Motorcycle Conspicuity – What Factors Have the Greatest Impact

MIDWEST TRANSPORTATION CONSORTIUM

Final Report
June 2012

Center for Transportation Research and Education

IOWA STATE UNIVERSITY
Institute for Transportation

Sponsored by
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Midwest Transportation Consortium
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16. Abstract

The objective of this project was to determine the effect of headlight configuration (daytime running lights, high beam, modulating) and rider color (bright yellow, blue denim, and black torso and helmet) on the conspicuity of a motorcycle to a driver of a passenger vehicle in a simulated environment. To achieve this, 36 participants completed three drives on a National Advanced Driving Simulator (NADS)-2 driving simulator.

During two of the drives, participants were presented with six oncoming motorcycles and three leading parked motorcycles, each with a different combination of rider color and headlight configuration. Each of the nine motorcycles was present in either the urban or rural driving environment.

Participants indicated when each motorcycle was first visible to them by pressing a button on the steering wheel of the driving simulator. The detection distances from the motorcycles to the participant vehicles were then recorded. Participants were within one of two groups: younger drivers (25 to 55) or older drivers (65 and older).

This research applied repeated measures analysis of variance to investigate the impact of headlight configurations and rider color on motorcycle conspicuity in urban and rural environments. The researchers found that oncoming motorcycles with modulating headlights were detected at the greatest distance compared to motorcycles with high beam or daytime running lights.

Participant ability to detect an oncoming motorcycle was also significantly influenced by the combination of headlight configurations with black or bright yellow rider colors. Leading motorcycles in urban environments were detected at a greater distance compared to those in rural environments. Leading motorcycles with riders having bright yellow clothing and helmet were detected at the greatest distance, followed by motorcycles with riders having blue denim and black rider colors. A significant interaction effect among the driving environment, rider color, and age group was also found for the detection distance of leading motorcycles.

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MOTORCYCLE CONSPICUITY – WHAT FACTORS HAVE THE GREATEST IMPACT

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EXECUTIVE SUMMARY

The Iowa Motorcycle Operator Manual states that when a motorcycle and another vehicle collide, more than half of these crashes are caused by drivers entering the rider's right-of-way. Furthermore, in crashes with motorcyclists, drivers often say they never saw the motorcycle. Therefore, increasing motorcycle conspicuity could help address these issues, resulting in fewer crashes (and injuries and damage).

Background

In 2009, the Iowa Department of Transportation (DOT) awarded a contract to the Center for Transportation Research and Education (CTRE) to study motorcycle conspicuity in Iowa using crash data analysis. That project, completed as of September 2010, reviewed previous studies on motorcycle conspicuity with a focus on the effectiveness of proposed measures for enhancing motorcycle conspicuity and examined the distribution of conspicuity-related factors in light and dark conditions in two-vehicle crashes that could potentially relate to collisions between motorcycles and other vehicles.

The limitations of examining motorcycle conspicuity by analysis of crash data were also discussed. More specifically, potential conspicuity-related factors, such as rider clothing, motorcycle color, helmet color, and motorcycle type, could not be collected from the crash database.

Driving simulator studies provide a promising avenue for the desired information to be collected in investigating motorcycle conspicuity. Driving simulators provide a safe, controlled environment in which to study situations that are hazardous in the real world. In addition, simulators enable the same situation to be presented to multiple participants, as well as multiple situations to a single participant.

Objective and Scope

The objectives of this project were to determine the following:

- Impact of modulating headlight and rider clothing and helmet color on motorcycle conspicuity in both urban and rural driving environments
- Differences in driver awareness of motorcyclists by age (younger versus older drivers)
- Differences in the conspicuity of motorcycles seen from the front (oncoming motorcycles) and from the rear (leading parked motorcycles)

Research Methodology

To achieve the research objectives, 36 participants completed three drives on a National Advanced Driving Simulator (NADS)-2 driving simulator.

During two of the drives, participants were presented with six oncoming motorcycles and three leading parked motorcycles, each with a different combination of rider color and headlight configuration. Each of the nine motorcycles was present in either the urban or rural driving environment.

Participants indicated when each motorcycle was first visible to them by pressing a button on the steering wheel of the driving simulator. The detection distances from the motorcycles to the participant vehicles were recorded. Participants were within one of two groups: younger drivers (25 to 55) or older drivers (65 and older).

The recorded detection distances for the oncoming and leading parked motorcycles from the participant vehicles were then used to analyze the simulator data. Motorcycles detected at greater distances by study participants were considered more conspicuous.

This research then applied repeated measures analysis of variance to investigate the effect of headlight configurations and rider color on motorcycle conspicuity in urban and rural environments to younger and older driver (participant) groups.

For headlight configuration, the study compared daytime running lights (DRLs), high beam lamps, and modulating headlights. For rider color, the study compared bright yellow, blue denim, and black torso clothing and helmets.

The analysis was conducted separately for oncoming and leading parked motorcycles. It must be noted that the implications of the detection distances reported in this study are relative rather than absolute, given this study was conducted in a simulated environment.

Key Findings

Overall, the study results revealed that motorcycles with modulating headlights had longer detection distances than high beams or DRLs for both younger and older drivers in both urban and rural environments.

The results also indicated that motorcycle riders wearing bright yellow clothing and helmets were detected at the longest distance by both younger and older drivers in both rural and urban environments.

1. INTRODUCTION

1.1 Problem Statement

Previous studies in the US and internationally suggest that low motorcycle conspicuity, or the inability of the motorcyclist to be seen by other road users, is thought to be an important factor associated with risk of motorcycle crashes. However, there has been limited research on motorcycle conspicuity in the US in the past two decades, while, at the same time, there has been a renewed interest from states in increasing motorcycle conspicuity and motorist awareness.

The Iowa Motorcycle Operator Manual states when a motorcycle and another vehicle collide, more than half of these crashes are caused by drivers entering a rider's right-of-way. Furthermore, in crashes with motorcyclists, drivers often say they never saw the motorcycle. Increasing the conspicuity of the motorcycle would help address this issue.

1.2 Background Information

In 2009, the Iowa Department of Transportation (DOT) awarded a contract to the Center for Transportation Research and Education (CTRE) to study motorcycle conspicuity in Iowa by analysis of crash data. That project, completed as of September 2010, reviewed previous studies on motorcycle conspicuity with a focus on the effectiveness of proposed measures for enhancing motorcycle conspicuity, compared single-and two-vehicle motorcycle crashes, and examined the distribution of conspicuity-related factors in light and dark conditions in two-vehicle crashes that could potentially relate to a collision between a motorcycle and another vehicle.

The limitations of examining motorcycle conspicuity by analysis of crash data were also discussed. More specifically, potential conspicuity-related factors, such as rider clothing, color of motorcycle, helmet color, and motorcycle type, could not be collected from the crash database.

Driving simulator studies provide a promising avenue for such information to be collected in research on motorcycle conspicuity. Driving simulators provide a safe, controlled environment in which to study situations that are hazardous in the real world. In addition, simulators enable the same situation to be presented to multiple participants as well as multiple situations to a single participant.

Simulator data collection allows both between- and within-subject experimental designs and enables consistent presentation of independent variables to allow comparisons across participant groups and situations. In a nutshell, the researchers determined that the use of a driving simulator would allow modification of factors influencing motorcycle conspicuity in this study.

This study was designed to determine the effect of two factors, headlight configuration and rider color, on the conspicuity of a motorcycle to a driver of a passenger vehicle.

The rider color includes both the color of the torso and the helmet of a rider in this study. The researchers expected that brighter rider colors and a modulating headlight make a motorcycle more conspicuous to a driver. They also expected that some colors will increase the conspicuity of the motorcycle more than others and that some combinations may have a greater impact. In addition, the impact of headlight configuration and rider color factors on motorcycle conspicuity is expected to vary by driver age (younger versus older drivers).

The results of this study will help make informed recommendations to the Iowa DOT regarding motorcycle-related campaigns and interventions.

1.3 Research Objectives and Tasks

These were the principal investigation objectives of this research:

- Impact of modulating headlight/rider color on motorcycle conspicuity in both urban and rural driving environments
- Differences in driver awareness of motorcyclists by age (younger versus older drivers)
- Differences in the conspicuity of motorcycles viewed from the front (oncoming motorcycles) and from the rear (leading motorcycles)

Thirty-six participants completed a drive on a National Advanced Driving Simulator (NADS)-2 driving simulator. During the drive, they were presented with several motorcycles in their driving environment, each with a different combination of rider colors and headlight configurations. Participants indicated when each motorcycle was first visible to them by pressing a button on or near the steering wheel of the driving simulator.

The participants were presented with both oncoming and leading motorcycles during their drive in the simulator. For oncoming motorcycles, participants were presented with a combination of headlight configurations and rider colors, while there were only a set of rider colors presented for leading motorcycles.

The two primary dependent variables, detection distance and time to encounter, were calculated based on participant button presses. The detection distance and time to encounter data were analyzed to find out which rider colors and headlight configurations, both individually and in combination, made the motorcycles in the driver's environment the most conspicuous, as indicated by larger detection distance and longer time to encounter.

To achieve the study objectives, the following tasks were conducted.

Task 1: Establish a technical advisory committee (TAC) for the project

Potential technical advisory committee (TAC) members were identified in consultation with representatives from the Iowa DOT Office of Traffic and Safety and Motorcycle Task Force. A meeting of the TAC was convened within the first quarter of the project. Subsequent TAC meetings were scheduled in consultation with the project manager at the Iowa DOT as needed. TAC members included representatives from organizations such as Iowa DOT, University of Iowa Hospitals and Clinics, and community members involved in driver and motorcycle rider education.

Task 2: Development of experimental protocol and materials

The research team developed an experimental protocol for the collection of data using human subjects. Experimental materials for obtaining informed consent, experimenter scripts, and participant questionnaires were created. This task culminated with the submission of the experimental materials to the Institutional Review Board (IRB) for approval.

Task 3: Development of driving simulator scenarios

The research team consulted previously-funded work that analyzed motorcycle crash data to identify urban or rural areas with a higher risk for motorcycle crashes than others. Driving scenarios were created based on the characteristics of areas with higher risk for crashes.

Within the driving scenarios, motorcycle models were created. The models were integrated into the NADS-2 driving simulator to present combinations of motorcycle conspicuity factors in both rural and urban conditions.

Task 4: Internal pilot of driving scenarios and experimental participant protocol

An internal pilot was conducted to test driving scenarios and the experimental protocol. Naïve staff members, who had not contributed significantly to the development of the protocol and scenarios, served as pilot participants. The pilot was followed by any necessary changes to scenarios and protocol prior to data collection with consented research participants.

Task 5: Collection of driving simulator data sampling in two age groups

Experimental data were collected in the NADS research facility in Iowa City, Iowa. Thirty-six participants in two age groups consented and completed the experimental protocol, including driving the simulator and completing questionnaires. Following data collection, the data were prepared for analysis.

Task 6: Analysis of driving simulator data and preparation of final report

The simulator data were analyzed using general linear model repeated measure analysis of the detection distances from the participants to the motorcycles at the time of pressing the button within the driving scenario across age groups (younger versus older), driving environments (urban versus rural), and conspicuity-related factors (headlight configurations and rider color).

2. LITERATURE REVIEW

2.1 Factors Affecting Motorcycle Conspicuity

Several studies in the literature investigate the effectiveness of various conspicuity measures in daytime and nighttime conditions. Most of these studies were performed during the 1970s and 1980s and some of were already reviewed in the final report of *Enhancing Motorcycle Conspicuity Awareness in Iowa* (Gkritza et al. 2010).

Quite a few studies showed that motorcycles with headlights on, flicking/dipped headlamps, or daytime running lights (DRLs) were detected at greater distances (Janoff and Casses 1971, Janoff 1973, Woltman and Austin 1973, Kirkby and Fulton 1978, Mortimer and Schuldt 1980, Hole and Tyrrell 1995, Hole et al. 1996). Other studies also revealed that riders with fluorescent waistcoats, jackets, or helmets, retroreflective garments or helmets, dark blue jackets against a light background, or yellow jackets against a dark background produced higher detection rates for motorcycles (Kirkby and Stroud 1978, Olson et al. 1979 and 1981, Fulton et al. 1980, Stroud et al. 1980, Watts 1980, Donne and Fulton 1987, Hole et al. 1996).

The next section summarizes recent studies on factors affecting motorcycle conspicuity such as daytime running lights, non-motorcycle vehicle driver age, different configurations of motorcycle front lights, error in judgment by non-motorcycle vehicle drivers, motorcycle rider clothing and motorcycle speed.

2.2 Review of Recent Studies

A comprehensive review of daytime running lights was provided by Rumar (2003). Overall, the review indicated a rapidly increasing trend toward daytime lighting on both cars and powered two wheelers (PTWs) in Europe as well as in the other regions. The Association des Constructeurs Européens de Motorcycles (ACEM) members already equip PTWs with automatic headlamp-on (AHO). In addition, riders are required to use headlamps during daytime in Denmark, Spain, France, Germany, Italy, Lithuania, Poland, Sweden, and Finland.

Brooks et al. (2005) conducted an experimental investigation to verify whether potential PTW conspicuity improvements could be studied in driving simulator experiments. Overall, the simulator methodology was found to be a powerful tool for examining differences in driver behavior and collision probability due to daytime lighting treatments in a sample of real-time crash scenarios.

A recent study assessed the accuracy of individuals being able to discriminate between the speeds of motorcycles and cars in daytime and nighttime conditions (Gould et al. 2011). Computer simulations of different headlight configurations for motorcycles and cars approaching participants were used. The results demonstrated that individuals were significantly more accurate at judging the speed of the approaching car compared with both the solo and tri-headlight motorcycles during the daytime condition.

In addition, the results revealed that individuals were extremely poor at judging the speed of the motorcycle with a solo headlight during nighttime conditions. Conversely, in nighttime conditions, participants were significantly more accurate at judging the speed of the motorcycle equipped with a tri-headlight configuration.

Röger et al. (2012) conducted a laboratory experiment to show that motorcycles with a T-shaped light configuration were identified more quickly, particularly when the motorcycles are in visual competition with other motorized road users.

Another recent study investigated the effect of motorcyclist speed on “looked-but-fail-to-see” (LBFS)

Crashes by precise kinematic reconstruction of 44 crash cases involving a motorcyclist and another road user at intersections (Clabaux et al. 2011). The results showed that, in urban environments, the initial speeds of motorcyclists involved in LBFS crashes were significantly higher than in other crashes. On the other hand, the difference in speed for motorcyclists between LBFS crashes and other crashes was not significant in rural environments.

Smither and Torres (2010) studied the effect of the age of car drivers and DRL on motorcycle conspicuity using a driving simulator and presenting video clips to participants with different combinations of headlight conditions (headlight on, off, and modulated) for motorcycles and vehicles following motorcycles (headlight on and off).

Seventy-five participants were asked to indicate when they saw motorcycles. Participant reaction times were collected and analyzed. Results revealed that younger adults were significantly faster than middle-aged and older adults to detect motorcycles. The results also revealed that males were faster than females at detecting motorcycles across all conditions.

Motorcycles with DRL were detected much faster than motorcycles with no lights and the difference was significant. The results also suggested that, when followed by a vehicle with low beams or DRLs on, a motorcycle that had its headlight on or headlights modulated were more quickly detected than a motorcycle without headlights or modulators on.

The study did not find any interaction effects between age and motorcycle lighting conditions. One of the major limitations of this study was the absence of a complete driving task with participants seated in the simulator as if they were driving.

Rogé et al. (2012) studied whether the cognitive conspicuity and sensory conspicuity of car drivers were low when it came to detecting motorcycles. Forty-two car drivers (21 motorcyclists and 21 non-motorcyclists) carried out a motorcycle detection task in a car-driving simulator.

Results revealed that a high level of color contrast enhanced the visibility of motorcycles when the motorcycle appeared in front of the participants. Motorcyclist motorists detected oncoming motorcycles at a greater distance than non-motorcyclist motorists when motorcycles appeared from behind the participants.

Gershon et al. (2010) studied the effects of driving scenarios, motorcycle rider clothing (outfits), and motorcycle distance from the viewer on attention and search conspicuity of motorcycles by conducting two experiments. In the first experiment, compared to black outfits, reflective and white outfits increased motorcycle attention conspicuity when the background surrounding the motorcycle was more complex and multi-colored on urban roads. On the other hand, on inter-urban roads, black outfits provided an advantage for the motorcycle detectability when the background was solely a bright sky.

The same study results revealed that the average reaction time to identify the presence of a motorcycle was the shortest in the inter-urban environment.

In the second experiment, the detection rate for motorcycles, which represented search conspicuity, showed similar results to the first experiment on urban and inter-urban roads with respect to different outfits.

Lastly, the Motorcycle Safety Foundation (MSF) and Virginia Tech Transportation Institute (VTTI) are partnering on what is likely the world's first large-scale, naturalistic motorcycle riding study. This study is underway and, once finished, will greatly enhance the understanding of interactions among rider, motorcycle, roadway, other roadway users, and environment.

One hundred motorcycles owned by riders in California, Florida, and Virginia are to be instrumented with highly-capable data acquisition systems (DASs) that use distributed cameras to collect data and investigate the sequence of events, actions of other vehicles, successful and unsuccessful maneuvers, types of events and frequency, and other factors.

3. DATA COLLECTION AND DECRIPTION

3.1 Data Collection Procedure in NADS

This chapter begins with a discussion of the experimental design and independent and dependent measures. The first section is followed by a description of the participant groups and experimental protocol, which includes participant recruitment and procedures, and the study visit by the participants to NADS.

An overview of the experimental procedures is included in Appendix A. The methodology described here was utilized in the main data collection. An internal pilot using naïve staff as participants was utilized to test driving scenarios and the experimental protocol.

3.2 Experimental Design

Thirty-six participants completed three drives on the NADS-2 driving simulator. During two of the drives, participants were presented several motorcycles, each with a different combination of rider color and headlight configuration. Participants indicated when each motorcycle was first visible to them by pressing a button on the steering wheel of the driving simulator. The following section discusses the independent variables and the dependent variables.

Two experimental designs were used for the driving simulator data as summarized in Table 3.1.

Table 3.1. Summary of driving simulator experimental designs

Motorcycles	Factors
Oncoming	Headlight configurations = modulating, DRL, high beam (3 factors) × rider color = black, bright yellow (2 factors) × environment = rural, urban (2 factors)
Leading	Rider color = black, blue denim, bright yellow (3 factors) × environment = rural, urban (2 factors)

3.2.1 Independent Variables

The combination of the levels of independent variable resulted in six oncoming motorcycles and three leading parked motorcycles with each of the nine motorcycles present in both the urban and rural environments as shown in Figures 3.1 through 3.3.

