat.



The data from this study will be stored in a secured area at the Virginia Tech Transportation Institute. Access to the data will be under the supervision of Dr. Tom Dingus, Dr. Vicki Neale, Ms. Sheila Klauer, Dr. Ron Knipling, and Ms. Heather Foster. Data reductionists assigned to work on this project will also have access to your data. Data reduction will consist of examining driving performance under various conditions. During the course of this study, the video will not be released to anyone other than individuals working on the project without your written consent. Following the study, some data may be made available to the contact sponsor, the National Highway Traffic Safety Administration (NHTSA), for research purposes only. Please note that NHTSA is under the same obligation to keep your data confidential.

If you are involved in a crash while participating in this study, the data collection equipment in your vehicle will likely capture the events leading up to the event. The data collection equipment SHOULD NOT be given to police officers or any other party. You are under NO LEGAL OBLIGATION to mention that you are participating in this study.

We will do everything we can to keep others from learning about your participation in the research. To further help us protect your privacy, the investigators have obtained a Confidentiality Certificate from the Department of Health and Human Services. With this Certificate, the investigators cannot be forced (for example by court subpoena) to disclose information that may identify you in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. Disclosure will be necessary, however, upon request of DHHS for audit or program evaluation purposes.

You should understand that a Confidentiality Certificate does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. Note however, that if an insurer, employer, or someone else learns about your participation, and *obtains your consent* to receive research information, then the investigator may not use the Certificate of Confidentiality to withhold this information. This means that you and your family must also actively protect your own privacy. In addition to the Confidentiality Certificate, we have also obtained approval through the NHTSA Human Use Review Panel for your protection.

Finally, you should understand that the investigator is not prevented from taking steps, including disclosing information to authorities, to prevent serious harm to yourself or others. For example, if we learned about offenses such as child abuse or habitual driving under the influence, we would take appropriate action to protect you and someone else, even though we will still maintain privacy of the data.

VI. COMPENSATION

You will be compensated $125.00 per month for approximately 12 months of participation in this study. If you choose to withdraw from participation prior to the 12-month period, you will be compensated for the proportion of time that you have participated. You will also receive a $300 study completion bonus at the end of the 12-month period and equipment de-installation. This bonus will be provided at the out-processing.

In addition to this compensation, you will be given $10 for travel on the days that instrumentation is installed and removed.

VII. FREEDOM TO WITHDRAW

You are free to withdraw from the study at any time without penalty. If you choose to withdraw, you will be compensated for the portion of the time of the study.

VTTI has the right to terminate your participation in the study at any time. For example, VTTI may withdraw you from the study if the quantity or quality of data is insufficient for study purposes or if you pose a threat to yourself or to others. Subjects withdrawn from the study will receive pro-rated payment (at $125 per month) and will be required to schedule equipment de-installation as soon as possible.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, by the Virginia Tech Transportation Institute.

______________________________ ______________________________

IRB Approval Date Approval Expiration Date

IX. Driver's Responsibilities

I voluntarily agree to participate in this study. I understand the procedures and responsibilities described above, in particular in **Section II, Procedures and Subject Responsibilities.**

X. Driver's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Signature of Driver: ____ Date:______________

Signature of Additional Driver:

____ Date: ______________

Signature of Legal Guardian if any additional driver is minors:

____ Date: ______________

Signature of Additional Driver:

____ Date: ______________

Signature of Legal Guardian if any additional driver is minors:

____ Date: ______________

Signature of Additional Driver:

____ Date: ______________

Signature of Legal Guardian if any additional driver is minors:

____ Date: _____________

Should I have any questions about this research or its conduct, I may contact:

Heather Foster [Redacted]
Research Specialist/Northern Virginia Center, Virginia Tech Transportation Institute

Dr. Ronald R. Knipling [Redacted]
Northern Virginia Site Manager/Falls Church, Virginia Tech Transportation Institute

Dr. Vicki L. Neale [Redacted]
Co- Principal Investigator, Virginia Tech Transportation Institute

Dr. David M. Moore [Redacted]
Chair, IRB
Office of Research Compliance
Research & Graduate Studies

All drivers must be given a complete copy (or duplicate original) of the signed Informed Consent.

[REVISED 10-22-02]

INFORMED CONSENT FOR DRIVERS OF PRIVATE VEHICLES

INFORMED CONSENT FOR PARTICIPANTS IN RESEARCH PROJECTS INVOLVING HUMAN SUBJECTS

Title of Project: Naturalistic Driving Study

Research Conducted by: Virginia Tech Transportation Institute (VTTI)

Research Sponsored by: National Highway Traffic Safety Administration (NHTSA)

Investigators: Dr. Tom Dingus, Dr. Vicki Neale, Sheila Klauer, Dr. Ron Knipling, Heather Foster

I. PURPOSE OF THIS RESEARCH PROJECT

The objective of this study is to instrument drivers' personal vehicles to collect data on driving behavior. There are no special tasks for the driver to perform; instead, the driver is requested to merely drive as they regularly would to their normal destinations. This instrumentation is designed such that it will in no way interfere with the driving performance of the vehicle and will not obstruct the driver in any way. Due to the number of vehicles that are being instrumented and the time period involved, it is likely that crashes and the events leading up to them will be recorded.

One hundred high-mileage drivers are being recruited to participate in this research. All age groups and both men and women are being asked to participate. To participate, drivers must have a valid drivers' license and own a vehicle of which they are the primary driver for the experimental period of one year.

II. PROCEDURES AND SUBJECT RESPONSIBILITIES

The following describes procedures for the study and participant responsibilities:

Preparation for study:

1. Review entire study information package
2. Read this informed consent form carefully; make a note of any questions. You may call Heather Foster of VTTI [Redacted] to discuss any questions.
3. Sign and date this form.
4. Ensure that any person likely to drive the instrumented vehicle has signed this informed consent form. (If you wish to add another driver at a later time, an informed consent form can be obtained from VTTI.)
5. Provide close-up pictures (head-shots) of all consenting drivers.

In-processing (requires two hours):

6. Call Heather Foster of VTTI at [Redacted] to schedule an appointment for in-processing.
   In-processing will ordinarily be scheduled for 8-10 a.m. or 4-6 p.m on weekdays, and 9-11 a.m. on Saturdays, at
   the VT Northern Virginia Center, 7054 Haycock Road, Falls Church, VA 22043.
   (Parking is available in the Visitors Parking Lot)
7. Bring the following to the subject in-processing:
   - Signed informed consent form (this document)
   - Valid driver's license
   - Proof of insurance for your vehicle
   - Vehicle registration
   - Social Security Number
   - Two forms of identification
8. Listen to a short overview orientation to the study, and "Q&A" discussion. Sign remaining administrative forms; a copy of all signed forms will be provided to you for your records.
9. Take a vision exam.
10. Take a hearing exam. (Note: a free hearing exam is available for all prospective drivers, family members, and other frequent passengers, provided they agree to the re-testing in the event of a crash.)
11. Complete surveys regarding your health, sleep hygiene, stress levels, overall personality, and driving behaviors and practices.
12. Take one or more brief performance tests.
13. Schedule your vehicle for equipment installation. (see below)

Equipment installation:

14. Bring your vehicle to Hurley's Auto Audio (1524 Springhill Road, McLean, VA 22102, Phone [Redacted] for equipment installation this will require a full day. We will provide $10 to cover Metro fare or other transportation needs.

Data collection during driving:

15. Wear your seatbelt at all times.
16. Drive your vehicle as you normally would.
17. Do not wear sunglasses unless absolutely necessary
18. In the event of a safety-related incident, [i.e. a crash, near-crash, driving error, or unsafe condition involving your vehicle or adjacent vehicles], press the red incident button located above the rear-view mirror after the incident as soon as it is safe to do so. For one minute, a microphone (directed toward the driver) will be activated; during this time, please briefly describe what happened, and why. In particular, what was the driving error that caused the incident?

Data downloading:

Note: the location of your vehicle will be known to VTTI researchers via a radio transmitter providing Global Positioning System (GPS) coordinates. This information will be used to locate vehicles for data downloading.

19. Permit VTTI researchers to access your vehicle (at your home or work location) every 1-4 weeks to download data. Most data downloads will require a data line to be plugged into a

data port near the vehicle license plate on the outside of the vehicle. (No access to the inside of the vehicle is required.) Subject to your approval, data downloads will be completed between 7am and 11pm.

Equipment maintenance:

20. In the event of equipment malfunctioning or damage, notify VTTI as soon as possible.
21. Permit a service call at your home or office for repairs (if preferred, vehicle may be brought to Hurley's). If repairs cannot be made in a service call, bring the vehicle in to Hurley's for repairs. We will provide $10 to cover Metro fare or other transportation needs.

