

Impact of Distracted Driving on Traffic Flow Parameters

Despina Stavrinos, PhD
Postdoctoral Fellow, University of Alabama at Birmingham University Transportation Center
Birmingham, AL, USA, email: dstavrin@uab.edu

Annie A. Garner, MA
Graduate Research Assistant, University of Alabama at Birmingham University Transportation Center
Birmingham, AL, USA, email: aiartiga@uab.edu

Crystal A. Franklin, MPH
Program Administrator, University of Alabama at Birmingham University Transportation Center
Birmingham, AL, USA, email: crynklin@uab.edu

David Ball, MA, MDIV
Information Systems Specialist, Department of Psychology, University of Alabama at Birmingham
Birmingham, AL, USA, email: dball@uab.edu

Karlene K. Ball, PhD
Professor and Chair, Department of Psychology, University of Alabama at Birmingham
Birmingham, AL, USA, email: kball@uab.edu

Virginia P. Sisiopiku, PhD
Associate Professor, Department of Civil, Construction and Environmental Engineering,
University of Alabama at Birmingham
Birmingham, AL, USA, email: vsisiopi@uab.edu

Philip R. Fine, PhD, MSPH
Professor and Director, University of Alabama at Birmingham University Transportation Center
Birmingham, AL, USA, email: rfine@uab.edu

ABSTRACT

Studies have documented a link between distracted driving and diminished safety; however, an association between distracted driving and traffic congestion has not been investigated in depth. The present study examined the behavior of teens and young adults operating a driving simulator while engaged in various distractions (i.e., cell phone, texting, and undistracted) and driving conditions (i.e., free flow, stable flow, and oversaturation). Seventy five participants 16 to 25 years of age drove a STISIM simulator three times, each time with one of three randomly presented distractions. Each drive was designed to represent daytime scenery on a 4 lane divided roadway and included three equal roadway portions representing Levels of Service (LOS) A, C,

and E as defined in the 2000 *Highway Capacity Manual*. Participants also completed questionnaires documenting demographics and driving history.

Repeated Measures Multivariate Analysis of Variance was employed to analyze the experimental data. Results revealed that more simulated vehicles passed the participants who, in addition, exhibited slower driving speeds when distracted. Participants displayed a significant increase in fluctuation of speed while texting. More crashes occurred while texting and crash frequency was higher during stable flow conditions. No significant differences were detected between age groups.

The results indicate that distracted driving, particularly texting, may lead to reduced traffic flow, thus having a negative impact on traffic operations. These results suggest that all drivers, regardless of age, may drive in a manner that impacts traffic negatively when distracted.

Keywords: Distracted driving, traffic flow, driving simulation.

INTRODUCTION

Distracted Driving and Its Impact on Driving Performance

With advancing technology, the number of distractions to which motor vehicle drivers are exposed continues to increase. One of the most common distractions in which motor vehicle drivers engage is using a cell phone. A recent poll by the Pew Research Center revealed that 75% of U.S. teens own cell phones, with texting being the preferred method of communication (Lenhart et al., 2010). Half of teens who own a cell phone reported talking on their cell phone while driving, while one-third reported texting while driving, further demonstrating the growing demand for electronic communication.

However, it is important to underscore that cell phone-related distraction is not just a teen problem. The U.S. Department of Transportation (DOT) and Consumer Reports found that nearly a third of individuals under the age of 30 who reported using a hand-held phone while driving also reported texting while driving. This is in comparison to 9% of individuals over the age of 40 who report using a hand-held phone while driving (Consumer Reports, 2010 as cited in consumersunion.org).

It is well-established that cell phones compromise the performance of motor vehicle drivers (Caird et al., 2008; Drews et al., 2008; Horrey & Wickens, 2006). The explanation for this is because cell phone conversations impose certain cognitive demands that interfere with driving performance due to the verbal and attentional processing required to successfully engage in both tasks (Charlton, 2009). Given the cognitive and motor constraints required to complete both tasks simultaneously, the effect of text messaging on driving performance may be even more detrimental than the effect of a cell phone conversation. For example, one recent study examining text messaging and driving in a young adult population (ages 18-21) found that teens spent 400% more of the simulator time with their eyes off of the road while texting than when undistracted (Hosking et. al., 2009).

Outcomes Related to Traffic Congestion

At the individual level, congestion affects three critical aspects of the motor vehicle driver's life: time, finances and health. Consider: In 2009, the average yearly peak delay for an individual driver was 34 hours – almost an entire work week – causing the average consumer to incur an estimated \$808 congestion cost (Schrang et al., 2010). Moreover, traffic congestion has been linked to increases in heart rate and systolic blood pressure (Gotholmsdeder et al., 2009; Hennessy & Wiesenhal, 1999; Stokols et al., 1978) and, to workplace aggression (Hennessy, 2008). Further, the impact of poor air quality and increases in traffic emissions on health have been documented as consequences of traffic congestion (Hollander et al., 1999; Levy et al., 2010).

