Journal of Ergonomics

Palumbo TJ et al, J Ergonomics 2015, S3:013
http://dx.doi.org/10.4172/2165-7556.S3-013

Research Open Access

# The Effects of Texting and DUI Simulation on Driving Performance in a Driving Simulator

**Theresa J Palumbo[1], Doreen Head[2], Aaron Swift[2], Gordon Rumschlag[1], Jeremy Ing[1], Cindy Ngo[1], Matthew Surducan[1], Eric Lahoud[1], Brenna Johnson[1], Benjamin Mackie[1] and Randall L Commissaris[1*]**

[1]Department of Pharmaceutical Sciences, EACPHS; Eugene Applebaum College of Pharmacy and Health Sciences, Wayne State University, Detroit, MI 48202, USA

[2]Department of Health Care Sciences, EACPHS, Eugene Applebaum College of Pharmacy and Health Sciences, Wayne State University, Detroit, MI 48202, USA

[*]**Corresponding author:** Randall L Commissaris, Department of Pharmaceutical Sciences, 3126 Applebaum Building, College of Pharmacy and Health Sciences, Wayne State University, Detroit, MI 48202, USA, Tel: 7347515534; Email: Commissaris@wayne.edu

**Rec date:** Jan 09, 2015, **Acc date:** Mar 30, 2015, **Pub date:** April 7, 2015



## Abstract

Alcohol and texting each have serious effects on driving ability, leading to crashes and fatalities. The combined effects of alcohol intoxication and texting on driving behavior have not been well-studied. The present study utilized ‘Beer Goggles’ (BG) to test the hypothesis that the visual disturbances typically observed with ethanol intoxication potentiate the disruptive effects of texting on driving. Subjects were 18–26 years of age. While ‘driving’ on a straight roadway, subjects were engaged in brief text conversations. Subjects wore normal safety goggles and BG that simulated the visual disturbance associated with 0.07-0.1 % EtOH (legally drunk). The primary dependent variables were (1) the position of the car on the roadway and (2) eye glances on the phone-v-the roadway during texting. In all subjects, texting while driving was associated with a series of glances back and forth between the phone and the roadway, with slightly more than half this time spent looking at the phone and NOT at the roadway. Texting alone significantly impaired driving performance. BG alone did not negatively affect driving. BG significantly increased the disruptive effects of texting on driving performance and also increased (1) mean (and median) glance duration, (2) the average number of glances off the roadway per text conversation, (3) the duration of the Longest Glance Off the Roadway and finally (4) the Total duration of Eyes Off the Roadway. The present study confirms past reports that texting impairs driving performance. Moreover, the effects of texting on driving are dramatically worse when vision has been moderately impaired by BG. Given the high likelihood of texting while driving and after drinking, these data suggest that ‘No Texting While Driving’ education and public service messages need to be continued, and they should be expanded to focus on the negative interaction between texting, drinking and driving.

**Keywords:** Driving simulator; Texting and driving; Distracted driving; DUI simulation; Alcohol and driving; Drunk texting; Fatal Vision goggles

## Introduction

Distracted driving accounts for more than 3,000 motor vehicle crash deaths annually [1]. Texting is a particularly common and potent form of distracted driving [2-6]. At any given daylight moment across America, approximately 660,000 drivers are using cell phones or manipulating electronic devices while driving, a number that has held steady since 2010 [1]. Indeed, the term ‘intexticated’ has been coined to describe traffic crashes related to texting while driving (**http://www.urbandictionary.com/define.php?term=intexticated**). Studies in driving simulators also have demonstrated the disruptive effects of texting on driving performance [6-9]. Drews et al. [7] have reported that texting while driving increased brake onset times (both when reading/receiving and when entering a text), increased lane crossings and increased lane reversals.

As a visual-motor task, texting reduces the time when a driver’s eyes are focused on the roadway [6, 10-15], this can be expressed in terms of the number of glances from the roadway to the phone, the average (or median) glance duration, the total time with eyes off the roadway (TEOR) or as the longest glance off the roadway (LGOR). Klauer et al. [16] have found that the duration of eye glances away from the roadway correlates with the odds ratio for having a crash or near-crash (100 car study). In recognition of the importance of eye glances off the roadway, NHTSA has recommended that in-car electronic devices “… be designed so that tasks can be completed by the driver with glances away from the roadway of 2 seconds or less and a cumulative time spent glancing away from the roadway of 12 seconds or less….” [17].

Alcohol intoxication also is a major cause of traffic fatalities. In 2012, alcohol intoxication was estimated to be responsible for nearly one third of the annual 30,000 motor vehicle crash deaths in the United States [18]. Alcohol also negatively affects driving performance in a simulator [19-21]. This disruption often is characterized by increased lane excursions, increased latency to avoid an obstacle (blocking vehicle) [19]. Indeed, for many measures of driving simulator performance, cell phone use, especially texting, is as bad or worse than the effects of alcohol [22-24].