In the event of a crash (applies to all collisions, regardless of severity):

22. Contact VTTI as soon as possible after the crash. (Accident reporting instructions and phone numbers will be placed in glove box during equipment installation.)
23. Participate in a short phone interview with VTTI about the crash.
24. Schedule an appointment for hearing re-testing, to be conducted **as soon as possible** after the crash. Re-testing is conducted at Professional Hearing Services (6231 Leesburg Pike Suite 512 Falls Church, VA 22044 Phone [Redacted]. Re-testing results will be provided to you and to VTTI.
25. Encourage all passengers whose hearing has been tested to schedule this re-testing.
26. If the crash is police-reported, request a copy of the Police Accident Report from the police, and provide a copy to VTTI. VTTI will remove all personal identifiers to ensure confidentiality. "Personal identifiers" include names, addresses, phone numbers, and license plate numbers.
27. Request and provide copies of medical report(s) associated with your crash injuries and treatment. For some crashes, crash and injury information may already be available to NHTSA, and thus to this study, in conjunction with other NHTSA-sponsored studies in the Northern Virginia area.
28. Permit VTTI and/or Hurley's to check and test the vehicle instrumentation.

In the event of an airbag deployment:

29. Permit a Special Crash Investigation team from NHTSA to inspect the vehicle.
30. Participate in an in-person interview with the Crash Investigation team.

Equipment de-installation:

VTTI will contact you at the end of the 12-month study, to schedule equipment de-installation and out-processing.

31. Bring your vehicle to Hurley's Auto Audio for equipment de-installation, which will require a full day. We will provide $10 to cover Metro fare or other transportation needs.
32. Inspect your vehicle at Hurley's and sign form to verify that all recording equipment has been removed, and that the vehicle has been restored to its original state. Keep copy for your records.

Out-processing/study completion (requires one hour):

33. Complete out-processing administrative paperwork.
34. Complete short questionnaires regarding stress levels and driving behavior and

performance over the past year, and study evaluation.
35. Receive final payment for your participation.

Equipment Installation and Data Collection

You are being asked to drive with the instrumentation for approximately one year. No holes will be drilled into your vehicle to mount equipment. Instead, holes holding existing apparatus will be used. The data collection system is approximately 8” x 18” x 24.” The computer/data storage system is housed in the back of the trunk and mounted to the trunk “roof” (not to the trunk lid). A camera module will be mounted above the rear-view mirror and an incident push-button will be located on the camera module. This will be done without drilling holes or making any permanent modifications to the vehicle. Wires will not be visible.

As part of the data collection system, forward- and rearward-looking radar will be installed behind the front and rear license plates. For the radar to function, we will need to replace you state license plate with plastic plates for the duration of the study. You will be provided with a temporary registration and an authorization letter from the state DMV for your records. At the end of the study your original license plates will be reinstalled on the vehicle.

The data on the vehicle will be downloaded via a data port located behind the rear license plate or via short range wireless communication (if there is no access to the vehicle). Once the data is downloaded, it will be stored on a project specific data server that will be accessed only by research staff affiliated with the project.

The data collection system is designed to require no maintenance and will not require you to perform any maintenance. However, if a diagnostic check of the data confirms a disruption of the data collection, a technician will be assigned to correct the problem. To perform the maintenance, VTTI or Hurley’s will contact you to receive permission to work on the vehicle and schedule the repair. We will try to avoid interfering with your commuting schedule.

Insurance

Please note that since you are driving your own vehicle, Virginia Tech is not liable for the expenses incurred in any accident you may have. In the event of an accident, you are not responsible for coverage of the instrumentation in the vehicle.

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation. Under Commonwealth of Virginia law, workers compensation does not apply to volunteers; therefore, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

If you should become injured in an accident, whether in or out of an automobile, the medical treatment available to you would be that provided to any person by emergency medical services in the vicinity where the accident occurs.

Automatic Collision Notification

The vehicle will also be equipped with an automatic collision notification system, triggered by collision impacts. The system is intended to notify VTTI in the event of a collision impact. When serious impacts are detected by VTTI staff, they will notify local emergency services. However, VTTI cannot guarantee continuous 24-hour coverage or coverage of all vehicle locations. Therefore, in the event of a crash, you should not expect an emergency response based on this system. Notify police and emergency services as you otherwise would following a crash. However, this automatic collision notification system may enable emergency service to be dispatched to you faster after a crash.

III. RISKS

The risk to you is no more than you would normally incur while driving. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard in any foreseeable way. None of the data collection equipment will interfere with any part of your normal field of view. The addition of the data collection systems to the vehicle will in no way affect the operating or handling characteristics of the vehicle.

Please note that you are being asked not to wear sunglasses unless absolutely necessary; however, if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and your surrounding environment, sunglasses are recommended.

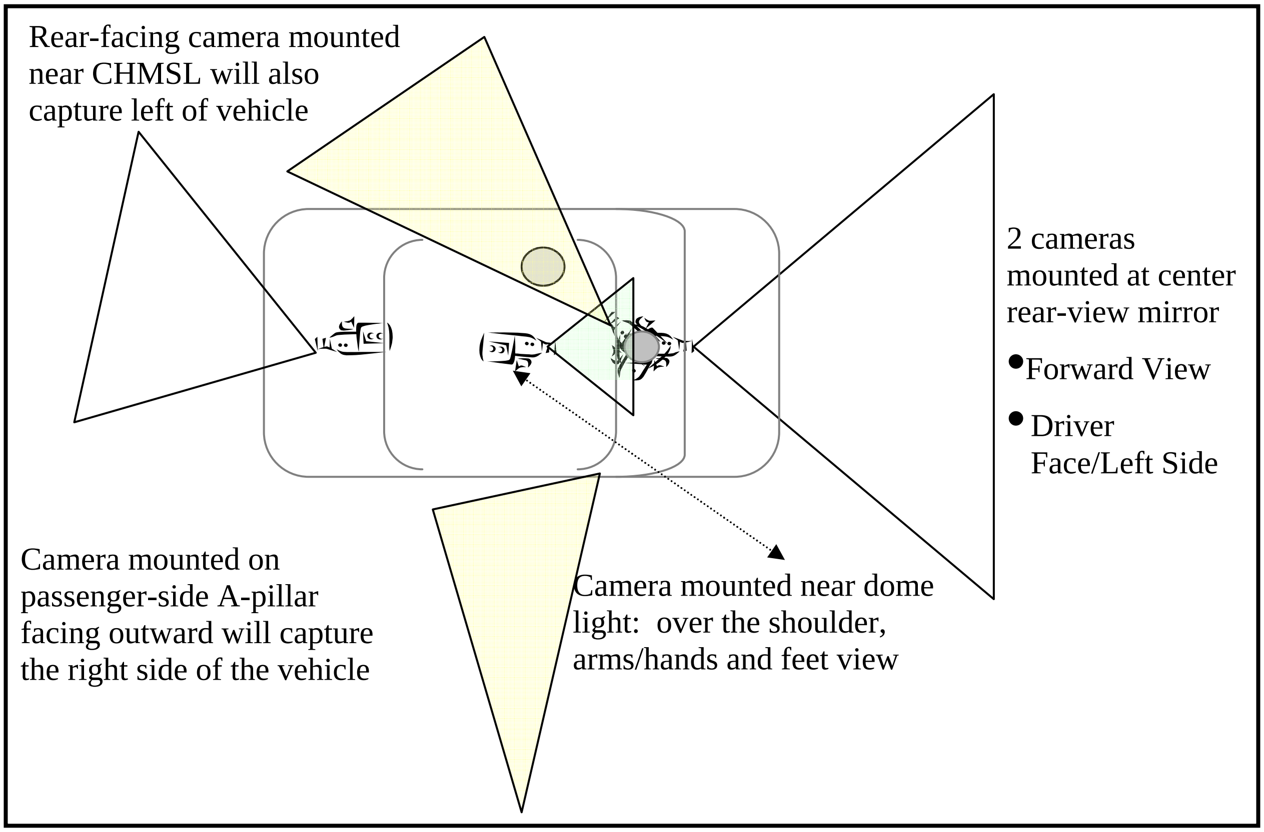
IV. BENEFITS

While there are no direct benefits to you from this research, you may find the experiment interesting. No promise or guarantee of benefits is being made to encourage participation. Your participation will help to improve the body of knowledge regarding driving behavior and performance.

V. EXTENT OF ANONYMITY AND CONFIDENTIALITY

Video information will be taken during the course of data collection. The data gathered in this experiment will be treated with confidentiality. Drivers' names will be separated from the collected data. A coding scheme will be employed to identify the data by subject number only (e.g., Driver No. 3).