Extending beyond the costs of traffic congestion for the individual, the Texas Transportation Institute estimates that the economic cost of traffic congestion in the U.S. was around \$115 billion in 2009 (Schrang et al., 2010). For these reasons, maximizing transportation efficiency and minimizing congestion was identified as and continues to be a critical highway and research need by the National Highway R&T Partnership (2002).

Additional Considerations

Driver inefficiency is a probable contributor to traffic congestion. Thus, it is of more than casual interest that distraction very likely contributes to driver inefficiency. Examples of specific inefficiencies observed when drivers are distracted include navigating at slower speeds, leaving larger intervals between their own vehicle and the vehicle in front of them, and reduced reaction times (Horrey & Wickens, 2006).

Impact of Distracted Driving on Traffic Flow

Despite conducting an extensive literature review, we were able to identify only one research study directly examining the impact of distracted driving by younger drivers on traffic movement (Cooper et al., 2009). In this study, 36 undergraduate students (mean age 21.5 years) drove in varying levels of simulated traffic flow in two conditions: (a) while distracted by a cell phone conversation; and, (b) while undistracted. Results indicated that when distracted, drivers were less likely to change lanes and more likely to drive at slower speeds, independent of traffic flow. When changing lanes while distracted, participants left less space between their car and surrounding cars than they did when driving without distraction, indicating degradation in driving performance under distracted driving conditions. When distracted, drivers also spent more time tailgating in all levels of traffic flow. The authors concluded that because participants engaged in behaviors previously identified as characteristic of reduced traffic movement, distracted driving appears to have a negative impact on traffic flow.

While Cooper's research provides an important contribution to the understudied area of distracted driving's impact on traffic flow, like most other studies it has its limitations. For example, the dependent variables fail to directly measure overall traffic movement and flow. Additionally, the investigation is limited to the effects of only one form of distracted driving

(i.e., cell phone conversation); thus, the study's generalizability is limited. While Cooper and colleagues were the first to consider the impact of cell phone distraction on traffic movement and flow, it is clear that additional studies are warranted to more fully understand the impact of distracted driving on traffic flow.

The Present Study

The present study examined the driving behavior of 75 participants between 16 and 25 years of age operating a virtual driving simulator with driving conditions varying across three Levels of Service (LOS) (namely LOS A "free flow", LOS C "stable flow", and LOS E "oversaturation"), as defined by the *Highway Capacity Manual* (2000). This investigation included two categories of variables measuring traffic congestion: (1) indicators of driver traffic inefficiencies and (2) indicators of congested traffic environment. It was hypothesized that engagement in any distracting condition (i.e., cell phone conversation or texting) would lead to behavior(s) capable of obstructing traffic flow. In addition, it was hypothesized that both distracting conditions (i.e., cell phone conversation or texting) would induce behaviors resulting in impeded traffic movement and that the effects would be greatest during the text messaging condition.

METHODOLOGY

Participant Recruitment/Consent

Potential participants were recruited from advertisements in local newspapers, flyers and social networking websites. Advertisement content included contact information, information regarding the desired age range of the prospective participants and a brief statement describing that participants would drive a simulator for monetary compensation. Subsequently, prospective participants phoned the number listed in the advertisement to receive additional information about the study. Parents or guardians of prospective participants who were 18 years of age or younger were requested to be part of the phone call. Prospective participants were screened for eligibility and, if eligibility criteria were met, they were mailed or e-mailed a University of Alabama at Birmingham (UAB) Institutional Review Board (IRB) approved consent form. A follow-up phone call was made no sooner than 24 hours after eligibility screening, at which point prospective participants could schedule an appointment.

Upon arrival for testing, participants provided staff with the signed IRB consent forms. For participants whose age rendered them minors by state law, a parent/guardian was required to provide written IRB consent in addition to the teen's participant consent. This was accomplished by either signing appropriate documents before the teen came to the appointment or signing it at the time of the appointment. Tasks were administered by a team of undergraduate and graduate student research assistants using standardized protocols. Participants took part in two activities presented in random order during the session, driving in a virtual simulator and completing the questionnaire.

Participants

Demographic characteristics of the sample are presented in Table 1. Seventy-five participants were divided into two age groups: 16 – 18 for novice drivers; and, 19 – 25 for young adults. Inclusion criteria included possession and regular use of a cell phone with text messaging capability and a willingness to use their personal cell phone for 30 minutes during the session. Participants were also required to possess a valid Alabama driver's license. Exclusion criteria for both groups included physical disabilities (e.g., severe visual or hearing impairment, use of a wheelchair) that would have physically precluded a person with one of the aforementioned disabilities from being able to complete the experimental protocol.