Alcohol is a general central nervous system depressant that adversely affects many components of driving behavior. Alcohol reduces muscle coordination and increases reaction times, impairs judgment, increases aggression and increases the likelihood of risk-taking behaviors; alcohol also adversely affects vision, with slowed pupil reaction (accommodation) times, reductions in peripheral vision and double vision as possible effects of alcohol use [25,26]. One way to mimic the visual disturbances associated with alcohol intoxication is the use of beer goggles, which simulate the visual impairment effects of alcohol [27-29]. Beer Goggles produce at least two prominent visual effects that resemble the effects of ethanol intoxication: (1) blurred vision and (2) disruption of guided movement akin to the finger-to-nose challenge during Field Sobriety Testing. Beer Goggles do not produce many other effects typically associated like ethanol intoxication, e.g., impaired judgment, decreased reaction time, increased aggression. Thus, studies with beer goggles can be used to examine the influence of visual impairment without the many other effects of ethanol exposure.

Texting while intoxicated is not uncommon, as evidenced by websites such as 'My Drunk Texts' (http://www.mydrunktexts.com) and 'Drunktext.com' (http://www.drunktext.com). It is likely that some of these drunk texters will be driving, and it might be predicted that the triple combination of drunk texting while driving will be associated with an even greater likelihood of causing an accident when compared to either texting while driving or drunk driving. Indeed, a recent 'Google search' using the terms 'texting drunk driving' revealed one report in 2014 [30], but four newspaper reports of arrests for texting while driving and drunk in the first three months of 2015 alone; in two of these cases, the victim was killed by the driver. It is somewhat surprising, therefore, that the combined effects of alcohol intoxication and texting on driving behavior have not been well-studied, either on the road or in a driving simulator.

The present studies utilized 'Beer Goggles' to test the hypothesis that the visual perception disturbances associated with ethanol intoxication potentiate the disruptive effects of texting on driving performance. We also determined the effects of texting on eye glance behavior, and examined the relationship between eye glance behavior and driving performance while texting, with and without beer goggles.

## Materials and Methods

### Subject demographics

The subjects were 8 males and 8 females (22.8 ± 1.8 years old; Mean ± SD); they were recruited from the population of students, faculty and staff at the EACPHS; 18-26 year old subjects were selected because this age group is perhaps the most likely to engage in the behavior we are modeling in the present study (texting while driving drunk). They reported a history of 6.6 ± 1.6 years driving experience, an average of 11.2 ± 4.6 hours driving per week; they reported sending 75.9 ± 33.5 texts per week. All of the subjects self-reported as highly-skilled texters.

### The EACPHS driving simulator

Study participants were seated in a fixed base driving simulator (Drive Safety, Inc) that consisted of a four-door vehicle (2001 Chevrolet Impala) equipped with steering wheel, pedals, ignition switch, gear shift, rear and side view mirrors, headlights, turn signals and a radio. A fully immersed virtual driving experience was created by six networked computers generating the simulated roadway via three forward projection screens (6 feet x 4 feet; left, center, right) to provide a 150 degree forward field of view, and one rear projection screen. Driving scenarios were created using Hyper Drive software, a tile-based scripting tool.

### Experimental design (four parts)

In Part 1, subjects 'drove' the simulator in a brief (3-5 min) drive (50-60 mph) to acclimate to the driving experience. The subjects then completed a survey asking about demographic information, their texting behavior, ethanol consumption and some of their driving habits. In Part 3, the subjects again drove the simulator; on this drive the subjects were engaged in series of brief text conversations with a member of the research team. The text messages involved simple, short questions that typically required only a one-word answer; e.g., what is your favorite color? Did you play sports in high school? Text conversations were conducted on a straight part of the road. There was a pace car which traveled at 60 mph; subjects were instructed to follow the pace car at a safe distance. There was no other traffic on the roadway. Subjects wore normal safety goggles for two text conversations (Control) and 'Beer Goggles' (Fatal Vision, Inc.) for two text conversations; the sequence of goggle type (Control Goggles first v Beer Goggles first) was balanced across the subjects. The Beer Goggles simulated the visual disturbance associated with 0.07-0.1% EtOH (legally drunk). In Part 4, the subjects reflected on their experience in a brief survey.

### Data collection and dependent variables

One dependent variable was the position of the car on the roadway before (i.e., 10 seconds prior to texting: pre-texting period) and during texting while driving. Because of a technical failure, parameters related to car performance (e.g., steering variance, lane position, lane excursions) could not be collected from the Drive Safety software. Therefore, driving performance (before and during texting) was reviewed and scored using drive videos and a 1-4 scale: 1=no weaving; 2=weaving, but remained in the proper lane; 3=excursion outside the driving lane; 4= multiple excursions outside the driving lane. Drives were scored by 6 members of the research team who were blind regarding the treatment conditions. In a separate experiment, this scoring rubric was found to be highly reliable when 'calibrated' against steering variance data (see 'Calibration Experiment' below).