While you are driving the vehicle, a camera will record your face and the left exterior side of vehicle, the right exterior side of the vehicle, the forward view, the rear-view, and the instrument panel view. This is shown below. Note that no other passengers in the vehicle will be within the camera view. Also, there is audio recording capability in the vehicle, but it will only record for one minute when you activate the incident push button. Please note that the audio microphone is directional and will only record your voice from the driver's seat.



The data from this study will be stored in a secured area at the Virginia Tech Transportation Institute. Access to the data will be under the supervision of Dr. Tom Dingus, Dr. Vicki Neale, Sheila Klauer, Dr. Ron Knipling, and Heather Foster. Data reductionists assigned to work on this project will also have access to your data. Data reduction will consist of examining driving performance under various conditions. During the course of this study, the video will not be released to anyone other than individuals working on the project without your written consent. Following the study, some data may be made available to the contact sponsor, the National Highway Traffic Safety Administration (NHTSA), for research purposes only. Please note that NHTSA is under the same obligation to keep your data confidential.

If you are involved in a crash while participating in this study, the data collection equipment in your vehicle will likely capture the events leading up to the event. The data collection equipment SHOULD NOT be given to police officers or any other party. You are under NO LEGAL OBLIGATION to mention that you are participating in this study.

We will do everything we can to keep others from learning about your participation in the research. To further help us protect your privacy, the investigators have obtained a Confidentiality Certificate from the Department of Health and Human Services. With this Certificate, the investigators cannot be forced (for example by court subpoena) to disclose information that may identify you in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. Disclosure will be necessary, however, upon request of DHHS for audit or program evaluation purposes.

You should understand that a Confidentiality Certificate does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. Note however, that if an insurer, employer, or someone else learns about your participation, and *obtains your consent* to receive research information, then the investigator may not use the Certificate of Confidentiality to withhold this information. This means that you and your family must also actively protect your own privacy. In addition to the Confidentiality Certificate, we have also obtained approval through the NHTSA Human Use Review Panel for your protection.

Finally, you should understand that the investigator is not prevented from taking steps, including disclosing information to authorities, to prevent serious harm to yourself or others. For example, if we learned about offenses such as child abuse or habitual driving under the influence, we would take appropriate action to protect you and someone else, even though we will still maintain privacy of the data.

VI. COMPENSATION

You will be compensated $125.00 per month for approximately 12 months of participation in this study. If you choose to withdraw from participation prior to the 12-month period, you will be compensated for the proportion of time that you have participated. You will also receive a $300 study completion bonus at the end of the 12-month period and equipment de-installation. This bonus will be provided at the out-processing.

In addition to this compensation, you will be given $10 for travel on the days that instrumentation is installed and removed.

VII. FREEDOM TO WITHDRAW

You are free to withdraw from the study at any time without penalty. If you choose to withdraw, you will be compensated for the portion of the time of the study.

VTTI has the right to terminate your participation in the study at any time. For example, VTTI may withdraw you from the study if the quantity or quality of data is insufficient for study purposes or if you pose a threat to yourself or to others. Subjects withdrawn from the study will receive pro-rated payment (at $125 per month) and will be required to schedule equipment de-installation as soon as possible.

VIII. APPROVAL OF RESEARCH

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, by the Virginia Tech Transportation Institute.

____________________________ IRB Approval Date

____________________________ Approval Expiration Date

IX. DRIVER'S RESPONSIBILITIES

I voluntarily agree to participate in this study. I understand the procedures and responsibilities described above, in particular in **Section II, Procedures and Subject Responsibilities.**

X. DRIVER'S PERMISSION

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

Signature of Driver: ____ Date:______________

Signature of Additional Driver:

____ Date: ______________

Signature of Legal Guardian if any additional driver is minors:

____ Date: ______________

Signature of Additional Driver:

____ Date: ______________

Signature of Legal Guardian if any additional driver is minors:

____ Date: ______________

Signature of Additional Driver:

____ Date: ______________

Signature of Legal Guardian if any additional driver is minors:

____ Date: ______________

Should I have any questions about this research or its conduct, I may contact:

Heather Foster [Redacted]
Research Specialist/Northern Virginia Center, Virginia Tech Transportation Institute

Dr. Ronald R. Knipling [Redacted]
Northern Virginia Site Manager/Falls Church, Virginia Tech Transportation Institute

Dr. Vicki L. Neale [Redacted]
Co- Principal Investigator, Virginia Tech Transportation Institute

Dr. David M. Moore [Redacted]
Chair, IRB
Office of Research Compliance
Research & Graduate Studies

All drivers must be given a complete copy (or duplicate original) of the signed Informed Consent.

APPENDIX B: OPERATIONAL DEFINITIONS OF SPECIFIC/GENERAL DRIVING BEHAVIORS

INAPPROPRIATE SPEED

Exceeded speed limit – Speed limit is estimated by video analysts based upon locality and speed of surrounding traffic; the driver must exceed this speed limit by 10 mph or more.

Speeding or other unsafe actions in work zone - Speeding or any other action in a work zone that could put the driver or others at risk.

Exceeds safe speed but not speed limit – Driver exceed safe speed for current driving condition (weather, traffic situation) that call for slower speeds.

Driving slowly below speed limit – Speed limit is estimated by video analysts based upon locality and speed of surrounding traffic; the driver is traveling 10 mph below the estimated speed limit.

Driving slowly in relation to other traffic but not below speed limit – Example, driver is on the interstate driving the speed limit and being passed by most traffic.

IMPROPER PASSING

Illegal passing – Example, crossing double solid yellow line or passing on the shoulder.

Passing on the right – The subject driver intentionally moves to the right lane to pass a vehicle.

Other improper or unsafe passing – Example, passing on a two-lane road with limited sight distance or with other vehicle present.

PROXIMITY

Cutting in too close in front of other vehicle – Subject driver changes lanes or turns into the lane too close in front of other vehicle.

Cutting in too close behind other vehicle – Subject driver changes lanes or turns into the lane too close behind other vehicle.

Following too closely – This was determined by video analysts by using speed, distance from the radar, and dash marks in the road. If the estimated distance was consistently less than 2 s from the lead-vehicle following too closely was marked.

IMPROPER TURN

Making turn from wrong lane – Example, subject driver turns across lanes or turns from a non-turning lane.

VISUAL

Did not see other vehicle during lane change or merge – The subject driver did not see other vehicle or initially did not see other vehicle while changing lanes or merging. This does not have to be a complete lane change, for example, if the subject started to change lanes then noticed a vehicle in the other lane and jerked back.

Driving in other vehicles blind zone – The subject driver is continuously driving in another driver's blind zone.

WILLFUL BEHAVIOR
Aggressive driving, specific, menacing actions – Intentional, aggressive actions directed toward another vehicle or pedestrian.

Aggressive driving, other – This includes reckless driving without menacing actions. Examples; excessive speed, weaving in and out of traffic, tailgating, etc.

Failed to signal or improper signal – Subject driver did not use turn signal in accordance with traffic laws (changing lanes or turning with no signal, signaling late or after lane change or turn has already begun).

Improper turn: wide right turn – Example, subject driver makes a right turn wide and cuts into left lane or into the oncoming traffic lane.

IMPROPER TURN
Improper turn: cut corner on left turn – Example, the subject driver makes a left turn and cuts into the adjacent lane to the left or into oncoming traffic.

Other improper turning – Example, turning from a non-turn lane.

IMPROPER BACKING
Improper backing, did not see – Subject driver did not check mirrors or area behind vehicle when backing.

Improper backing, other – Example, backing into traffic.

IMPROPER PARKING
Improper start from a parked position – Subject driver did not check mirrors or windows while exiting the parking spot.

TRAFFIC CONTROL DEVICE VIOLATION
Disregarded officer or watchman – Subject driver was unaware of watchman or was too late to react.

Signal violation, apparently did not see signal – Subject driver was unaware of signal or was too late to react.

Signal violation, intentionally ran a red light – Subject driver ran a red light and was purposeful (e.g. Driver purposefully accelerated through intersection).

Signal violation, tried to beat signal change – Subject ran a red light trying to pass through the intersection while the light was yellow.

Stop-sign violation, apparently did not see stop sign - Subject driver was unaware of stop sign or was too late to react.

Stop-sign violation, intentionally ran stop sign at speed – Subject purposefully ran the stop sign without decelerating below a speed of 15 mph.

Stop-sign violation, "rolling stop" – the subject slowed to a speed less than 15 mph for the stop sign but did not come to a complete stop.

Other sign violation, apparently did not see sign – Example, did not see yield sign.

Other sign violation, intentional disregard – Purposefully disregard sign.

Other sign violation – Any other sign violation that is not accounted for by the other sign violation categories.

Non-signed crossing violation – Example, driveway entering road.

Right-of-way error, recognition failure – Subject inadvertently did not recognize the right of way.

Right-of-way error, decision failure – Subject misjudged the situation. Example, subject turns into traffic and misjudges the gap.

