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During and After Event Analysis of Cell Phone Talking and Texting-A Driving Simulator Study

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DURING AND AFTER EVENT ANALYSIS OF CELL PHONE TALKING AND TEXTING - A DRIVING SIMULATOR STUDY

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Science

in

The Department of Civil and Environmental Engineering

by

Raju Thapa
B.Eng. (Civil), IOE, Western Region Campus, 2006
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# TABLE OF CONTENTS

ACKNOWLEDGEMENTS ............................................................................................................. ii

LIST OF TABLES ...................................................................................................................... v

LIST OF FIGURES ................................................................................................................... vi

ABSTRACT ................................................................................................................................ viii

CHAPTER 1. INTRODUCTION ................................................................................................ 1
  1.1 Definition of Driver Distraction ......................................................................................... 1
  1.2 Problem Statement ........................................................................................................... 4
  1.3 Research Objectives ......................................................................................................... 4
  1.4 Scope .................................................................................................................................. 5
  1.5 Thesis Outline .................................................................................................................... 5

CHAPTER 2. LITERATURE REVIEW ......................................................................................... 6
  2.1 Background ....................................................................................................................... 6
  2.2 Cell Phone Texting and Distraction .................................................................................. 7
  2.3 Cell Phone Conversation and Distraction ........................................................................ 10
  2.4 Cell Phone Usage and Pedestrians .................................................................................. 13

CHAPTER 3. METHODOLOGY ............................................................................................... 14
  3.1 Participants ....................................................................................................................... 14
  3.2 Equipment ......................................................................................................................... 14
    3.2.1 SimCreator .................................................................................................................... 15
    3.2.2 SimVista ....................................................................................................................... 16
    3.2.3 SimObserver ............................................................................................................... 16
    3.2.4 Data Distillery ............................................................................................................. 17
  3.3 Driving Scenario .............................................................................................................. 18
  3.4 Anxiety Level of Participants ........................................................................................... 20
  3.5 Experimental Design ......................................................................................................... 21
  3.6 Procedure .......................................................................................................................... 22

CHAPTER 4. DATA COLLECTION ........................................................................................... 25

CHAPTER 5. STATISTICAL ANALYSIS .................................................................................. 29
  5.1 Post-Task / Reporting of the difficulty level of task ......................................................... 29
  5.2 Main Event ....................................................................................................................... 31
    5.2.1 Phone conversation event ............................................................................................. 32
    5.2.2 Texting event ................................................................................................................ 33
  5.3. Post Event Analysis .......................................................................................................... 33
    5.3.1 Post-phone conversation event ..................................................................................... 35
    5.3.2 Post-texting event .......................................................................................................... 36
  5.4 Comparison of During and Post Event Level of Distraction ............................................. 38
LIST OF TABLES

Table 1. Summary of the statistical analysis for the main event .............................................. 33
Table 2. Relation between variables (Velocity and Lane Position).............................................. 40
Table 3. Statistical analysis within different factors affecting post event .................................... 43
Table 4. Pairwise comparison among groups during the main event of texting ......................... 44
Table 5. Pairwise comparison among groups during the post event of texting ............................ 45
Table 6. Summary analysis of duration of post event effect in three different groups ................. 46
LIST OF FIGURES

Figure 1. Internal sources of distraction ................................................................. 2
Figure 2. External sources of distraction ................................................................. 3
Figure 3: Different forms of distraction ................................................................. 3
Figure 4. The LSU Driving Simulator ................................................................. 15
Figure 5. Interface used for the operation of driving simulator .................................. 16
Figure 6. Different sections in a driving route (overhead structures, ramp to freeway, straight, curvilinear) ................................................................. 19
Figure 7. Different driving environments ............................................................... 19
Figure 8. Scores of state and trait anxiety level of each participant .............................. 20
Figure 9. Profile plot of velocity of Participants 37 and 44 ........................................ 23
Figure 10. Different positions of camera ............................................................... 24
Figure 11. Effect of Phone Conversation on Mean Velocity for Participants 2 and 12 .......... 26
Figure 12. Effect of Texting on Mean Velocity for Participants 7 and 9 .......................... 27
Figure 13. Effect of Phone Conversation on Lane Position for Participants 10 and 12. .......... 28
Figure 14. Effect of Texting on Lane Position for Participants 18 and 20. ......................... 28
Figure 15. Overall ranking of the tasks based on difficulty level ................................... 30
Figure 16. Trend plot for difference in Mean Velocity ................................................ 31
Figure 17. Trend plot for difference in Lane Position ............................................... 32
Figure 18. Duration of post event effect of cell phone conversation ............................. 35
Figure 19. Descriptive analysis of post-event effect duration of Phone Conversation .......... 36
Figure 20. Duration of post event of texting ........................................................... 37
Figure 21. Descriptive analysis of post-event effect duration of Texting ......................... 38
Figure 22. Groups mean effects for main and post events .......................................... 39
Figure 23. Level of distraction during main event (texting) and for three seconds after texting . 39
Figure 24. Duration of post event effect (in descending order).............................................. 41
Figure 25. Effect of time of day and age on the duration of post event effect ......................... 42
Figure 26. Effect of weather on the duration of post event effect ........................................... 42
Figure 27. Sample size calculation using G-power 3.1 statistical software.............................. 46
ABSTRACT

A number of studies have been done in the field of driver distraction, specifically on the use of cell phone for either conversation or texting while driving. However, till now, researchers have focused on the driving performance of drivers when they were actually engaged in the task, i.e. during the texting or phone conversation event. The primary objective of this study is to analyze the post event effect of cell phone usage in order to verify whether the distracting effect lingers on after the actual event had ceased. The research utilizes a driving simulator study of thirty-six participants to test whether a significant decrease in driver performance occurs during and after cell phone usage (texting and conversation). The standard deviations of lane position and mean velocity was used as dependent measures to represent lateral and longitudinal control of the vehicle respectively. Linear mixed model with subject as a random factor and F-test for the equality of variance were used as statistical measures. The results from the study suggest that there was no significant decrease in driver performance during and after the cell phone conversation both laterally and longitudinally. On the contrary, during the texting event, a significant decrease in driver performance was observed both in the lateral and longitudinal control of the vehicle. The diminishing effect of texting on longitudinal control ceased immediately after the texting event but the diminishing effect of texting on lateral control lingered on for an average of 3.388 seconds. The number of text messages exchanged did not affect the magnitude and duration of the diminished lateral control. This indicates that the distraction and subsequent elevated crash risk of texting while driving linger on even after the texting event has ceased. Such finding has safety and policy implications in the fight to reduce distracted driving.
CHAPTER 1. INTRODUCTION

1.1 Definition of Driver Distraction

Different definitions of distraction have been developed (Tasca, 2005). It can be defined in terms of inattention, fatigue, attraction, demand and control. Inattention can be classified as distraction and drowsiness (Wilmot et al., 2005). Treat, (1980) defined distraction as a kind of inattention when drivers fail to respond to the events which are critical to safe driving. Research study found out that one night sleep deprivation can cause drowsiness and has a negative effect on the visual field missing a lot of signals (Roge et al, 2003). In terms of fatigue, it may arise due to excessive driving which results in the increment in reaction time and unstable driving performance (Ting et al., 2008). Distraction may also result due to tasks that drivers do which are not primarily related to the main driving task that shifts the drivers’ attention away from the task of driving (Patten et al., 2004). Moreover, distraction occurs as a result of a mismatch between the demand of the roadway and the demand of the competing activities (Regan et al., 2009). In normal driving conditions, the attention devoted by drivers is mostly greater than the attention demanded by the roadway, which implies safe driving condition. Conversely, in distraction the drivers have to react with the demand from the competing activities and from the driving task. If the resulting demand is greater than the capacity of the driver then distraction occurs (Lee et al., 2013). Driving task can also be defined as the combination of three different types of controls: operational, tactical and strategic control (Milchon, 1985). Operation control deals with the longitudinal and lateral control of the vehicle along with the resource investment (operation of the driving task). Tactical control deals with the choice of lane and speed while strategic control deals with the decision regarding the routes and the travel patterns, and control exposure to the potentially demanding situation. Distraction occurs when there is breakdown in any of these
three controls (Lee & Strayer, 2004). In an attempt to agree on an operational definition for driver distraction, a study conducted by Foley et al., (2013) concluded that driver distraction could best be defined as “the diversion of attention away from activities critical for safe driving toward a competing activity, which may result in insufficient or no attention to activities critical for safe driving”. The use of cell phone during driving, either for texting or conversation has been acknowledged by several studies to be a significant competing activity to many drivers, resulting in higher crash risk potential (Distraction.gov).

According to the report from World Health Organization on mobile phone usage, its sources can be categorized as the sources within the vehicle and outside the vehicle. Figure 1 and Figure 2 show some typical example of different sources of distraction seen in our daily lives.

a) Sources within the vehicle/ Internal source of distraction:

Various examples of internal sources of distraction are texting, cell phone conversation, audiovisual-entertaining system, navigation system and communication system, eating, drinking, radio tuning, conversing with the passenger, singing etc. Figure 21 shows some of the internal sources of distraction such as cell phone texting, conversation and musical devices.

Figure 1. Internal sources of distraction

b) Sources outside the vehicle/ External source of distraction:

Outside sources of distraction could be signs on the road, crash scenes, advertising billboard, natural scenery etc. Figure 2 shows some of the external sources of distraction like back mirror light, hoarding board and adverse environment such as wind, fog.
According to Governors Highway Safety Association (GHSA), (2011), which is also responsible for the implementation of the programs related to impaired driving, there are four different types of distraction:

- Visual: looking at something other than the road
- Auditory: hearing something not related to driving
- Manual: manipulating something other than the wheel
- Cognitive: thinking about something other than the driving

Figure 3 shows the three different forms of distraction. As texting is associated with all three forms of distraction, it is considered more dangerous (3 types of distracted driving /www.esurance.com).