Table 1 Demographic Characteristics of Sample by Age Groups

	Novice Drivers		Young Adult Drivers	
	Mean	SD	Mean	SD
Age (years)	17.67	1.18	23.39	1.81
Time Since Licensure (years)	1.28	0.93	6.76	1.99
Engagement in Distracted Driving (days per week)				
Talking on hands held cellular	3.00	2.07	3.62	2.12
Talking on a hands free cellular	0.47	1.20	1.23	2.11
Send a text	3.27	2.91	3.47	2.53
Read a text	4.67	2.38	4.07	1.99
Send an email	0.07	0.37	0.91	1.97
Read an email	0.40	1.25	1.68	2.21
Access the internet	0.47	1.25	2.18	2.74
Use GPS	0.90	1.09	1.42	1.59
Change songs on an MP3 Player	3.63	2.98	2.96	2.81
	Frequency	Percent	Frequency	Percent
Gender				
Male	11	36.7	23	51.1
Female	19	63.3	22	48.9
Ethnicity				
Caucasian	16	53.3	19	42.2
Minority	14	46.7	26	57.8

*Note. Driving outcomes result from self-report. **Bold** indicates significant difference between groups ($p < .05$).

Driving Simulator Activity

Before driving the simulator, each participant provided the study assistant with their cell phone number to “test” whether the cell phone was capable of receiving phone calls and transmitting text messages. Participants were instructed to adjust their cell phone to the loudest ringer volume (to assure the ring would be audible in the simulator room while the driving bouts were in progress). Participants were familiarized with the simulator during a brief calibration session, involving a “car following paradigm” devised by Strayer and co-workers (2006) to assure that all participants met a minimum standard of proficiency with basic driving tasks (e.g. being able to maintain a steady speed and demonstrating acceptable braking performance).

In the Strayer-based car following paradigm, participants drove a standardized scenario with no distraction until they satisfied the criteria for stable driving performance. Participants were instructed to drive within 200 feet from the vehicle in front of them. If a participant fell more than 200 feet behind the lead vehicle, a verbal warning was presented. At the end of the 5 minute practice drive, study assistants summed the number of verbal warnings participant-drivers received to make a determination about whether additional practice was needed (threshold was set to > 6 warnings would constitute a “fail” and would require another practice driving bout). The majority of participants (93.2%) received 5 or fewer verbal warnings during the practice drive. Six participants required, and passed, a second practice drive. Previous studies have used “familiarization drives” to rule out learning effects (Weafer et al., 2008), but few have employed measurable proficiency tests that test for stable levels of driving performance.

Participants then drove in the simulator three times, each time with one of three randomly presented distractions (cell phone, texting, and undistracted). Cell phone and text messaging conditions were semi-structured to imitate a typical conversation between unfamiliar individuals, and research assistants maintained a natural conversation flow. Typical conversational questions included inquiries such as “What is your favorite television show?” and “What do you like to do for fun?”

During each driving scenario, participants were instructed to drive as they typically would on a real road for approximately 30 minutes, obeying the speed limit. The virtual road environment featured a four-lane divided freeway and day-time suburban scenery; and, closely matched driving situations typically encountered in the Birmingham metropolitan area. The three driving scenarios differed in terms of traffic flow and density and were based on three Levels of Service (LOS) outlined in the *Highway Capacity Manual* (2000). Each drive was designed to represent daytime scenery and included three equal roadway portions representing three driving conditions: LOS A (6.5 vehicles per mile in right and left lane combined); LOS C (40 vehicles per mile in right and left lane combined); LOS E (170 vehicles per mile in right and left lane combined).

Questionnaire

The questionnaire activity involved completing a demographic questionnaire in a private room, some distance away from the virtual driving simulator (see Measures section). Study assistants gave participants the option of completing the questionnaire on their own (after a brief

introduction) or with the assistance of a study assistant (to accommodate any participant who might have had difficulty reading or who might not have disclosed being unable to read).

Debriefing

After the three driving scenarios and completing the questionnaire, participants were debriefed. The debriefing included two components: (1) a discussion of topics relevant to the present work and (2) the presentation of a take home brochure describing the dangers of distracted driving. Participants received a single monetary payment at the end of the session.

Measures

Indicators of the impact of distracted driving on traffic flow were divided into two categories: (1) variables related to driver behavior and (2) variables related to the traffic environment. Operational definitions and the rationale for the use of these indicators are provided below.