Right-of-way error, unknown cause – Subject did not recognize who had right of way, caused by an unknown factor.

IMPROPER BRAKING

Sudden or improper braking on roadway - The subject brakes suddenly or in an in an improper manner that could put the subject or other vehicles at risk (late braking, hard braking).

Sudden or improper stopping on roadway - The subject stops suddenly or in an improper manner that could put the subject or other vehicles at risk (hard or late braking when coming to a stop, or stopping on roadway putting self and others at risk).

IMPROPER PARKING

Parking in improper or dangerous location – Parking in an undesignated area put self and others at risk. Example, parking on shoulder of interstate.

FAILURE TO SIGNAL

Failure to signal with other violations or unsafe actions – Examples, failing to signal during a lane change that was illegally executed in the middle of an intersection.

Failure to signal, without other violations or unsafe actions – Examples, changing lanes without signaling or turning without signaling.

AVOIDING OBJECT
Avoiding pedestrian – Inappropriate maneuver made to avoid pedestrian, Example, braking or swerving into oncoming traffic.

Avoiding other vehicle – Inappropriate maneuver made to avoid hitting another vehicle. Example, braking or swerving into traffic or onto a sidewalk where pedestrians are present.

Avoiding animal – Inappropriate maneuver made to avoid hitting an animal. Example, braking or swerving into oncoming traffic.

APPARENT UNFAMILIARITY
Apparent unfamiliarity with roadway – Driver's behavior is consistent with being lost in a particular location. Examples, performing repeated U-turns, reading maps/papers, etc.

Apparent unfamiliarity with vehicle – Driver's behavior demonstrates lack of knowledge of vehicle controls. Examples, turning on wipers instead of turn signal, etc.

Apparent general inexperience driving Driver's behaviors demonstrate general inexperience driving. Examples include, Hyper-focused driving, overly cautious maneuvers, etc.

DRIVER IMPAIRMENT
The driver's behavior, judgment or driving ability is altered or hindered. Includes drowsiness, distraction, use of drugs or alcohol, illness, lack of or incorrect use of medication, or disability. See Dingus et al. (2006) for a complete description.

WILLFUL BEHAVIOR
The driver knowingly and purposefully drives in an unsafe or inappropriate manner, includes aggressive driving, purposeful violation of traffic laws, and use of vehicle for improper purposes (i.e. intimidation).

APPENDIX C: DATA REDUCTION VARIABLES

1. Vehicle Number

Comment: Each vehicle will be assigned a vehicle number. Information will originate in the raw data stream.

FORMAT: Integer value.

2. Epoch Number

The Epoch file number is arranged by vehicle identification number, date and time. The first three numbers represent the vehicle identification number, the next two numbers represent the year (Ex. 03 for 2003), the next two numbers represents the month (Ex. 03 for March), the next two numbers represent the day of the month, the next four numbers represent the time in military time. The last six numbers are the epoch ID

002 03 02 28 1209 000000

Comment: Each valid driving performance trigger will be assigned to an epoch. An epoch will consist of 1 minute of video prior and 30 s of video after the initial onset of a trigger. If a second trigger occurs within this 1.5 minute segment, the epoch will extend to include a full one minute prior to the onset of the initial trigger and 30 s after the onset of the last trigger.

3. Event Severity – A general term referring to all valid triggered occurrences of an incident, near-crash, or crash that begins at the precipitating event and ends when the evasive maneuver has been completed.

- Invalid trigger – Any instance where a trigger appears but no safety-relevant event is present.
  - Non-subject conflict - Any safety-relevant event captured on video (incident, near-crash, or crash) that does not involve the driver.
- Non-conflict - Any event that increases the level of risk associated with driving, but does not result in a crash, near-crash, or incident, as defined below. Examples include: driver control error without proximal hazards being present; driver judgment error such as unsafe tailgating or excessive speed; or cases in which drivers are visually distracted to an unsafe level.
- Proximity Event - Any circumstance resulting in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver(s), pedestrians, cyclists or animals, there is no avoidance maneuver or response. Extraordinarily close proximity is defined as a clear case where the absence of an avoidance maneuver or response is inappropriate for the driving circumstances (including speed, sight distance, etc.).

- Crash-Relevant - Any circumstance that requires a crash avoidance response on the part of the subject vehicle. Any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive maneuver (as defined above), but greater in severity than a "normal maneuver" to avoid a crash. A crash avoidance response can include braking, steering, accelerating, or any combination of control inputs. A "normal maneuver" for the subject vehicle is defined as a control input that falls inside of the 99% confidence limit for control input as measured for the same subject.

- Near-crash - Any circumstance that requires a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. A rapid, evasive maneuver is defined as a steering, braking, accelerating, or any combination of control inputs that approaches the limits of the vehicle capabilities. As a guide: subject vehicle braking greater than 0.5 g, or steering input that results in a lateral acceleration greater than 0.4 g to avoid a crash, constitutes a rapid maneuver.

- Crash - Any contact with an object, either moving or fixed, at any speed, in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, objects on or off the roadway, pedestrians, cyclists or animals.

Comment: Initial coding step. Invalid events result in no further coding. Non-subject and non-conflicts will only result in a brief narrative written, but no other coding. Other coding choices will determine which specific subset of variables that will be coded. Specified at early onset of data reduction software.

4. Trigger Type (C-N-I)

The triggers were specific data signatures that were specified during the sensitivity analysis performed after 10% of the data were collected. The specific data signatures that were used to identify valid events are as follows:

- Lateral acceleration - Lateral motion equal or greater than 0.7 g.
- Longitudinal acceleration - Acceleration or deceleration equal or greater than 0.6 g.
- CI button – Activated by the driver upon pressing a button located on the dashboard when an incident occurred that he/she deemed critical.

- Forward Time To Collision (FTTC) - Acceleration or deceleration equal to or greater than 0.5 g coupled with a forward TTC of 4 s or less.
- All longitudinal decelerations between 0.4 g and 0.5 g coupled with a forward TTC value of ≤ 4 s and that the corresponding forward range value at the minimum TTC is not greater than 100 ft.
- Rear Time To Collision (RTTC) - Any rear TTC trigger value of 2 s or less that also has a corresponding rear range distance of ≤ 50 ft. AND any rear

TTC trigger value where the absolute acceleration of the following vehicle is greater than 0.3 g.

- Side object detection – Detects presence of other vehicles/objects in the adjacent lane.
- Lane change cut-off – Identifies situations in which the subject vehicle cuts in too close either behind or in front of another vehicle by using closing speed and forward TTC.
- Yaw rate – Any value greater than or equal to a plus AND minus 4 deg change in heading (i.e., vehicle must return to the same general direction of travel) within a 3 s window of time.

5. Driver Subject Number (C-N-I-B)

All primary drivers' subject number will be a 3 digit number followed by the letter "A." Any secondary drivers should be given the same 3 digit number followed by the letters "B', "C', and so on.

6. Onset of Precipitating Factor

Using video frame numbers, the reductionists will determine the onset of the precipitating event (i.e., onset of lead vehicle brake lights for a lead vehicle conflict).

7. Resolution of the Event

Using video frame numbers, the reductionists will determine when the evasive maneuver (or lack thereof) has been executed and the level of danger has returned to normal.

Event Variables

1. Event Nature (C-N-I)

This variable specified the type of crash, near-crash, or incident that occurred. The reductionists chose from the following variables that were modified from GES variables "Manner of Collision' and "Most Harmful Event."

1=Conflict with a lead vehicle
2=Conflict with a following vehicle
3=Conflict with an oncoming traffic
4=Conflict with a vehicle in adjacent lane
5=Conflict with a merging vehicle
6=Conflict with a vehicle turning across subject vehicle path (same Direction)
7=Conflict with a vehicle turning across subject vehicle path (opposite direction)
8=Conflict with a vehicle turning into subject vehicle path (same direction)
9=Conflict with a vehicle turning into subject vehicle path (opposite direction)
10 =Conflict with a vehicle moving across subject vehicle path (through intersection)
11=Conflict with a parked vehicle
12=Conflict with a pedestrian
13=Conflict with a pedal cyclist
14=Conflict with an animal

15=Conflict with an obstacle/object in roadway
16=Single vehicle conflict
17=Other
18=No known conflict (for RF sensor trigger)
99=Unknown conflict

2. Incident Type (Coded for Crashes and Near-Crashes only)

1 = Rear-end, striking
2 = Rear-end, struck
3 = Road departure (left or right)
4 = Road departure (end)
5 = Sideswipe, same direction (left or right)
6 = Opposite direction (head-on or sideswipe)
7 = Violation of stop sign or signal at intersection
8 = Straight crossing path, not involving sign/signal violation
9 = Turn across path
10 = Turn into path (same direction)
11 = Turn into path (opposite direction)
12 = Backing, fixed object
13 = Backing into traffic
14 = Pedestrian
15 = Pedalcyclist
16 = Animal
17 = Other (specify)
99 = Unknown

3. Pre-Event Maneuver (GES Variable Vehicle 1 Maneuver Prior to Event)
This represents the last action that the subject vehicle driver engaged in just prior to the point that the driver realized impending danger. Note that the variables in italics are those GES variables that were expanded.

