Distracted Driving and Associated Crash Risks

PRINCIPAL INVESTIGATOR

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TRB KEYWORD

Human Factors, Driver Distraction, Crash Risk, Roadway Safety.

FUNDS REQUESTED

The total project cost is $127,829 . This includes a total of $50,000 from UTC, $39,367 matching funds from LTRC, and $38,462 matching funds from LSU.

PROJECT SUMMARY

Factors affecting the cognitive tasks associated with driving are increasingly becoming critical to the overall roadway safety performance. Therefore, more research is needed in order to understand the complexity and the impact of distraction on driving behavior. The acquisition of a driving simulator at LSU provides ample research opportunities for conducting research in the area of human factors and particularly in driver distraction. This research proposal intends to use the driving simulator on the LSU campus to measure the risks associated with various distractions faced by the driving population. Participants will be placed in simulated environments while being exposed to differing driver distractions to determine the effect on the driving task. This will assist highway safety professionals in developing behavioral strategies to mitigate crashes due to distracted driving. The main objectives of this research are to: (1) conduct a thorough literature review on driver distraction and roadway safety, including the cause and extent of distraction associated with driving tasks, (2) identify a set of cognitive tasks that are believed to have the most impact on driver distraction, (3) establish a set of performance measures for the type and level of distraction based on the driving behavior, (4) design and conduct simulation experiments involving a sample of human subjects, (5) compare using appropriate statistical techniques the driving behavior of the human subjects with and without the identified distraction factors, and (6) analyze the results and make conclusions.

PROJECT DESCRIPTION

Research Problem Statement

Factors affecting the cognitive tasks associated with driving are increasingly becoming critical to the overall roadway safety performance. Therefore, more research is needed in order to understand the complexity and the impact of distraction on driving behavior. Such distractions are likely to affect the

driving performance and consequently elevate the crash risk. As such, there is a dire need to understand the prevalence of driver distractions in conjunction with crashes and near-crashes. Research is essentially needed to better understand distracted driving and the factors that elevate crash risk for cognitive tasks such as hands-free talking, texting, eating, reading, etc.

The acquisition of a driving simulator at LSU provides ample research opportunities for conducting research in the area of human factors and particularly in driver distraction. This research proposal intends to use the driving simulator on the LSU campus to measure the risks associated with various distractions faced by the driving population. Participants will be placed in simulated environments while being exposed to differing driver distractions to determine the effect on the driving task. This will assist highway safety professionals in developing behavioral strategies to mitigate crashes due to distracted driving. It will also allow for the development of public awareness and education programs specifically targeting distracted driving. Additionally, it will provide information to elected officials and inform decision makers on matters related to distracted driving.

Background

The concept of distracted driving and associated crash risks has long been acknowledged as a significant road safety concern across the globe (Regan et al., 2008) and various researches have focused on this concern over the last two decades. Even so, drivers continue to engage in distracting non-driving related activities while driving. Such activities can be classified under three main types, namely visual, cognitive and physical distraction. All these types of distraction have been acknowledged to negatively affect driver performance and thus, increase the risks of associated crashes and near-misses (Amditis et al., 2010; Sussman et al., 1985). Driver performance is affected in the following areas: reduced lateral and longitudinal control, with effects being more pronounced in older drivers (Reed and Green, 1999; Engstrom et al., 2005; Rakauskas et al., 2004; Strayer et al., 2004); reduced situation awareness (Kass et al., 2007); and slower response times of up to 50% to roadway hazards (Burns et al., 2002; Lee et al., 2001). It is therefore not surprising that The National Safety Council estimated that 28% of all crashes in 2008 involved driver distraction, particularly handheld and hands-free cell phone talking and texting, accounting for 1.6 million crashes that year (Kolosh, 2009).

With the rapid advancement in human-in-the-loop simulation technologies, along with the continuous decrease in their cost, driving simulators have recently attracted the attention of researchers in the area of transportation engineering. Driving simulators have proven repeatedly their potential use in a variety of applications that can substantially improve traffic operation and safety (Bella, 2009). Providing a safe, inexpensive alternative to conventional experiment, driving simulators have advantages in terms of experimental control and data collection. The following section provides a brief overview of three selected distraction-related driving simulator studies.