Figure 3.1. Simulated urban and rural environments

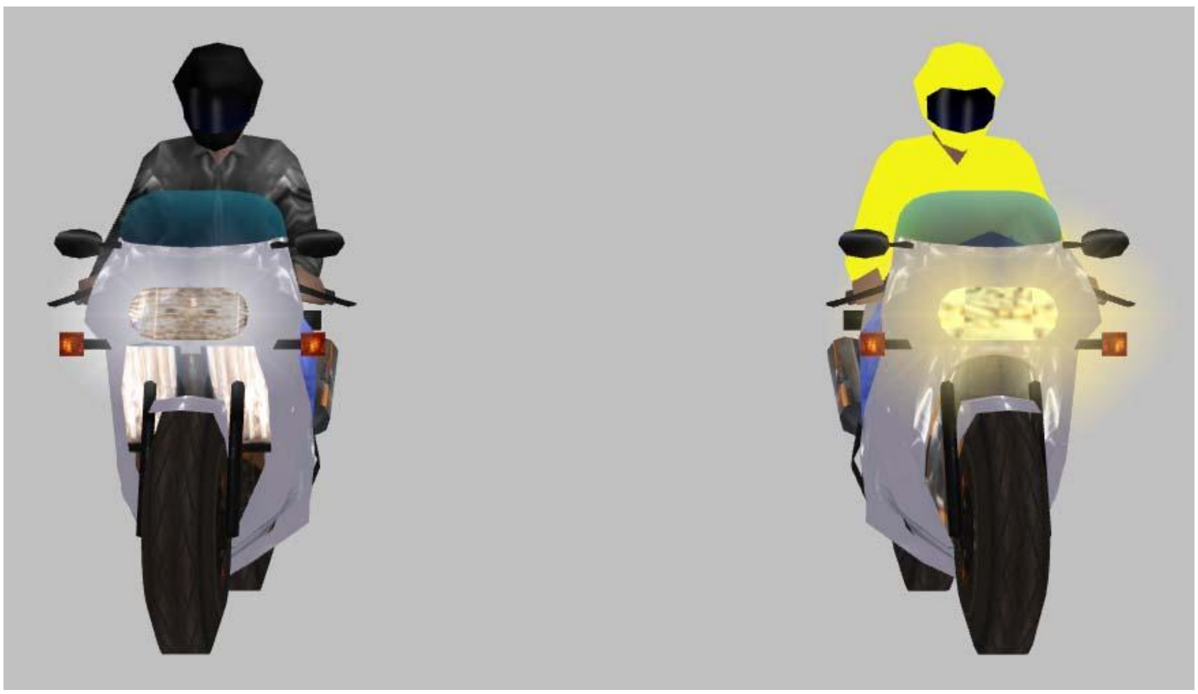

Figure 3.2. Two of the six oncoming rider and headlight combinations

Figure 3.3. The three combinations for leading parked motorcycles

The oncoming motorcycles were part of traffic traveling in the opposite direction of the driver in the adjacent lane and, therefore, were visible to the driver from the front. The leading motorcycles were parked on the side of the road facing the same direction as the driver and, therefore, were visible to the driver from the rear.

While the locations within the drives of oncoming versus leading motorcycles were set, the order in which the six oncoming and the three leading motorcycle were presented at each location was randomized for participants.

3.2.1.1 Headlight Configurations

Headlight configuration was presented at three levels: modulating, DRL, and high-beam. This independent variable was considered to investigate the impact of different configurations of headlights on motorcycle conspicuity in rural and urban environments.

The headlight configurations were implemented only on the motorcycles presented as oncoming traffic because, during pilot testing, the researchers confirmed that headlights do not contribute significantly to the conspicuity of motorcycles viewed from the rear, as is the case with leading motorcycles.

3.2.1.2 Rider Color

Rider color can potentially affect the ability of other motorists to see motorcyclists. The objective was to investigate the impact of different rider colors on motorcycle conspicuity in urban and rural environments. Rider color consisted of both the motorcycle driver's jacket and helmet color.

For oncoming motorcycles, rider color was presented in only black and bright yellow and for leading motorcycles, rider color was presented in black, blue denim, and bright yellow. Only the darkest and brightest colors were used for oncoming motorcycles because, during pilot testing, the researchers determined that headlight configuration was the dominant factor in the conspicuity of motorcycles viewed from the front. All motorcycle riders were presented with a pant color of blue denim.

3.2.1.3 Age of the Participants

The addition of age group as an experimental variable was considered to investigate the differences in driver awareness of motorcyclists by age. Participants were within one of two groups: younger drivers (25 to 55) and older drivers (65 and older).

3.2.2 Dependent Variable

Table 3.2 defines the dependent variable (adjusted detection distance) considered for this study.

Table 3.2. Primary measures (dependent variable)

Variable	Definition
Adjusted detection distance (ft)	Distance from the participant's vehicle to motorcycles when he/she first sees the motorcycles and represented by the button press adjusted to account for each participant's mean physical reaction time to press the button and their speed at the time of the button press

3.3 Test Devices

The experimental drives were conducted on the NADS-2, a medium-fidelity, fixed-base driving simulator. The simulator consisted of a Jeep Cherokee cab equipped with active feel on steering, brake, and accelerator pedal and a fully operational dashboard. The audio subsystem consisted of speakers inside and outside the cab, which provided sound for wind, tire, engine, vehicle noise, passing traffic, and other environmental noises.

Driving data was collected at 240 Hz. The NADS-2 enhanced visual system has sufficient angular pixel resolution to satisfy 20/20 visual acuity. The commonly-accepted standard of 20/20 visual acuity is the ability to resolve 1 arc minute of detail. The projectors are 1,400 x 1,050 pixel digital light processing (DLP) projectors with five image generator channels and digital video (DVI) delivered over fiber optic cable. The three center channels are configured for high spatial resolution (0.5 arc minute/pixel) and two side channels are configured as lower spatial resolution and serve as larger field-of-view "expansion" channels. The three center channels have a field-of-view of 11.5 degrees vertically by 31 degrees horizontally, with the driver's eye point 136 in. from the screen. The addition of the side channels results in a horizontal field-of-view of approximately 62 degrees.

3.4 Recruitment Method

The primary recruitment tools were the NADS participant recruitment database, University of Iowa students, faculty and staff, and a listserv managed by the University of Iowa, College of Engineering.

The NADS database currently contains more than 5,500 names of potential participants that are interested in participating in driving studies conducted at NADS. A database query of the prospective age groups was completed. From this query, a list of names was generated, and potential participants were either sent an email message or phoned with information about the study. A recruitment email message was also sent to the University of Iowa community and the College of Engineering listserv that includes current students, faculty, staff, alumni, and friends of the college.

The recruitment materials provided NADS contact information for those interested in participating in the study (Appendix B). Those expressing interest were contacted by NADS staff.

A phone screening was conducted to determine if potential participants met study criteria (Appendix C). Those who met the study criteria were scheduled for participation at a study appointment.

3.5 Inclusion/Exclusion Criteria

Potential participants had to be of an age that falls into one of the age groups in this study and meet general driving and health criteria to be enrolled. The general driving and health criteria are included in the telephone screening procedure. Participants were asked questions about their driving license and endorsements, driving experience, vision and restrictions while driving, previous simulator experience, and other general driving criteria. There were also questions for general health inclusion criteria in the Telephone Screening Procedure.

3.6 Simulator Drives

Each participant completed a practice drive, a reaction-time task, and two study drives while in the driving simulator. The practice drive was approximately six minutes and allowed participants to become accustomed to the simulator.

Following the practice drive, participants completed the reaction-time test. During this task, the participant did not drive. Their physical reaction time from the appearance of a vehicle to press the button was measured for nine stationary vehicles, including some motorcycles, which were presented 60 to 80 feet in front of them in the oncoming lane. Each vehicle disappeared when the participant pressed the response button, followed by the next vehicle after a 1 to 3 second delay. The mean reaction time from this task for each participant was used to adjust the detection distance to account for the distance they traveled between seeing a target vehicle and the actual button press.

Participants then completed each of the study drives, one in a rural environment and one in an urban environment (Figure 3.1). The posted speed limit was 55 mph in the rural environment and 35 mph in the urban environment. The drive in each environment was along a straight roadway with no obstructions or curves that would hinder the visual detection of a vehicle ahead. The order in which the urban and rural drives were completed was counter balanced across participants. The study drives lasted approximately 20 minutes each.

During each study drive, six oncoming motorcycles and three leading motorcycles were presented at predetermined locations. The sample images shown in Figures 3.2 and 3.3 illustrate the viewing angle and colors. In Figure 3.2, an example of the DRL setting for the headlight is also shown.

The order of both the oncoming and leading motorcycles was randomized for each participant. Participants indicated when each motorcycle was first visible to them by pressing a button on the steering wheel of the driving simulator.

To reduce the potential for participants to become more vigilant than they would normally be toward motorcycles, participants were also asked to identify two other vehicle types, cargo and pick-up truck, during their drives. These other vehicles were present throughout the drives as part of the ambient traffic that included other vehicle models as well. These vehicles were placed so they did not interfere with the visual detection of the motorcycles.

3.7 Experimental Protocol

Upon arrival for their study visit, informed consent was obtained for each participant (Appendix D). Video release and payment forms were completed; then, the Driving Survey was completed (Appendix E). The Driving Survey was reviewed by research staff to confirm inclusion criteria were met.

Vision testing followed the paper work (Appendix F). Immediately prior to entering the driving simulator, participants viewed the training PowerPoint that introduced the simulator and explained the tasks they would perform while in the simulator (Appendix G).

Once comfortably seated in the driving simulator with their seatbelt fastened, each participant completed the practice drive, the reaction-time test, and, then, each of the two study drives.

Following the simulator drives, participants completed surveys including the Motorcycle Conspicuity Related Factors (Appendix H). A debriefing statement was read to participants that clarified the purpose of the study and asked them not to reveal this purpose to anyone until a date when data collection was expected to be complete (Appendix I). This was done to maintain the consistency of expectations of participants across the data collection period.

3.8 Discussion of Descriptive Statistics of Participant Survey Data

Questions were asked to acquire information about demographic factors, driving behavior, and driving comfort, and repeated driving history and health status of the participants from the NADS survey. A separate questionnaire was provided to the participants to rate different factors that might be potentially helpful to increase the conspicuity of motorcycles.

Table 3.3 shows the summary statistics for the demographic factors, driving habits, and license-related factors for both the younger (25 to 55) and older (65 and older) participants. In the interest of space, data is presented horizontally separated by slashes (such as 0.00/16.67/5.56/5.56/…), rather than vertically (with only one value or set of data per line or table cell/column) in these tables. The values in parentheses in the tables provide the standard deviation (SD) values as indicated in their column headings.

Table 3.3. Descriptive statistics of participant survey data

Factors	Younger Participant (25-55 years) Mean (SD) or %	Older Participant (≥65 years) Mean (SD) or %
Gender (Male/female)	50/50	50/50
Age	36.06(10.95)	71.33(6.02)
Total household income (in 1,000s) 20-29/30-34.9/35-39/40-49/50-59/ 60-69/70-79/80-89/90-99/100 or more	0.00/16.67/5.56/5.56/ 11.11/5.56/33.33/5.56/ 5.56/11.11	5.56/0.00/0.00/11.11/ 22.22/5.56/0.00/11.11/ 11.11/33.33
Driving starting age	15.11(2.2.29)	14.75(2.14)
Commercial truck license Yes/No	0/100	0/100
Motorcycle license Yes/No	0/100	0/100
Other license Yes/No	0/100	0/100
Driving frequency At least once daily/at least once weekly	77.28/22.22	83.33/16.67
Work-related driving Yes/No	38.89/61.11	27.78/72.22
Speed in residential area (mph)	26.71(2.11)	25.75(1.77)

SD = standard deviation (in parentheses in this table data)

Distribution of the gender of the participants was even with half males and half females. Average age of the participants was 55.2 with a standard deviation of 18.54 including both younger and older drivers participating in the simulator study.

The researchers made sure none of the participants had a motorcycle or commercial truck driving license.

The average driving speed of the participants in residential environments was 26.71 mph for younger participants and 25.75 mph for older participants. Some demographic information of the participants is presented in pie charts for better visual representations later in this chapter.

Figures 3.4 through 3.7 show that almost two-thirds of the participants were married, half were full-time employees, and more than a third had a graduate degree. Nearly half of the participants drive 8,000 to 12,999 miles per year.

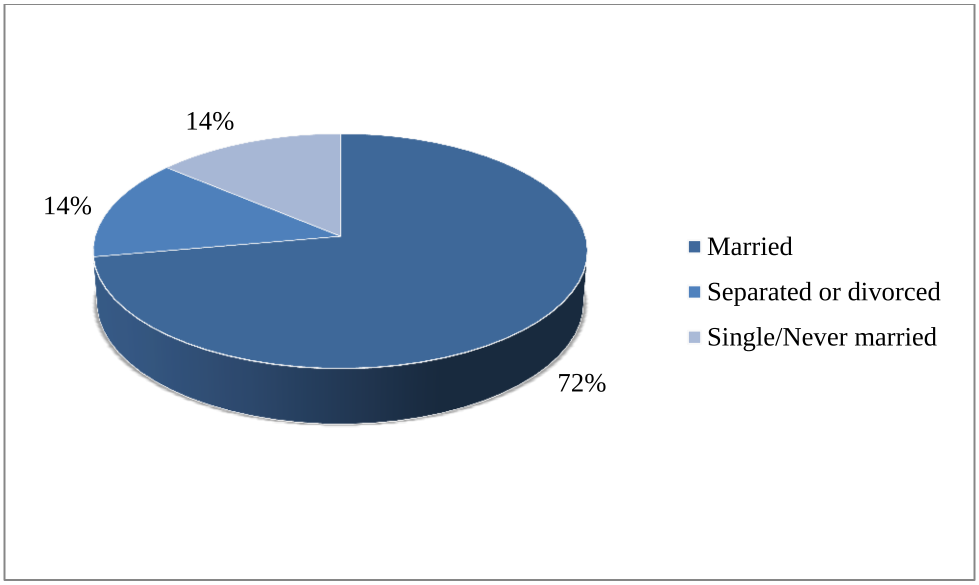

Figure 3.4. Marital status of the study participants

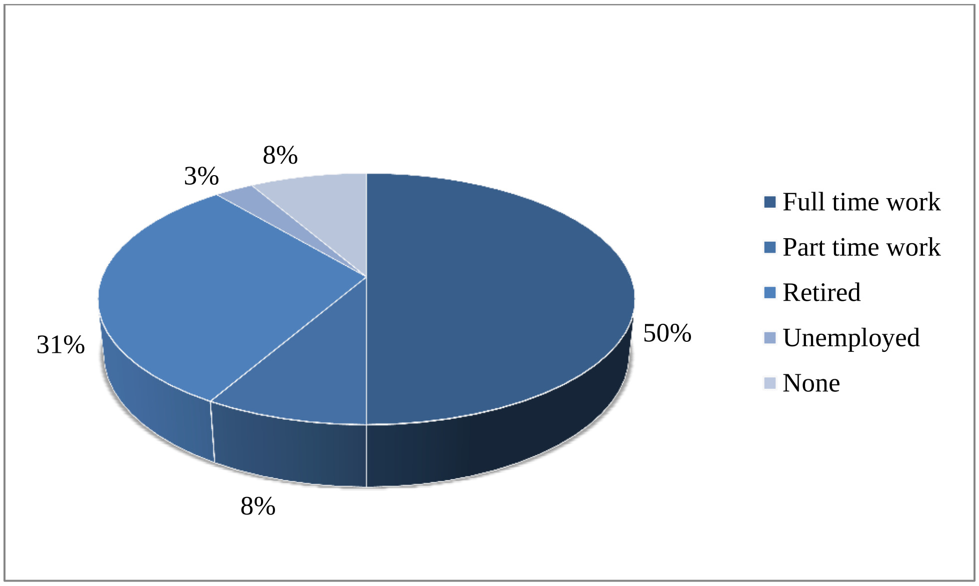

Figure 3.5. Employment status of the study participants

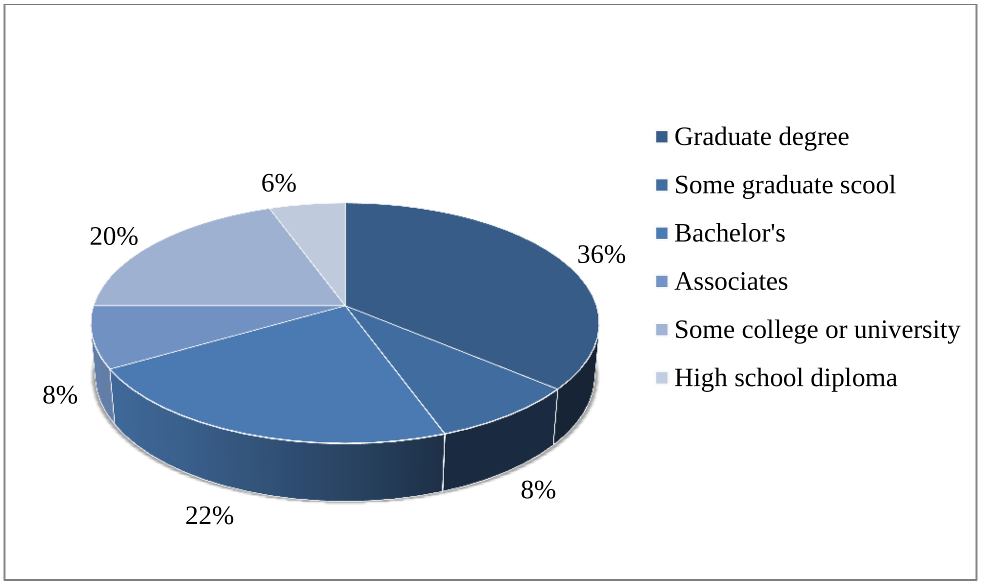

Figure 3.6. Educational qualifications of the study participants

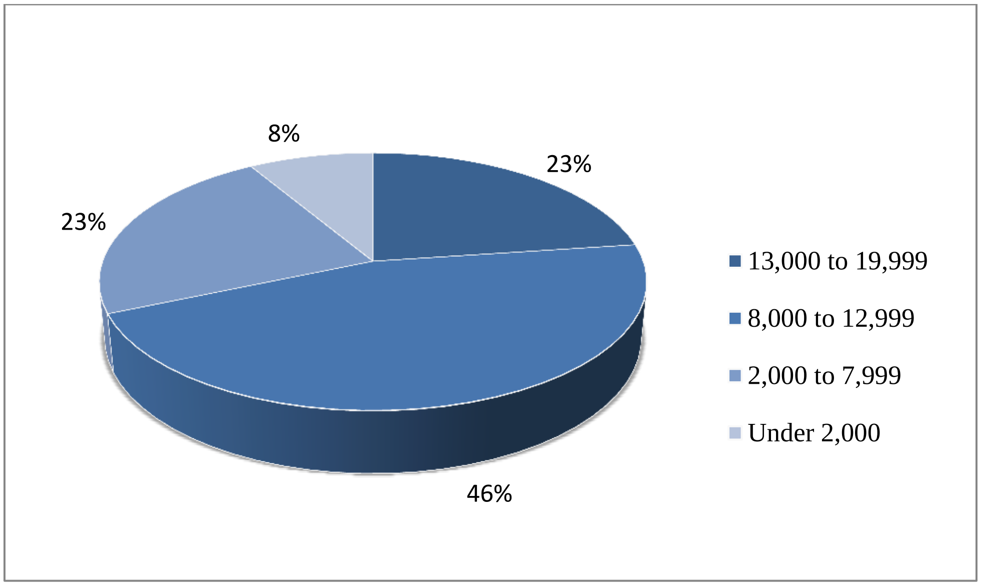

Figure 3.7. Yearly vehicle miles traveled by the study participants

Table 3.4 summarizes participant responses to questions related to their driving behavior. The questions were asked to understand how frequently the participants executed certain tasks representing their driving behavior.