1a = Going straight, constant speed
1b = Going straight ahead, accelerating
1c = Going straight, but with unintentional "drifting" within lane or across lanes
2 = Decelerating in traffic lane
3 = Accelerating in traffic lane
4 = Starting in traffic lane
5 = Stopped in traffic lane
6 = Passing or overtaking another vehicle
7 = Disabled or parked in travel lane
8 = Leaving a parked position
9 = Entering a parked position
10 = Turning right
11 = Turning left
12 = Making U-turn

13 = Backing up (other than for parking purposes)
14 = Negotiating a curve
15 = Changing lanes
16 = Merging
17 = Successful corrective action to previous action
18a = Maneuvering to avoid an animal
18b = Maneuvering to avoid a pedestrian/pedalcyclist
18c = Maneuvering to avoid an object
18d = Maneuvering to avoid a vehicle
97 = Other
99 = Unknown

Source/comment: GES Variable V21, Movement Prior to Critical Event. Also, very similar to VA PAR Variable 19/20.
FORMAT: Integer value as listed above.

4. Judgment of Vehicle 1 Maneuver Prior to Event
This variable provided additional information about the pre-event maneuver as to whether this maneuver was either safe or legal.

1 = Safe and legal
2 = Unsafe but legal
3 = Safe but illegal
4 = Unsafe and illegal
99 = Unknown

5. Precipitating Factor (GES Variable V26, Critical Event)
The driver behavior or state of the environment that begins the event and the subsequent sequence of actions that result in a crash, near-crash, or incident, independent of who caused the event (driver at fault). The precipitating factor occurs outside the vehicle and does not include driver distraction, fatigue, or disciplining child while driving.

A. This Vehicle Loss of Control Due to:

001 = Blow-out or flat tire
002 = Stalled engine
003 = Disabling vehicle failure (e.g., wheel fell off)
004 = Minor vehicle failure
005 = Poor road conditions (puddle, pothole, ice, etc.)
006 = Excessive speed
007 = Other or unknown reason
008 = Other cause of control loss
009 = Unknown cause of control loss

B. This Vehicle Traveling:

018a = Ahead, stopped on roadway more than 2 s
018b = Ahead, decelerated and stopped on roadway 2 s or less
021 = Ahead, traveling in same direction and decelerating
022 = Ahead, traveling in same direction with slower constant speed
010 = Over the lane line on the left side of travel lane
011 = Over the lane line on right side of travel lane
012 = Over left edge of roadway
013 = Over right edge of roadway
014 = End departure
015 = Turning left at intersection
016 = Turning right at intersection
017 = Crossing over (passing through) intersection
019 = Unknown travel direction
020a = From adjacent lane (same direction), over left lane line behind lead vehicle, rear-end crash threat
020b = From adjacent lane (same direction), over right lane line behind lead vehicle, rear-end crash threat

C. Other Vehicle in Lane:

050a = Ahead, stopped on roadway more than 2 s
050b = Ahead, decelerated and stopped on roadway 2 s or less
051 = Ahead, traveling in same direction with slower constant speed
052 = Ahead, traveling in same direction and decelerating
053 = Ahead, traveling in same direction and accelerating
054 = Traveling in opposite direction
055 = In crossover
056 = Backing
059 = Unknown travel direction of the other motor vehicle

Another Vehicle Encroaching into This Vehicle's Lane:

060a = From adjacent lane (same direction), over left lane line in front of this vehicle, rear-end crash threat
060b = From adjacent lane (same direction), over left lane line behind this vehicle, rear-end crash threat
060c = From adjacent lane (same direction), over left lane line, sideswipe threat
060d = From adjacent lane (same direction), over right lane line, sideswipe threat
060e = From adjacent lane (same direction), other
061a = From adjacent lane (same direction), over right lane line in front of this vehicle, rear-end crash threat
061b = From adjacent lane (same direction), over right lane line behind this vehicle, rear-end crash threat
061c = From adjacent lane (same direction), other
062 = From opposite direction over left lane line.

063 = From opposite direction over right lane line
064 = From parallel/diagonal parking lane
065 = Entering intersection—turning in same direction
066 = Entering intersection—straight across path
067 = Entering intersection – turning into opposite direction
068 = Entering intersection—intended path unknown
070 = From driveway, alley access, etc. – turning into same direction
071 = From driveway, alley access, etc. – straight across path
072 = From driveway, alley access, etc. – turning into opposite direction
073 = From driveway, alley access, etc. – intended path unknown
074 = From entrance to limited access highway
078 = Encroaching details unknown

E. Pedestrian, Pedalcyclist, or other Non-Motorist:

080 = Pedestrian in roadway
081 = Pedestrian approaching roadway
082 = Pedestrian in unknown location
083 = Pedalcyclist/other non-motorist in roadway
084 = Pedalcyclist/other non-motorist approaching roadway
085 = Pedalcyclist/or other non-motorist unknown location
086 = Pedestrian/pedalcyclist/other non-motorist—unknown location

F. Object or Animal:

087 = Animal in roadway
088 = Animal approaching roadway
089 = Animal unknown location
090 = Object in roadway
091 = Object approaching roadway
092 = Object unknown location
099 = Unknown critical event

6. Evasive Maneuver (GES Variable V27 Corrective Action Attempted)
The subject vehicle driver's reaction to the precipitating factor.

0 = No driver present
1 = No avoidance maneuver
2 = Braking (no lockup)
3 = Braking (lockup)
4 = Braking (lockup unknown)
5 = Releasing brakes
6 = Steered to left
7 = Steered to right
8 = Braked and steered to left
9 = Braked and steered to right

10 = Accelerated
11 = Accelerated and steered to left
12 = Accelerated and steered to right
98 = Other actions
99 = Unknown if driver attempted any corrective action

7. Vehicle Control After Corrective Action (GES Variable V28—Coded only for Near-crashes and crashes):

0 = No driver present
1 = Vehicle control maintained after corrective action
2 = Vehicle rotated (yawed) clockwise
3 = Vehicle rotated (yawed) counter-clockwise
4 = Vehicle slid/skid longitudinally – no rotation
5 = Vehicle slid/skid laterally – no rotation
9 = Vehicle rotated (yawed) unknown direction
20 = Combination of 2-9
94 = More than two vehicles involved
98 = Other or unknown type of vehicle control was lost after corrective action
99 = Unknown if vehicle control was lost after corrective action.

Contributing Factors

1. Driver Behavior: Driver 1 Actions/Factors Relating to the Event (VA PAR Variable 17/18)

This variable provides a descriptive label to the driver's actions that may or may not have contributed to the event.

0 = None
1 = Exceeded speed limit
2= Inattentive or distracted
3 = Exceeded safe speed but not speed limit
4 = Driving slowly: below speed limit
5 = Driving slowly in relation to other traffic: not below speed limit
6 = Illegal passing (i.e., across double line)
7 = Passing on right
8 = Other improper or unsafe passing
9 = Cutting in, too close in front of other vehicle
10 = Cutting in, too close behind other vehicle
11 = Making turn from wrong lane (e.g., across lanes)
12 = Did not see other vehicle during lane change or merge
13 = Driving in other vehicle's blind zone
14 = Aggressive driving, specific, directed menacing actions
15 = Aggressive driving, other, i.e., reckless driving without directed menacing actions
16 = Wrong side of road, not overtaking

17 = Following too close
18 = Failed to signal, or improper signal
19 = Improper turn - wide right turn
20 = Improper turn - cut corner on left turn
21 = Other improper turning
22 = Improper backing, did not see
23 = Improper backing, other
24 = Improper start from parked position
25 = Disregarded officer or watchman
26 = Signal violation, apparently did not see signal
27 = Signal violation, intentionally ran red light
28 = Signal violation, tried to beat signal change
29 = Stop sign violation, apparently did not see stop sign
30 = Stop sign violation, intentionally ran stop sign at speed
31 = Stop sign violation, "rolling stop"
32 = Other sign (e.g., Yield) violation, apparently did not see sign
33 = Other sign (e.g., Yield) violation, intentionally disregarded
34 = Other sign violation
35 = Non-signed crossing violation (e.g., driveway entering roadway)
36 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
37 = Right-of-way error in relation to other vehicle or person, apparent decision failure (i.e., did see other vehicle prior to action but misjudged gap)
38 = Right-of-way error in relation to other vehicle or person, other or unknown cause
39 = Sudden or improper stopping on roadway
40 = Parking in improper or dangerous location, e.g., shoulder of Interstate
41 = Failure to signal with other violations or unsafe actions
42 = Failure to signal, without other violations or unsafe actions
43 = Speeding or other unsafe actions in work zone
44 = Failure to dim headlights
45 = Driving without lights or insufficient lights
46 = Avoiding pedestrian
47 = Avoiding other vehicle
48 = Avoiding animal
49 = Apparent unfamiliarity with roadway
50 = Apparent unfamiliarity with vehicle, e.g., displays and controls
51 = Apparent general inexperience driving
52 = Use of cruise control contributed to late braking
53 = Other, specify