In Australia, Horberry et al. (2006) investigated the effects of distraction on driving performance for thirty one drivers in three age groups using the driving simulator. The distraction involved one out-vehicle task (effect of visual clutter) and two in-vehicle tasks (operating the vehicle entertainment system and simulating a hands-free mobile phone conversation). The findings revealed that all drivers slowed down to respond to the complex visual clutter environment, but performance (mean speed and deviation from the posted speed limit) was impaired for both in-vehicle tasks, with the entertainment system having the greatest impact.

In the United Kingdom, Chattington et al., (2009) undertook a driving simulator and integrated eye-tracking system study to compare driving behavior (standard deviation of lane positioning and speed, deceleration rate, maximum brake position and speed), across a number of experimental advertising conditions. Forty eight participants, representing the driving population of UK, were tested. The findings

indicated that driving performance was significantly affected by both advertising conditions tested, with the performance more impaired by video adverts than static adverts. This provided more insight into effects of roadside billboard advertising on driver behavior.

In the USA, Horrey et al. (2009) used the driving simulator to investigate how concurrent driving and in-vehicle activities at different levels of engagements affected driver performance and compared against subjective estimates of demand and performance as reported by the drivers. The test involved forty one younger and older drivers completing a series of cognitive tasks while driving. The first task involved an engaging guessing game and the second task involved a simple mental arithmetic task. Results indicated that both tasks impaired both younger and older driver performance (brake response time, pace clock accuracy, and lane keeping ability) with the engaging guessing task having the more negative impact. Importantly, drivers' subjective estimates of their own performances were higher than their actual performances. Also, drivers underscored on estimating the added demands in the first task. This test provided insights into drivers' perception of what they consider distracting while driving.

Driving Simulators

With the rapid advancement in human-in-the-loop simulation technologies, along with the continuous decrease in their cost, driving simulators have recently attracted the attention of researchers in the area of transportation engineering. Driving simulators have proven repeatedly their potential use in a variety of applications that can substantially improve traffic operation and safety. Providing a safe, inexpensive alternative to conventional experiment, driving simulators have advantages in terms of experimental control and data collection, especially for perceptual treatments testing. The open literature shows that driving simulators, generally categorized into fixed-base or motion-base, have been used in several applications including: (1) the study of human factors involved in driving tasks or assessing the influence of alcohol, drugs, hypo-vigilance and fatigue on driving performance; (2) the study of driving performance of specific driver categories (e.g. elderly, young people, etc.), and/or in particular weather conditions (e.g. fog); (3) the design or assessment of in-vehicle systems that assist the driver with the driving task; (4) driver training; and (5) improving highway geometric design.

The driving simulator does away with the conventional problems in safety studies. Safety countermeasures can be tested and evaluated in a lab environment rather than in the real world where it would be impossible. This would reduce the timeline for evaluating the effectiveness of several countermeasures, and also reduce the risk of failure of these countermeasures. This would save millions of dollars in costs for evaluating safety countermeasures in the field. Various policies such as the use of cell phone, alcohol and other driver behavior related laws can be typically tested with the driving simulator, where such policies can be evaluated quickly and safely in a laboratory setting. The full-size driving simulator is now housed in the LSU driving simulator lab at the Department of Civil and Environmental Engineering. This lab is developed as a multi-use facility and a multi-disciplinary program for research, instruction, and training.

Goals and Objectives

In order to effectively evaluate the level of driver distraction on the road, a set of criteria must be first established to quantify the level of distraction associated with certain type of cognitive activities. The main objectives of this research are:

1. Conduct a thorough literature review on driver distraction and roadway safety, including the cause and extent of distraction associated with driving tasks.
2. Identify a set of cognitive tasks that are believed to have the most impact on driver distraction.

3. Establish a set of performance measures for the type and level of distraction based on the driving behavior.
4. Design and conduct simulation experiments involving a sample of human subjects.
5. Compare using appropriate statistical techniques the driving behavior of the human subjects with and without the identified distraction factors.
6. Analyze the results and make conclusions.