Traffic Flow-Related Indicators of Driver Behavior

1. The total number of cars the participant-driver passed indicated whether the participant maintained appropriate flow in traffic. Specifically, fewer cars passed by the participant indicated increased traffic obstruction.
2. Average driving speed where lower average driving speed is considered an indicator of obstructed traffic flow.
3. Fluctuation in driving speed was computed for each driving scenario. Greater fluctuation in driving speed indicated inefficient driving and was considered to negatively impact traffic flow.
4. Lane change frequency was used as an indicator of traffic flow and defined as the number of instances participants exited their lane and fully entered an adjacent lane. Greater lane change frequency is indicative of better traffic flow. Fewer number of lane changes were considered to indicate reduced traffic flow as it is often an obtrusive form of driving (Cooper et al., 2009).
5. Time of scenario completion was calculated as the time elapsed from the beginning to the end of a driving scenario and it was reasoned that a longer time of completion for the scenario would be indicative of a negative impact on the traffic flow (Cooper et al., 2009).

Traffic Flow-Related Indicators of Environment

1. The more cars that passed the participant-driver indicated that the participant negatively impacted traffic flow.

Questionnaire

The Questionnaire Assessing Distracted Driving (QUADD; Welburn et al., 2010; Welburn et al., 2011), a laboratory-developed questionnaire, assessed demographic variables of interest

including, demographic information (i.e., gender, age, time since licensure), cell phone and text messaging use, and driving history and experience.

Data Analysis

To examine the influence of age on driving behavior across various levels of traffic flow and distraction, participants were divided into two age groups. Three traffic flow conditions (LOS A, LOS C, LOS E) and 3 distraction conditions: text, cell phone, no distraction were considered. A Repeated Measures Multivariate Analysis of Variance (within subjects variables: distraction, flow; between subjects factor: age) was performed to explore the impact of distracted driving on the traffic environment. Dependent variables included number of cars the participant-driver passed, average driving speed, fluctuation in speed, lane change frequency, and time of scenario completion (i.e., traffic flow-related indicators of driver behavior). Significant main effects of Distraction, Age, and the Distraction x Age two-way interactions were of particular interest. Also, a 3 traffic flow (LOS A, LOS C, LOS E) and 3 distraction condition (text, cell phone, no distraction) Repeated Measures Analysis of Variance model (within subjects variables: distraction, flow; between subjects factor: age) was tested to explore the impact of distracted driving on the traffic environment. The number of cars that passed the participant-driver served as the dependent variable (i.e., traffic flow-related indicator of environment, rather than the driver).

RESULTS

Traffic Flow-Related Indicators of Driving Behavior

The omnibus multivariate model revealed a significant main effect of distraction, $F(10, 250) = 4.55$, $p < .001$, partial $\eta^2 = 0.15$. Further inspection of the overall significant main effect indicated that driving behavior varied across levels of distraction for four of the five driving variables measured (all except Number of Cars the Participant Driver Passed). The main effect of Age and the 2-way Distraction x Age interaction were not significant. Univariate results are described in greater detail below.

Number of Cars the Participant-Driver Passed

No significant differences emerged for the number of cars the participant-driver passed across distraction types among the two age groups considered.

Driving Speed

A significant main effect of distraction for Average Driving Speed was found, $F(2, 250) = 4.89$, $p < .01$, partial $\eta^2 = .07$. Post hoc tests suggested that while in the text messaging condition, participant-drivers displayed significant slower driving speeds than during the no distraction condition (Table 2 and Figure 1).