(Extracted from: http://www.esurance.com/safety/3-types-of-distracted-driving)
1.2 Problem Statement

Numerous research studies have measured the distraction potential of different types of distraction sources while driving. Most of the studies have regarded the use of cell phone as a major source of distraction while driving with a higher potential of crash risk. Owing to this reason, 41 states including District of Columbia have banned cell phone texting during driving and 12 U.S. states prohibits all handheld cell phone conversation while driving. Due to the high crash rate associated with the use of cell phone while driving, researchers have done many studies on the impact of cell phone usage on driving performance. In addition, studies have been done on the effect of cell phone usage on pedestrian safety. All related studies to date have only focused on the driving performance of the driver while the task (phone conversation or texting) is being performed. However, it is still unknown whether the impact of cell phone usage ceases immediately after the end of the task. Therefore, the main objective of the study is to find out the post event effect of cell phone usage on driving performance.

1.3 Research Objectives

The main objective of this study is to find a post event distracting effect of cell phone texting and cell phone conversation on driving performance. If there is a post event distracting effect, then the research study examines the duration of the post event effect after the main event. The study also differentiates the level of distraction during the main event with the experienced post event. Further, the research is also designed to find the influence of duration of the main event on the level of the distraction. Regarding the duration of post event, the study investigates the effect of duration of main event on the post event duration. The study also aims to find different factors affecting the post event duration.
1.4 Scope

The study was limited to the use of the driving simulator at Louisiana State University to measure the post event duration of cell phone usage. Experimental work was conducted with the simulator using human subjects as drivers. Volunteers were sought from the LSU community of students and staff members and the general public to participate in the experimental work.

1.5 Thesis Outline

The first chapter includes the basic definition of distraction from different perspective, its sources, problem statement and objectives of the research.

Chapter 2 provides the summary of the various research studies on cell phone usage and distraction. The overall research is divided into three different headings: texting and distraction, phone conversation and distraction, and cell phone usage and pedestrians.

Chapter 3 describes the main experiment, methodology, driving scenario and overall design of the experiment.

Chapter 4 discusses the variables used for the analysis and the management of raw data from the driving simulator experiment which will be used for the statistical analysis.

Chapter 5 contains the statistical analysis of the study for both main and post event. A comparison was also be made between those two events. It also discusses the calculation of total sample size required for the post event effect analysis. G-power test was used for the calculation.

Chapter 6 includes the overall summary and the conclusion of study. Finally, Chapter 7 describes the possible future researches that can be conducted on post event. Appendix provides some relevant documents used for the experiment.
CHAPTER 2. LITERATURE REVIEW

2.1 Background

Currently, 41 U.S. states, the District of Columbia and the Virgin Islands and Guam have banned texting while driving. In addition, 12 U.S. states, the District of Columbia, the Virgin Islands and Guam have prohibited the use of all hand-held cell phone use while driving (GHSA, http://www.ghsa.org/html/stateinfo/laws/cellphone_laws.html). This legislation is the result of several studies that have found a high crash rate associated with cell phone use while driving. Even so, 9 U.S. states continue to allow texting behind the wheel, and 38 U.S. states continue to allow some form of cell phone use behind the wheel. According to the United States Department of Transportation (USDOT), 3,331 people died in 2011 and 387,000 people were injured in motor vehicle crashes involving a distracted driver, compared to 3,267 people killed and 416,000 injured in 2010 (Distraction.gov). The use of cell phones and other electronic devices has been acknowledged to be one of the leading causes of distracted driving, with an estimated 660,000 drivers involved in such activity while driving at any given moment in the United States (Pickrell & Ye, 2013). Though the percentage of drivers using handheld cell phone remained constant at 6% from year 2009 to 2011, the percentage of drivers texting while driving or visibly manipulating handheld devices increased from 0.6 to 1.3 % at the same time period (Driver electronic device use in 2010). Several studies have attempted to find the negative impacts of cell phone usage on driving performance. Caird et al., (2008) found the reaction time of the driver increased by 0.25 second in all types of phone related tasks such as cell phone conversation and texting (messaging). The use of cell phone was also found to be associated with an increased crash risk potential (McAvoy, 2006; Redelmeier & Tibshirani, 1997; Schattlet et al., 2006) and was also further supported by Sullivan & Tijerina, (2012), who explored the driving report of
survey of National Highway Traffic Safety Administration (NHTSA) conducted in 2009. A total of 995 cell phone fatalities were studied in depth to find the effect of cell phone usage. The study also found different fatal traffic accidents resulting due to cell phone usage. The distraction by cell phone usage was predominant among younger group of drivers. In 2011, NHTSA conducted a survey among 6000 drivers above the age of 18 in all 50 states and the District of Columbia. The survey found that younger drivers between the ages of 18 to 20 reported the highest level of crash and near crash experience.

The cell phones are integrated with various types of application. However, most of the studies conducted on cell phone usage till now have focused their research on the primary use of the cell phone (cell phone talking and texting) and its effect on the driving performance.

2.2 Cell Phone Texting and Distraction

Of the various types of distraction, cell phone texting is considered to have the highest level of distraction potential (Ranney et al., 2011). Texting involves an extra mental effort, longer glances away from the road, and higher wheel position variance. These variables have a greater effect especially during the process of sending a message, as compared to receiving a message (Owens et al., 2011). According to Drews et al.,(2009), while texting drivers prefer to increase the headway with a leading vehicle and departs off regularly from the lane. They found only one collision during single task (driving only) driving whereas six out of the seven participants collided while texting and driving. The study was conducted in a simulating environment and emphasized the potential of distraction while drivers were both driving and texting. Many researcher studies found an increment in the reaction time of the driver while texting (Anderson et al., 2012, Burge & Chaparro, 2012). Texting is also associated with greater variability in the lane position and speed (Reed & Robbins, 2008). Research studies have also
found differences in driving performance during texting using two different interfaces; touch screen interface and hard button interface. Ranney et al., (2011) used low fidelity simulator to find the effect of texting using two such interfaces. A total of 100 participants between age 25 and 64 drove in the low fidelity driving simulator and texted using touch screen (i-phone, android) and hard button interface (blackberry). They found that texting has a highest potential of distraction. Comparatively, touch screen interface was found to affect the driving performance more than the hard button interface. Similarly, Crandall & Chaparro, (2012) found that effect of texting using touch screen interface was more in compared to the texting with physical keypad. They also concluded that participants texting using touch screen interface was found to make eleven times more text input errors than texting using physical keypads. Further, participants reported higher mental and physical workload when using touchscreen than using the physical keyboard. However, Alosco et al., (2012) concluded no significant difference between texting with hard bottom interface and touch screen interface. Research used a total of 186 participants in the Kent Multidimensional Assessment Driving Simulator where each participant had to do texting in the simulated driving condition. The multivariate analysis of variance (MANOVA) resulted no significant difference in the driver performance between hard button keypad (QWERT t-phone) and touch screen interface. The research study also found the act of copying the text message in the touch screen interface during driving to be less distracting than alphabetizing the text (putting text message into the alphabetical order) (Burge & Chaparro, 2012). The study used copying a text message as a low cognitive load task in compared to alphabetizing the text.

The act of texting involves three different tasks: receiving the text message, sending the text message and both receiving and sending the text message. Researchers have attempted to
differentiate the effect of these different tasks on the driving performance. Young et al., (2006) studied the effect of text driving on young novice drivers between the age of 18 and 21. The experiment had a total of twenty participants, all of whom had a driver’s license issued less than six months from the test. Each participant was required to drive in two simulated driving conditions. In the first condition, the drivers were required to send and receive a text message while driving whereas in the other driving condition, the driver was only required to drive. A mixed model 2 x 2 repeated measures analysis of variance (ANOVA) test was then performed to find the effect of texting. Their results and analysis showed the task of sending text message to be detrimental to driving such as the inability to maintain a lateral position, detection of hazards (parked vehicles, pedestrians and turning cars), and response time to the traffic signs, as compared to receiving a text message. This was because sending text message requires higher mental demanding and longer glances away from the roadway than receiving text message (Owens et al., 2011). This study was further supported by a survey conducted in New Zealand where 1057 drivers were questioned regarding receiving and sending text message while driving and whether or not it affected their driving. Out of the 1057 respondents, 89% of the driver responded that driving performance was affected by texting, and sending text message was found to be more distracting than reading a text message (Hallett et al., 2012). However, Yager et al., (2012) found the similar impairments in the driving performance during both reading and writing text message in QWERTY keyboard mobile phone (mobile phone with physical keyboard). Rudin-Brown et al., (2013) performed a study on the effect of text messaging inside a tunnel. For this study, the researchers used a Monash University Accident Research Centre (MUARC) advanced driving simulator to assess the effect of texting inside the tunnel. The study had twenty-four participants between the age of 25 and 50 years who were considered to be the
“regular users of text messaging services”. For the test, each participant had to drive twice with each drive of 7 km and two text messages was sent to each participant during the test drive. In the first drive, the participant had to read the text message aloud whereas in the second the drive the participant had to read aloud the text message and reply afterwards. The different driving performance parameters such as speed, speed variability, standard deviation of lane positioning, driver visual behavior were analyzed using two way (2 x 3) repeated measures ANOVA. The result showed the task of both reading and writing the text messages to be distracting to the drivers in both tunnel and freeway environments. In addition, the participants performing text-messages tasks inside the tunnel had a tendency to drive slower and deviate inside the lane.