About 28 percent said they frequently exceeded the speed limit and 39 percent stated that they made left turns frequently at uncontrolled intersections.

Table 3.4. Participant responses about driving behavior questions from survey

Questions	Driving Behavior (%)
Change lanes on interstate or highway	
Always/frequently/occasionally	22.22/33.33/44.44
Keep up with traffic in town	
Always/frequently/occasionally	50/42/8
Keep up with traffic in two-lane highway	
Always/frequently/occasionally	52.8/41.7/5.6
Keep up with traffic on interstate or highway	
Always/frequently/occasionally	44.4/47.2/5.6
Pass other cars on the interstate or freeway	
Always/frequently/rarely	11.1/41.7/5.6
Wear a safety belt	
Always/frequently/occasionally	88.9/5.6/2.8
Make left turns at uncontrolled intersections	
Always/frequently/occasionally/rarely/never	13.9/38.9/27.8/11.1/2.8

Table 3.5 summarizes participant survey responses related to their driving comfort level with various situations/conditions. Most of the participants were comfortable driving on highways/freeways and the responses showed the majority of participants were more or less comfortable driving under most of the conditions asked about.

Table 3.5. Participant responses about driving comfort questions from survey

Questions	Driving Comfort (%)
Driving on Highway/Freeway	
Very comfortable/slightly comfortable/slightly uncomfortable/very uncomfortable	83.3/8.3/5.6/2.8
Driving with Children	
Very comfortable/slightly comfortable/slightly uncomfortable/very uncomfortable/not applicable	58.3/13.9/11.1/2.8/13.9
Driving in High Density Traffic	
Very comfortable/slightly comfortable/slightly uncomfortable/very uncomfortable/not applicable	22.2/50/16.7/8.3/2.8
Passing Other Cars	
Very comfortable/slightly comfortable/slightly uncomfortable/very uncomfortable	61.1/27.8/5.6/5.6
Changing Lanes	
Very comfortable/slightly comfortable/slightly uncomfortable/very uncomfortable	69.4/32/5.6/2.8
Making a Left Turn at Uncontrolled Intersections	
Very comfortable/slightly comfortable/slightly uncomfortable/very uncomfortable	55.6/22.2/8.3/5.6

The participant driving survey also included questions about driving history (violations in the past five years). Table 3.6 shows the results of the responses to these questions. The majority of the participants did not receive a ticket for most of the traffic violations mentioned in the survey questions. However, nearly 28 percent of the participants were involved in a crash in the past five years.

Table 3.6. Participant response about driving history questions from survey

Questions	**Driving History or Violations in past 5 years (%)**
Speeding	
0 ticket/1 ticket/2 tickets	66.7/25/5.6
Going too Slowly	
0 ticket	100
Failure to Yield Right of Way	
0 ticket	100
Disobeying Traffic Lights	
0 ticket	100
Disobeying Traffic Signs	
0 ticket	100
Improper Passing	
0 ticket	100
Improper Turning	
0 ticket/1 ticket	94.4/2.8
Reckless Driving	
0 ticket	100
Following another Car too Closely	
0 ticket	100
Driving while Intoxicated	
0 ticket/1 ticket	94.4/2.8
Any other Tickets other than the ones listed above	
Yes/No	86.1/8.3
Crashes in the Past Five Years	
none/one	72.2/27.8

One interesting finding from the participant responses to the driving behavior questions was that almost 20 percent of the participants were used to exceeding the speed limit frequently while driving on the roadway. Figure 3.8 summarizes participant responses about how often they exceed the speed limit while driving.

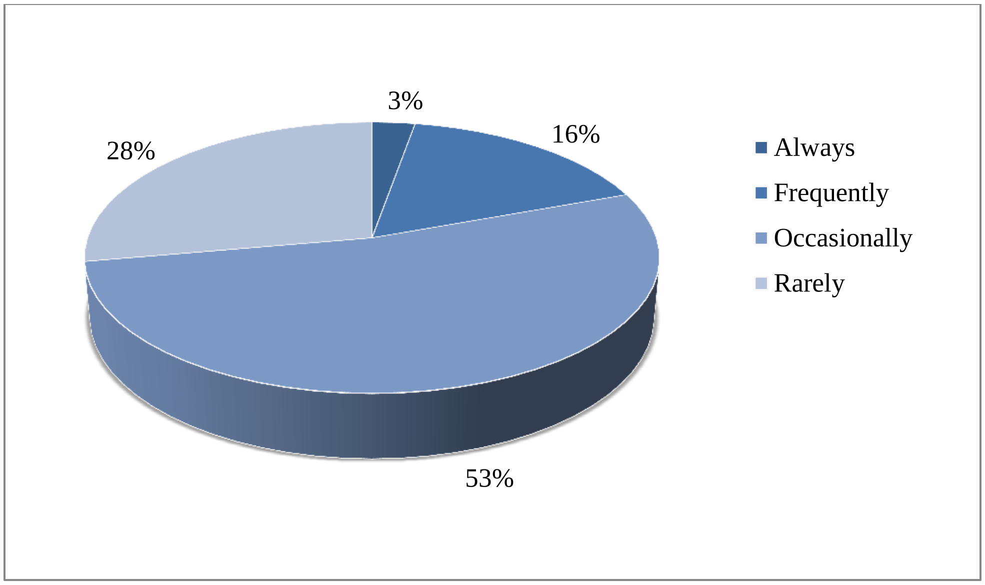

Figure 3.8. Percentage of participants exceeding speed limit while driving

More than half of the survey participants were slightly or very uncomfortable driving after drinking alcohol while a third of them indicated they don't drive after drinking alcohol by responding not applicable. Figure 3.9 shows the distribution of the responses of the participants to the survey question.

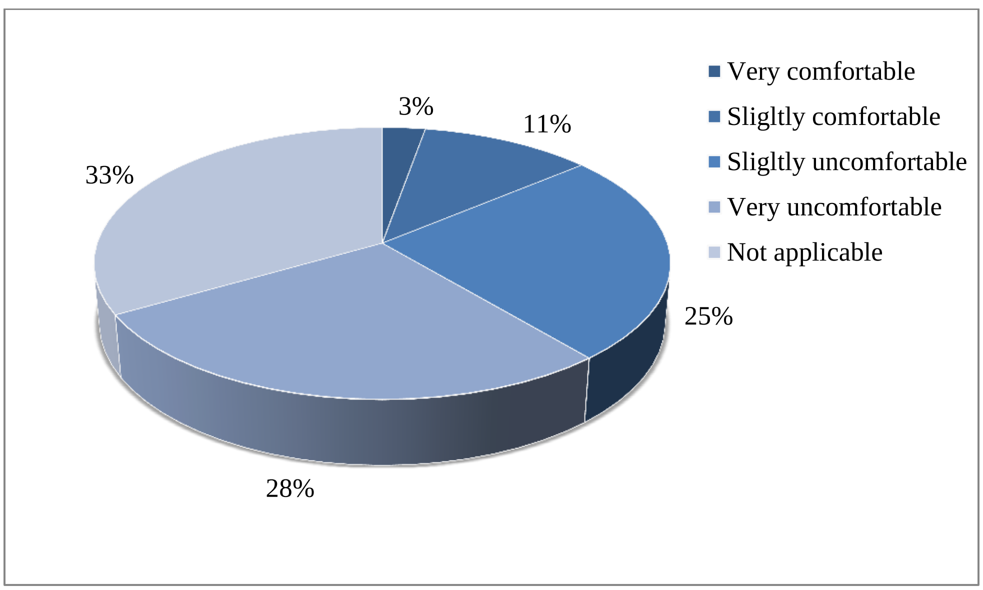

Figure 3.9. Participant driving comfort after drinking alcohol

Participants were also asked to give their opinions about how helpful it was for them as drivers to see motorcyclists on the road when the riders used certain measures. Note that the survey was administered after the participants finished the simulator drive, so the conspicuity factors used in the experiment may have affected the responses.

Figure 3.10 shows the opinions of the participants about different measures taken by motorcyclists to improve conspicuity. The majority of participants considered the use of DRLs and modulating headlamps by motorcyclists as very helpful measures to increase conspicuity.

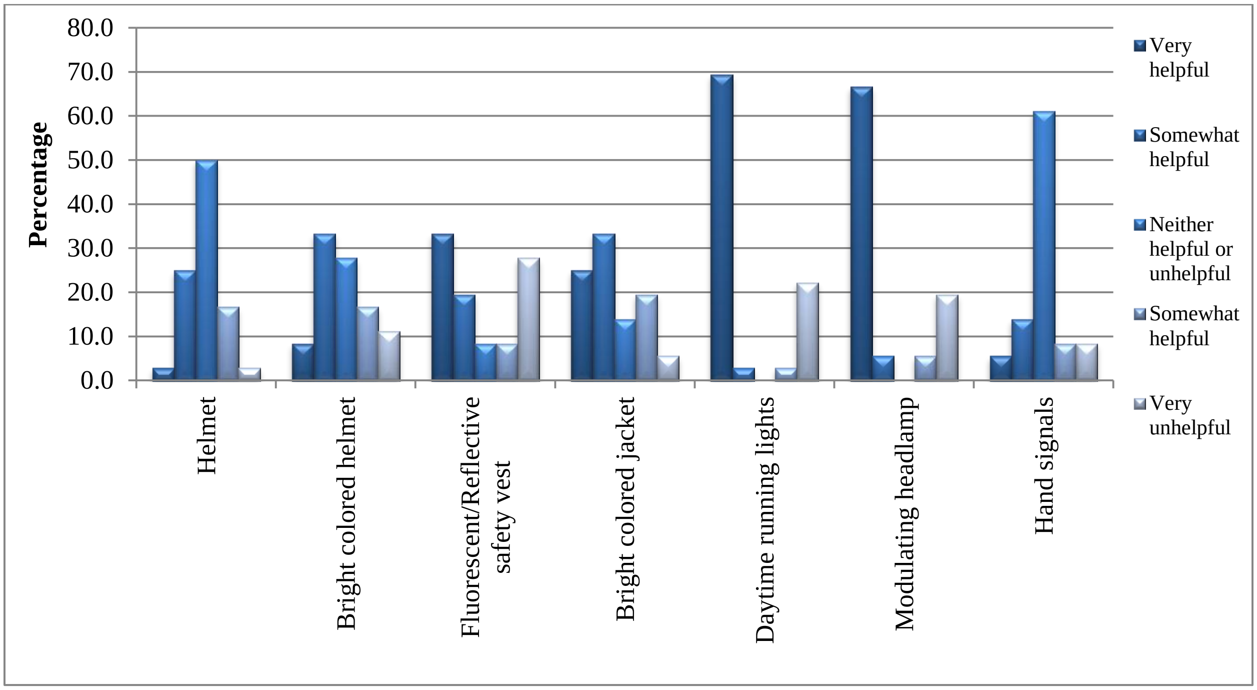

Figure 3.10. Participant opinions about the effectiveness of different measures to improve motorcycle conspicuity

3.9 Driving Simulator Data

The two experimental designs for collecting the simulator data were a 3 (headlight configurations=modulating, DRL, high beam) × 2 (rider color=black, bright yellow) × 2 (environment=rural, urban) factorial experiment for oncoming motorcycles and a 3 (rider color=black, blue denim, bright yellow) × 2 (environment=rural, urban) factorial experiment for leading motorcycles in the simulator (as shown in Table 3.1).

There were four cases where participants either missed the motorcycles or saw the motorcycles but did not press the button completely. All of these participants were from the older age group and one of these missing cases occurred for the oncoming motorcycles and the rest for the leading motorcycles. These cases were treated as missing data and were discarded from further data analysis.

The leading and oncoming motorcycles with different combinations of rider colors and headlight configurations were presented to the participants in random order. The number of participant responses, equal to the number of detection distances recorded for oncoming and leading motorcycles, is detailed to account for the number of missing cases in Table 3.7.

Table 3.7. Number of responses by participants for oncoming and leading motorcycles

	Oncoming Motorcycles	Leading Motorcycles
Number of participants	36	36
Experimental Factorial	3X2X2	3X2
Original Sample Size	36X3X2X2 = 432	36X3X2 = 216
Missing Cases	1	3
Reduced Sample Size	431	213

The distribution of the detection distances for oncoming motorcycles seems to follow a normal distribution, while the distribution of the detection distances for leading motorcycles shows some positive skewness, as shown in Figures 3.11 and 3.12.

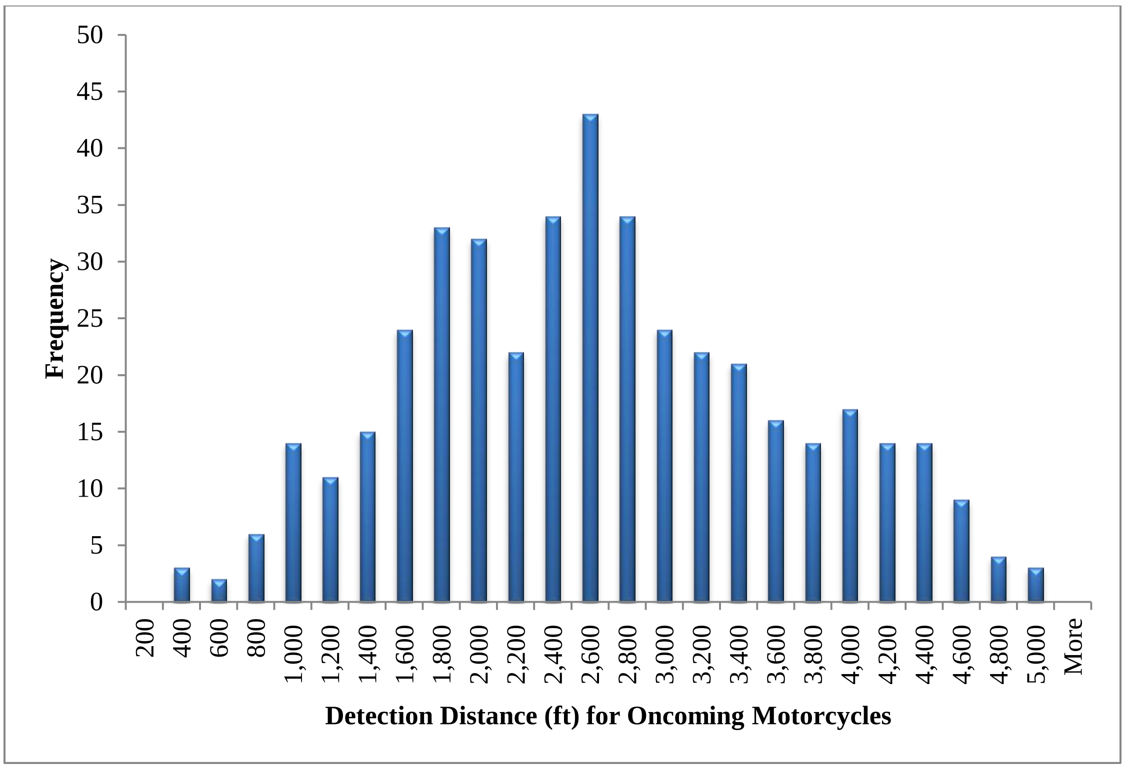

Figure 3.11. Distribution of the detection distances for oncoming motorcycles

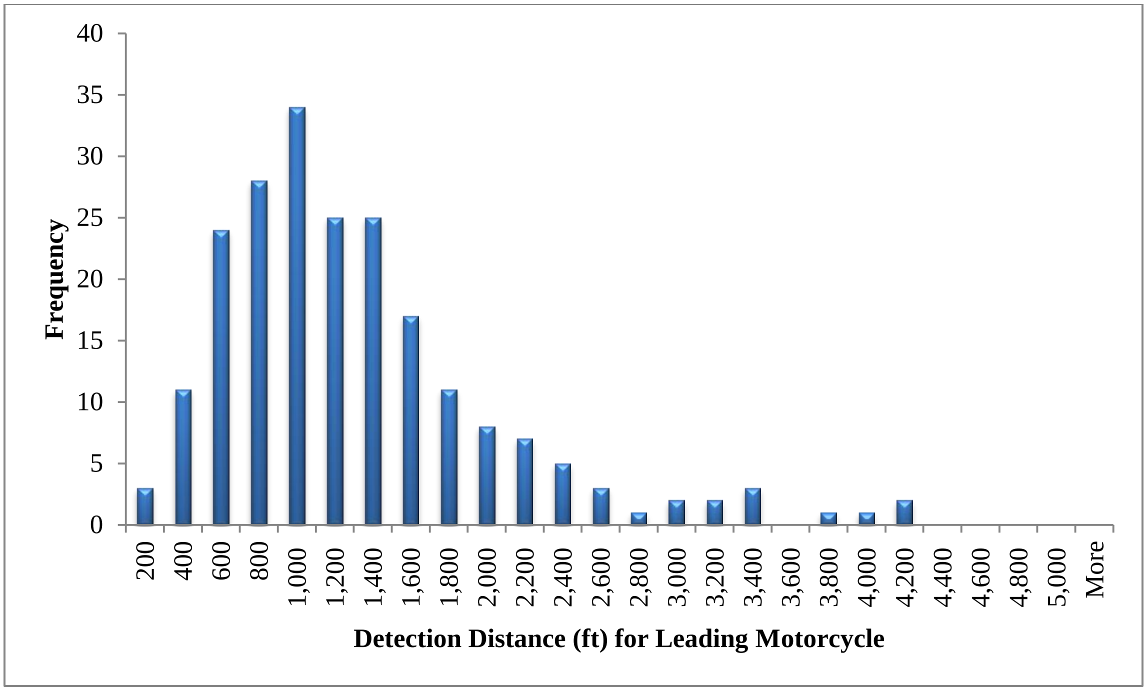

Figure 3.12. Distribution of detection distances for leading motorcycles

Besides the distributions of the overall detection distances for the two experimental designs (oncoming and leading motorcycles), the distribution of detection distances for each possible experimental condition was also examined for oncoming and leading motorcycles. With 12 experimental conditions for oncoming motorcycles and six for leading motorcycles, all of them showed distributions similar to those above for oncoming and leading motorcycles, so the researchers didn't include them in this report.