2. Driver 1 Physical/Mental Impairment (GES Variable D3: Driver Physical/Mental Condition)

0 = None apparent
1 = Drowsy, sleepy, asleep, fatigued

2 = Ill, blackout
3a = Angry
3b = Other emotional state
4a = Drugs-medication
4b = Drugs-Alcohol
5 = Other drugs (marijuana, cocaine, etc.)
6 = Restricted to wheelchair
7 = Impaired due to previous injury
8 = Deaf
50 = Hit and run vehicle
97 = Physical/mental impairment – no details
98 = Other physical/mental impairment
99 = Unknown physical/mental condition

Source: GES D3, Driver Physical/Mental Condition. Element 3 expanded to separate anger from other emotions. Element 50 not applicable.
Coded in General State Variables: Driver's General State, Causal/Contributing Factors, & Precipitating Event.
FORMAT: 16-bit encoded value(s) as listed above.

3. Driver 1 Distracted By (GES Variable D7: Driver Distracted By)

This variable was recorded if the reductionists observed the drivers engaging in any of the following secondary tasks 5-10 s prior to the onset of the precipitating factor. For a complete definition of these tasks, see Appendix D.

00 = Not Distracted

15 = Cognitive distraction
97 = Lost in thought
01 = Looked but did not see
15a = Reading
15b = Talking/singing without obvious passenger
15c = Dancing to the radio
15d = Reading

03 = Passenger in vehicle
3a = Passenger in adjacent seat
3b = Passenger in rear seat
3c = Child in adjacent seat
3d = Child in rear seat

= Object/Animal/Insect in Vehicle
4a = *Moving object in vehicle (i.e. object fell off seat when driver stopped hard at a traffic light)*
4b = Insect in vehicle
4c = Pet in vehicle

4d = Object dropped by driver
4e = Reaching for object in vehicle (not cell phone)

5 = Cell phone operations
05a = Talking/listening
06a = Dialing hand-held cell phone
06b = Dialing hand-held cell phone using quick keys
06c = Dialing hands-free cell phone using voice activated software
06d = Locating/reaching/answering cell phone

17 = PDA operations
15a = Locating/reaching PDA
15b = Operating PDA
15c = Viewing PDA

16 = In-vehicle system operations
7 = Adjusting climate control
8a = Adjusting the radio
8b = Inserting/retrieving cassette
8c = Inserting/retrieving CD
9 = Adjusting other devices integral to vehicle (unknown which device)
9a = Adjusting other known in-vehicle devices (text box to specify)

12 = External Distraction
12a = Looking at previous crash or highway incident
12b = Pedestrian located outside the vehicle
12c = Animal located outside the vehicle
12d = Object located outside the vehicle
12e = Construction zone

= Dining
13a = Eating with a utensil
13b = Eating without a utensil
13c = Drinking from a covered container (i.e. straw)
13d = Drinking from an uncovered container

= Smoking
14a = Reaching for cigar/cigarette
14b = Lighting cigar/cigarette
14c = Smoking cigar/cigarette
14d = Extinguishing cigar/cigarette

18. Personal Hygiene
18a = Combing/brushing/fixing hair
18b = Applying make-up
18c = Shaving

18d = Brushing/flossing teeth
18e = Biting nails/cuticles
18f = Removing/adjusting jewelry
18g = Removing/inserting contact lenses
18h = Other

19. Inattention to the Forward Roadway
19a = Left window
19b = Left rear-view mirror
19c = Center rear-view mirror
19d = Right rear-view mirror
19e = Right passenger window

3a. Time Distraction Began
Reductionists entered the video frame number corresponding to the time at which the driver became distracted or began to engage in the distracting task.

3b. Time Distraction Ended
Reductionists entered the video frame number corresponding to the time at which the driver disengaged from the distracting task or the driver's attention returned to the forward roadway.

3c. Outcome (of Incident) Impacted
Reductionists also marked whether they believed that the secondary task that was present at the onset of the precipitating factor impacted the severity or the outcome of the event. Note that all distraction analyses conducted in this report only used those secondary tasks that were marked "yes" or "not able to determine."

1 = Yes
2 = No
3 = Not able to determine
99 = Unknown

4. Willful Behavior
Reductionists marked this variable when they believed that the driver was aware or cognizant of their poor behavior. There were 3 options, written in sequential order of increasingly willful or aggressive behavior.

1 = Aggressive driving
2 = Purposeful violation of traffic laws
3 = Use of vehicle for improper purposes (Intimidation/weapon)
99 = Unknown

Source/comment: This variable came from the Light/Heavy Vehicle Interaction Study Taxonomy.

5. Driver Proficiency
Reductionists marked this variable when it was believed that the driver was generally unaware of their poor driving behavior. There are 4 options, written in order of decreasing levels of proficiency (the last is the most drastic measure of poor driving proficiency).

1 = Violation of traffic laws
2 = Driving techniques (incompetent to safely perform driving maneuver)
3 = Vehicle kinematics (incompetent handling the vehicle)
4 = Driver capabilities (incompetent on what maneuvers are safe and appropriate)

Source/comment: This variable came from the Light/Heavy Vehicle Interaction Study Taxonomy.

6. Driver 1 Drowsiness Rating (Coded for Crashes and Near-Crashes only)
An observer rating of drowsiness will be assigned for the 30 s prior to the event based on review of driver videos. For drowsiness levels above a criterion level of and ORD of 60 or above, a manual calculation of PERCLOS will be measured by the analyst. This variable will be coded for all crashes and near-crashes (Wierwille & Ellsworth, 1994).

7. Driver 1 Vision Obscured by (GES Variable D4: Vision Obscured by)
Reductionists will ascertain to the best of their ability whether the driver's vision was obscured by any of the following:

0 = No obstruction
1 = Rain, snow, fog, smoke, sand, dust
2a = Reflected glare
2b = Sunlight
2c = Headlights
3 = Curve or hill
4 = Building, billboard, or other design features (includes signs, embankment)
5 = Trees, crops, vegetation
6 = Moving vehicle (including load)
7 = Parked vehicle
8 = Splash or spray of passing vehicle [any other vehicle]
9 = Inadequate defrost or defog system
10 = Inadequate lighting system
11 = Obstruction interior to vehicle
12 = Mirrors
13 = Head restraints
14 = Broken or improperly cleaned windshield
15 = Fog
50 = Hit & run vehicle
95 = No driver present

96 = Not reported
97 = Vision obscured – no details
98 = Other obstruction
99 = Unknown whether vision was obstructed

8. Vehicle Contributing Factors (GES Variable V12, Vehicle contributing factors)
Reductionists will determine if any of the following contributed to the severity or the presence of an event.

0 = None
1 = Tires
2 = Brake system
3 = Steering system
4 = Suspension
5 = Power train
6 = Exhaust system
7 = Headlights
8 = Signal lights
9 = Other lights
10 = Wipers
11 = Wheels
12 = Mirrors
13 = Driver seating and controls
14 = Body, doors
15 = Trailer hitch
50 = Hit and run vehicle
97 = Vehicle contributing factors, no details
98 = Other vehicle contributing factors
99 = Unknown if vehicle had contributing factors

Environmental Factors: Driving Environment

1. Weather (GES Variable A20I, Atmospheric condition and VA PAR Variable 4)
Reductionists will determine the type of weather using the video and record as part of the data reduction process.

1 = Clear
2 = Cloudy
3 = Fog
4 = Mist
5 = Raining
6 = Snowing
7 = Sleeting
8 = Smoke dust
9 = Other
99 = Unknown

2. Light (GES Variable A19I, Light Condition and VA PAR Variable 7)
Reductionists will determine the type of ambient light conditions are present using the video and record as part of the data reduction process.

1 = Dawn
2 = Daylight
3 = Dusk
4 = Darkness, lighted
5 = Darkness, not lighted
99 = Unknown

3. Windshield Wiper Activation
Analysts will determine the windshield wiper activation through video reduction.

0 = Off
1 = On
99 = Unknown

4. Surface Condition (VA PAR Variable 5)
Reductionists will determine the type of surface condition at the onset of the precipitating factor and record as part of the data reduction process.