2.3 Cell Phone Conversation and Distraction

Cell phone conversation is another distracting source for a driver. Despite the negative impact in the driving performance, most of the drivers were found to be engaged in cell phone conversation even when the flow was uninterrupted (Singh, 2010). Strayer et al., (2004) used a total of 64 participants in a driving simulator to find the effect of cell phone conversation on driving performance. Each participant had to drive two times during the test. The first task involved driving only condition whereas the second task involved driving accompanied by a phone conversation. ANOVA was then utilized to analyze the data. The result showed cell phone conversation to increase the potential of crash risk. According to this study, during a cell phone conversation while driving, the driver fails to see the object in front though they seem to be looking ahead. It is also because cell phone conversation can decrease the perceptual visual field and makes driver less aware with the surrounding environment (Maples et al., 2008). Some other researchers have attempted to study the effect of easy and difficult phone conversation on the driving performance. The studies have found the intensity of the conversation to have no
significant impact on the driving performance, however, cell phone conversation was found to be detrimental to driving (Rakauskas et al., 2004). However, the study by Dula et al., (2011) resulted in a significant effect of intensity of the phone conversation (emotional conversation) on driving performance. They studied the effect of different levels of phone conversation on the driving performance. Participants were randomly assigned into three different types of phone call scenarios: no call, mundane call and intense or emotional call. A multivariate analysis of variance showed that the effect of call condition was significant in terms of speed occurrence, percentage of time speeding, center line crossing and collision. It was further supported by Briggs et al., (2011). They attempted to study the effect of emotional phone conversation and the level of distraction it causes. A total of 64 participants had to drive in two driving conditions. In the first condition, the driver drove undistracted (drove in silence) whereas during the second condition, the driver conversed about spiders while driving. Spider phobic questionnaire was also executed before doing test in the simulator to find the phobic and non-phobic state of the individual. It was concluded that spider phobic group made more number of driving errors showing that they were more distracted than the non-phobic group. Other than the intensity, timing of the conversation while driving has also been found to affect the speed of the vehicle. In 1996, Violanti & Marshall did case control studies over 100 drivers who were involved in accidents in past two years and another 100 drivers who were not involved in any type of accident for past 10 years to find the association of cell phone usage with its crash risk. The result showed that cell phone talking for more than 50 minutes a month increase the collision risk by about 5.59 times in comparison to the drivers not using the cell phone at all. Rosenbloom, (2006) found an effect of duration of call on the driving performance and found that for a short conversation (less than 11 minutes) speed decreased at the time of conversation whereas the
speed increased during a long conversation (over 16 minutes). Different from the other research studies, a study by Holland & Rathod, (2013) found that even if the driver is ignoring a call the driving performance is affected due to the attention diverted by the ringtone and the intention to receive the call. Surprisingly, their study showed that the lower the intention of the driver to ignore the call had a greater distracting effect on the driver. The study also found exceeding the speed limit, pedestrian collision, and vehicle collisions were significantly greater when distracted by the caller tones than with no distractions. However, the limitation of this study was that the participants were asked for their phone number before the experiment suggesting the driver might have been aware of receiving a phone call and might even have contemplated one.

However, Green et al., (1993) found that cell phone conversation as no more a distracting source at all. They used car phone which is similar to a handheld phone device to find the effect of phone task (dialing and conversation) on the driving performance. They concluded that lateral position of the vehicle was unaffected by cell phone conversation. Further, speed during the car phone task was lower than base line (driving with no task) but the overall effect in terms of speed was not significant. Several others have also found hands-free cell phone conversation to have no significant effect on driver performance during driving (Alm & Nilsson, 1995; Beede & Kass, 2006; Briem & Hedman., 1995; Parkes & Hooijmeijer, 2001; Tornos & Bolling, 2005). Alm et al., (1995) found no significant distracting effect in the lateral position of the vehicle while Beede et al., (2006) found no significant effect on the speed of the vehicle during the hands free conversation. Research studies also found that both hands free and handheld cell phone conversation produce similar level of decrements in the driving performance (Consiglio et al., 2003; Redelmeier & Tibshirani, 1997; Strayer & Johnston, 2001). Yet still, a recent study by Fitch et al., (2013) concluded that neither handheld or hands free conversation increased the risk
of crash. However, Kircher et al., (2003) found a significant decrement in the lateral position variance during the hands free cell phone conversation while for handheld phone mode it was non-significant. The result from their study is different from the findings from the previous research studies in terms of the distracting effect of handheld and hands free cell phone conversation. This may explain why there is no consistency among different U.S. states in legislation governing cell phone use during driving.

2.4 Cell Phone Usage and Pedestrians

Researchers have also found the negative impact of cell phone conversation and texting on pedestrian safety. According to different studies (Hatfield & Murphy, 2007; Neider et al., 2010), for the pedestrians crossing the road conversing on a cell phone, safety can be an issue. To find the effect of cell phone usage on pedestrian safety, Schwebel et al., (2012) used 138 college students including 88 women between age 17 to 45 and randomly categorized them into four different groups depending upon the task while crossing the road: crossing while texting, crossing while talking on the phone, crossing while undistracted and crossing while listening to music. Parameters measured were named as average time left to spare, look left and light, look away, hit by the vehicle while crossing and missed opportunities. All these parameters were computed to measure the distraction of pedestrian while crossing. They finally concluded “texting group experienced more hits than the undistracted participants did, but that the phone conversing group did not”. Participants in all three distracted group: crossing while texting, crossing while talking on the phone and crossing while listening to music, were likely to look away from the street during crossing. It suggests that both texting and phone conversation have negative impact on the pedestrians safety.
CHAPTER 3. METHODOLOGY

This chapter outlines the general description of methods used for the entire experiment. Initially, it describes the participants used for the experiment. It is followed by the description of the LSU driving simulator used for the main experiment. The driving scenarios used for the experiment is also described in detail. In addition, the chapter discusses the detail procedure of assessing the anxiety level of each participants and experimental design set up for the study. Finally, the chapter presents the different sections of the experiment and its details.

3.1 Participants

A total of thirty six participants from Louisiana State University (LSU); six females and thirty males with an average age of 28.44 years (standard deviation of 9.26 years) participated in the study. Overall 42 were recruited but 6 were unable to fully participate because of simulator sickness. All participants were in general health with normal or corrected visual acuity, were active driver with a valid driver’s license, and had experience using cell phone for texting and having conversation while driving. They were recruited using flyers on university bulletin boards and in accordance with the university’s Institutional Review Board’s (IRB) standards.

3.2 Equipment

Participants were tested in the LSU driving simulator, a full-sized passenger car (Ford Fusion but with no wheels) combined with a series of cameras, four projectors (rear, front, right side and left side projections) and screens to provide a high fidelity virtual environment. Some of the features of the driving simulator include the Internet Scene Assembler, used for modification of the virtual environment; and Sim-Observer, integrated with the virtual environment and used for data and video synchronization, video capture and after-action review. Figure 4 shows pictures of one side of the LSU driving simulator and some of its series of computer screens. The
first two computers on the left side were used to run the simulator and edit the model, while the remaining two on right hand side were used to extract the data and video clips of the main driving experiment.

![Simulator setup](image)

(a) Desktop computers  (b) Ford Fusion simulator cab

Figure 4. The LSU Driving Simulator.

Also, there are four accompanying softwares within the driving simulator as well as an audio software and hardware so that the participant can drive with engine sound, tire sound and noise from the vehicle. The four softwares are:

1. SimCreator
2. SimVista
3. Sim-Observer
4. Data Distillery

3.2.1 SimCreator

SimCreator is used for graphical simulation and as a modeling system. Different components are connected with each other to make a model. Each component can either be a group of different component or a C/C++ code component. But generally standards within the driving simulator itself can be used to make a model. A model in a SimCreator is itself a component as it can be added to another component to make a new model. After the model is prepared, it should be saved, loaded, compiled and run. The Sims Creator model has an
extension of “.cmp”. Figure 5 shows the interface for the operation of the driving simulator from where different Sim-creator file (.cmp file) can be selected.

![SimCreator Interface](image)

Figure 5. Interface used for the operation of driving simulator

### 3.2.2 SimVista

The SimVista is a scenario development tool and is used to create different driving simulation environment. It is integrated with the Internet Scene Assembler (ISA) to create this environment and environment was created under the metric unit of system. Therefore, an output of any variable is in metric unit. For example, speed is expressed in meter per second (m/s) and acceleration in meter per second squared (m/s²). In this software the scenario script language is a JavaScript based language. Once a scene is created in ISA it should be published to be used in the simulation model. After publishing, the scene will be saved as a released object (.VRML file) which cannot be further modified. In order to modify the object it must be saved as a different file before publishing.

### 3.2.3 SimObserver

SimObserver is a software used to capture video from the camera and which then compresses it into an MPEG-2 format at 30 fps capturing rate. The video from the camera
displays the activity of the participants for different driving scenarios and based on the activities of driver, the main event is finally separated from the post event. Whenever the main experiment is running, it should be turned on in the screen to record all the activities and data from the simulated driving. The SimObserver is controlled by the SimObserver computer and the output files of it are as follows:

a. Video file (MPEG-2 format): The format of the file is in “.mpg file”. This file contains the video of the entire experiment after it starts recording the data. The video is used to determine the length of road over which different tasks are performed.

b. Log file: The format of this file is in “.log file” and includes the system messages, errors and warnings.

c. Event file: The format of this file is in “.vt file”. It contains a start time, stop time and it labels all the events logged during the video capture.

d. DAT file in the form of video CD movie: The format of this file is in “.dat file”. It is the main data file used for the measurement of driving performance. Data are categorized into different columns. Some of the variables in the DAT file are longitudinal acceleration, lateral acceleration, throttle, and headway distance.