Tables 3.8 and 3.9 shows the mean of the detection distances (in feet) recorded for oncoming and leading motorcycles for all the possible experimental conditions. It can be observed from the tables that the average detection distance of both oncoming and leading motorcycles for younger participants was higher than that for older participants for almost all the experimental conditions except for one (urban, bright yellow, modulating for oncoming motorcycles), where older participants detected oncoming motorcycles at a greater distance than the younger participants did.

Table 3.8. Mean and standard deviation of recorded detection distances for oncoming motorcycles given all possible experimental conditions

Combination of Driving Environment, Rider Colors, and Headlights	Younger Participant (25-55 years) Mean (SD) ft	Older Participant (≥65 years) Mean (SD) ft
Rural, Black, DRL	2,125.21(693.71)	2,026.51(505.67)
Rural, Black, High Beam	2,766.31(1,173.60)	2,440.46(800.27)
Rural, Black, Modulating	3,002.22(1,327.69)	2,837.28(920.53)
Rural, Bright Yellow, DRL	2,318.90(647.22)	2,017.60(647.70)
Rural, Bright Yellow, High beam	2,622.32(808.79)	2,232.55(688.56)
Rural, Bright Yellow, Modulating	3,647.33(1183.75)	2,932.36(934.01)
Urban, Black, DRL	2,102.36(490.82)	1,938.84(621.38)
Urban, Black, High Beam	2,549.29(753.12)	2,507.81(886.04)
Urban, Black, Modulating	3,068.90(1223.69)	2,987.36(1,008.43)
Urban, Bright Yellow, DRL	2,298.39(809.43)	2,070.77(934.45)
Urban, Bright Yellow, High Beam	2,378.90 (1,023.17)	2,162.60(931.94)
Urban, Bright yellow, Modulating	2,925.21(1,366.41)	3,101.00(1,092.10)

SD = standard deviation (in parentheses in this table data)

Table 3.9. Mean and standard deviation of recorded detection distances for leading motorcycles given all possible experimental conditions

Combination of Driving Environment and Rider Colors	Younger Participant (25-55 years) Mean (SD) ft	Older Participant (≥65 years) Mean (SD) ft
Rural, Black	895.62(381.68)	713.60(298.54)
Rural, Blue Denim	1,232.14(550.86)	727.86(284.94)
Rural, Bright Yellow	1,563.71(518.60)	1,450.96(353.97)
Urban, Black	1,075.09(532.81)	964.68(854.20)
Urban, Blue Denim	1,049.51(630.63)	1,124.51(1,068.13)
Urban, Bright Yellow	2,143.20(1037.45)	1,653.28(588.65)

SD = standard deviation (in parentheses in this table data)

4. METHODOLOGY

4.1 Generalized Linear Model (GLM) Repeated Measure Analysis of Variance

The generalized linear model (GLM) repeated measure is a procedure used to model dependent variables measured at multiple times using analysis of variance. This is the method to use for analysis of variance when the same measurement is made several times on each subject or case (Garson, 2012).

If the between-subject factors are specified, the population can be divided into groups. Using GLM repeated measure analysis of variance, the null hypothesis about the effects of both the between-subjects factors and the within-subjects factors can be examined. It is also possible to investigate the interactions between factors, as well as the effect of individual factors. In a repeated measure analysis of variance, the effects of interest are as follows:

- Between-subject effects (such as between two different age groups of participants)
- Within-subject effects (such as rider color, headlight configurations, environment)
- Interaction between two or more types of effects (such as environment×rider color×headlight configuration)

GLM repeated measure analysis of variance was used to analyze the simulation data for the two experimental designs (one for oncoming and one for leading motorcycles). The inherent assumptions include linear relationships, normal distribution of the dependent variables, and fixed effects of the dependent variables (Garson, 2012). The two types of models to consider for the repeated measure analysis of variance are as follows:

- Univariate
- Multivariate

4.1.1 Univariate Model

Univariate repeated measures models, also called split plot designs or mixed model designs, assume that the dependent variables are responses to the levels of a within-subject factor. For example, if a dependent variable y has p levels or measure outcomes and k predictor variables, for a single observation i, the linear model is as shown in equation (1).

$$y_i = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_k X_{ik} + e_i \tag{1}$$

Equation (1) can be expressed more compactly by a set of matrices as follows.

$$y_i = X_i \beta + e_i \tag{2}$$

where y is the matrix with dimension of $(p\times 1)$, X is of size $p\times(1+k)$, β is of size $(1+k)\times 1$, and e is of size $(p\times 1)$.

Or, alternatively:

$$\begin{bmatrix} y_{i1} \\ \vdots \\ y_{ip} \end{bmatrix} = \begin{bmatrix} 1 & \cdots & X_{ik} \\ \vdots & \ddots & \vdots \\ 1 & \cdots & X_{ik} \end{bmatrix} \begin{bmatrix} \beta_0 \\ \vdots \\ \beta_k \end{bmatrix} + \begin{bmatrix} e_{i1} \\ \vdots \\ e_{ip} \end{bmatrix} \tag{3}$$

The equation for the first measurement of the first observation is as follows:

$$y_{11} = \beta_0 + \beta_1 X_{11} + \cdots + \beta_k X_{1k} + e_{11} \tag{4}$$

In practical terms, three measures of y for a within-subject factor denoting y_1, y_2, *and* y_3 can be considered and so a dummy-coded set of indicators for which y is in the data can be used. Three measures make two dummy-coded columns in X with one for y_1 and one for y_2 with y_3 being the reference in this case. The intercept will be the mean of the measure y_3, the first regression coefficient will be the difference between y_1 and y_3, and the second regression coefficient will be the difference between y_2 and y_3. The first observation including all the measurements for a subject can be expressed as follows:

$$\begin{bmatrix} y_{11} \\ y_{12} \\ y_{13} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_{k2} \end{bmatrix} + \begin{bmatrix} e_{11} \\ e_{12} \\ e_{13} \end{bmatrix} \tag{5}$$

Univariate models use an assumption called “sphericity,” which tests whether the variance-covariance matrix of the dependent variables can be shown to be circular in form. This is demonstrated by Mauchly’s test of sphericity (Huynh and Mandeville, 1979).

A spherical matrix has equal variances, and covariances equal to zero. A finding of non-significance in this test corresponds to concluding that assumptions are met for the univariate models.

Levene’s test examines the assumption of homogeneity of variance for univariate models. In a well-fitting model, the error variance of each repeated measure dependent variable should be the same across groups formed by the between-subject factors. Non-significance in this test implies that the assumption is met. Note that failure to meet the assumption of homogeneity is not critical if the assumption of sphericity is met.

4.1.2 Multivariate Model

The multivariate tests assume a multivariate model where the dependent variables represent measurements of more than one variable for the different levels of the within-subject factors, unlike the univariate model (Garson, 2012).

The multivariate test provides F-tests of the within-subject factor and its interaction with the between-subjects grouping factors. Wilks' lambda is the most commonly reported test statistic for the multivariate tests.

Multivariate models assume that the variance-covariance matrices are the same for each cell formed by the between-subject grouping variables. This is examined with the Box's M test for the homogeneity of variance-covariance matrix (Box's Test of Equality of Covariance Matrices). This test also examines the assumption that the dependent variables in a multivariate model are drawn from a multivariate normal distribution. Non-significance in this test results in not rejecting the null hypothesis of observed variance covariance matrices of the dependent variables being equal across between-subject groups.

4.1.3 Hypothesis Testing

Results are usually very similar for the univariate and multivariate tests. The F value for the analysis of variance is to be reported and higher F value compared to the critical F value will result in rejecting the null hypothesis.

For univariate analysis of variance, and for random samples $X_{l1}, X_{l2}\ldots, X_{ln_l}$ from $N(\mu_l, \sigma^2)$ and $l = 1, \ldots g$, it is of interest to know if the population means of the groups are different; that is, if the model formulation is as follows:

$$x_{lj} = \mu + \tau_l + e_{lj} \tag{6}$$

with the constraint $\sum_{l=1}^{g} n_l \tau_l = 0$, which leads to the null hypothesis notation of the following:

$$H_o\text{: } \tau_1 = \tau_2 = \cdots = \tau_g = 0 \tag{7}$$

Then, the hypothesis is tested using equation (8):

$$F = \frac{SS_{Tr}/(g-1)}{SS_{Res}/(\sum_{l=1}^{g} n_l - g)} \sim F_{g-1,\, \sum n_l - g}(\alpha) \tag{8}$$

where SS_{Tr} is the sum of squares for between-subject factors and SS_{Res} is the sum of squares for the within-subject factors.

For multivariate analysis of variance, the null hypothesis is as follows:

$$\mathrm{H}_0: \tau_1 = \cdots = \tau_l = 0 \tag{9}$$

Then, the hypothesis is tested using equation (10).

$$\Lambda = \frac{|W|}{|B+W|} \tag{10}$$

Λ is called the Wilks' Lambda and *W* and *B* are the sum of squares matrices for between-subject factors and within-subject factors, respectively. The null hypothesis is rejected if Λ is too small. All hypotheses are considered to be significant at alpha = .05 in this study.

5. RESULTS

The results are discussed in this chapter for both experimental designs: oncoming motorcycles and leading motorcycles. The dependent variable for all conditions evaluated was the detection distance (in feet).

The Box's M Test showed non-significance for the dependent variables when oncoming motorcycles were considered; whereas, it was significant for the dependent variables when considering leading motorcycles.

The null hypothesis that the observed covariance matrices of the dependent variables are equal across groups could not be rejected for the oncoming motorcycles, while it was rejected for leading motorcycles. So, the results of the multivariate tests are reported for the oncoming motorcycles. For leading motorcycles, results of the univariate tests are reported after checking the assumption of Mauchly's sphericity.

5.1 Detection Distance of Oncoming Motorcycles

Table 5.1 presents the results of the multivariate analysis of variance for the detection distances of oncoming motorcycles. A finding of nonsignificance for the Box's M test ($p=0.249$) supported the results of the multivariate tests. Wilks' Lambda was used for interpretation of all the multivariate tests of significance unless otherwise noted. Table 5.2 presents the test results of the between-subject (age group) effects.

Multivariate tests revealed one significant main effect and two significant interaction effects. The main effect was found for headlight configurations. One interaction effect was found significant between rider colors and headlight configurations. Another interaction effect was found to be significant only at 90 percent confidence. No main effect for the age was found for the detection distances of oncoming motorcycles. This means the difference in detection distances of oncoming motorcycles for younger and older participants was not statistically significant.

The analysis indicated a significant main effect for headlight configurations, $F(2, 32) = 45.83$, $p < .05$, partial $\eta^2 = 0.741$. The value of the partial η^2 indicates almost 74 percent of the total variance in the detection distances is accounted for by the variance among the three different headlight configurations (DRL, high beam, and modulating) for oncoming motorcycles. Planned pairwise comparisons were conducted and headlight configuration was found to significantly affect detected distance measures, whereby motorcycles with high beam (mean = 2,437.15 ft and SD = 113.12 ft) were detected at greater distance than motorcycles with DRL (mean = 2,094.75 ft and SD = 84.85 ft) and motorcycles with the modulating headlight were detected at the greatest distance (mean = 3,075.6 ft and SD = 152.95 ft) compared to motorcycles with the DRL and the high beam at a level of $p < 0.05$ across all conditions. Figure 5.1 shows the detection distance as a function of motorcycle headlight configurations for oncoming motorcycles.

Table 5.1. Results of multivariate tests for oncoming motorcycles

Effect	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Environment	.655	1.000	33.000	.424	.019
Environment × AgeGroup	1.243	1.000	33.000	.273	0.36
RiderColor	.171	1.000	33.000	.682	.005
RiderColor × AgeGroup	1.534	1.000	33.000	.224	.004
Headlight	45.826	2.000	32.000	**<.001****	.741
Headlight × AgeGroup	.136	2.000	32.000	.874	.008
Environment × RiderColor	1.024	1.000	33.000	.319	.030
Environment × RiderColor × AgeGroup	.970	1.000	33.000	.332	.029
Environment × Headlight	.508	2.000	32.000	.606	.031
Environment × Headlight × AgeGroup	2.545	2.000	32.000	**.094***	.137
RiderColor × Headlight	3.800	2.000	32.000	**.033****	.192
RiderColor × Headlight × AgeGroup	.039	2.000	32.000	.962	.002
Environment × RiderColor × Headlight	.995	2.000	32.000	.381	.059
Environment × RiderColor × Headlight × AgeGroup	1.702	2.000	32.000	.198	.096

df = degree of freedom
Sig. = Significance
**significant at alpha = 0.05
*significant at alpha = 0.10

Table 5.2. Test of between-subject (age group) effects for oncoming motorcycles

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	224882240.349	1	224882240.349	572.193	.000	.945
AgeGroup	459514.159	1	459514.159	1.169	.287	.034
Error	12969591.782	33	393017.933			

df = degree of freedom
Sig. = Significance

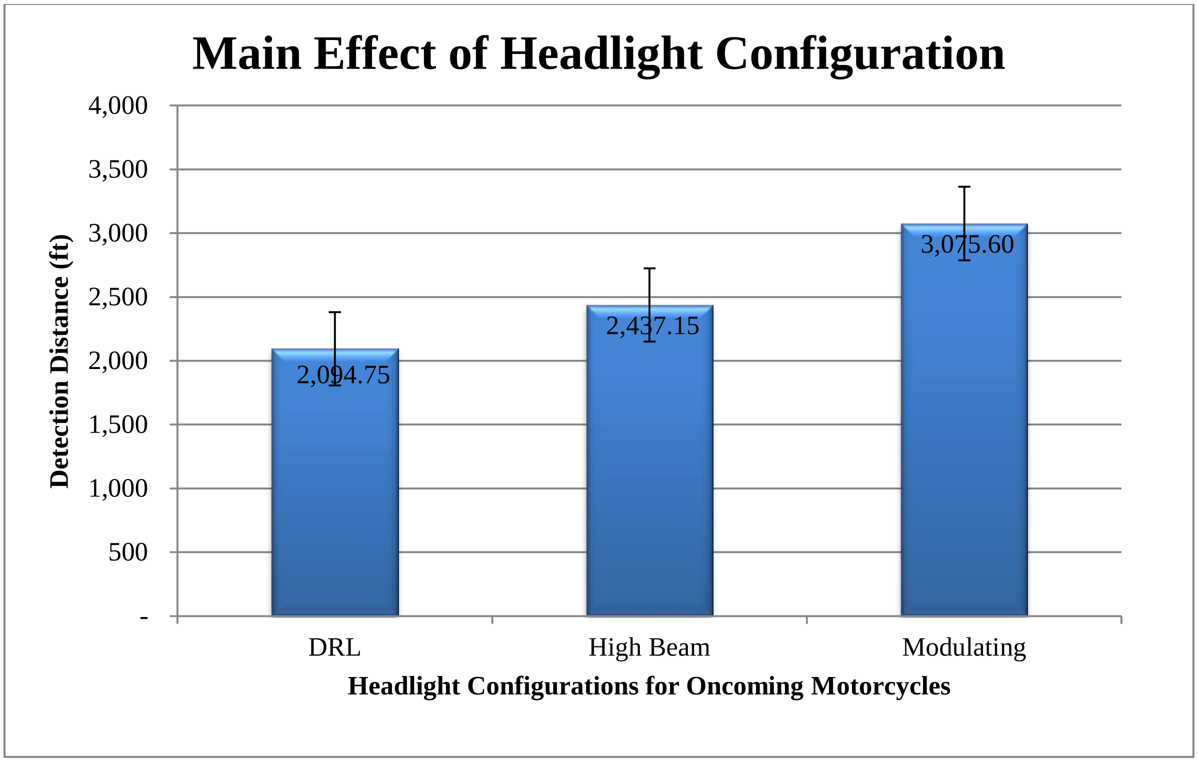

Figure 5.1. Detection distance as a function of headlight configurations for oncoming motorcycles (means and standard errors)

Results also revealed a significant interaction between rider colors and headlight configurations. The interaction between these two factors influenced participant ability to detect a motorcycle significantly, $F(2, 32) = 3.8$, $p < .05$, partial $\eta^2 = 0.65$. The value of the partial $\eta^2 = 0.65$ indicates that 65 percent of the total variance in detection distance for oncoming motorcycles is accounted for by the variance due to the interaction among different levels of rider colors and headlight configurations.

Figure 5.2 shows the interaction between rider colors and headlight configurations. Results revealed when riders were wearing black or bright yellow (jacket and helmet), motorcycles with modulating headlights were detected at a greater distance compared to those with high beam or DRL.

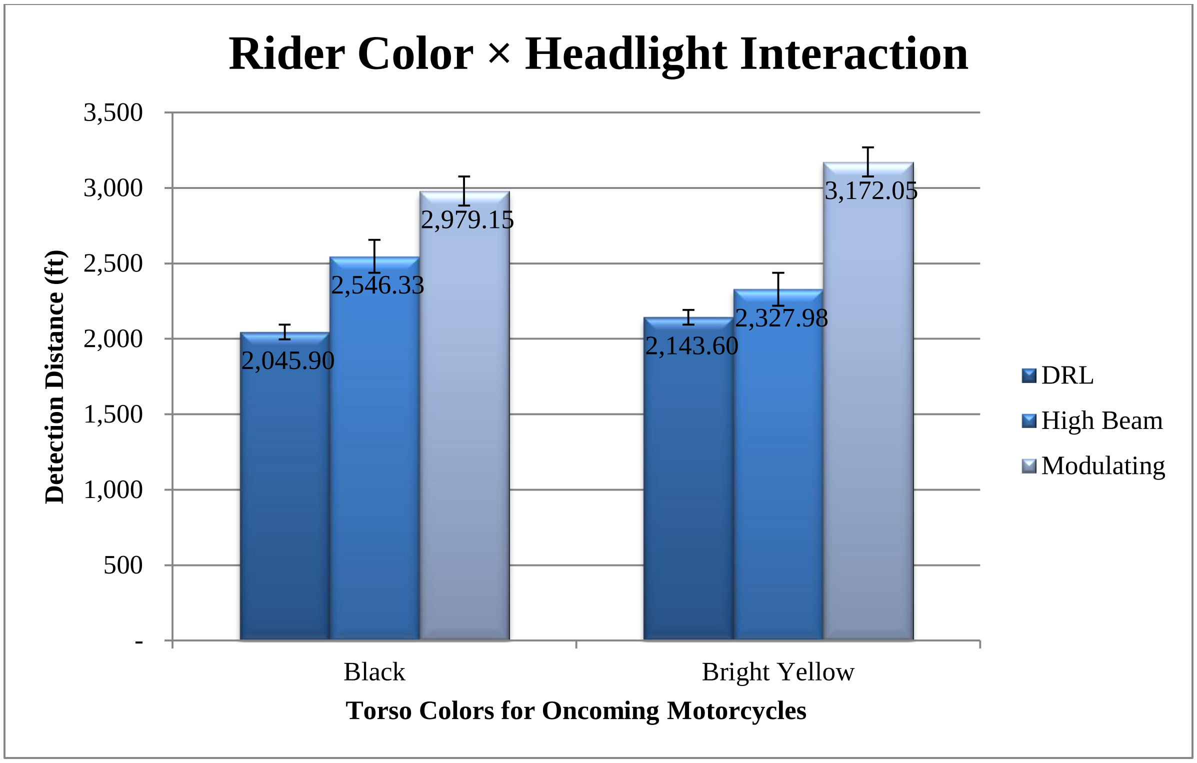

Figure 5.2. Detection distance as a function of motorcycle headlight configurations for rider colors of back and bright yellow (means and standard errors)

5.2 Detection Distance of Leading Motorcycles

As mentioned in section 5.1, the Box's M test resulted in ($p = 0.15$) significance leading to the rejection of null hypothesis that the variance covariance matrices of the dependent variables are equal across all between-subject factors. That is why the results of the univariate tests were reported for the detection distances of leading vehicles.