1 = Dry
2 = Wet
3 = Snowy
4 = Icy
5 = Muddy
6 = Oily
7 = Other
99 = Unknown

5. Traffic Density (Level of Service)
Reductionists will determine the level of traffic density at the time of the precipitating factor and record as part of the data reduction process.

1 = LOS A: free flow
2 = LOS B: Flow with some restrictions
3 = LOS C: Stable flow, maneuverability and speed are more restricted
4 = LOS D: Unstable flow – temporary restrictions substantially slow driver
5 = LOS E: Flow is unstable, vehicles are unable to pass, temporary stoppages, etc.
6 = LOS F: Forced traffic flow condition with low speeds and traffic volumes that are below capacity. Queues forming in particular locations.
99 = Unknown

Driving Environment: Infrastructure
1. Kind of Locality (VA PAR Variable 8)
Reductionists will determine the kind of locality at the onset of the precipitating factor and record as part of the data reduction process.

1 = School
2 = Church
3 = Playground
4 = Open Country
5 = Business/industrial
6 = Residential
7 = Interstate
8 = Other
9= *Construction Zone (Added)*
99 = Unknown

2. Relation to Junction (GES Variable A9)
Reductionists will determine the whether the precipitating factor occurred near a roadway junction and record as part of the data reduction process.

Non-Interchange Area
00 = Non-Junction
01 = Intersection
02 = Intersection-related
03 = Driveway, alley access, etc.
04 = Entrance/exit ramp
05 = Rail grade crossing
06 = On a bridge
07 = Crossover related
08 = Other, non-interchange area
09 = Unknown, non-interchange
20 = Parking lot [Added]

FORMAT: Integer value as listed above**.**

Interchange Area
10 = Non-Junction
11 = Intersection
12 = Intersection-related
13 = Driveway, alley access, etc.
14 = Entrance/exit ramp
16 = On a bridge
17 = Crossover related
18 = Other location in interchange area
19 = Unknown, interchange area
99 = Unknown if interchange

3. Trafficway Flow (GES Variable A11)
Reductionists will determine the whether the roadway was divided at the time of the precipitating factor and record as part of the data reduction process.

1 = Not divided
2 = Divided (median strip or barrier)
3 = One-way traffic
99 = Unknown

4. Number of Travel Lanes (GES Variable A12)
Reductionists will determine the number of travel lanes at the time of the precipitating factor and record as part of the data reduction process.

1 = 1
2 = 2
3a = 3 lanes in direction of travel (divided or one-way trafficway)
3b = Undivided highway, 3 lanes total, 2 in direction of travel
3c = Undivided highway, 3 lanes total, 1 in direction of travel
4 = 4
5 = 5
6 = 6
7 = 7+
99 = Unknown

5. Traffic Control (VA PAR Variable 1)
Reductionists will determine whether there was a traffic control device present and record as part of the data reduction process.

1 = No traffic control
2 = Officer or watchman
3 = Traffic signal
4 = Stop sign
5 = Slow or warning sign
6 = Traffic lanes marked
7 = No passing signs
8 = Yield sign
9 = One way road or street
10 = Railroad crossing with markings or signs
11 = Railroad crossing with signals
12 = Railroad crossing with gate and signals
13 = Other
99 = Unknown

Source: VA PAR Variable 1.
Coded in General State Variables: Road/Traffic Variables.

FORMAT: Integer value as listed above.

6. Alignment (VA PAR Variable 3)
Reductionists will determine whether there what the road alignment was at the onset of the precipitating factor and record as part of the data reduction process.

1 = Straight level
2 = Curve level
3 = Grade straight
4 = Grade curve
5 = Hillcrest straight
6 = Hillcrest curve
7 = Dip straight
8 = Up curve [need definition]
9 = Other
99 = Unknown

Driver State Variables
1. Driver 1 Hands on Wheel (C-N-I-B)
Reductionists will the number of hands the driver had on the steering wheel at the time of the precipitating factor and record as part of the data reduction process.

0 = None
1 = Left hand only
2 = Both hands
3 = Right hand only
99 = Unknown

2. Occupant Safety Belt Usage (C)
Reductionists will determine whether the driver had a seatbelt fastened at the time of the precipitating factor and record as part of the data reduction process.

1 = Lap/shoulder belt
2 = Lap belt only
3 = Shoulder belt only
5 = None used
99 = Unknown if used.

3. Driver 1 Alcohol Use (GES Variable V92)
Reductionists will determine whether drivers were using alcohol or under the influence of alcohol at the time of the precipitating factor and record as part of the data reduction process.

1a = Use observed in vehicle without overt effects on driving
1b = Use observed in vehicle with overt effects on driving
1c = Use not observed but reported by police

1d = Use not observed or reported, but suspected based on driver behavior.
2 = None known
99 = Unknown

4. Fault Assignment
1 = Driver 1 (subject vehicle)
2 = Driver 2
3 = Driver 3
4 = Driver 4
5 = Driver 5
6 = Driver 6
7 = Driver 7
8 = Driver 8
9 = Driver 9
10 = Driver 10
11 = Other (textbox)
99 = Unknown

5. Average PERCLOS (Percentage Eyes Closed) (C, N)
For crashes and near-crashes where the driver's observer rating of drowsiness is above a criterion level an ORD of 60, the average PERCLOS value for the 30 s pre-event period will be obtained through video reduction.

6. Driver 1 Eye Glance Reconstruction (C-N)
Eye glances for the previous 30 s will be classified using the following categories and described as a timed, narrative sequence of the following numbers:
1 = Center forward
2 = Left forward
3 = Right forward
4 = Left mirror
5 = Right mirror
6 = Left window
7 = Right window
8 = Instrument panel
9 = Passenger
10 = Object
11 = Cell Phone
12 = Other

Comment: The analysis will include a recording of time the driver's eyes were not "on the road," i.e., straight ahead, forward right, or forward left. When possible, eye glances will be characterized in greater detail than the general directions and areas listed above, e.g., when known, the specific object of regard will be noted in the narrative. For the instrument panel, for example, specific components such as the radio/CD will be noted in the narrative. When applicable and possible, the eye glance reconstruction will also include an assessment of driver reaction time to a stimulus, e.g., braking reaction time following a potential crash-precipitating event.

Driver/Vehicle 2

1. Number of other Vehicle/Person (s)
Reductionists will identify the number of vehicles in the immediate environment and then record the following variables.

2. Location of other Vehicle/Persons
Reductionists will identify the location of vehicles in the immediate environment with respect to the subject vehicle and then record the following variables.

A = In front of subject vehicle
B = In front and to the immediate right of the subject vehicle
C = On the right side of the subject vehicle, closer to front seat of the vehicle.
D = On the right side of the subject vehicle, closer to rear seat of the vehicle.
E = Behind and to the immediate right of the subject vehicle.
F = Behind the subject vehicle
G = Behind and to the immediate left of the subject vehicle.
H = On the left side of the subject vehicle, closer to the rear seat of the vehicle.
I = On the left side of the subject vehicle, closer to the front seat of the vehicle.
J = In front and to the immediate left of the subject vehicle.

3. Vehicle/Person 2 Type (Modified version of GES Variable V5, Body Type)
Data reductionists will record what type of vehicles that are in the subject vehicle's immediate surroundings.

1 = Automobile
14 = Sport Utility vehicles
20 = Van-based truck (minivan or standard van)
30 = Pickup truck
50 = School Bus
58a = Transit bus
58b = Greyhound bus
58c = Conversion bus
64a = Single-unit straight truck: Multistop/Step Van
64b = Single-unit straight truck: Box
64c = Single-unit straight truck: Dump
64d = Single-unit straight truck: Garbage/Recycling
64e = Single-unit straight truck: Concrete Mixer
64f = Single-unit straight truck: Beverage
64g =Single-unit straight truck:Flatbed
64h =Single-unit straight truck:Tow truck
64i = Single-unit straight truck: Other
64j = Single-unit straight truck: Unknown

64k = Straight Truck + Trailer
66 = Tractor only
66a = Tractor-trailer: Enclosed box
66b = Tractor-trailer: Flatbed
66c = Tractor-trailer: Tank
66d = Tractor-trailer: Car carrier
66e = Tractor-trailer: Livestock
66f = Tractor-trailer: Lowboy trailer
66g = Tractor-trailer: Dump trailer
66h = Tractor-trailer: Multiplel trailers/Enclosed box
66i = Tractor-trailer: Multiple trailers/grain
66e = Tractor-trailer: Other
93 = Other Large Construction Equipment
8 = Motorcycle or moped
9a = Ambulance
9b = Fire truck
9c = Police
10 = Other vehicle type
11 = Pedestrian
12 = Cyclist
13 = Animal
99 = Unknown vehicle type

4. Vehicle 2 Maneuver (GES Variable V21, Movement Prior to Critical Event)
Reductionists will record what the other vehicle's actions were just prior to the onset of the precipitating factor.