3.2.4 Data Distillery

Data Distillery is a data review and reduction software package. The main purpose of this tool is to improve the efficiency of data reduction. The tool is also used for compiling the captured video and data from the SimObserver. Data Distillery provides fine details of the collected data to understand the nature of the behavior or system being observed. The log file, video file and the data file are all be displayed on the same screen. It also can be utilized to find position of the vehicle along with the number of lane exceedences.
3.3 Driving Scenario

The driving scenarios used for the experiment consisted of a four lane divided roadway section with two-way traffic in each of the two lanes. The roadway included all necessary features of an interstate highway system such as exits, speed limit sign and other necessary traffic signals along the roadway with a paved shoulder on the side of the road. Most of the sections of the road were straight with few flat horizontal curves. The gradient of the alignment was almost horizontal. Pedestrian movement was not considered for the experiment. Figure 6 shows the different sections of the whole route used for the experiment. As shown in figure, the roadside features included green landscape with some restaurants and gas stations placed along the route and without high-rise buildings and traffic lights. The topographical feature of the scenario was designed to maintain the sight distance requirement and the minimum sight distance required for a certain speed limit was maintained all over the loop. During the entire experiment, participants were prohibited from taking an exit. They were required to drive on the right lane of the roadway following the leading vehicle. The speed of the leading vehicle was controlled by the simulator software and always maintained higher than the test vehicle. In addition, the test vehicle was not allowed to pass the leading vehicle throughout the experiment is due to selection of the dependent variables (standard deviation of Lane Offset and Mean Velocity) used for the statistical analysis. Further, while driving participants were not allowed to perform any other additional activities, such as drinking water and conversing with the researcher about the test. In the same driving conditions, there are different driving environments; like snow, fog and rain with both day and night conditions used for the experiment. Figure 7 shows the snapshots of different driving environments. Each participant
had to randomly draw cards to select the driving scenario. For all of the driving scenarios, the design of the texting and phone conversation was uniform for the same group of participants.

Figure 6. Different sections in a driving route (overhead structures, ramp to freeway, straight, curvilinear)

Figure 7. Different driving environments
3.4 Anxiety Level of Participants

Anxiety levels of participants were assessed using the State-Trait Anxiety Inventory Form Y questionnaire (Spielberger et al., 1970) which was administered just before the test. The questionnaire, designed to measure an individual’s current psychological state by differentiating between temporary emotional states versus long-standing personality trait anxiety, scores a participant across a range of 20 to 80, with higher scores indicating greater anxiety. Participants having score within that range were only used for the experiment. State anxiety tells about the anxiety level at the time of event while trait anxiety deals with the anxiety level of the general characteristics of a person. Twenty questions were used to measure the state anxiety level while another twenty sets were used to measure the trait level. Each question was rated on four point scale as almost never, sometimes, often and almost always. Figure 8 shows the state and trait anxiety level of all the thirty six participants.

![Graph of State and Trait Anxiety Level](image_url)

**Figure 8.** Scores of state and trait anxiety level of each participant
Because research (Queensland University of Technology Center, 2013) suggests anxious drivers are unable to fully focus their attention on the road especially when distracted, this questionnaire was used as a screening tool to help improve the accuracy of the experiment findings. Scores for all participants ranged from 20 to 54. Hence, all the participants were included in the experiment. Figure 8 shows that the state and trait anxiety level of all participants which ranges between 20 and 54 and assumed to be acceptable for the real simulator test.

3.5 Experimental Design

The experiment was designed as a 3 x 3 repeated measure design with duration of the event as a between-subject factor (three levels), and event as a within-subject factor (three levels comprising no-distraction, phone conversation, and texting). Each of the thirty six participants performed all the three events i.e. no-distraction, phone conversation and texting under identical traffic conditions. However, for the duration of the phone conversation event, eleven participants were engaged for 90 seconds (group A), thirteen participants for 150 seconds (group B), and twelve participants for 210 seconds (group C). Similarly, for the texting event eleven participants were asked to respond to a single text message (group A), thirteen participants (group B) were engaged in a back-and-forth texting that required them to read and respond to four text messages, and lastly twelve participants had to read and respond to seven text messages (group C). It was assumed that the number of text messages exchanged was directly proportional to the duration of the texting event. For both the phone conversation and texting events, data were collected during the main event and a full minute after the event for the post event. For the no-distraction drive, data was collected for a duration based on a judgment on the typical duration for the other events. During the experiment, participants used their own handheld cell phone for texting and conversation. A transcript of text messages sent to participants were included in Appendix 2.


### 3.6 Procedure

The first part of the experiment is termed “the pre-event” stage. Upon arrival at the driving simulator lab, participants were briefed on the experiment and asked to review the university’s IRB approved consent sheet before signing it. This was then followed by the State-Trait Anxiety Inventory Form Y questionnaire test to screen out participants with higher than normal anxiety levels. Participants were then asked to randomly arrange a selection of cards to determine the event order for their experiment i.e. the order of the control, handheld phone conversation, or texting drives. Each participant was then allowed to practice with the driving simulator until such time that they became familiar with the controls and its operation. This ended the pre-event stage.

The second part of the experiment is termed “the main event” stage and this is when the actual test was administered. Participants were asked to drive as they would normally on their way to work or college but to always stay in the right-lane, avoid changing lanes or overtaking, and maintain a consistent following distance that they considered as safe. The other vehicles in the simulated environment drove at about 65 mph speeds, which was the posted speed limit. The profile plot of the velocity of participants thirty seven and forty-four during texting and phone conversation is shown in Figure 9. It shows the profile plot of velocity for about five minutes of driving with task condition and few seconds after the main event. As mean velocity was considered as a measure of driving performance, the main objective of velocity plot is to observe the effect of leading vehicle on the test vehicle. As the curve looks smooth, it shows that there was no significant disturbance of other vehicles on the test vehicle. Participants were asked to use their own cell phones (all had touch-pad surfaces) for the texting and phone conversation events. For the text messaging event, the task began as soon as participants picked up their
phones to retrieve the first text message. Participants were asked to read the texts and respond accordingly. After responding to the last text message, participants had to return the phone to its original location, an empty space near the cup holder compartment in the vehicle. A copy of the text messages that were sent to each group has been included in Appendix 3. For the handheld phone conversation event, participants were asked to retrieve and dial a pre-arranged contact name from their address book. They were specifically instructed to utilize their phone’s contact feature to access the stored name and call this person. Participants had to briefly explain the experiment they were involved in to the contact at the other end. Data collection for both main events (text messaging and phone conversation) began when participants picked their phones and ended when the phone was returned to its original location. For the no-distraction event, participants were not asked to undertake any tasks. Data collection for the main event began when participants began to drive and ended when enough data had been collected that spanned the data points collected for the other drives to allow direct comparisons.

![Profile of Velocity](image)

**Figure 9.** Profile plot of velocity of Participants 37 and 44.
The third part of the experiment is termed “the post event” stage and is defined as the time period immediately after the end of the main event. For both the texting and phone conversation events, data collection for the post event began after participants had returned the phone to the original position and ended after a full minute. For the no-distraction event, data was collected for a duration based on a judgment on the typical duration for the texting and phone conversation.

Participants were then thanked for their time and participation and escorted out of the experimentation lab. That concluded a participant’s involvement in the experiment. The longest drive was during the phone conversation task for Group C, spanning about 5 minutes for both the main and post event data collection. The average time for a participant to complete the entire experimental procedure was 45 minutes. Within this duration, participant completed all afore mentioned three different parts of an experiment. Figure 10 shows the placement of four different cameras used to determine the beginning and end point of the main event. All the activities (visual and manual) of participants were monitored during the entire test using all the cameras.

Figure 10. Different positions of camera
CHAPTER 4. DATA COLLECTION

Some previous studies have used Lane Position variability (Caird et al., 2008; Drews et al., 2009; Holland & Rathod, 2013; Tornros & Bolling, 2005) and average speed (Rakauskas et al., 2009; Schattlet et al., 2006; Tornros & Bolling, 2005) as dependent variables in distracted driving studies. For this study, velocity and lane position were initially chosen. Velocity was measured in meter per second and reflected the speed with which a participant drove. It was chosen to represent longitudinal control of the vehicle. Lane Position can be defined as the position of the vehicle measured from the center of the road, in meters. A positive number indicates a vehicle on the right side of the center line while a negative number indicates a vehicle on the left. It was used to represent the lateral control of the vehicle. Data were collected on these two dependent variables at a frequency of 60 Hz through the Sims-Observer proprietary software of the driving simulator. This resulted in repeated observations taken at different time points along the route for each participant and for each factor. Each of the two variables was then summarized for each participant in order to obtain a single value for each measured variable for each subject. For velocity, the mean value was chosen while for lane position, the standard deviation was chosen. The resulting derived dataset contained thirty six rows of observations, one row for each of the thirty six participants, with each row containing the participant’s identity number, the participant’s standard deviation of lane position, and mean of the participant’s velocity for each event, i.e. no-distraction, phone conversation, and texting. The six derived variables were as follows:

- $\sigma_{LP,PC}$ = standard deviation of Lane Position during the phone conversation event
- $\sigma_{LP,XT}$ = standard deviation of Lane Position during the texting event
- $\sigma_{LP,ND}$ = standard deviation of Lane Position during the no-distraction event
• $\bar{V}_{V,PC} =$ mean Velocity during the Phone conversation event

• $\bar{V}_{V,TXT} =$ mean Velocity during the texting event

• $\bar{V}_{V,ND} =$ mean Velocity during the no-distraction event

Figure 11 and Figure 12 show the effect of phone conversation and texting on the mean velocity for four participants. On the x-axis, the value zero denotes the main event (either texting or phone conversation) while the subsequent numbers i.e. 1 through 10 denote the time in seconds after the main event. “With” refers to the driver performing a particular task (either phone conversation or texting) while “without” shows the normal or control driving condition (without using task). The one-second interval was chosen because the driving simulator is able to provide 60 data points during a one second interval, and this sample size was considered sufficient to allow a time-step analysis to check for evidence of lingering distraction. The figures show that generally, the mean Velocity decreases for participants as they become distracted or perform task during the experiment. It is also noted that there is a slight decrease in the mean Velocity from completion of the main event (time = 0 second), to the subsequent times (time = 1 to 10 seconds after the event) which might be due to the lingering main event effect.