SCOPE

The scope of this study is limited to the use of the newly acquired driving simulator at LSU to measure the level of driver distraction. Experimental work will be conducted with the simulator using human subjects as drivers. Volunteers will be sought from the LSU community of students and staff members to participate in the experimental work. No monetary compensation will be provided for participants.

RESEARCH WORK PLAN

The following tasks will be completed in order to achieve the stated research objectives:

Task 1

In this task, the research team will search for studies with the purpose of gaining the state of the art knowledge on the subject matter. Published reports and journal manuscripts will be thoroughly reviewed to expand on the preliminary literature search presented in this proposal. This task is expected to be completed within the first three months of the project.

Task 2

Based on the literature search conducted in Task 1, the research team will identify a set of cognitive tasks that previous research considered as distracting to drivers. This includes but is not limited to texting, eating, reading, hands-free talking, etc. The selected cognitive tasks will be used with the human subjects to measure the level of distraction associated with each. This task is expected to be completed within the first four months of the project.

Task 3

Given the driver behavior data typically collected from the driving simulator during an experiment, this task will identify the most appropriate set of parameters that measure the driving behavior under distraction. Examples of such performance measures include the vehicle trajectory data (e.g. speed variance, lane deviation, lane changing frequency, etc.). Other implicit measures can also be used by presenting the drivers with random roadside information along the trip and asking them about it at the end of the experiment to reveal if the driver was able to recognize such information or events. This task is expected to be completed within the first 6 months of the project.

Task 4

This task involves setting up the experimental work and conducting the simulation experiments. The following considerations will apply:

1. Human subjects will be selected from LSU community (students and staff). Sample size requirements will be used to determine how many human subjects will participate. At least 25 participants will be used.
2. The sample will also include participants from different age groups to measure the effect of age on the level of distraction associated with the selected cognitive tasks.

3. Participants' level of distraction will be evaluated under different driving conditions (urban vs. freeway settings), as well as different weather conditions (fog vs. no fog, rain vs. no rain, snow vs no snow, day vs. night).
4. Each participant will be screened carefully and will be required to complete a training session on the simulator in order to overcome the driving familiarity factor. The driving behavior will be monitored during the training session to determine when a driver has reached an acceptable familiarity level.
5. Each participant will be required to complete a set of experiments without being engaged in any distracting task in order to capture the typical driving behavior. Then, the participant will be asked to perform certain tasks while driving and the driving behavior will be observed using the set of performance measures identified in Task 3.
6. Participants will also be monitored with digital cameras and videos will be recorded during the experiment to analysis their behavior afterwards. There is also a possibility of adopting an eye tracking device to track the focus point of drivers during the experiment.
7. Participants will also be required to respond to a questionnaire after the experiment. Some of the questions will be focused on whether the driver was paying attention during to specific details along the route (e.g. a fire truck on the side of the road, a pedestrian crossing the road, road signs, etc.). This can implicitly measure the level of distraction if a driver was not able to notice important information along the route.

This task is expected to be completed within the first 12 months of the project.

Task 5

This task involves the statistical analysis of the data collected from the simulation experiments. Appropriate statistical tools will be used to make comparisons between the driving behavior with and without the distraction factors and to determine whether differences, if any, are statistically significant. The selected performance measures will be used to make such comparisons. The analysis will also include the video data collected from the cameras and any possible eye tracking device available. The task will provide conclusions based on the results of the experiments. This task is expected to be completed within the first 14 months of the project.

Task 6

This task involves preparation of a final report, documenting the entire research effort and providing a detailed description of the data and the results. The final report will summarize all research tasks accomplished. This task is expected to be completed 3 months before the end of the project.

WORK PLAN

The table below shows the anticipated timeline for each of the project tasks.

Task	Month																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	X	X	X															
2	X	X	X	X	X	X												
3	X	X	X	X	X	X	X	X										
4				X	X	X	X	X	X	X	X	X						
5											X	X	X	X				
6														X	X	X	X	X

PROJECT TEAM

The study team involves Dr. Ishak (PI) and one graduate student. Dr. Ishak will lead the execution of all project tasks. Dr. Ishak assumes the responsibility of timely submission of progress and final reports. A graduate student at the MS level will be hired on this project to assist in all research tasks (setting up the experiments, data collection and analysis).