The main assumption for supporting the results of the univariate tests was examined by performing Mauchly's sphericity test. The test resulted in nonsignificance ($p = .262$ for rider color and $p = .895$ for environment×rider color) and the results of the univariate tests were supported.

Table 5.3 presents the results of the univariate tests for leading motorcycles and Table 5.4 presents the results of the tests for between-subject effects. Given the Mauchly's test showed no violation of sphericity, the interpretation of all univariate tests of significance was conducted under the assumption of sphericity.

Table 5.3. Results of univariate tests for leading motorcycles

Source	df	F	Sig.	Partial Eta Squared
Environment	1	7.689	**.009****	.184
Environment×Age	1	.283	.598	.008
Error(Environment)	34			
TorsoColor	2	51.686	**.000****	.603
TorsoColor×Age	2	.431	.652	.013
Error(TorsoColor)	68			
Environment×TorsoColor	2	1.110	.336	.032
Environment×TorsoColor×Age	2	3.098	**.052***	.084
Error(Environment×TorsoColor)	68			

df = degree of freedom
Sig. = Significance
**significant at alpha = 0.05
*significant at alpha = 0.10

Table 5.4. Test of between-subject (age group) effects for leading motorcycles

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	53246209.000	1	53246209.000	344.494	.000	.910
Age	438170.448	1	438170.448	2.835	.101	.077
Error	5255160.997	34	154563.559			

df = degree of freedom
Sig. = Significance

The analysis indicated a significant main effect for environment, $F(1, 34) = 7.689$, $p < .05$, partial $\eta^2 = 0.184$. The value of the partial η^2 indicates that 18.4 percent of the total variance in the detection distances is accounted for by the variance between the two different environments (rural versus urban) for leading motorcycles.

Planned pairwise comparisons were conducted and environmental condition was found to affect detected distance measures significantly, whereby motorcycles on urban roads (mean = 1,335.04 ft and SD = 96.21 ft) were detected at greater distance than motorcycles on rural roads (mean = 1,097.30 ft and SD = 54.82 ft) at a level of $p < 0.05$ across all conditions. Figure 5.3 shows the detection distance as a function of environment (rural and urban) for leading motorcycles.

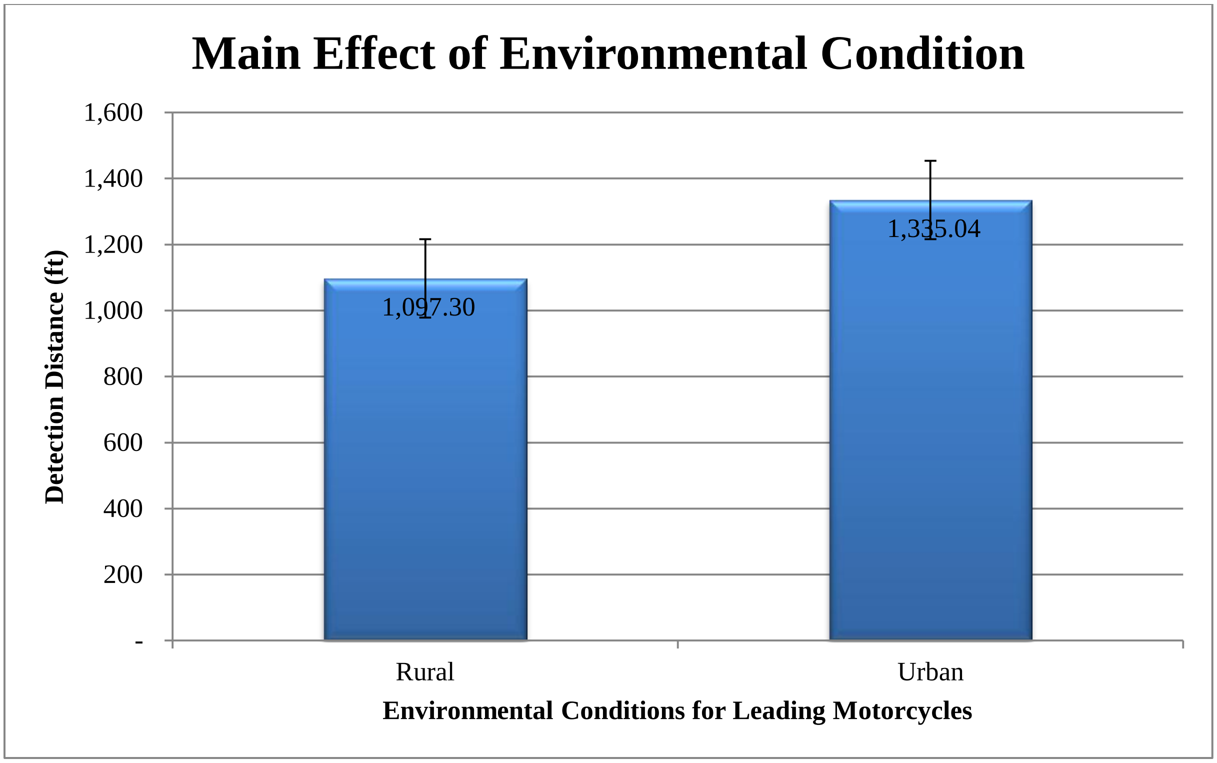

Figure 5.3. Detection distance as a function of environmental conditions (means and standard errors)

The results revealed another main effect for rider color, $F(2, 68) = 51.686$, $p < .05$, partial $\eta^2 = 0.603$. The value of the partial η^2 indicates that 60 percent of the total variance in the detection distances is accounted for by the variance among the three different colors (black, blue denim, and bright yellow) of the riders for leading motorcycles.

Planned pairwise comparisons revealed that rider color affected detected distance measures significantly, whereby motorcycles with riders having blue denim color (mean = 1,033.5 ft and SD = 92.75 ft) were detected at greater distance than motorcycles with riders having black color (mean = 912.24 ft and SD = 69.72 ft) and motorcycles with riders having bright yellow color were detected at the greatest distance (mean = 1,702.80 ft and SD = 80.2 ft) at a level of $p < 0.05$ across all conditions. Figure 5.4 shows the detection distance as a function of rider color (black, blue denim, and bright yellow).

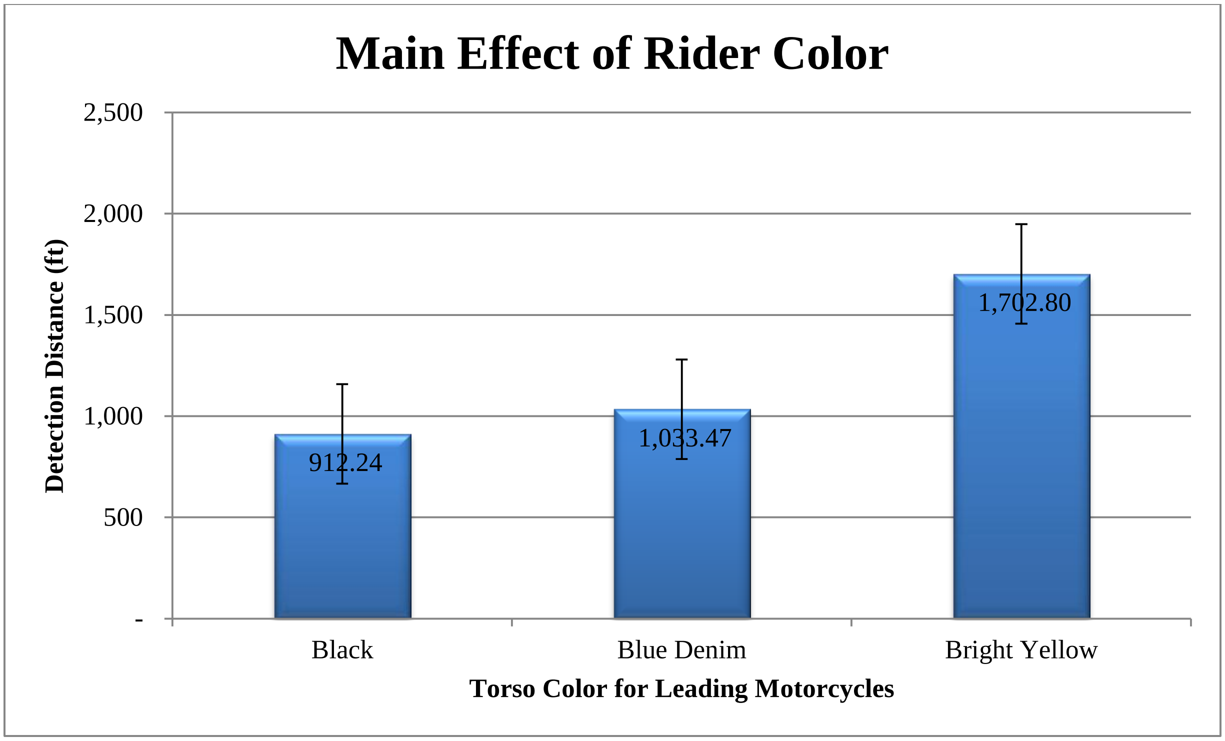

Figure 5.4. Detection distance as a function of rider color (means and standard errors)

A significant interaction among the environment, rider color, and age was found as well. The test was significant marginally at the alpha = 0.05 level. The interaction among these three factors influenced participant ability to detect a leading motorcycle significantly, F (2, 68) = 3.098, $p < .10$, partial $\eta^2 = 0.084$. The value of the partial $\eta^2 = 0.084$ indicates that only 8.4 percent of the total variance in detection distance for leading motorcycles is accounted for by the variance due to the interaction among different levels environment, rider colors, and age group of participants.

These effects were further explained through the use of planned pairwise comparison to evaluate the simple effects of these factors. An interaction effect was found between the conditions with a rider having the blue denim or bright yellow color and the age groups in rural or urban environments. The results suggest that, in a rural environment, the younger participants detected the motorcycles having blue denim rider color at a greater distance than older participants, F (1, 34) = 11.895, $p < 0.05$, partial $\eta^2 = 0.259$. It is to be noted the results did not indicate significant differences between the detection distances for younger and older participants for riders with black and bright yellow colors in a rural environment.

The results also revealed that when a rider wore bright yellow clothing and helmet in an urban environment, the younger participants detected the motorcycles at a greater distance than older participants, F (1, 34) = 3.036, $p < 0.10$, partial $\eta^2 = 0.082$. There were no significance differences between the detection distances for younger and older participants for riders with black and blue denim colors in an urban environment. Figure 5.5 shows this interaction effect and the boldfaced detection distances indicate that those are significantly different for younger and older participants.

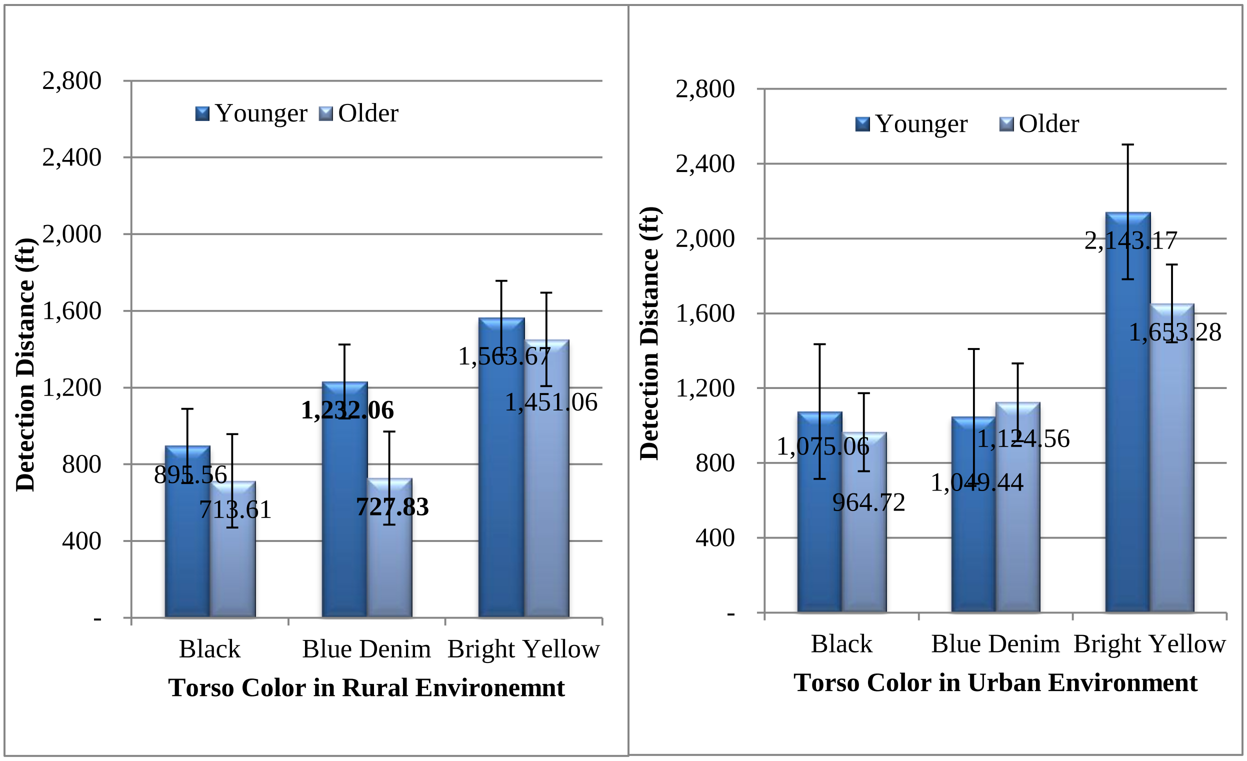

Figure 5.5. Detection distance as a function of participant age group with blue denim and bright yellow riders in rural and urban environments (means and standard error)

Furthermore, the study showed that older participants detected motorcycles with riders wearing a blue denim color at greater distance in the urban environment compared to the rural environment, $F(1, 34) = 4.137$, $p < 0.05$, partial $\eta^2 = 0.108$. Similar results were found for younger participants with riders wearing a bright yellow color, $F(1, 34) = 6.783$, $p < 0.05$, partial $\eta^2 = 0.166$. Figure 5.6 shows this interaction effect.

The boldfaced detection distances in the following figures indicate that they are statistically different from each other.

No statistically-significant difference was found between the detection distances of black and blue denim motorcycle riders in rural and urban environments by younger participants. There were also no statistically-significant differences between the detection distances of black and bright yellow riders in rural and urban driving environments by older participants.

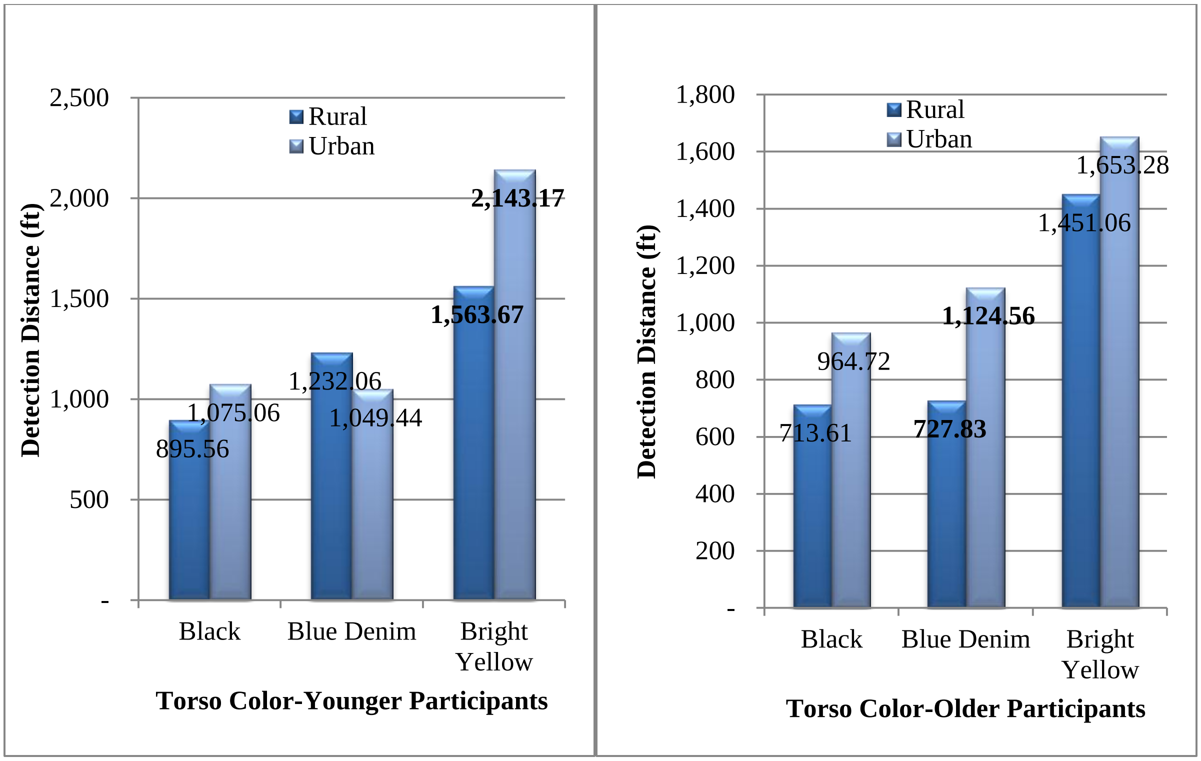

Figure 5.6. Detection distance as a function of the driving environment with bright yellow and blue denim riders for younger and older participants in rural and urban environments (means and standard error)

The analysis results also revealed a significant interaction effect between the driving environments and rider colors for younger and older participants (Figures 5.7 and 5.8). For older participants, the detection distance for motorcycles with a rider wearing a bright yellow color was greater than blue denim and black in a rural environment, $F(2, 33) = 29.216$, $p < 0.05$, partial $\eta^2 = 0.639$. The same was true in an urban environment $F(2, 33) = 5.263$, $p < 0.05$, partial $\eta^2 = 0.242$. However, the results did not indicate statistical significance in the difference between detection distances for black and blue denim colors in either rural or urban environments.