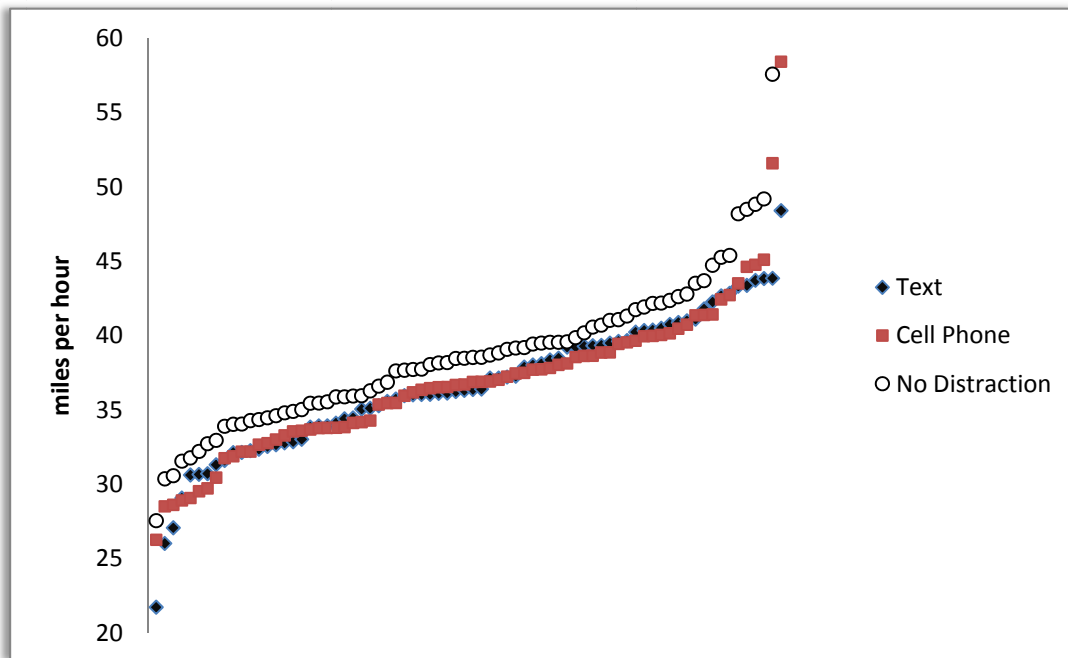


Figure 1 An illustration of the impact of distraction on driving speed

Fluctuation in Speed

A significant main effect of distraction for Fluctuation in Speed was revealed, $F(2, 250) = 3.56$, $p < .05$, partial $\eta^2 = .05$. Post hoc tests indicated that significantly greater variability in driving speed was exhibited during the text messaging condition as compared to no distraction (Table 2 and Figure 2).

Lane Changing Frequency

A significant main effect of distraction for Lane Changing Frequency, $F(2, 250) = 9.51$, $p < .001$, partial $\eta^2 = .13$, suggested a difference in the number of times participant-drivers changed lanes across distraction conditions. Post hoc tests suggested that when distracted (either by text messaging or cell phone conversation), participant-drivers changed lanes significantly fewer times than during the no distraction condition (Table 2 and Figure 3).