The second dependent variable was eye glances from the road to the phone by the subjects during texting while driving. (Subjects did not look at their phones during the pre-texting periods.) For each occasion of texting while driving, the sequence of eye glance behavior during texting (looking at the phone, at the roadway, at the phone, at the roadway, etc.) was scored to a resolution of 0.033 sec (i.e., 1 video frame at 30 frames per second). The primary eye glance measures for each texting and driving episode were (1) the mean (and median) glance duration on the phone, (2) the number of glances on the phone, (3) the total time with eyes off the roadway (TEOR) and the Longest Single Glance Off the Roadway (LGOR). As with drive scoring, eye glance data were scored by members of the research team who were blind regarding the treatment conditions.

### Calibration experiment

After the data collection/retrieval component of the driving simulator was repaired and reinstated, an experiment was conducted to 'calibrate' the drive scoring system described above. In this calibration experiment, two subjects drove the car on straight roadways and attempted to 'create' driving scores of 1, 2, 3 and 4 as described above. Steering variance data were collected during these drives; in addition, videotapes of these drives were scored by two raters who were blind regarding both the driver and drive target score. The results of this calibration experiment are shown in Figure 1. As can be seen, the target driving score was directly related to steering variance ($F[3,16]=55.41$, $p<0.05$; left panel) and with the viewer-based driving scores ($F[3,16]=126.62$, $p<0.05$; center panel). More importantly, steering variance was significantly correlated with video-based driving

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scores (Figure 1; right panel; r=0.71, p<0.05). These data indicate that the video scoring process described above provides a valid measure of driving performance.

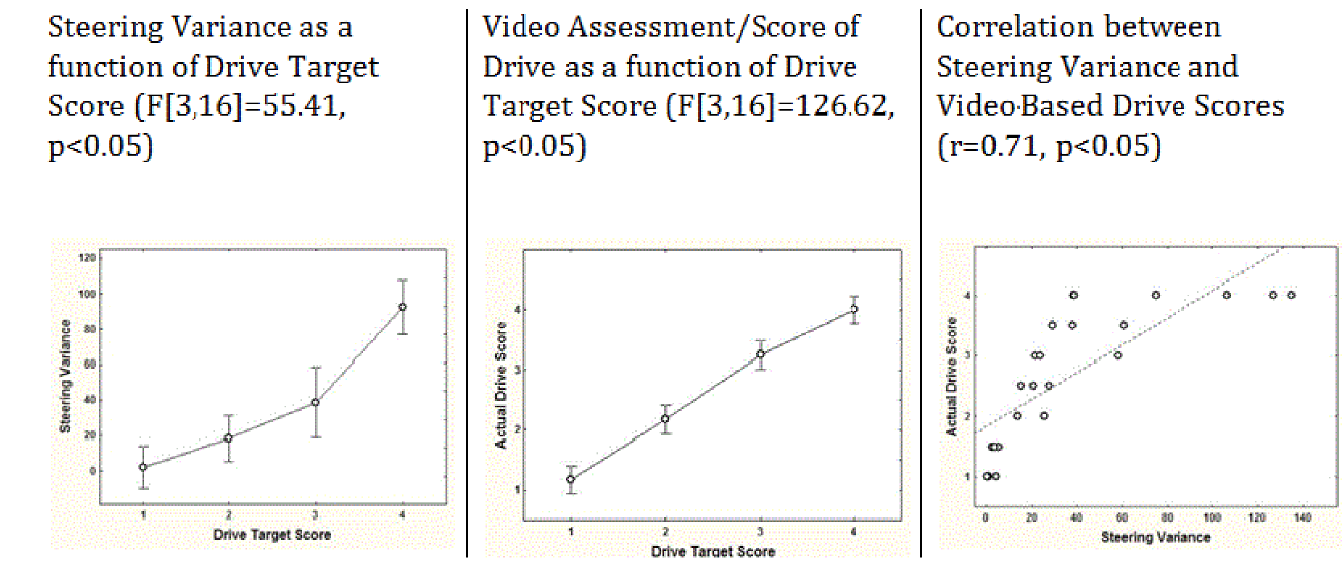


**Figure 1:** Calibration Experiment.

### Statistical analyses

The data from the two 'drives' with the Control goggles were pooled prior to analyses, as were the data from the two Beer Goggles drives. The effects of Beer Goggles -v- Control Goggles on driving performance before and during texting were analyzed using the 2 x 2 x 2 Factorial ANOVA, with Main Effects of Driver Gender (Male/Female), Goggle Condition (Control/Beer; repeated measure) and Driving Condition (Pre-texting/Texting; repeated measure). The effects of Beer Goggles -v- Control Goggles on eye glance measures were analyzed using 2 x 2 Factorial ANOVA, with Main Effects of Driver Gender (Male/Female) and Goggle Condition (Control/Beer; repeated measure). Statistical relationships between the dependent variables and subject demographics were assessed using multiple regression analyses. In all statistical comparisons, p<0.05 was used as the criterion for statistical significance.