Figure 11. Effect of Phone Conversation on Mean Velocity for Participants 2 and 12
Figure 12. Effect of Texting on Mean Velocity for Participants 7 and 9

Figure 13 and Figure 14 show that the standard deviation of lane position remains larger for participants when they are distracted, and remains particularly higher for the texting event than for the phone conversation event. The figures also show the sudden drop in the lane position variable after the main event ceases (after time = 0). It was also noted that contrary to what was expected, the sudden drop after the end of the main task remained consistent for the no-distraction drives. This could be explained by the fact that there will be expected lesser variability is expected in one-second worth of data for the post event than in the 150 seconds worth of data for the main events. It can be seen that as more time elapses after the completion of the main event, drivers regain lateral control of the vehicle, and the Lane Position plots for the no-distraction and event drives become identical.

In addition to the derived dataset of the six original variables (i.e., the three groups of two dependent variables), each row in the dataset contained four additional derived variables, which were calculated as follows:

\[ \Delta \sigma_{LP,PC} = \sigma_{LO,PC} - \sigma_{LP,ND} \]  \hspace{1cm} (1)

\[ \bar{X}_{V,PC} = \bar{X}_{V,PC} - \bar{X}_{V,ND} \]  \hspace{1cm} (2)
\[ \Delta \sigma_{LP,TXT} = \sigma_{LP,TXT} - \sigma_{LP,ND} \]  
\[ \Delta \bar{X}_{V,TXT} = \bar{X}_{V,TXT} - \bar{X}_{V,ND} \]

The first two variables, \( \Delta \sigma_{LP,PC} \) and \( \Delta \bar{X}_{V,PC} \) represent the difference between the single values obtained for the phone conversation variables and no-distraction variables, while the remaining two, \( \Delta \sigma_{LP,TXT} \) and \( \Delta \bar{X}_{V,TXT} \) represented the difference between the texting variables and no-distraction variables.

Figure 13. Effect of Phone Conversation on Lane Position for Participants 10 and 12.

Figure 14. Effect of Texting on Lane Position for Participants 18 and 20.
CHAPTER 5. STATISTICAL ANALYSIS

The PROC MIXED procedure (linear mixed model) in SAS was the analysis tool used to measure the correlation in observations resulting from the same participants experimenting in the control, phone call and texting tasks. Participants were used as the subject for the random variable. To analyze the post event effect, F-tests for the equality of variance were performed. One way ANOVA was employed to measure the impact of duration of main event both during and after the event. Further, comparison between main and post event, duration of post event among different groups were analyzed using one way ANOVA. All these tests were performed through SAS 9.3 at a 5% level of significance. The hypothesis was that if the treatment condition under study had no effect, then the mean variability (specifically, the standard deviation of Lane Position and mean Velocity) under that specific treatment condition (phone conversation or texting) would be the same as that under the no-distraction event, and hence, the difference between these means would be zero. For ANOVA, all data were first tested to ensure the normality assumptions of the tests were not violated. For this study, the level of significance chosen for the normality test was 1%. For non-normal data, negatively skewed data were cubed or square root transformed, while positively skewed data were log or squared transformed. The following sub-sections further describe all the analyses undertaken.

5.1 Post-Task / Reporting of the difficulty level of task

After the completion of the test, each participant ranked the difficulty level of cell phone conversation and texting. The rank for the task was prescribed as 1 and 2, 1 being the most difficult task. Based on the data, most of the participants (thirty four) found texting to be difficult compared to only two in cell phone conversation. Figure 15 shows overall ranking of the task from all the participants. In Figure 15, out of thirty-six only thirty-four participants ranked
texting as the difficult task than phone conversation. This indicates the severity of texting while driving. The ranking of the task was done in order to classify the task based on the participants' driving experience and was compared with the statistical analysis in the later sections. According to most of the participants, the visual demand during texting (plug in text) is the most prominent factor behind its severe distraction potential. Participants assumed cell phone conversation to be a comparatively simple task because they reported that they could see the road ahead while driving, which means less visual demand. However, the participants were not asked to report the post event situation of the task. In fact, they were not even aware of the post event effect being a part of the research. The post event effect was measured without the driver being aware of it. An assumption was made before the experiment that an effect of main task lingers which was considered as the post event effect and also assumed to be less than a minute. Hence, each participant had to drive an extra minute after finishing the main event. The post event effect of cell phone conversation and texting is analyzed statistically in the later sections.

![Ranking of Task](image)

Figure 15. Overall ranking of the tasks based on difficulty level
5.2 Main Event

The null hypotheses tested for both events were: \( H_0: \Delta \sigma_{LP} = 0 \); and \( H_0: \Delta \bar{X}_V = 0 \) implying no significant difference between the lateral control (and longitudinal control) during the treatment and no-distraction drive. Implicitly, the alternative hypotheses were: \( H_A: \Delta \sigma_{LP} > 0 \); and \( H_A: \Delta \bar{X}_V < 0 \) implying participants had less lateral control (and longitudinal control) during the treatment drives than they had for the no-distraction drive. Figure 16 shows the trend plot of \( \Delta \bar{X}_{V, PC} \) and \( \Delta \bar{X}_{V, TXT} \) for all participants while Figure 17 shows the plot of \( \Delta \sigma_{LP, PC} \) and \( \Delta \sigma_{LP, TXT} \) for all participants. In both the figures the difference of the mean velocity and standard deviation of lane position varies among participants. From Figure 16, it can be observed overall that there were more instances of negative values obtained indicating that the mean velocity of participants was higher during the no distraction event compared to texting and phone conversation. The more instances of negative values indicates the adverse effect of the task on driving performance. This trend seems to agree with what is generally accepted that distracted driving usually results in reduced mean speeds.

![Figure 16. Trend plot for difference in Mean Velocity](image-url)

31
In Figure 17, the difference of standard deviation of lane position during control driving and driving with phone conversation was both positive and negative while it shows more instances of positive values (greater $\sigma_{LP}$ of lane position during driving with task than control driving) than negative values during texting. The trend seems to agree with the general observation that distracted drivers produce larger lane position variability as they tend to waver more in their lanes.

![Figure 17. Trend plot for difference in Lane Position](image)

5.2.1 Phone conversation event

A linear mixed model analysis taking participants ID as a random factor was performed on the derived variables $\sigma_{LP,PC}$ and $\bar{x}_{V,PC}$ using all 36 participants. Using 5% level of significance, the results on the standard deviation of Lane Position variable [$t (99) = -0.03$, $p=0.974$] and Mean Velocity variable [$t (99) = -0.4$, $p=0.687$] showed no significant effect of cell phone conversation on the driving performance of the participants during the main event. Further, the negative “t” value indicates the better performance during the control driving.
5.2.2 Texting event

Similarly, a linear mixed model analysis was performed on the derived variables $\sigma_{LP,TXT}$ and $\bar{X}_{V,TXT}$ for all 36 participants. However, the results on the SD of Lane Position variable [$t (99) = -5.89$, $p<0.0001$] and Mean Velocity variable [$t (99) = -2.67$, $p=0.0088$] both showed significant effect of texting on the driving performance of participants during the main event. The result of the SAS analysis for both the task is summarized in Table 1.