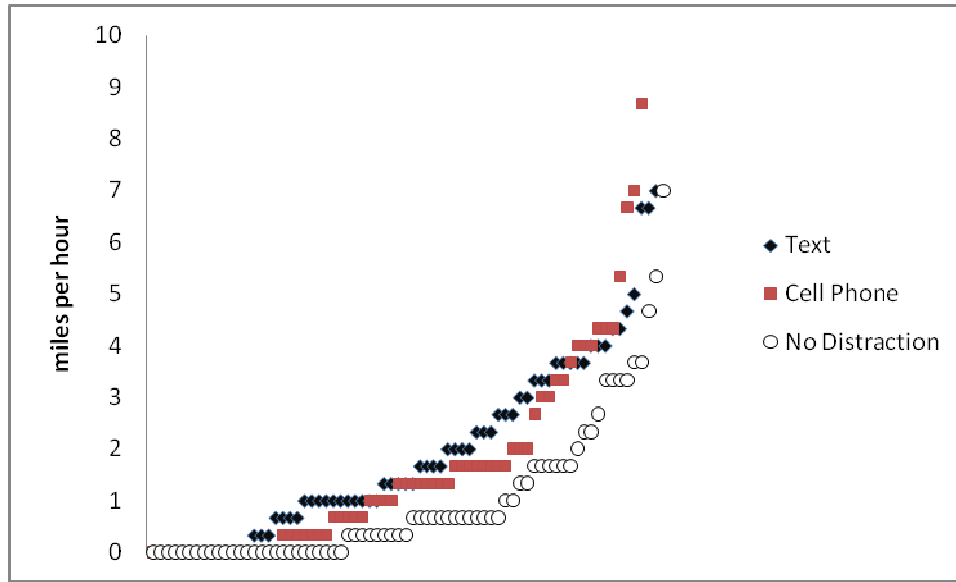


Figure 2 An illustration of the impact of distraction on fluctuation in speed

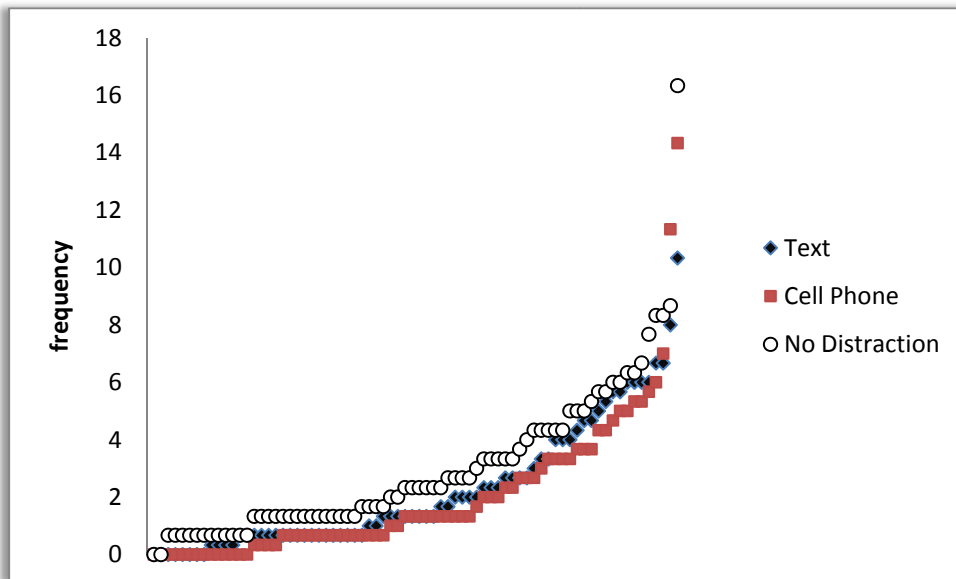


Figure 3 An illustration of the impact of distraction on lane changing frequency

Time to Complete Scenario

A significant main effect of distraction for Time to Complete Scenario emerged, $F(2, 250) = 5.05$, $p < .01$, partial $\eta^2 = .07$. Post hoc tests suggested that while in the text messaging condition, participant-drivers took significantly longer to complete the driving scenario than during the no distraction condition (Table 2 and Figure 4).

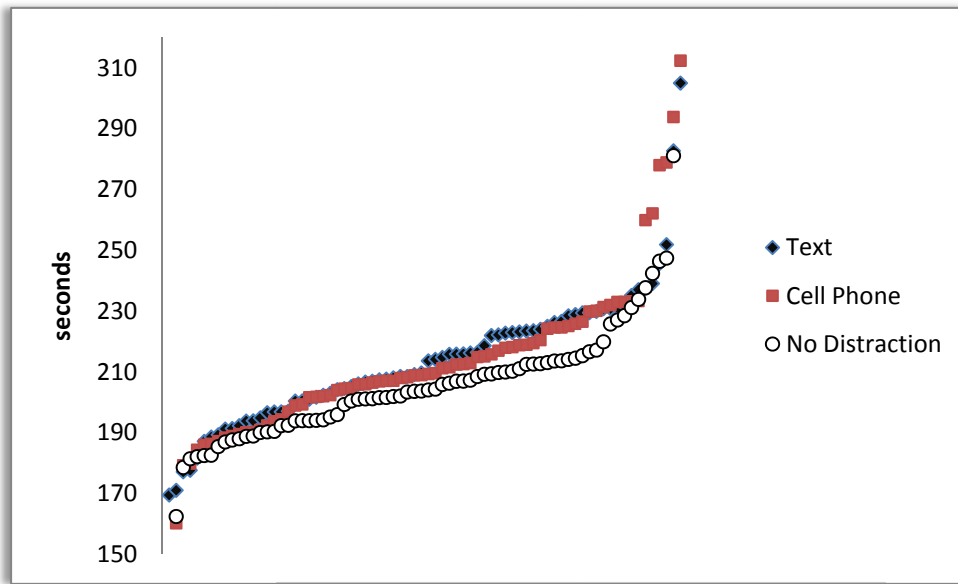


Figure 4 An illustration of the impact of distraction on time to complete scenario

Traffic Flow-Related Indicators of Environment

Cars that Passed the Participant-Driver

The overall model revealed a significant main effect of distraction, $F(2, 64) = 11.39, p < .001$, partial $\eta^2 = .26$. A significant main effect of distraction for the Number of Cars that Passed the Driver emerged, $F(2, 64) = 8.30, p < .001$, partial $\eta^2 = .11$. Post hoc tests revealed that significantly more cars passed the driver during any form of distraction (cell phone and text messaging) as compared to no distraction (Table 2 and Figure 5).