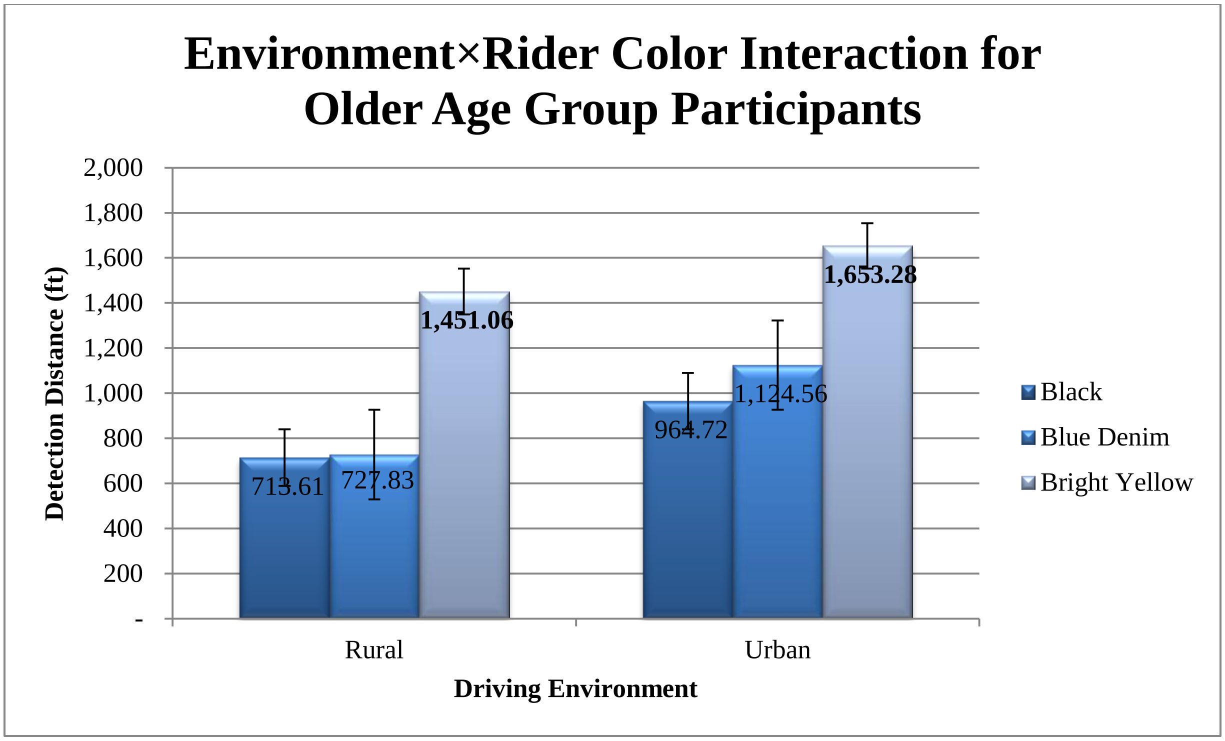

Figure 5.7. Detection distance as a function of rider color in rural and urban environments for older participants (means and standard error)

Finally, for younger participants, detection distance for motorcycles with riders wearing a blue denim color was greater than for black. Detection distance for motorcycles with riders wearing a bright yellow color was greater than those for black and blue denim in a rural environment, $F(2, 33) = 18.982$, $p < 0.05$, partial $\eta^2 = 0.535$.

For the urban environment, detection distance for motorcycles with riders wearing a bright yellow color was also greater than those for blue denim and black, $F(2, 33) = 14.772$, $p < 0.05$, partial $\eta^2 = 0.472$. The results did not indicate a significant difference between detection distances for black and blue denim riders in an urban environment. Figure 5.8 shows this interaction.

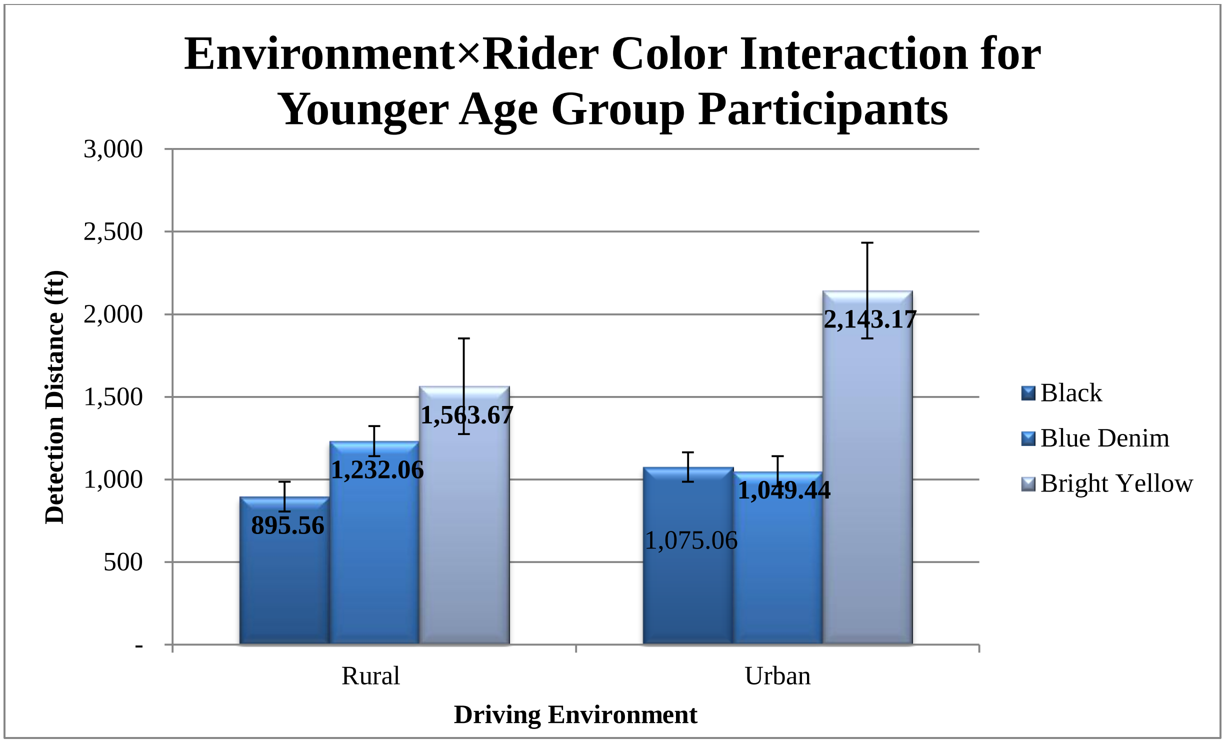

Figure 5.8. Detection distance as a function of rider color in rural and urban environments for younger participants (means and standard error)

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This research investigated the impact of motorcycle headlight configurations, rider colors, and age of the drivers (participants) on motorcycle conspicuity in simulated urban and rural environments. The recorded detection distances from the oncoming and leading motorcycles to the participant vehicles were used to analyze the simulator data. Motorcycles detected at greater distances by study participants were considered more conspicuous.

The GLM repeated measure analysis of variance was used to determine the effect of headlight configurations and rider clothing and helmet colors on the conspicuity of motorcycles in urban and rural environments to younger and older driver (participant) groups.

The analysis was conducted separately for oncoming and leading motorcycles. It must be noted that the implications of the detection distances reported in this study are relative rather than absolute as this study was conducted in a simulated environment.

Overall, the study results revealed that motorcycles with modulating headlights had longer detection distances than high beams or DRLs by both younger and older drivers in both urban and rural environments. The results also indicated that motorcycle riders wearing bright yellow clothing and helmets were detected at the longest distance by both younger and older drivers in both rural and urban environments.

6.1.1. For Oncoming Motorcycles

The analysis revealed a significant main effect for the headlight configurations (DRL, high beam, modulating) on detection distances. Motorcycles with modulating headlights were detected at the greatest distance and motorcycles with high beams were detected at a greater distance than motorcycle with DRLs by the study participants.

No significant main effect of the participant age groups on the detection distances was found. In addition, the driving environment (rural versus urban) did not have a significant main effect on the recorded detection distances.

A significant interaction between rider colors and headlight configurations was found. Participant ability to detect a motorcycle was significantly influenced by the headlight configurations when the motorcycles had black or bright yellow riders.

As expected, motorcycles with modulating headlights were detected at the greatest distance (compared to motorcycles with high beam and the DRL) for both cases where the riders had black and bright yellow rider colors.

6.1.2 For Leading Motorcycles

The analysis revealed a significant main effect for driving environment (rural versus urban) on detection distances. Motorcycles in urban environments were detected at a greater distance compared to those in rural environments.

The analysis results also revealed another main effect for rider color on the detection distances. As hypothesized, motorcycles with riders wearing blue denim were detected at a greater distance than those with riders wearing black. Motorcycles with riders wearing bright yellow were detected at the greatest distance by the study participants.

A significant interaction effect among the driving environment, rider color, and age group was also found for the leading motorcycles. Younger participants detected motorcycles with riders having bright colors (blue denim and bright yellow) at a greater distance than older participants in both urban and rural environments. So, it can be said that older participants might have more difficulty than younger participants in detecting leading motorcycles.

Furthermore, the researchers found that both younger and older participant groups detected motorcycles with riders having bright colors (blue denim and bright yellow) at a greater distance in the urban environment than in the rural environment. So, it can be concluded that on urban roads, where the background surrounding of the motorcycles is more complex and multi-colored, bright outfits can increase motorcycle conspicuity compared to black outfits.

6.2 Recommendations

In view of the analysis results, the following recommendations might be considered in implementing motorcycle conspicuity-related campaigns and interventions:

- The conspicuity of a motorcycle can be increased by using an appropriate rider outfit (bright) that distinguishes them from the surrounding background
- Using a modulating headlight on a motorcycle can increase the conspicuity of a motorcycle significantly, irrespective of the background environment
- Increasing the alertness and expectancy of drivers to the presence of motorcycles can increase conspicuity, as the study revealed that motorcycles were detected at greater distances in an urban environment compared to a rural environment
- Awareness programs targeted specifically to older drivers can be considered

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APPENDIX A. EXPERIMENTAL PROCEDURES

Experimental Procedures for the Motorcycle Conspicuity Study

The flow of the study is presented below. The document names are in bold.

Recruitment and Screening

- **Email Recruitment Script** will be sent to NADS volunteer database the University of Iowa students, faculty and staff, and a listserv managed by the College of Engineering
- **Telephone Screening Procedures** will be administered to those expressing interest in participation
  - Appointments for a study visit will be made for those who meet all inclusion and exclusion criteria.

Study Visit at NADS

- Briefing
  - Greet participants and introduce yourself
  - Summarize **Informed Consent** document verbally, encouraging participant to ask questions
  - Participant signs and dates **Informed Consent** document
  - NADS research assistant signs and dates **Informed Consent**
  - Participant signs the **Video Release Form**
  - Verify that participant has a valid driver's license
  - Participant fills out the **Payment Form**
  - Participant completes the **Driving Survey**
  - Participant completes a vision screening, using the **Vision Test Form** that includes:
    - Visual Acuity, Field of View and Colorblindness
  - Participant views the **Conspicuity Participant Training** PowerPoint slideshow
- Simulator Drives
  - Introduce simulator experimenter, who takes over at this point.
  - Escort participant to the simulator and allow him/her to be seated and fasten seatbelt
  - Show participant vehicle controls
  - Ask the participant if he/she has any questions.
  - Participants will complete 3 drives and the reaction time task the following order:
    - Familiarization drive
    - Reaction Time Task
    - Two study drives
  - After completing the Familiarization drive and the final study drive, administer the **Wellness Survey**
- Debriefing
  - Confirm participant has completed the second **Wellness Survey**
  - Offer participant snack/beverage
  - Participant completes **Motorcycle Conspicuity Factor Survey**
  - Participant completes the **Realism Survey**
  - Ask participant to read the **Debriefing Statement** and provide a copy for their records
  - If participant is not in NADS Volunteer Database, ask them to complete **Database Recruitment Form**
  - Review completed **Payment Form** with participant

Conclusion of participation

- Ask if participant has any questions.
- Participant is free to leave—escort him/her to entrance.

APPENDIX B. EMAIL SCRIPT

Email Script

Subject: Participants invited for driving study

THE
NATIONAL ADVANCED
DRIVING SIMULATOR

The National Advanced Driving Simulator at The University of Iowa Oakdale Campus is inviting adults to participate in a driving simulation research study evaluating awareness of driving environment.

Who can be part of this study?

- Adults ages 25-55 or 65 and over
- Have not participated in any driving simulation studies at the National Advanced Driving Simulator
- Able to attend 1 study visit up to two hours in length
- Do not have CDL or motorcycle endorsements on their driver's license

If you meet the above criteria and are interested in participating, please visit:

www.drivingstudies.com
Email: recruit@nads-sc.uiowa.edu
Call: 319-335-4719

If you do participate in the study, you will be paid for your time and effort. Even if you don't qualify to participate in this study, please forward this message to anyone you know who does!

APPENDIX C. TELEPHONE SCREENING PROCEDURES

Phone Screening Procedures

For a participant to be eligible for a study they must meet **ALL** of the following criteria:

- Be able to participate when the study is scheduled
- Meet all inclusion criteria
- Pass the phone health screening questions

Overview

The purpose of this research study is to evaluate procedures designed to understand drivers' awareness of the driving environment.

- **Study Information, Time Commitment and Compensation**:
  This study involves 1 study visit which will last approximately 1 - 2 hours in length. You will have to come to the University Research Park (formerly the Oakdale Campus) to participate.

  We ask that you not drink alcoholic beverages within 24 hours of this study visit. You will complete several questionnaires before and after your study drives. You will receive instructions regarding driving the simulator and the study drives at your visits.

  Compensation
  If you complete the study visit and procedures you will be paid $40 for your time and effort.
  If you withdraw from the study or your participation ends your compensation will be pro-rated: $5.00 for every 15 minutes of participation

  Are you still interested in participating?

  - If YES, continue with Inclusion Criteria
  - IF NO, ask if he/she would like us to keep him/her in our recruitment database for consideration of future participation.
    - IF NOT interested in future studies and wish to be removed from database
      - Make note regarding deletion
      - Reason if given

Inclusion Criteria ~ General Questions

Overview

Before this list of questions is administered, please communicate the following:

There are several criteria that must be met for participation in this study. I will need to ask you several questions to determine your eligibility. Before we begin, please have your driver's license available.

If a subject fails to meet one of the following criteria, proceed to Closing.

1) **Do you possess a valid U.S. Drivers' License and have been a licensed driver for two years?**
   -Must answer YES

2) **Please look at the back of your driver's license and read the class, endorsements and restrictions to me.**
   Note- the following are acceptable:
   - C non-commercial vehicle
   - Vision restriction, if vision is corrected to 20/20 with lenses
   Exclude:
   - Any commercial vehicle class
   - Motorcycle endorsements
   - Any restrictions, other than vision noted above

3) **Can you say that neither you nor any of your close family or friends drive a commercial vehicle or ride a motorcycle?**
   - Must answer YES

4) **Are you within the ages of 25-55, or 65 or over?**
   -Must answer YES

5) **Do you drive...**
   a. (persons age 25- 55) **at least 1,500 miles per year, but not more than 30,000 miles per year?**
   b. (persons over 65) **at least 700 miles per year, but not more than 15,000 miles per year?**
   -Must answer YES

6) **Do you drive <u>without</u> the help of special equipment such as pedal extensions, hand brake or throttle, spinner wheel knobs or other non-standard equipment? (no mechanical aid or use of prosthetic aid)**
   -Must answer YES

7) **Do you have normal or corrected to normal vision?**
   -Must answer YES

8) **Are you able to refrain from alcohol 24 hours before the day of the study visit?**
   -Must answer YES

9) **Would this be the first time you have participated in a driving simulator study?**
   (If NO to above)
   Where was the driving simulator located?
   -Exclude if the study was at NADS.

If General Inclusion Criteria are met – proceed to General Health Exclusion Criteria

General Health Exclusion Criteria

1.1.1 Overview

1.1.2 Before administering this list of questions, please communicate the following:

Because of pre-existing health conditions, some people are not eligible for participation in this study.
I need to ask you several health-related questions before you can be scheduled for a study session.
Your responses are voluntary and all answers are confidential.
You can refuse to answer any questions and only a record of your motion sickness susceptibility will be kept as part of this study.
No other responses will be kept.

- If a participant fails to meet one of the following criteria, proceed to the Closing (If unsure about exclusion criteria, consult Principal Investigator)

1) If the subject is female:
- **Are you, or is there any possibility that you are pregnant?**

Exclusion criteria:
- If there is ANY possibility of pregnancy

2) Have you been diagnosed with a serious illness?
- If YES, is the condition still active?
- Are there any lingering effects?
  - If YES, do you care to describe?

Exclusion criteria:
- Cancer (receiving any radiation and/or chemotherapy treatment within last 6 months)
- Crohn's disease
- Hodgkin's disease
- Parkinson's disease
- Currently receiving any radiation and/or chemotherapy treatment

3) Do you have Diabetes?
- Have you been diagnosed with hypoglycemia?
- If yes, do you take insulin or any other medication for blood sugar?

NOTE: Type II Diabetes accepted if controlled (medicated and under the supervision of physician)

Exclusion criteria:
- Type I Diabetes - insulin dependent
- Type II – **Uncontrolled** (see above)

4) Do you suffer from a heart condition such as disturbance of the heart rhythm or have you had a heart attack or a pacemaker implanted within the last 6 months?
- If YES, please describe?

Exclusion criteria:
- History of ventricular flutter or fibrillation
- Systole requiring cardio version (atrial fibrillation may be acceptable if heart rhythm is stable following medical treatment or pacemaker implants)

5) Have you ever suffered brain damage from a stroke, tumor, head injury, or infection? ➢ If YES, what are the resulting effects? ➢ Do you have an active tumor? ➢ Any visual loss, blurring or double vision? ➢ Any weakness, numbness, or funny feelings in the arms, legs or face? ➢ Any trouble swallowing or slurred speech? ➢ Any incoordination or loss of control? ➢ Any trouble walking, thinking, remembering, talking, or understanding?
Exclusion criteria: • A stroke within the past 6 months • An active tumor • Any symptoms still exist

6) Have you ever been diagnosed with seizures or epilepsy? ➢ If YES, how frequently and what type?
Exclusion criteria: • A seizure within the past 12 months

7) Do you have Ménière's Disease or any inner ear, dizziness, vertigo, hearing, or balance problems? ➢ Wear hearing aides - full correction with hearing aides acceptable ➢ If YES, please describe. ➢ **Ménière's Disease** is a problem in the inner ear that affects hearing and balance. Symptoms can be low- pitched roaring in the ear (tinnitus), hearing loss, which may be permanent or temporary, and vertigo. ➢ **Vertigo** is a feeling that you or your surroundings are moving when there is no actual movement, described as a feeling of spinning or whirling and can be sensations of falling or tilting. It may be difficult to walk or stand and you may lose your balance and fall.
Exclusion criteria: • Meniere's Disease • Any recent history of inner ear, dizziness, vertigo, or balance problems

8) Do you currently have a sleep disorder such as sleep apnea, narcolepsy or Chronic Fatigue Syndrome? ➢ If YES, please describe. ➢ Sleep apnea: how long under treatment and was treatment successful
Exclusion criteria: • Untreated sleep apnea • Narcolepsy • Chronic Fatigue Syndrome

9) Do you have migraine or tension headaches that require you to take medication daily? ➢ If YES, please describe.
Exclusion criteria: • Any narcotic medications

10) Do you currently have untreated depression, drug dependency, anxiety disorder, ADHD or claustrophobia?