<table>
<thead>
<tr>
<th>Main event</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Velocity</td>
</tr>
<tr>
<td>Phone Conversation</td>
<td>0.687</td>
</tr>
<tr>
<td>Texting</td>
<td>0.0088</td>
</tr>
</tbody>
</table>

5.3. Post Event Analysis

This analysis was undertaken to provide answers to the first two research questions of this study. The one-minute data collected after the texting event and the corresponding data for the no-distraction drive were segmented into one-second intervals. If $\sigma_{LP,TXT}(i, t)$ and $\sigma_{V,TXT}(i, t)$ respectively represent the standard deviation of the Lane Position and Mean Velocity variables for participant $(i)$ during a specific one-second time interval $(t)$ after the texting event; $\sigma_{LP,PC}(i, t)$ and $\sigma_{V,PC}(i, t)$ are the standard deviation for the data for the phone conversation task; and $\sigma_{LP,ND}(i, t)$ and $\sigma_{V,ND}(i, t)$ are the standard deviation of the corresponding data for the no-distraction drive, and $\sigma_{V,ND}(i, t)$ is the standard deviation of the corresponding data for the no-distraction drive, then an F-test for equality of variances can be performed for each of the 36 participants to check for statistical evidence of a post event effect, and consequently, determine how long such effect lasts. The null and alternative hypotheses used for F-test were:
Post Phone Conversation,

For the lateral control, the hypotheses tested are:

\[ H_0: \sigma_{LP,PC}^2(i, t) = \sigma_{LP,ND}^2(i, t) \]
\[ H_A: \sigma_{LP,PC}^2(i, t) > \sigma_{LP,ND}^2(i, t) \]  

(5)

For longitudinal control, the hypotheses tested are:

\[ H_0: \sigma_{V,PC}^2(i, t) = \sigma_{V,ND}^2(i, t) \]
\[ H_0: \sigma_{V,PC}^2(i, t) < \sigma_{V,ND}^2(i, t) \]  

(6)

Post Texting,

For lateral control, the hypotheses tested are:

\[ H_0: \sigma_{LP,TXT}^2(i, t) = \sigma_{LP,ND}^2(i, t) \]
\[ H_A: \sigma_{LP,TXT}^2(i, t) > \sigma_{LP,ND}^2(i, t); \]  

(7)

For longitudinal control, the hypotheses tested are:

\[ H_0: \sigma_{V,TXT}^2(i, t) = \sigma_{V,ND}^2(i, t) \]
\[ H_0: \sigma_{V,TXT}^2(i, t) < \sigma_{V,ND}^2(i, t) \]  

(8).

It is worth noting that the cell phone conversation main event did not produce any significant effect but since this study is investigating the post-event effect of cell phone use, the analysis on the post-phone conversation was performed for completeness of the study. The F-test was performed for each subsequent one-second interval following the texting and phone conversation events for 60 seconds as this time interval was considered a reasonable maximum post event time that any distraction could still be linked to the main event without possible intrusion of other distraction sources. Such time marked the duration of the post event effect. Visualizing the performance of a few participants for more than fifteen seconds, it showed the possible intrusion of other factor affecting the driving performance rather than the effect of main event. Considering this factor, the F-test was not conducted beyond ten seconds period for all 36 participants for both the event. The one second interval was chosen because the driving simulator is able to provide sixty data points during a second interval, and this sample size was considered
sufficient to allow a time-step analysis to check for evidence of lingering distraction. The F-test was conducted till results of the analysis became significant.

5.3.1 Post-phone conversation event

Figure 18 shows the individual distribution and Figure 19 shows the aggregated durations of the time periods that participants showed significant differences in the post-event analyses of the phone conversation event. For the SD of Lane Position variable, while the mean duration was found to be 1.75 seconds, the majority (50\%) of the participants showed no post-event effect at all. Similarly, for the Mean Velocity variable, while the mean duration was found to be 0.86 seconds, the majority (55\%) of the participants showed no post-event effect at all. Since there were no significant effects during the main event, and the majority of participants are also showing no effects for the post-event task, it may be prudent to conclude that the results indicate there is no evidence of an overall post event distracting effect of cell phone conversation on driving performance. Hence, further analysis on post event effect was no longer applicable to the phone conversation task.

Figure 18. Duration of post event effect of cell phone conversation

![Duration of post event effect-Phone Conversation](image-url)
5.3.2 Post-texting event

Similar to the phone conversation event, Figure 20 shows the individual distribution and Figure 21 shows the aggregated durations of the time periods that participants showed significant differences in the post-event analyses of the texting event. For the SD of Lane Position variable, the Figure 20 shows that before the first second after the man event elapsed, all participants continued to show significant distracting effect. The majority (approximately 56%) of the participants showed significant effect duration of 1.5 seconds and a mean duration of 3.38 seconds (SD=2.610 seconds) with a maximum post event effect of 9 seconds period. It can therefore be concluded that there is evidence of a post event distracting effect of cell phone.
texting on the lateral control of the simulator, and it lingers on for an average of 3.38 seconds even after the texting event has ceased. Since the SD of Lane Position variable produced significant differences for both the main and post-event texting task, further analyses were performed on this performance measure to answer the remaining research questions. For the Velocity variable however, the mean duration of the post-effect was found to be 0.97 seconds (SD=2.323 seconds) while overwhelming majority (approximately 75%) showed no post event effect in the longitudinal direction at all. For this reason, it may be prudent again to conclude that the results did not provide definitive evidence of an overall post event distracting effect of cell phone texting on the longitudinal control of the simulator. Research questions 2 to 5 are therefore no longer applicable to the Mean Velocity variable of the cell phone texting task. Further, the post event analysis was analyzed only for the texting in the lateral direction (using the SD of the lane position) due to its significance.

![Duration of post event effect-Texting](image)

Figure 20. Duration of post event of texting
Figure 21. Descriptive analysis of post-event effect duration of Texting

5.4 Comparison of During and Post Event Level of Distraction

This analysis was done to provide answers to the third research question. While Figure 22 presents visual evidence that the level of distraction for each of the three groups of participants during the main texting event is higher than that for the post event, the linear mixed model analysis was used to test for statistical significance in addition. The hypotheses tested are:

\[ H_0: \Delta \sigma_{LP,TXT} = \Delta \sigma_{LP,TXT}(t) \]
\[ H_1: \Delta \sigma_{LP,TXT} > \Delta \sigma_{LP,TXT}(t) \]

Where \( \Delta \sigma_{LP,TXT} \) represents the magnitude of the main event level of distraction, and \( \Delta \sigma_{LP,TXT}(t) \) represents that for the post event such that: \( \Delta \sigma_{LP,TXT}(t) = \sigma_{LP,TXT}(t) - \sigma_{LP,ND}(t) \). and “t” refers to the interval between the completion of the texting event and three seconds after, chosen because the distracting effect ceases to be significant after an average of 3.388 seconds.
The results \([F (2, 33) = 7.234, p = 0.011]\) suggest that the level of distraction experienced by participants during the texting \((M = 0.146, SD = 0.184)\) was significantly higher than the few seconds (three seconds) after the texting had ceased \((M = 0.0618, SD = 0.0792)\) and is shown in Figure 23.

Figure 22. Groups mean effects for main and post events.

Figure 23. Level of distraction during main event (texting) and for three seconds after texting
5.5 Relationship between Variables (Velocity and Lane Position) during Post Texting Event

To find the relation between velocity and lane position, if any, each participant was analyzed separately. All the participants were first categorized into four different groups based on the increase or decrease of the velocity and lane position just after the completion of the main task, which was texting. For participants in group 1 and 2, standard deviation of lane position initially increased at each second after the event and then started decreasing to end up with the main event effect. Increase in the standard deviation of lane position for those groups was associated with the decrease or increase in the velocity, with participants in group 1 increased velocity right after the task while participants in group 2 decreased the velocity. However, for group 3 and 4 the standard deviation of lane position initially started decreasing at each second interval after the event and the post event effect was negligible at some point of a time. The four different groups and associated number of participants is summarized in Table 2.

Table 2. Relation between variables (Velocity and Lane Position)

<table>
<thead>
<tr>
<th>Group</th>
<th>Feature</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SD of LP increases and Vel. decreases</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>SD of LP increases and Vel. increases</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>SD of LP decreases and Vel. increases</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>SD of LP decreases and Vel. decreases</td>
<td>6</td>
</tr>
</tbody>
</table>

(where, SD of LP=standard deviation of lane position and Vel. =velocity)

From Table 2, Group 2 and 3 were found to be associated with higher number of participants with an increase in the velocity just after finishing the task. However, a decrease in velocity of the vehicle was observed in some participants which indicated that the lane position was not affected by the velocity of the running vehicle. Hence, a specific trend between lane position and velocity could not be observed from the above table.
5.6 Other factors affecting the Post Event Duration of Texting laterally

The duration of the post event effect varied between individual participants. Post event effect varied from one to nine seconds. The change in the duration among different participants was checked in different weather conditions, time of the day, gender and age. As shown in Figure 24, the post event duration of each participant was plotted in descending order against their corresponding age. It can be observed that participants with higher age were associated with the longer duration of post event effect. Figure 25 (a) shows the higher effect of time of day on the post event duration. Similarly, Figure 26, shows longer post event duration during the snowy condition rather than in fog and normal. The post event effect was also directly affected by the age of the participants. As shown in Figure 25(b), older participants shows the longer post event duration compared to the younger ones. It might be due to change in the visibility with the change in age. Hence, analyzing the effect of age, weather and time of day, it can be concluded that higher post event effect was associated with the poor vision, which is responsible for longer time for the participants to readjust their eyes on to the roadway environment.

![Distribution of post event duration](image.png)

Figure 24. Duration of post event effect (in descending order)
However, Table 3 shows the result from ANOVA to find the difference in post event effect among time of day, weather and age effect separately. It resulted that the mean difference between the post event duration in different conditions: age effect, time of day effect and weather effect separately were not significant.
Table 3. Statistical analysis within different factors affecting post event

<table>
<thead>
<tr>
<th>Condition</th>
<th>p-value from one way ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of day effect</td>
<td>0.9612 (non-significant)</td>
</tr>
<tr>
<td>Age effect</td>
<td>0.1559 (non-significant)</td>
</tr>
<tr>
<td>Weather effect</td>
<td>0.7347 (non-significant)</td>
</tr>
</tbody>
</table>

5.7 Effect of Duration of Event (Texting) on Level of Distraction

This analysis was done to find the effect of duration of main event on the level of distraction both during the main and post event. First, an analysis was performed for the main event to determine whether the texting duration influenced the level of distraction during the actual texting event; and secondly, a post event analysis was performed for the three seconds after the texting event. As described earlier, the total participants were categorized into three different groups based on the level of duration of the texting event: Group A (short duration) for those that responded to a single text message, Group B (medium duration) for those that responded to four text messages, and Group C (long duration) for those that responded to seven text messages. Results from the pairwise comparisons undertaken through the linear mixed model analysis have been presented in Table 4 and Table 5 for the main texting event and post texting event using the groups of means of the derived variables, $\Delta \sigma_{LO,TXT}$, as the surrogate measure of the level of distraction.