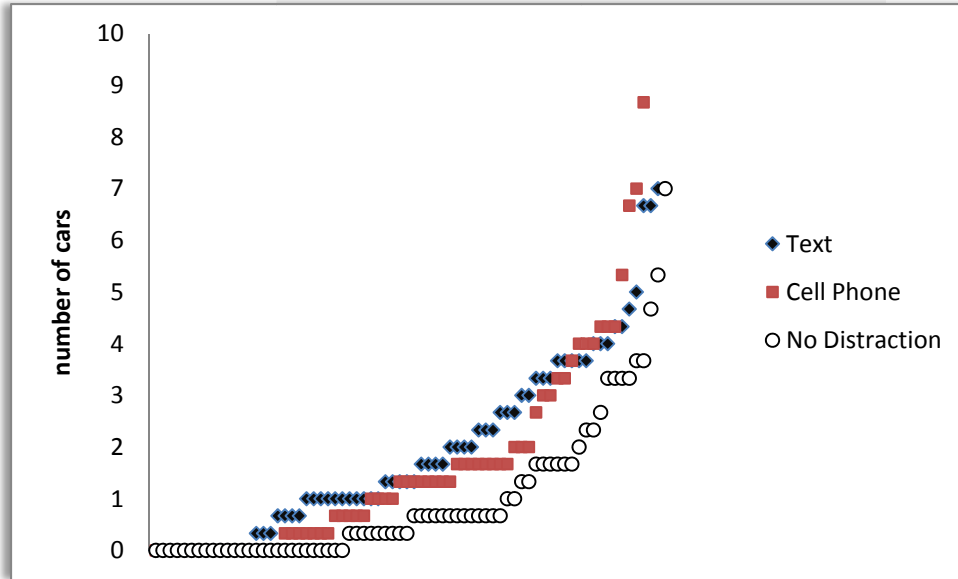


Figure 5 An illustration of the impact of distraction on traffic environment

Table 2 Estimated Marginal Means and Standard Errors for Distraction Main Effect

	Distraction Type		
	Text	Cell phone	No Distraction
<i>Traffic Flow-Related Indicators of Driving Behavior</i>			
Cars that the Driver Passed (total #)	0.535 (0.12)	0.280 (0.06)	0.411 (0.08)
Driving Speed (mph)*	37.06 (0.53) ^a	37.76 (0.59)	38.92 (0.84) ^a
Fluctuation in Speed (mph)*	8.54 (0.32) ^a	8.15 (0.34)	7.55 (0.29) ^a
Lane Changing Frequency (total #)*	2.39 (0.29) ^a	2.20 (0.34) ^b	3.21 (0.34) ^{a,b}
Time To Complete Scenario* (seconds)	210.88 (2.42) ^a	207.48 (2.39)	202.63 (198.04) ^a
<i>Traffic Flow-Related Indicators of Environment</i>			
Cars that Passed the Driver (total #)*	1.86 (0.22) ^a	1.54 (0.21) ^b	0.92 (0.17) ^{a,b}

Note: * $p < .05$; superscripts indicate post-hoc significant differences between distraction types within a particular driving outcome

DISCUSSION

As new technologies emerge and continue to become more commonplace, it is increasingly important that investigators examine the potential implications such activities have on transportation not only from a safety perspective but also from a traffic operations perspective. This study examined the impact of distracted driving on congestion within varying levels of

traffic flow. Results were largely consistent with our hypotheses: Text messaging had the greatest negative impact on traffic flow (regardless of LOS) across all variables measured except for the number of cars the participant-driver passed.

Distraction did not appear to affect the number of cars that the participant-driver passed. In fact, participant-drivers passed cars as much when undistracted as they did when texting or engaging in a cell phone conversation, suggesting that distraction has little influence on this particular driving behavior. However, inspection of fluctuations in driving speed across distractions suggests that participant-drivers fluctuated their speed more when texting. Taken together, these results suggest that participant-drivers were attempting to keep up with (or catch up to) the flow of traffic rather than simply passing the cars ahead of them. It seems reasonable to conclude that, at times, distracted drivers (in particular those distracted by text messaging) may have obstructed traffic flow.

Overall, our results are quite similar to those reported by Cooper et al. (2009). For example, like Cooper, we found that participant-drivers changed lanes less frequently when distracted than when not distracted. However, the present study additionally demonstrates that texting reduces the frequency of lane changing in the same manner as distraction by cell phone. Contrary to our hypothesis, texting while driving does not reduce lane changing behavior to a greater extent than cell phone use while driving. Thus, for this particular measure of traffic flow, the two forms of distraction contribute to reduced traffic flow to similar extents.

This study extended Cooper's work by including younger participants who frequently engage in distracted driving. However, no significant differences were detected between age groups. While other studies seem to confirm that younger drivers are more likely to engage in distracted driving, these results suggest that all drivers, regardless of age, may drive in a manner that impacts traffic negatively when distracted.

Moreover, our findings may enhance the fidelity of future modeling simulations by providing a more informed account of distracted driver behavior. When taking into account the average 8 second delay in time to complete the driving scenario participant-drivers exhibited when distracted by texting as compared to when undistracted, obstructive driving might have serious implications in a real-world situation. Consider a LOS C scenario where approximately 40 vehicles are located within a 1 mile freeway segment. If each driver within this particular segment was distracted by texting, the total drive delay due to driver distraction could reach as much as 6.67 minutes.