1 = Going straight ahead
2 = Making right turn
3 = Making left turn
4 = Making U-turn
5 = Slowing or stopping
6 = Starting in traffic lane
7 = Starting from parked position
8 = Stopped in traffic lane]
9 = Ran off road right
10 = Ran off road left
11 = Parked
12 = Backing
13 = Passing
14 = Changing lanes
15 = Other
16 = Accelerating in traffic lane
17 = Entering a parked position
18 = Negotiating a curve
19 = Merging

99 = Unknown

5. Driver/Vehicle 2 Corrective Action Attempted (GES V27, Corrective Action Attempted)
Reductionists will record the corrective action attempted for each vehicle immediately surrounding the subject vehicle.

0 = No driver present
1 = No avoidance maneuver
2 = Braking (no lockup)
3 = Braking (lockup)
4 = Braking (lockup unknown)
5 = Releasing brakes
6 = Steered to left
7 = Steered to right
8 = Braked and steered to left
9 = Braked and steered to right
10 = Accelerated
11 = Accelerated and steered to left
12 = Accelerated and steered to right
98 = Other actions
99 = Unknown if driver attempted any corrective action

Coded: From PAR and/or video.
Source: GES V27, Corrective Action Attempted.
Coded in General State Variables: Driver/Vehicle 2.
FORMAT: Integer value as listed above.

6. Driver/Vehicle 2 Physical/Mental Impairment (GES D3, Driver Physical/Mental Condition)
Reductionists will mark only for those crashes that a police accident report form is collected from the subject.

0 = None apparent
1 = Drowsy, sleepy, asleep, fatigued
2 = Ill, blackout
3a = Angry
3b = Other emotional state
4 = Drugs-medication
5 = Other drugs (marijuana, cocaine, etc.)
6 = Restricted to wheelchair
7 = Impaired due to previous injury
8 = Deaf
50 = Hit and run vehicle
97 = Physical/mental impairment – no details
98 = Other physical/mental impairment
99 = Unknown physical/mental condition

7. Driver 2 Actions/Factors Relating to Crash/Incident (VA PAR Variable 17/18)
Reductionists will code this for crashes and near-crashes only for each vehicle immediately surrounding the subject vehicle.

0 = None
1 = Exceeded speed limit
2 = Inattentive or distracted (coded in previous variable)
3 = Exceeded safe speed but not speed limit
4 = Driving slowly: below speed limit
5 = Driving slowly in relation to other traffic: not below speed limit
6 = Illegal passing (i.e., across double line)
7 = Passing on right
8 = Other improper or unsafe passing
9 = Cutting in, too close in front of other vehicle
10 = Cutting in, too close behind other vehicle
11 = Making turn from wrong lane (e.g., across lanes)
12 = Did not see other vehicle during lane change or merge
13 = Driving in other vehicle's blind zone
14 = Aggressive driving, specific, directed menacing actions
15 = Aggressive driving, other, i.e., reckless driving without directed menacing actions
16 = Wrong side of road, not overtaking
17 = Following too close
18 = Failed to signal, or improper signal
19 = Improper turn: wide right turn
20 = Improper turn: cut corner on left turn
21 = Other improper turning
22 = Improper backing, did not see
23 = Improper backing, other
24 = Improper start from parked position
25 = Disregarded officer or watchman
26 = Signal violation, apparently did not see signal
27 = Signal violation, intentionally ran red light
28 = Signal violation, tried to beat signal change
29 = Stop sign violation, apparently did not see stop sign
30 = Stop sign violation, intentionally ran stop sign at speed
31 = Stop sign violation, "rolling stop"
32 = Other sign (e.g., Yield) violation, apparently did not see sign
33 = Other sign (e.g., Yield) violation, intentionally disregarded
34 = Other sign violation
35 = Non-signed crossing violation (e.g., driveway entering roadway)
36 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
37 = Right-of-way error in relation to other vehicle or person, apparent decision failure (i.e., did see other vehicle prior to action but

misjudged gap)

38 = Right-of-way error in relation to other vehicle or person, other or unknown cause
39 = Sudden or improper stopping on roadway
40 = Parking in improper or dangerous location, e.g., shoulder of Interstate
41 = Failure to signal with other violations or unsafe actions
42 = Failure to signal, without other violations or unsafe actions
43 = Speeding or other unsafe actions in work zone
44 = Failure to dim headlights
45 = Driving without lights or insufficient lights
46 = Avoiding pedestrian
47 = Avoiding other vehicle
48 = Avoiding animal
49 = Apparent unfamiliarity with roadway
50 = Apparent unfamiliarity with vehicle, e.g., displays and controls
51 = Apparent general inexperience driving
52 = Use of cruise control contributed to late braking
53 = Other, specify

APPENDIX D: TUKEY TEST MATRICES

Table 45. Post Hoc Tukey Test Results for the Frequency Counts per MVMT for Each Range of Lateral Acceleration. T-Values Are on Top of the Probability Values.

	0.3-0.39	**0.40-0.49**	**0.50-0.59**	**0.60-0.69**	**0-70-0.79**	**0-80-0.89**	**0-90-0.99**
0.3-0.39	**--**	**22.83 <0.001**	**29.14 <0.001**	**30.18 <0.001**	**30.34 <0.001**	**30.37 <0.001**	**30.39 <0.001**
0.40-0.49		**--**	**6.31 <0.001**	**7.35 <0.001**	**7.51 <0.001**	**7.54 <0.001**	**7.56 <0.001**
0.50-0.59			--	**N/S** 0.95	N/S 0.89	N/S 0.88	N/S 0.88
0.60-0.69				--	N/S 1.00	N/S 1.00	N/S 1.00
0-70-0.79					--	N/S 1.00	N/S 1.00
0-80-0.89						--	N/S 1.00
0-90-0.99							--

Table 46. Post Hoc Tukey Test Results for Longitudinal Acceleration

		0.30-0.39	**0.40-0.49**	**0.50-0.59**	**0.60-0.69**	**0.70-0.79**	**0.80-0.89**	**0-90-0.99**
Safe Drivers	**0.30-0.39**	--	5.41 <0.0001	6.45 <0.0001	6.77 <0.0001	6.81 <0.0001	6.81 <0.0001	6.81 <0.0001
Moderately Safe Drivers	**0.30-0.39**	--	5.41 <0.0001	5.82 <0.0001	5.86 <0.0001	5.87 <0.0001	5.88 <0.0001	5.88 <0.0001
Unsafe Drivers	**0.30-0.39**	--	10.74 <0.0001	12.85 <0.0001	13.42 <0.0001	13.52 <0.0001	13.57 <0.0001	13.60 <0.0001

Table 47. Post Hoc Tukey Test Results and Probability Values for Frequency of Occurrence per MVMT of Peak Longitudinal Decelerations

	0.3-0.39	**0.40-0.49**	**0.50-0.59**	**0.60-0.69**	**0-70-0.79**	**0-80-0.89**	**0-90-0.99**
0.3-0.39	--	**15.32** <0.0001	**18.10** <0.0001	**18.70** <0.0001	**18.84** <0.0001	**18.92** <0.0001	**18.95** <0.0001
0.40-0.49		--	**2.78** 0.08	**3.39** 0.01	**3.53** 0.008	**3.61** 0.006	**3.64** 0.006
0.50-0.59			--	N/S 1.0	N/S 1.0	N/S 1.0	N/S 1.0
0.60-0.69				--	N/S 1.0	N/S 1.0	N/S 1.0
0-70-0.79					--	N/S 1.0	N/S 1.0
0-80-0.89						--	N/S 1.0
0-90-0.99							--

Table 48. Post Hoc Tukey Test Results for the Average Frequency Counts for the Ranges of Yaw Rates per MVMT

	0.3-0.39	**0.40-0.49**	**0.50-0.59**	**0.60-0.69**	**0-70-0.79**	**0-80-0.89**	**0-90-0.99**
0.3-0.39	--	**11.02** <0.0001	**14.64** <0.0001	**16.82** <0.0001	**18.16** <0.0001	**18.73** <0.0001	**15.19** <0.0001
0.40-0.49		--	**3.62** <0.001	**5.80** <0.0001	**7.13** <0.0001	**7.71** <0.0001	**4.16** <0.001
0.50-0.59			--	N/S 0.30	**3.52** 0.009	**4.09** 0.001	N/S 1.0
0.60-0.69				--	N/S 0.83	N/S 0.48	N/S 0.66
0-70-0.79					--	N/S 1.0	**2.97** 0.05
0-80-0.89						--	**3.54** 0.008
0-90-0.99							--

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