- ➢ If YES, please describe.

Exclusion criteria:

- Untreated depression
- Agoraphobia, hyperventilation, or anxiety attacks
- ADHD (treated and untreated)
- Dependency or abuse of psychoactive drugs, illicit drugs, or alcohol

11) Are you currently taking any prescription or over the counter medications?

- ➢ If YES, what is the medication?
- ➢ Are there any warning labels on your medications, such as potential for stimulation or drowsiness?

Exclusion criteria:

- Sedating medications or drowsiness label on medication UNLESS potential participant indicates they have been on the medication consistency for the last 6 months AND states they have NO drowsiness effects from this medication
- Stimulant medication UNLESS potential participant indicates they have been on the medication consistency for the last 6 months AND states they have NO drowsiness effects from this medication

12) Do you experience any kind of motion sickness?

- ➢ If YES, what were the conditions you experienced: when occurred (age), what mode of transportation, (boat, plane, train, car), and what was the intensity of your motion sickness?
- ➢ On a scale of 0 to 10, **how often** do you experience motion sickness with **0 = Never and 10 = Always**
- ➢ On a scale of 0 to 10, **how severe** are the symptoms when you experience motion sickness with **0 = Minimal and 10 = Incapacitated**

Exclusion criteria:

- One single mode of transportation where intensity is high and present
- More than 2 to 3 episodes for mode of transportation where intensity is moderate or above
- Severity and susceptibility scores rank high

13) Have you experienced any pain from neck or back injuries within the last year?

- ➢ If YES, is it current or chronic neck or back injury?

Exclusion criteria:

- Any current skeletal, muscular or neurological problems in neck or back regions
- Chronic neck and back pain
- Pinched nerves in neck or back
- Back surgery within last year

Proceed to Closing

Closing

MEETS ALL CRITERIA

Instructions:

- Refrain from drinking alcohol and taking any **NEW** prescription or over the counter drugs for the 24 hours preceding your driving session. If you do need to take a new medication 24 hours preceding your driving session, please call us. Ibuprofen, regular Tylenol, aspirin, and vitamins are acceptable to take prior to driving session.

- Bring your Driver's License with you to your appointment.

- We ask that cell phones and pagers be turned off, left home or in your car outside as they are not allowed while participating in the driving study.

- Please wear flat shoes to drive in.

- No hats worn or gum chewing allowed while driving.

- Refrain from wearing artificial scents (perfume or cologne) as some staff allergic to scents.

- You will be required to wear a seat belt while driving.

- If your appointment is before 8am or after 5pm, the front door will be locked. Someone should be waiting for you in the lobby. If they have been momentarily delayed, please use the After Hours Call Box located at the right side on the front door. Press the call button and someone will let you in.

- If you are unable to make this appointment please call **(319) 335-4774** as soon as possible. We prefer 24 hours' notice, but would rather receive a last minute call than no call. Please leave a message if you reach voicemail and a staff member will return your call.

Provide directions, explain where to park and ask them to check in at the front desk inside the main entrance.

DOES NOT MEET CRITERIA:

- Inform participant that they may qualify for a future study and ask if they wish to remain in our database to be called for future studies.

- If participant is not in our database, ask if they would like to be considered for future driving research studies, if yes, fill out NADS database form.

APPENDIX D. INFORMED CONSENT DOCUMENT

FOR IRB USE ONLY
APPROVED BY: IRB-02
IRB ID #: 201104733
APPROVAL DATE: 12/08/11
EXPIRATION DATE: 05/19/12

INFORMED CONSENT DOCUMENT

Project Title: Awareness of Driving Environment

Principal Investigator: Dawn Marshall

Research Team Contact: Dawn Marshall 319-335-4774

This consent form describes the research study to help you decide if you want to participate. This form provides important information about what you will be asked to do during the study, about the risks and benefits of the study, and about your rights as a research subject.

- If you have any questions about or do not understand something in this form, you should ask the research team for more information.
- You should discuss your participation with anyone you choose such as family or friends.
- Do not agree to participate in this study unless the research team has answered your questions and you decide that you want to be part of this study.

WHAT IS THE PURPOSE OF THIS STUDY?

This is a research study. We are inviting you to participate in this research study because you are:

- between the ages of 25 and 55 or are at least 65 years old,
- are in good general health,
- have held a valid U.S. driver's license without commercial vehicle, motorcycle endorsements or restrictions other than corrective lenses for at least two years and
- drive at least 1,500, but not more than 30,000 miles per year if you are between the ages of 25 and 55 or at least 700, but not more than 15,000 miles per year if you are over the age of 64.

The purpose of this research study is to understand drivers' awareness of the driving environment. The goal is to determine what vehicle characteristics contribute to a driver's awareness of its presence.

HOW MANY PEOPLE WILL PARTICIPATE?

Approximately, 60people will take part in this study at the University of Iowa.

HOW LONG WILL I BE IN THIS STUDY?

If you agree to take part in this study, your involvement will last for 1 to 2 hours.

WHAT WILL HAPPEN DURING THIS STUDY?

Once you have agreed to take part in this study by signing this document, we will ask you to sign a video release form and a payment form. We will also confirm you have a valid U.S driver's license and have no commercial vehicle or motorcycle endorsements or restrictions other than a vision restriction. Then you will be asked to complete a questionnaire that asks for personal information including your gender, date of birth, age, student status, occupation, and contact information, driving experience and

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history, including violations and accidents. This questionnaire also asks about your motion sickness history, current medications and alcohol consumption in the past 24 hours and whether you have participated in other driving simulator studies and where those studies took place.

Next you will complete vision evaluations for acuity, field of view and colorblindness. You must have 20/40 visual acuity in at least one eye and no colorblindness. If you do not meet these criteria, your participation will in this study will end. The data collected to this point will be kept even if your participation does not continue and included in a summary describing the sample of people who were enrolled in this study. No video data will have been collected by this point in your participation.
If you are eligible to continue in the study, you will watch a PowerPoint presentation that describes the driving simulator, the study tasks and study drives. Any questions you have will be answered.

Prior to entering the simulator, temporary stickers will be applied to your face so that we may track your eye and head movements while you drive. These stickers are commercially manufactured and are the same type of stickers that are given to children at doctor's offices. The eye tracking cameras are mounted on the vehicle dashboard and will record your head and eye movements during the drive by following the movement of the stickers. If you are allergic to latex, please inform study staff and we will use temporary tattoos in place of stickers containing latex. If tattoos are used, a damp cloth will be pressed upon the tattoo that is applied to your face for about 30 seconds after which the damp cloth and tattoo backing will be removed leaving the tattoo. If tattoos are used instead of stickers, you will be asked to remove the tattoos before leaving, using your choice of several available over the counter cleansers. The stickers will be removed at the end of the study drives.

Then you will be escorted to the driving simulator and complete three drives and a reaction time task. The first drive will allow you become familiar with the driving simulator, will last six to ten minutes, and will be followed by the reaction time task. During the reaction time task you will press a button on the steering wheel when you see a vehicle appear on the screen in front of you. The two study drives will each be 20 to 30 minutes long. During each of these drives you will indicate when you notice specific vehicles by pressing the same button on the steering wheel you used during the reaction time task. You will be asked to complete a survey about how you feel after your familiarization drive and again after your last study drive.

When your simulator drives are done, you will be asked to complete two surveys; one about the visual appearance of vehicles and another about the realism of the driving simulator. Your payment voucher will be reviewed with you. Any questions you have about the study will be answered before the end of your visit.

You may skip any questions that you do not wish to answer on the questionnaires.

We will keep your name and information about you, including birth date and contact phone numbers on file so that in the future, we may contact you to see if you would be willing to complete questionnaires, interviews, or drives relating the data from this study to future studies. Agreeing to participate in this study does not obligate you to participate in future studies. If you are interested in participating in future studies we will ask you to complete a database recruitment form during your study visit or complete the same information online. You will be asked to give a separate consent for any future studies.

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Audio/Video Recording or Photographs

All driving trials will be recorded on video. The simulator contains sensors that measure vehicle operation, vehicle motion, and your driving actions. The system also contains video cameras that capture images of you while driving (e.g., driver's hand position on the steering wheel, forward road scene). These sensors and video cameras are located in such a manner that they will not affect you or obstruct your view while driving. The video cameras will record images that include your face. The information collected using these sensors and video cameras are recorded for analysis by research staff and may be used as described in the Confidentiality section below.

SOCIAL SECURITY NUMBER (SSN) USAGE

You will be asked to provide your social security number on a subject payment form that is sent to the University of Iowa Business Office. The collection of your social security number is necessary to process your payment. Your social security number will **not** be used for any purpose other than to process your payment. The collection of your social security number, **for research purposes other than payment**, is strictly optional and is not required for participation in the study.

______ I allow you to collect and use my social security number for the purposes outlined above.

______ I do NOT allow you to collect or use my social security number for the purposes outlined above.
(Initial your choice above)

WHAT ARE THE RISKS OF THIS STUDY?

You may experience one or more of the risks indicated below from being in this study. In addition to these, there may be other unknown risks, or risks that we did not anticipate, associated with being in this study.

The risk involving driving the simulator is possible discomfort associated with simulator disorientation. Previous studies with similar driving intensities and simulator setups produced few disorientation effects. When effects were reported, they were usually mild to moderate and consisted of slight uneasiness, warmth, or eyestrain for a small number of participants. These effects typically last for only a short time, usually 10-15 minutes, after leaving the simulator. You may quit driving at any time if you experience any discomfort.

If you ask to quit driving as a result of discomfort, you will be allowed to quit at once. If you ask to quit driving due to discomfort, you will be escorted to a room, asked to sit and rest, and offered a beverage and snack. A trained staff member will determine if and when you will be allowed to leave. If you show few or no signs of discomfort, you will be able to go home or transportation will be arranged if you feel you are unable to drive home. If you experience anything other than slight effects, a follow-up call will be made to you 24 hours later to ensure you're not feeling ill effects.

Risks associated with latex stickers can be dryness, itching, burning, scaling, and lesions of the skin, and mild discomfort when they are removed (similar to removing a bandage).

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Risks associated with temporary tattoos can be mild skin irritation during removal.

WHAT ARE THE BENEFITS OF THIS STUDY?

You will not benefit from being in this study. However, we hope that, in the future, other people might benefit from this study because understanding what vehicle characteristics help people notice them may lead to recommendations that help drivers have fewer crashes.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?

You will not have any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?

You will be paid for being in this research study. You will need to provide your social security number (SSN) in order for us to pay you. You may choose to participate without being paid if you do not wish to provide your social security number (SSN) for this purpose. You may also need to provide your address if a check will be mailed to you. If your social security number is obtained for payment purposes only, it will not be retained for research purposes.

If you agree to participate in this study, you will be paid $40 if you complete all study visits and procedures. If you withdraw or your participation ends, your compensation will be pro-rated at $5 for every 15 minutes of participation.

WHO IS FUNDING THIS STUDY?

The Iowa Department of Transportation and the Midwest Transportation Consortium are funding this research study. This means that the University of Iowa is receiving payments from The Iowa Department of Transportation and the Midwest Transportation Consortium to support the activities that are required to conduct the study. No one on the research team will receive a direct payment or increase in salary from The Iowa Department of Transportation or the Midwest Transportation Consortium for conducting this study.

WHAT ABOUT CONFIDENTIALITY?

We will keep your participation in this research study confidential to the extent described in this document and permitted by law. However, it is possible that other people such as those indicated below may become aware of your participation in this study and may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

- federal government regulatory agencies,
- auditing departments of the University of Iowa, and
- the University of Iowa Institutional Review Board (a committee that reviews and approves research studies)

To help protect your confidentiality, you will be assigned a study number which will be used instead of

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your name to identify all data collected for the study. The list linking your study number and your name will be stored in a secure location and will be accessible only to the researchers at the University of Iowa. All records and data containing confidential information will be maintained in locked offices or on secure password protected computer systems that are accessible to the researchers, the study sponsor, and its agents. It is possible that persons viewing the video data may be able to identify you.

The **engineering data** collected and recorded in this study (including any performance scores based on these data) will be analyzed along with data gathered from other participants. These data may be publicly released in final reports or other publications or media for scientific (e.g., professional society meetings), regulatory (e.g., to assist in regulating devices), educational (e.g., educational campaigns for members of the general public), outreach (e.g., nationally televised programs highlighting traffic safety issues), legislative (e.g., data provided to the U.S. Congress to assist with law-making activities), or research purposes (e.g., comparison analyses with data from other studies). Engineering data may also be released individually or in summary with that of other participants, but will not be presented publicly in a way that permits personal identification, except when presented in conjunction with video data.

The **video data** (video image data recorded during your drive) recorded in this study includes your video-recorded likeness and all in-vehicle audio including your voice (and may include, in some views, superimposed performance information). Video and in-vehicle sounds will be used to examine your driving performance and other task performance while driving. Video image data (in continuous video or still formats) and associated audio data may be publicly released, either separately or in association with the appropriate engineering data for scientific, regulatory, educational, outreach, legislative, or research purposes (as noted above).

The **simulator data** is captured and stored on hard drives located within a limited access area of the NADS facility. Access to simulator data is controlled through permissions established on a per-study basis.

If we write a report or article about this study or share the study data set with others, we will do so in such a way that you cannot be directly identified.

IS BEING IN THIS STUDY VOLUNTARY?

Taking part in this research study is completely voluntary. You may choose not to take part at all. If you decide to be in this study, you may stop participating at any time. If you decide not to be in this study, or if you stop participating at any time, you won't be penalized or lose any benefits for which you otherwise qualify.

Can Someone Else End my Participation in this Study?

Under certain circumstances, the researchers might decide to end your participation in this research study earlier than planned. This might happen because you drink alcohol within the 24 hours to your study visit, you do not meet the vision requirements, or if you fail to operate the research vehicle in accordance with the instructions provided or if there are technical difficulties with the driving simulator.

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WHAT IF I HAVE QUESTIONS?

We encourage you to ask questions. If you have any questions about the research study itself, please contact: Dawn Marshall at 319-335-4774. If you experience a research-related injury, please contact Dawn Marshall at 319-335-4774.

If you have questions, concerns, or complaints about your rights as a research subject or about research related injury, please contact the Human Subjects Office, 105 Hardin Library for the Health Sciences, 600 Newton Rd, The University of Iowa, Iowa City, IA 52242-1098, (319) 335-6564, or e-mail irb@uiowa.edu. General information about being a research subject can be found by clicking "Info for Public" on the Human Subjects Office web site, http://research.uiowa.edu/hso. To offer input about your experiences as a research subject or to speak to someone other than the research staff, call the Human Subjects Office at the number above.

This Informed Consent Document is not a contract. It is a written explanation of what will happen during the study if you decide to participate. You are not waiving any legal rights by signing this Informed Consent Document. Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Subject's Name (printed): ____

Do not sign this form if today's date is on or after **EXPIRATION DATE: 05/19/12** .

_______________________________ _______________________
(Signature of Subject) (Date)

Statement of Person Who Obtained Consent

I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative. It is my opinion that the subject understands the risks, benefits, and procedures involved with participation in this research study.

_______________________________ _______________________
(Signature of Person who Obtained Consent) (Date)

APPENDIX E. DRIVING SURVEY

Driving Survey

As part of this study, it is useful to collect information describing each participant. The following questions ask about you and your health, your driving patterns, and your alcohol consumption. Please read each question carefully. If something is unclear, ask the researcher for help. Your participation is voluntary and you have the right to omit questions if you choose. Please remember that all of your answers will be kept confidential.

Background Information

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

2) What age are you today? __________

3) What is your gender?

- ❒ Male
- ❒ Female

4) What is your marital status? (Check only one)

- ❒ Single, never married
- ❒ Married
- ❒ Domestic Partnership
- ❒ Separated or Divorced
- ❒ Widowed

5) What was your total household income last year? (Check only one)

- ❒ $0- $24,999
- ❒ $25,000- $29,999
- ❒ $30,000 - $34,999
- ❒ $35,000 - $39,999
- ❒ $40,000 - $49,999
- ❒ $50,000 - $59,999
- ❒ $60,000 - $69,999
- ❒ $70,000 - $79,999
- ❒ $80,000 - $89,999
- ❒ $90,000 - $99,999
- ❒ $100,000 or more

6) What is your present employment status? (Check only one)

- ❒ Unemployed
- ❒ Retired
- ❒ Work part-time
- ❒ Work full-time
- ❒ None of the above

7) What type of work do you do (e.g., teacher, homemaker)? ______________________________

Continue to next page.

1

8) Of which ethnic origin(s) do you consider yourself? (Check all that apply)

- ❒ American Indian/Alaska Native
- ❒ Asian
- ❒ Black/African American
- ❒ Hispanic/Latino
- ❒ Native Hawaiian/Other Pacific Islander
- ❒ White/Caucasian
- ❒ Other

9) What is the highest level of education that you have completed? (Check only one)

- ❒ Primary School
- ❒ High School Diploma or equivalent
- ❒ Technical School or equivalent
- ❒ Some College or University
- ❒ Associate's Degree
- ❒ Bachelor's Degree
- ❒ Some Graduate or Professional School
- ❒ Graduate or Professional Degree

Driving Experience

10) How old were you when you started to drive? ________ years of age

11) For which of the following do you currently hold a valid driver's license within the United States? (Check all that apply)

	Vehicle Type	Year When FIRST Licensed (May be Approximate)
❒	Passenger Vehicle License	___ ___ ___ ___
❒	Commercial Truck License	___ ___ ___ ___
❒	Motorcycle License	___ ___ ___ ___
❒	Other: ____________________	___ ___ ___ ___
❒	Other: ____________________	___ ___ ___ ___

12) How often do you drive? (Check the most appropriate category)

- ❒ Less than once weekly
- ❒ At least once weekly
- ❒ At least once daily

13) Approximately how many miles do you drive per year in each vehicle type, excluding miles driven for work-related activities? (Check only one for each vehicle)

Car	Motorcycle	Truck	Other: ____________
❑Do not drive	❑Do not drive	❑Do not drive	❑Do not drive
❑Under 2,000	❑Under 2,000	❑Under 2,000	❑Under 2,000
❑2,000 - 7,999	❑2,000 - 7,999	❑2,000 - 7,999	❑2,000 - 7,999
❑8,000 - 12,999	❑8,000 - 12,999	❑8,000 - 12,999	❑8,000 - 12,999
❑13,000 - 19,999	❑13,000 - 19,999	❑13,000 - 19,999	❑13,000 - 19,999
❑20,000 or more	❑20,000 or more	❑20,000 or more	❑20,000 or more

14) Is any driving you do work-related? (Check only one)

❒ No (Go to question# 15)
❒ Yes (please complete question 17a below)

14a) How many work-related miles do you drive per year? (Check only one)
❒ Under 2,000
❒ 2,000 - 7,999
❒ 8,000 - 12,999
❒ 13,000 - 19,999
❒ 20,000 or more

15) How frequently do you drive in the following environments? (Check only one for each environment)

	Never	Yearly	Monthly	Weekly	Daily
Residential	❒	❒	❒	❒	❒
Business District	❒	❒	❒	❒	❒
Rural Highway (e.g., Route 6)	❒	❒	❒	❒	❒
Interstate (e.g., Interstate 80)	❒	❒	❒	❒	❒
Gravel Roads	❒	❒	❒	❒	❒

16) Have you ever had to participate in any driver improvement courses due to moving violations?