5.7.1 Main Texting Event

The derived analysis variable $\Delta \sigma_{LP,TXT}$, was categorized into three groups and group means of levels of distraction was compared. The hypotheses are: $H_0: \Delta \sigma_{LP,TXT, GROUP A} = \Delta \sigma_{LP,TXT, GROUP B} = \Delta \sigma_{LP,TXT, GROUP C}$ and $H_A$: at least one group mean is different
The statistical comparison was non-significant, F (2, 33) = 0.344, p=0.7117, even though group mean comparisons (A= 0.110, B = 0.153, C = 0.174) as shown in Table 4 shows that higher duration of the event produced higher levels of distraction. The table shows every group were not significantly different from others. The mean difference also indicates the higher differences with the increase in the number of text messages (A-B= -0.043, A-C= -0.064 and B-C= -0.021). Therefore, it was concluded that the duration of the event did not have any significant effect on the level of distraction experienced during the texting event.

Table 4. Pairwise comparison among groups during the main event of texting

<table>
<thead>
<tr>
<th>Pairwise Comparisons</th>
<th>Dependent Variable</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIFF.SDLP.MAIN EVENT. TEXT</td>
<td>A to B</td>
<td>-.043</td>
<td>.077</td>
<td>.580</td>
</tr>
<tr>
<td>DIFF.SDLP.MAIN EVENT. TEXT</td>
<td>A to C</td>
<td>-.064</td>
<td>.079</td>
<td>.421</td>
</tr>
<tr>
<td>DIFF.SDLP.MAIN EVENT. TEXT</td>
<td>B to A</td>
<td>.043</td>
<td>.077</td>
<td>.580</td>
</tr>
<tr>
<td>DIFF.SDLP.MAIN EVENT. TEXT</td>
<td>B to C</td>
<td>-.021</td>
<td>.075</td>
<td>.783</td>
</tr>
<tr>
<td>DIFF.SDLP.MAIN EVENT. TEXT</td>
<td>C to A</td>
<td>.064</td>
<td>.079</td>
<td>.421</td>
</tr>
<tr>
<td>DIFF.SDLP.MAIN EVENT. TEXT</td>
<td>C to B</td>
<td>.021</td>
<td>.075</td>
<td>.783</td>
</tr>
</tbody>
</table>

where, DIFF.SDLP.MAIN EVENT. TEXT = SD of lane position during main texting event – SD of lane position during no-distraction event

5.7.2 Post Texting Event

As in the main event analysis, $\Delta \sigma_{LP,TXT}(t)$ was categorized into three groups and group means of levels of distraction was compared. The hypothesis are: $H_0: \Delta \sigma_{LP,TXT,GROUP_A}(t) = \Delta \sigma_{LP,TXT,GROUP_B}(t) = \Delta \sigma_{LP,TXT,GROUP_C}(t)$ and $H_A$: at least one group mean is different.

The result was non-significant, F (2, 33) = 1.01, p=0.3739, even though the group means comparisons (Group A = 0.037, Group B = 0.061 and Group C = 0.084) as shown in Table 5 shows that higher duration of the event produced higher levels of distraction. The table shows no
significant difference between any two groups during the post event of texting. Similarly, the
group with more text messages showed the higher level of distraction (A-B=-0.025, A-C=-0.047
and B-C=-0.022). It was therefore concluded that the duration of the event did not have any
significant effect on the level of distraction experienced during the few critical seconds after the
texting event had ceased.

Table 5. Pairwise comparison among groups during the post event of texting

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable</th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DIFF.SDLP.POST EVENT TEXTING</td>
<td>B</td>
<td>-.025</td>
<td>.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>-.047</td>
<td>.033</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>B</td>
<td>.025</td>
<td>.032</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>-.022</td>
<td>.032</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>B</td>
<td>.047</td>
<td>.033</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>.022</td>
<td>.032</td>
</tr>
</tbody>
</table>

where, DIFF.SDLP.POST EVENT TEXTING= SD of lane position during post texting event –
SD of lane position during no-distraction event

5.8 Effect of Duration of Event on Duration of Post Event Distraction

This analysis was done to find the effect of duration of main event on the duration of post
event effect. Using the same three groups, ANOVA was performed on the duration of the post
event effect observed on each participant and the resultant distribution of mean duration. The
result was non-significant, F (2, 33) =0.06, p=0.9379 with Group A showing a mean post event
distraction duration of 3.18 seconds, Group B showing 3.38 seconds and Group C showing 3.58
seconds. Table 6 shows the summary analysis of post event duration for three different groups.
As discussed earlier, the duration of texting and phone conversation depends upon the type of
groups. It shows that the duration of the post event effect ranges from minimum of a second to
the maximum of nine seconds with almost same variation in the duration. The results suggest
that even though higher duration of the texting event result in the post event distracting effect lingering on much longer, the differences observed are non-significant.

Table 6. Summary analysis of duration of post event effect in three different groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Observations</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>3.1818</td>
<td>2.8219</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>B</td>
<td>13</td>
<td>3.3846</td>
<td>2.3642</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>3.5833</td>
<td>2.8749</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

5.9 Post-hoc Analysis of Sample Size

Following on the analysis, G-power 3.1 software (Faul et al., 2007) was used to verify whether the sample size utilized for the study was adequate to give enough power. Due to the non-significant effect of the Mean Velocity variable, it was not used to calculate the effect size since its effect size will be smaller than the significant effect of the SD of Lane Position variable. The effect size is calculated based on an equality of variance test for the texting and no-distraction drives. Figure 27 shows the different sample sizes that will correspond to an expected power for the study. It can be seen that a sample size of 36, as used for the study, generates a power of almost 95%. Therefore, the sample size utilized for the study is deemed suitable.

Figure 27. Sample size calculation using G-power 3.1 statistical software
CHAPTER 6. SUMMARY, CONCLUSION AND FUTURE RESEARCH

6.1 Summary

Distracted driving continues to gain media attention and research interest because of its elevated crash risks. Using a cell-phone while driving is one of the causes of distracted driving in the United States and many studies have analyzed its effect on driver performance. This study examined the effect of being engaged in a cell phone conversation and texting while driving, as well as analyzed their post event effect. Two variables, standard deviation of Lane Position and mean Velocity, were used as performance measures to respectively represent lateral and longitudinal control of the vehicle. Participants were initially screened to ensure that observations from overly anxious drivers were not included since such drivers tend to perform worse when distracted and their observations could therefore skew the overall results.

6.2 Conclusion and Discussion

The results suggest that being engaged in a hand-held cell phone conversation while driving did not provide significant lateral or longitudinal deviation from driving without distraction, which supports similar findings from some previous studies. However, other studies have found the use of both hand-held and hands-free cell phone conversation distracting. The inconsistencies in conclusions from research on the distracting effect of cell-phone conversation could be attributed to the nature of the conversation itself and its impact on the driver’s mood. Intuitively, conversations that involve significant cognitive effort such as retrieval of information from memory, and other emotional and distressing types will have higher impact on a driver’s concentration levels more than would a normal conversation. In this study, however, participants were engaged in normal conversation that did not cause any distress, and consequently, no significant impact was detected.
On the contrary, the results of this study suggest that texting while driving resulted in significant lateral and longitudinal deviation from what would be observed when not distracted. Again, this result agreed with other past studies. The consensus on the distracting nature of texting may also explain why as many as 41 U.S. states have banned drivers from texting but only 12 states have banned any use of cell-phones.

Additionally, this study analyzed the distracting effect after the phone conversation and texting events had been completed, an area that has not been investigated. The results suggest that there were no significant post event lateral and longitudinal deviations on the driving performance from the phone conversation task. However, for the post event effect of the texting task, the results suggest that there were significant lateral deviations but not significant longitudinal deviations on the driving performance. For this reason, further analysis was performed on the texting task using the standard deviation of Lane Position variable. In comparing the distraction levels experienced during the texting event and the post event effect, the results suggest that even though the post event distracting effect was considerably lower than that of the main texting event, drivers still showed significant lateral deviations up to an average 3.38 seconds after the texting event. This equates to a post event effect lingering on for a distance of nearly 0.062 miles for a vehicle travelling at 65 mph. The observation could be attributed to the fact that texting involves more visual demand on the drivers than cell phone conversation. The residual effect of re-adjusting the eyes onto the road from the phone could be what is observed as the lingering effect.

Interestingly, the results also suggest that the duration of the main event, in this case represented by the number of text messages exchanged, did not affect the distraction levels experienced by drivers during and after the texting event. Likewise, the duration of the main
event did not affect the duration of the post event distracting effect. These results suggest that drivers getting distracted momentarily, as in responding to a single text message, could be potentially as dangerous as being engaged in prolonged distraction such as continual text messaging.

6.3 Future Research

Based on the current study of the post event effect of cell phone usage, the following are the recommendations for future research.