Dr. Ishak has research experience in several and diversified topics in transportation engineering including traffic simulation, data collection technologies, traffic operations, traffic safety, Intelligent Transportation Systems applications, and artificial intelligence. Project management skills as a result of managing and directing as a PI and Co-PI several research projects. Some related previous and current research projects are:

- S. Ishak (PI), "A Driving Simulator to Study Human Behavior and Improve Traffic Operation and Safety in Louisiana," LA Board of Regents, $182,060 (2010-2011).
- S. Ishak (PI), "Resilient Transportation: An Integrated Corridor Management Approach," US Department of Transportation, $37,023 (2009-2010).
- S. Ishak (PI) and B. Wolshon, "Establishing an Intelligent Transportation Systems (ITS) Lab at LTRC," Louisiana Department of Transportation and Development / Louisiana Transportation Research Center, $49,994 (2007-2008).
- B. Wolshon (PI) and S. Ishak (Co-PI), "Safety and Operational Assessment of Unconventional Lane Merges in Freeway Work Zones", Louisiana Department of Transportation and Development / Louisiana Transportation Research Center, $140,000 (2007-2000).
- S.S. Ishak (PI), "The Urban Data Warehousing/Data Mining (Dw/Dm) Component For ITS: Statewide Planning Phase," Louisiana Transportation Research Center through Tulane University (2003-2005).
- S.S. Ishak (PI), "Exploring New Traffic Characteristics and Performance Measures Using Feature Extraction and Texture Characterization of Spatiotemporal Traffic Contour Maps," National Science Foundation (2003-2006).

Recent Refereed Journal Publications

1. Ishak, S., Y. Qi, and P. Rayaprolu. Crash Analysis and Safety Evaluation of Joint and Conventional Lane Merge Configurations for Freeway Work Zones, Journal of Traffic Injury Prevention, Vol. 12 (2), 2012.
2. Korkut, M.*, S. Ishak, and B. Wolshon. (2010) Freeway Truck Lane Restriction and Differential Speed Limits: Crash Analysis and Traffic Characteristics, Transportation Research Record, Journal of the Transportation Research Board, No. 2194, 11-20.
3. Ishak, S., H.C. Shin, B. Sridhar*, and D. Zhang. (2010) Characterization and development of truck axle load spectra for future implementation of new pavement design practices in Louisiana, Transportation Research Record, Journal of the Transportation Research Board, No. 2153, 121-129.
4. Ishak, S., C. Mamidala, and Y. Qi*. (2010) Stochastic Characteristics of Freeway Traffic Speed during Breakdown and Recovery Periods, Transportation Research Record, Journal of the Transportation Research Board, No. 2178, 79-89.
5. Sun, X., B. Huang, S. Ishak, and B. Wolshon. (2009) Estimating the Safety Impact of Differential Speed Limit and Truck Lane Restriction on Interstate-10 through Atchafalaya basin in Louisiana, Journal of Transportation Safety and Security, Vol. 1, 169-180.
6. Wolshon, B., S. Ishak, Y. Qi*, M. Korkut*, X. Sun, and C. Alecsandru. (2009) Trucker Perceptions of Lane Restriction and Differential Speed Limit Policies on Freeways, Journal of Transportation Safety and Security, Vol. 1, 1-20.

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13. Horberry T., J. Anderson, M.A. Regan, T.J. Triggs and J. Brown (2006). Driver distraction: the effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. Accident Analysis and Prevention 38, 185-191.
14. Chattington, M., N. Reed, D. Basacik, A. Flint and A. Parkes (2009). Investigating driver distraction: the effects of video and static advertising – a driving simulator study. Transport Research Laboratory, published project report PPR409, UK.
15. Horrey W.J., M.F. Lesch and A. Garabet (2009). Dissociation between driving performance and drivers' subjective estimates of performance and workload in dual-task conditions. Journal of safety Research 40, 7-12.