❒ No
❒ Yes (Please describe) ____________________

17) When driving, how frequently do you perform each of the following tasks/maneuvers?

(Check the most appropriate answer for each task/maneuver)

	Never	Rarely	Occasionally	Frequently	Always	Not Applicable
Change lanes on Interstate or freeway	❒	❒	❒	❒	❒	❒
Keep up with traffic in town	❒	❒	❒	❒	❒	❒
Keep up with traffic on two-lane highway	❒	❒	❒	❒	❒	❒
Keep up with traffic on Interstate or freeway	❒	❒	❒	❒	❒	❒
Pass other cars on Interstate or freeway	❒	❒	❒	❒	❒	❒
Exceed speed limit	❒	❒	❒	❒	❒	❒
Wear a safety belt	❒	❒	❒	❒	❒	❒
Make left turns at uncontrolled intersections	❒	❒	❒	❒	❒	❒

Continue to next page.

18) How comfortable do you feel when you drive in the following conditions or perform the following maneuvers? (Check the most appropriate answer for each condition)

	Very Uncomfortable	Slightly Uncomfortable	Slightly Comfortable	Very Comfortable	Not Applicable
Highway/freeway	❐	❐	❐	❐	❐
After drinking alcohol	❐	❐	❐	❐	❐
With children	❐	❐	❐	❐	❐
High-density traffic	❐	❐	❐	❐	❐
Passing other cars	❐	❐	❐	❐	❐
Changing lanes	❐	❐	❐	❐	❐
Making left turns at uncontrolled intersections	❐	❐	❐	❐	❐

Violations

19) Within the past five years, how many tickets have you received for the following? (Please check a response for each ticket)

	0	1	2	3+
Speeding	❐	❐	❐	❐
Going too slowly	❐	❐	❐	❐
Failure to yield right of way	❐	❐	❐	❐
Disobeying traffic lights	❐	❐	❐	❐
Disobeying traffic signs	❐	❐	❐	❐
Improper passing	❐	❐	❐	❐
Improper turning	❐	❐	❐	❐
Reckless driving	❐	❐	❐	❐
Following another car too closely	❐	❐	❐	❐
Operating While Intoxicated (OWI) or Driving Under the influence (DUI)	❐	❐	❐	❐
Other (please specify **type** and **frequency** of violation) ________________				

Accidents

20) In the past five years, how many times have you been the driver of a car involved in an accident?

❐ 0 (Go to question # 29 on page 7)
❐ 1
❐ 2
❐ 3
❐ 4 or more

Please provide information for each accident on the next page.

Accident 1

Was another vehicle involved?	❒ No	❒ Yes
Was a pedestrian involved?	❒ No	❒ Yes
Were you largely responsible for this accident?	❒ No	❒ Yes
Did you go to driver's rehabilitation?	❒ No	❒ Yes
Weather Condition: ______________________	Month/Year: ______________________	
Description: ____		

Accident 2

Was another vehicle involved?	❒ No	❒ Yes
Was a pedestrian involved?	❒ No	❒ Yes
Were you largely responsible for this accident?	❒ No	❒ Yes
Did you go to driver's rehabilitation?	❒ No	❒ Yes
Weather Condition: ______________________	Month/Year: ______________________	
Description: ____		

Accident 3

Was another vehicle involved?	❒ No	❒ Yes
Was a pedestrian involved?	❒ No	❒ Yes
Were you largely responsible for this accident?	❒ No	❒ Yes
Did you go to driver's rehabilitation?	❒ No	❒ Yes
Weather Condition: ______________________	Month/Year: ______________________	
Description: ____		

Continue to next page.

Health Status

21) How often do you experience motion sickness? (Circle only one)

0	1	2	3	4	5	6	7	8	9	10
Never										Always

22) How severe are your symptoms when you experience motion sickness (Circle only one)

0	1	2	3	4	5	6	7	8	9	10
None										Severe

23) Have you taken any medication in the past 48 hours? (Check only one)

❒ No
❒ Yes (Please list all) ____

____

24) Have you consumed any alcohol or other drugs in the past 24 hours?

❒ No
❒ Yes (Please list all) ____

____

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APPENDIX F. VISION TEST FORM

VISION SCREENING RECORD FORM

IDOTMC

Subject Number   Subject Initials   Date __ / __ / __   Study

This screening is used to test your field of view. The exam will be administered for each eye separately, beginning with your right eye.

Control Panel Setup:

- ☐ RIGHT Eye
- ☐ FAR
- ☐ SLIDE #1

✓ **NOTE TO EXPERIMENTER: LIGHTS WILL APPEAR ON THE EYE BEING TESTED**

Instructions to Participant:

1. Look at the center of the slide. A small flashing light will appear to the left or to the right. Please tell me when you see the light and indicate which side. (***Press NASAL button for three seconds or until you get a response and circle 45 if seen 0 if not seen***). Person must see nasal to pass.

If they could not see and are wearing glasses, the temple piece may obstruct their view. Have them remove glasses and repeat step 1.

2. Continue to look at the center of the slide. A small flashing light will appear to the left or to the right. Tell me when you see a light and indicate which side. ***Press 55° button for 3 seconds or until you receive a response. SCORE: circle 55 if correct or 0 if incorrect under the appropriate eye***
3. Tell me when you see a light and indicate which side. ***Press 70° button for 3 seconds or until you receive a response. SCORE: circle 70 if correct or 0 if incorrect under the appropriate eye***
4. Tell me when you see a light and indicate which side. ***Press 85° button for three seconds or until you receive a response. SCORE: circle 85 if correct or 0 if incorrect under the appropriate eye***

✓ **Switch to Left eye and repeat procedure**

RIGHT EYE	LEFT EYE
NASAL 45 / 0	NASAL 45 / 0
55 / 0	55 / 0
70 / 0	70 / 0
85 / 0	85 /0

Scoring: Sum of the highest RIGHT and highest LEFT temporal readings (55, 70, and 80)

VISUAL FIELD OF VIEW: ____________

VISION SCREENING RECORD FORM

☐☐☐ ☐☐ / ☐☐ / ☐☐ **IDOTMC**

Subject Number | Subject Initials | Date | Study

This screening is used to test how well you see at a distance. The exam will be administered for both eyes simultaneously.

Control Panel Setup:

- ☐ RIGHT Eye
- ☐ LEFT Eye
- ☐ FAR
- ☐ SLIDE #3

Participant Instructions:

1. **Please look at the numbers on the screen by pressing the bar with your forehead. Do you see three columns of numbers?**
   - ☐ YES *(Move onto question 2)*
   - ☐ NO *(Ensure control panel is set up and forehead is pressed against black bar – green ready light appears on control panel. If set up properly and you can see lines, turn off left then right on control panel to make certain subject can see in both eyes.)*

2. **Please read the numbers on line 7 from left to right.** 2 9 8 6 5   3 5 2 6 9   6 5 3 8 2
   - ☐ ≤ 2 missed/any group record a vision of 20/20 below.
   - ☐ > 2 missed in any group go to question 3.

3. **Please read the numbers on line 6 from left to right.** 3 2 5 9 6   6 8 3 5 2   8 2 6 3 5
   - ☐ ≤ 2 missed/any group record a vision of 20/30 below.
   - ☐ > 2 missed in any group go to question 4.

4. **Please read the numbers on line 5 from left to right.** 5 8 6 9   2 6 8 3   9 5 3 2
   - ☐ ≤ 2 missed/any group record a vision of 20/40 below.
   - ☐ > 2 missed in any group go to question 5.

5. **Please read the numbers on line 4 from left to right.** 9 2 8 6   5 9 6 3   2 8 5 9
   - ☐ ≤ 2 missed/any group record a vision of 20/50 below.
   - ☐ > 2 missed in any group go to question 6.

6. **Please read the numbers on line 3 from left to right.** 5 3 6 2   9 8 5 6   2 3 6 5
   - ☐ ≤ 1 missed/any group record a vision of 20/70 below.
   - ☐ > 1 missed in any group go to question 7.

7. **Please read the numbers on line 2 from left to right.** 8 5 2   3 9 5   6 2 8
   - ☐ ≤ 1 missed/any group record a vision of 20/100 below.
   - ☐ > 1 missed in any group

Far Visual Acuity Reading: ☐☐ / ☐☐

VISION SCREENING RECORD FORM

Subject Number	Subject Initials	Date	Study
	☐☐☐	☐☐/☐☐/☐☐	IDOTMC

This screening tests your ability to distinguish between various colors such as red/green and blue/yellow. The screening will be administered for both eyes simultaneously.

Control Panel Setup:

- ☐ RIGHT Eye
- ☐ LEFT Eye
- ☐ FAR
- ☐ SLIDE #5

Participant Instructions:

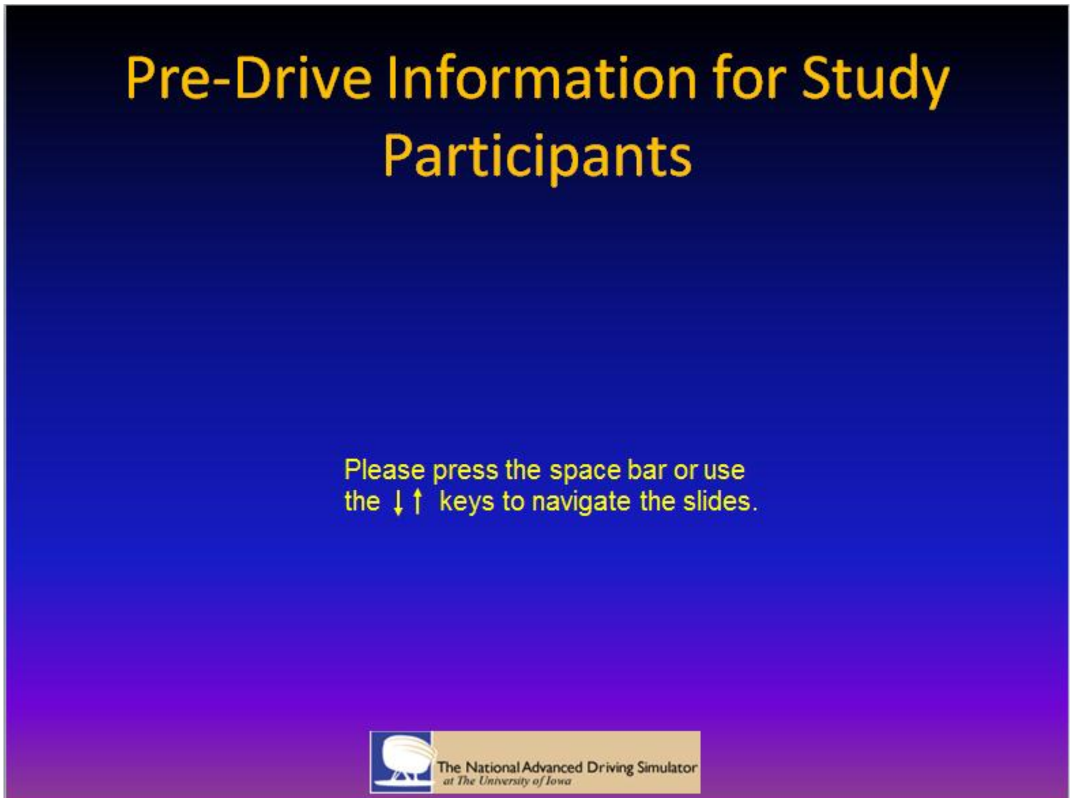
1. **Please look at the circles on the screen by pressing the bar with your forehead. Do you see six circles?**
   - ☐ YES *(Move onto question 2)*
   - ☐ NO *(Ensure control panel is set up and forehead is pressed against black bar – green ready light appears on control panel. If set up properly and you can see lines, turn off left then right on control panel to make certain subject can see in both eyes.)*

2. **Please read the digits in each circle starting with Circle A and ending with Circle F.** ***(Record the responses below).***

CIRCLE	NUMBER	RESPONSE
A	12	☐☐
B	5	☐
C	26	☐☐
D	6	☐
E	16	☐☐
F	Blank	______

Total # Digits Correct (not including blank): ☐

APPENDIX G. PARTICIPANT TRAINING



Driver Tasks

During your drives you will be asked to do the following:

- Press a button with a finger of your right hand
- Indicate when you first notice specific vehicles
- Complete a questionnaire

The following slides will explain more about these items.

The National Advanced Driving Simulator at The University of Iowa

Pressing the Button

You will need to press the button installed on the RIGHT side of the steering wheel

- during the reaction time test and
- when you first notice one of the specified vehicles

The button is located on the back side of the steering wheel.

Press the button only once for each vehicle.

The button will beep when you press it.

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Vehicle Recognition

During the main drives, there will be many vehicles. You will indicate when you first notice any of the three vehicles below. These vehicles may be present one or more times during your drive and may be different colors than shown below.
Please press the button when you first notice any of these vehicles. Then say the type of vehicle out loud.

Pick-up

Motorcycle

Heavy Truck

Examples of the vehicles

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at The University of Iowa

Driving

Driving the Jeep is very much like driving any other vehicle with an automatic transmission. The gear selector lever is in the center console. It requires you to depress a button on the left side of the handle with your thumb in order to shift the lever.

To begin driving, press on the brake, shift into “D” for DRIVE, then press on the accelerator.

To end a drive, brake to a complete stop, and when the speedometer is at “zero”, shift into “P” for PARK, then assume the resting position.

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at The University of Iowa

Adjustments

When you are escorted to the simulator room a researcher will help you into the Jeep. Once you are seated, please adjust the seat and the steering wheel so you are in a comfortable driving position. Once adjusted, please fasten your seatbelt.

Seat adjustment controls

Seatback angle lever

Steering wheel tilt lever

You'll be shown the button once you are situated.

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Mirrors

There is no need to adjust any side or rearview mirrors for the drive today. They will not be used.

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Resting Position

Once you are buckled in, please sit in what we call the “resting position”, which is with your hands off of the steering wheel, and your feet off of the pedals. *[please click on picture at right]*

You will then be asked to face forward so the eye cameras can be aligned. After alignment, the researcher will close the cab door and turn off the room lights.

Demonstration of resting position

The National Advanced Driving Simulator
at The University of Iowa

Eye Tracking

Eye tracking uses two box-shaped cameras (A & B) mounted on the dash. The cameras will map your eye movements during your drives.

A researcher will guide you through the eye tracking calibration using the cab intercom.

Calibration is an automatic process. You should face straight ahead and a picture will be taken. It takes only a short time afterward to get the cameras calibrated.

You’ll then be asked to look at a few landmark points and eye tracking will be finished.

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at The University of Iowa

Familiarization Drive

Once eye tracking calibration is finished, you will hear instructions for your first drive. This drive is designed to help you get used to the simulator. You will be able to practice steering and braking.

You will be driving on city streets and a rural highway.

During the familiarization drive you will have the opportunity to detect the vehicles you were shown earlier. Remember to press the button when you first notice any of these vehicles. At the moment you first notice one of the vehicles, press the button and say the type of vehicle out loud.

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Questionnaire

After driving the first practice drive, you will be given a survey that determines how compatible you are with the simulator. A researcher will ask you to consider 17 different items and record your responses on the survey. Your answers will apply to how you feel immediately after the drive. The four options for each item are: None, Slight, Moderate or Severe.

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Reaction Time Test

You will not drive during the reaction time test.

The object of this test is to determine how fast you can press the button when a vehicle appears.

During the reaction time test, a series of vehicles will appear on the screen ahead of you. At the first moment you can see the vehicle, press the button then state the type of vehicle out loud. The vehicle will disappear when you press the button and before another vehicle appears.

When told to begin, position your finger near the button and wait for the first vehicle to appear.

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Main Study Drives

You will drive two main study drives. A pre-recorded instruction will be played before each drive and there is time to ask questions before you begin driving. During each drive you will encounter several vehicles. As described earlier, each time you notice one of the vehicles you were shown press the button and state the type of vehicle out loud.

You will be driving on city streets and a two-lane country road. Each drive will last approximately 20 minutes.

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Intercom System

The cab has an intercom system which allows the researchers to hear you at all times. It has already been adjusted for the drives today. If for any reason you want to stop driving, please tell us. The operator will hear you and can end the drive in just a few seconds.

The driving instructions and the end-of-the-drive instructions will also play through the intercom system.

If you happen to accidentally press the button at the wrong time, please advise the researcher of this. Also, please advise if you forget to press or inadvertently delayed your response on the button.

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Conclusion

This slide concludes the briefing presentation for your drives today. The researcher will be happy to answer any questions about the study that you may have at this time.

Three stickers for eye tracking will be placed on your face while you wait.

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APPENDIX H. MOTORCYCLE CONSPICUITY-RELATED FACTORS SURVEY

Motorcycle Conspicuity Related Factors

Please read each question carefully. If something is unclear, ask the researcher for help. Your participation is voluntary and you have the right to omit questions if you choose.

1) In your opinion, how helpful is it for you as a driver to see the motorcyclists on the road when they do the following?

A) Use a white helmet

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

B) Use a bright colored helmet

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

C) Use a fluorescent/ reflective safety vest?

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

D) Use a bright colored jacket

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

E) Use daytime running lights?

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

Continue to next page.

F) Use a modulating headlamp

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

G) Use hand signals

☐ Very Unhelpful	☐ Somewhat Unhelpful	☐ Neither Helpful or Unhelpful	☐ Somewhat Helpful	☐ Very Helpful

APPENDIX I. DEBRIEFING STATEMENT

Debriefing Statement

Thank you so much for participating in this study. Your participation was very valuable to us.

In this study, we were interested in understanding what makes motorcycles more easily seen by drivers. We couldn't tell you this because we didn't want you to pay more attention to motorcycles than other vehicles while you were driving.

For this reason, it is important that participants remain unaware of that our focus is motorcycles until after they have completed their drives. We need you to keep secret that we are focusing on motorcycles from people who may be in the study in the future. To this end, we ask that you not discuss any of the details of the study until April.