- Use larger sample size, it will be interesting to see the results from a multivariate analysis that incorporates several dependent variables rather than the univariate ANOVA used in this study that consider only single variable.
- The post event effect of texting in urban roadway, where the effect of cell phone usage might be different due to different geometry of the road, can be an option.
- Effect of intensity of phone conversation on the post event duration.
- Effect of the posted speed limit on the post event effect. It is because it might take longer time for a participant to dissipate the higher velocity.
- It would be better to find effect of different ages of the participants on the post event distracting effect as visibility changes after as people grow older.
- The current study was based on the simulator experiment. Post event effect of cell phone talking and texting can be carried out using a naturalistic driving condition.
- This study was limited with the cell phone usages particularly during talking and texting. However there are numerous distracting sources, which are assumed to have a major impact on the driving performance. Post event effect of those distracting sources can be the appropriate area to conduct future research.
REFERENCES


Governors Highway Safety Association (GHSA).


**APPENDIX 1: LIST OF DRIVING SIMULATOR VARIABLES**

<table>
<thead>
<tr>
<th>S/N</th>
<th>Performance Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longitudinal Acceleration</td>
<td>Values in m/s/s. Negative values are decelerations. Standard deviation was used as the point estimate</td>
</tr>
<tr>
<td>2</td>
<td>Lateral Acceleration</td>
<td>Value in m/s/s Mode was used as the point estimate</td>
</tr>
<tr>
<td>3</td>
<td>Throttle</td>
<td>Value between 0 and 90 degrees. This is the angle of the pedal position. Range was used as the point estimate</td>
</tr>
<tr>
<td>4</td>
<td>Heading error</td>
<td>Angle in degree between road path and current heading. Range was used as the point estimate</td>
</tr>
<tr>
<td>5</td>
<td>Headway Time</td>
<td>A value in seconds. This is the time between the centers of gravity of the vehicle and the lead vehicle. Standard deviation was used as the point estimate</td>
</tr>
<tr>
<td>6</td>
<td>Lane Position</td>
<td>A value in meters of the position of the vehicle from the center of the lane. Positive number are to the right and negative are to the left. Range was used as the point estimate</td>
</tr>
<tr>
<td>7</td>
<td>Yaw</td>
<td>The angle, in degrees, between the lane center and the center line through the length of the vehicle. Range was used as the point estimate</td>
</tr>
<tr>
<td>8</td>
<td>Steer</td>
<td>Value in radians describing the steering wheel position. Standard deviation was used as the point estimate</td>
</tr>
<tr>
<td>9</td>
<td>Velocity</td>
<td>Value in m/s. Standard deviation was used as the point estimate</td>
</tr>
<tr>
<td>10</td>
<td>Lateral Velocity</td>
<td>Value in m/s. Mode was used as the point estimate.</td>
</tr>
</tbody>
</table>
### APPENDIX 2. TEXT MESSAGES USED FOR THE STUDY

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of text messages</th>
<th>Text messages used for the entire experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Hi! What's your full name?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>Hi! What's your full name?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What is your major at LSU?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What is your number one vacation destination?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thank you so much for participating. Very much appreciated. What's your future plan?</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>Hi! What's your full name?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What is your major at LSU?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What is your number one vacation destination?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What do you enjoy most during the summer break?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What's your favorite sport?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How often do you drive to school?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thank you so much for participating. Very much appreciated. What's your future plan?</td>
</tr>
</tbody>
</table>
### APPENDIX 3. RATING FORM FOR CELL PHONE CONVERSATION AND TEXTING

<table>
<thead>
<tr>
<th>Questionnaire to be Used for Task F of Pilot Project</th>
<th>Date/Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
</tr>
<tr>
<td>Year of Birth</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
</tbody>
</table>

**Level**

- Faculty
- Staff
- Student
- Other

**Order of tasks perceived to be most demanding (1=most demanding; 5=least demanding)**

- Radio
- Navigation Device
- Phonebook
- Contact
- Phone Conversation
- Texting
- Front Seat Conversation

**Comments**

---

<table>
<thead>
<tr>
<th>Questionnaire to be Used for Task F of Pilot Project</th>
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<td>Year of Birth</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
</tbody>
</table>

**Level**

- Faculty
- Staff
- Student
- Other

**Order of tasks perceived to be most demanding (1=most demanding; 5=least demanding)**

- Radio
- Navigation Device
- Phonebook
- Contact
- Phone Conversation
- Texting
- Front Seat Conversation

**Comments**


APPENDIX 4. CONSENT FORM (I)

CONSENT FORM

Study Approved By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-678-8692 | www.lsu.edu(irb)

1. Study Title: Distracted Driving and Associated Crash Risks
   Approval Expires: 2/12/2014

2. Performance Site: Louisiana State University and Agricultural and Mechanical College, Patrick F.
   Taylor Hall, Room 2225.

3. Investigators: The following investigators are available for questions about this study, M-F, 9:00am – 5:00pm: Dr. Sherif Ishak, 578-4846, ishak@lsu.edu; Julius Codjoe, jcodies1@lsu.edu.

4. Purpose of the Study: This study investigates the use of the driving simulator on the LSU campus to measure risks associated with various distractions faced by the driving population.

5. Subject Inclusion: Subjects between the ages of 18 and 65 with normal or corrected to normal vision and possessing a driver's license.

6. Number of Subjects: 100

7. Study Procedures: Subjects will be asked to drive the LSU driving simulator as they would normally drive a real vehicle to work and will be exposed to differing driver distractions to determine the effect on the driving task. The study will take approximately 45 to 60 minutes to complete.

8. Benefits: This will assist highway safety professionals in developing behavioral strategies to mitigate crashes due to distracted driving.

9. Risks: Driving simulators may cause conditions known as simulator sickness. These conditions are similar to motion sickness, or those sensations one feels when flying, the symptoms of which include eyestrain, headache, postural instability, sweating, disorientation, vertigo, pallor, and nausea. If you have a predisposition towards motion sickness of any kind, please inform any of the investigators immediately. If you feel any discomfort, please press the emergency safety knob in the simulator at any time. This will bring the simulation to a stop. As a subject, using the immediate termination action during a session or otherwise will NOT penalize you for any loss or benefit you would otherwise have received. You are therefore encouraged to use this device as soon as you feel the slightest discomfort.

10. Right to Refuse: Subjects may choose not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which they might otherwise be entitled.

11. Privacy: Results of the study may be published, but no names or identifying information will be included in the publication. Subject identity will remain confidential unless disclosure is required by law.
12. Signatures: The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I may contact Dr. Robert Mathews, Chair of the Institutional Review Board, 203 B-1 David Boyd Hall, Baton Rouge, LA 70803, or by phone on (225) 578-8692. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Signature of Subject __________________________________________

Printed Name ________________________________________________

Date _________________________________________________________
APPENDIX 6: QUESTIONNAIRE FORM (I)

SELF-EVALUATION QUESTIONNAIRE (STAI Form Y-1)

Please provide the following information:

Name_________________________ Date_________ S________

Age_________________________ Gender (Circle) M F T________

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

1. I feel calm.......................... 1 2 3 4

2. I feel secure.......................... 1 2 3 4

3. I am tense.......................... 1 2 3 4

4. I feel strained....................... 1 2 3 4

5. I feel at ease....................... 1 2 3 4

6. I feel upset......................... 1 2 3 4

7. I am presently worrying over possible misfortunes............ 1 2 3 4

8. I feel satisfied..................... 1 2 3 4

9. I feel frightened................... 1 2 3 4

10. I feel comfortable............... 1 2 3 4

11. I feel self-confident............. 1 2 3 4

12. I feel nervous.................... 1 2 3 4

13. I am jittery....................... 1 2 3 4

14. I feel indecisive................... 1 2 3 4

15. I am relaxed...................... 1 2 3 4

16. I feel content................... 1 2 3 4

17. I am worried..................... 1 2 3 4

18. I feel confused................... 1 2 3 4

19. I feel steady..................... 1 2 3 4

20. I feel pleasant.................. 1 2 3 4

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www.mindgarden.com
## SELF-EVALUATION QUESTIONNAIRE

**STAI Form Y-2**

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
</table>

### DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

1. I feel pleasant........................................1 2 3 4
2. I feel nervous and restless ......................1 2 3 4
3. I feel satisfied with myself..........................1 2 3 4
4. I wish I could be as happy as others seem to be 1 2 3 4
5. I feel like a failure ...................................1 2 3 4
6. I feel rested ...........................................1 2 3 4
7. I am “calm, cool, and collected” ......................1 2 3 4
8. I feel that difficulties are piling up so that I cannot overcome them 1 2 3 4
9. I worry too much about something that really doesn’t matter 1 2 3 4
10. I am happy ..............................................1 2 3 4
11. I have disturbing thoughts .........................1 2 3 4
12. I lack self-confidence ................................1 2 3 4
13. I feel secure ............................................1 2 3 4
14. I make decisions easily ..............................1 2 3 4
15. I feel inadequate .....................................1 2 3 4
16. I am content ..........................................1 2 3 4
17. Some unimportant thought runs through my mind and bothers me 1 2 3 4
18. I take disappointments so keenly that I can’t put them out of my mind 1 2 3 4
19. I am a steady person ..................................1 2 3 4
20. I get in a state of tension or turmoil as I think over my recent concerns and interests 1 2 3 4
VITA

Raju Thapa was born in October, 1982 as a new family member of Nar Bahadur Thapa and Purna Kala Thapa. He finished his higher secondary school from SOS Hermann Gmeiner School, Gandaki in 2002. Then after, he joined Western Region Campus, Nepal to pursue Bachelor’s Degree in Civil Engineering. After the completion of his undergraduate degree in 2006, he joined the same university in a position of Lecturer and worked for about six years. In 2012, he joined Louisiana State University to pursue Master Degree in Civil Engineering. He is required to fulfill all the requirements for Master Degree in Civil Engineering and is anticipated to graduate in December 2014.