The present study provides empirical evidence regarding the impact of distracted driving on traffic congestion. However, no study is without limitations and our study is no different. For example, we observed driving behavior in a simulator which provided a safe, controlled environment required for examining the impact of distracted driving on varying traffic conditions. Future work might consider a naturalistic approach to determine whether similar inefficiencies translate to real world driving. In addition, future attempts may seek to include safety-related variables to determine the safety implications of distracted driving across varying levels of traffic congestion.

ACKNOWLEDGEMENTS

This work was supported through a grant from the University Transportation Center for Alabama and in kind support of the UAB University Transportation Center. The authors would like to thank the UAB Translational Research for Injury Prevention Laboratory for their assistance with data collection. Also thanks to Dr. Andrea Underhill for her help in preparation of this manuscript.

REFERENCES

- Caird, J.K., Willness, C.R., Steel, P., and Scialfa, C. (2008). "A meta-analysis of the effects of cell phones on driver performance", *Accident Analysis and Prevention*, 40, 1282-1293.
- Charlton, S.G. (2009). "Driving while conversing: Cell phones that distract and passengers who react", *Accident Analysis and Prevention*, 41, 160-173.
- Consumers Union. Younger drivers more likely to text and drive, less likely to view as a danger. <http://www.consumersunion.org/pub/2011/03/017477print.html> (Mar. 22, 2011).
- Cooper, J.M., Vladislavljevic, I., Medeiros-Ward, N., Martin, P.T., and Strayer, D.L. (2009). "An investigation of driver distraction near the tipping point of traffic flow stability", *Human Factors*, 51(2), 261-268.
- Drews, F.A., Pasupathi, M., and Strayer, D.L. (2008). "Passenger and cell phone conversations in simulated driving", *Journal of Experimental Psychology: Applied*, 14, 392-400.
- Gottholmseder, G., Nowotny, K., Pruckner, G., and Theurl, E. (2009). "Stress perception and commuting", *Health Economics*, 18(5), 559-576.
- Hennessy, D. (2008). "The impact of commuter stress on workplace aggression" *Journal of Applied Social Psychology*, 38(9), 2315-2335.
- Hennessy, D. and Wiesenthal, D. L. (1999). "Traffic congestion, driver stress and driver aggression", *Aggressive Behavior*, 25, 409-423.
- Hollander, D. A., Melse, J., Lebrecht, E., and Kramers, P. (1999). "An aggregate public indicator to represent the impact of multiple environmental exposures" *Epidemiology*, 10(5), 606-617.
- Horrey, W.J. and Wickens, C.D. (2006). "Examining the impact of cell phone conversations on driving using meta-analytic techniques", *Human Factors*, 48, 196-205.
- Hosking, S., Young, K., and Regan, M. (2009). "The effects of text messaging on young novice driver performance." Monash University Accident Research Centre, Report No. 246.

Lenhart, A., Ling, R., Campbell, S., and Purcell, K. (2010). "Teens and Mobile Phones", Pew Internet Research Center Report.

Levy, J., Buonocore, J., and Stackelberg, K. (2010). "Evaluation of the public health impacts on traffic congestion: a health risk assessment." *Environmental Health* 9, 9-65.

National Academy of Sciences. (2000). "Highway capacity manual", *Transportation Research Board*.

National Highway R&T Partnership Report. Highway Research and Technology: The need for greater investment. April 2002.

Schrank, D., Lomax, T., and Turner, S. (2010). "*TTI's 2010 urban mobility report, Powered by INRIX traffic data*" Texas Transportation Institute, The Texas A&M University System.

Stokols, D., Novaco, R., Stokols, J., and Campbell, J. (1978). "Traffic congestion, type A behavior, and stress." *Journal of Applied Psychology*, 63(4), 467-480.

Strayer, D. L., Drews, F. A., and Crouch, D. L. (2006). "A comparison of a cell phone driver and the drunk driver." *Human Factors*, 381-391.

Weafer, J., Camarillo, D., Fillmore, M.T., Milich, R., and Marczinski, C.A. (2008). "Simulated driving performance of adults with ADHD-C: Comparisons with alcohol intoxication." *Experimental and Clinical Psychopharmacology*, 16, 251-263.

Welburn, S.C., Garner, A.A., Schwartz, M., and Stavrinis, D. (2010, April). "Developing a self-report measure of distracted driving in young adults", *The 2010 University of Alabama at Birmingham Expo for Undergraduate Research*, Birmingham, AL.

Welburn, S.C., Garner, A.A., Franklin, C.A., Fine, P.R., and Stavrinis, D. (2011, April). "Psychometric validity of the Questionnaire Assessing Distracted Driving (QUADD)", *The 2011 University of Alabama at Birmingham Expo for Undergraduate Research*, Birmingham, AL.