## Results

In the absence of texting, i.e., during the 10-second pre-text period, all subjects were able to remain in the specified driving lane with only slight weaving; examination of longer periods (20-25 sec) of pre-text driving in a cohort of our drives revealed little no effect of drive duration on driving performance in the absence of texting (data not shown); this is largely because this is an easy, straight roadway and subjects can get near-perfect scores for long periods when they are not texting. Beer Goggles alone did not significantly affect driving (Control Pre-Testing: 1.06 ± 0.11; Beer Goggles Pre-Texting: 1.08 ± 0.11; open panels, Figure 2). Figure 2 also illustrates the effects of texting on driving performance in controls and in subjects wearing Beer Goggles. Statistically, texting impaired driving performance (Texting Main Effect F[1,14]=123.80, p<0.05), and Beer Goggles impaired driving performance (Beer Goggles Main Effect F[1,14]=14.11, p<0.05); most important, the effect of texting was greater when wearing Beer Goggles (Texting x Beer Goggles Interaction F[1,14]=13.63, p<0.05). There was no effect of Driver Gender on any driving performance measures (all F-ratios<1.0; data not shown).

When texting while driving, subjects looked at their phones–and NOT at the roadway–for an average TEOR 8.4 ± 4.1 seconds (Mean ± SD; data from Control Goggles) in a single text and reply. Texting while driving was NOT characterized by a single long glance at the phone in any subject.

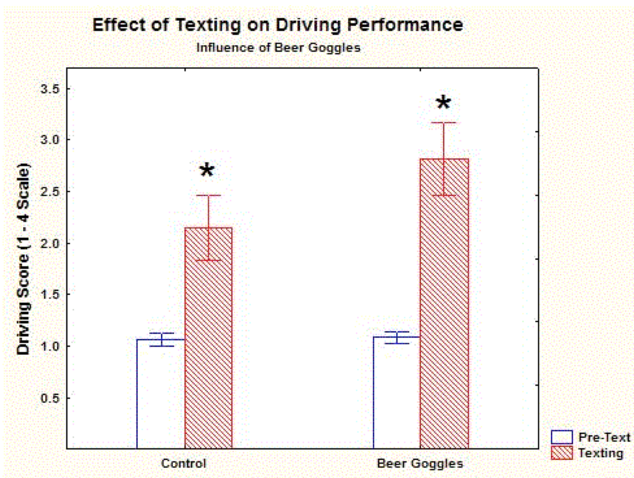


**Figure 2:** Texting significantly increased driving score relative to the Pre-Texting period (immediately prior to texting); Beer Goggle significantly potentiated the effects of texting on Driving Score. See text for details.

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Rather, texting while driving was characterized by a series of glances between the phone and the roadway; in the present study, the average number of glances was 9.2 ± 4.3 (Mean ± SD); the average glance duration was 0.90 ± 0.21 sec (Mean ± SD); the average value for the single longest glance off the roadway in controls was 1.59 ± 0.64 (Mean ± SD; data from Control Goggles).

Figure 3 illustrates the effects of texting while driving on eye glances away from the roadway under Control Goggles versus Beer Goggles. Beer Goggles significantly increased the mean number of eye glances associated with texting (left panel; F[1,14]=6.46, p<0.05). Beer Goggles also significantly increased the average duration of eye glances away from the roadway while texting (middle panel; F[1,14]=21.73, p<0.05); a similar effect of Beer Goggles to increase the median duration of eye glances away from the roadway also was observed (Controls: 1.0 sec; Beer Goggles: 1.3 sec; Z=2.77, (n=13), p=0.008, Wilcoxon Matched Pairs Test; data not shown). Finally, Beer Goggles significantly increased the total time with eyes off the roadway (TEOR; Figure 4) while texting (right panel; F[1,14]=11.79,p<0.05). The factor of driver gender was not statistically significant for any measure, but there was tendency for a greater total number of glances (F[1,14]=1.94, p=0.19) and a tendency for a greater TEOR (F[1,14]=1.52, p=0.24) for Male compared to Female drivers (data not shown). There were no interactions between driver gender and goggle condition on any eye glance measure (all F-ratios<1.0; data not shown).

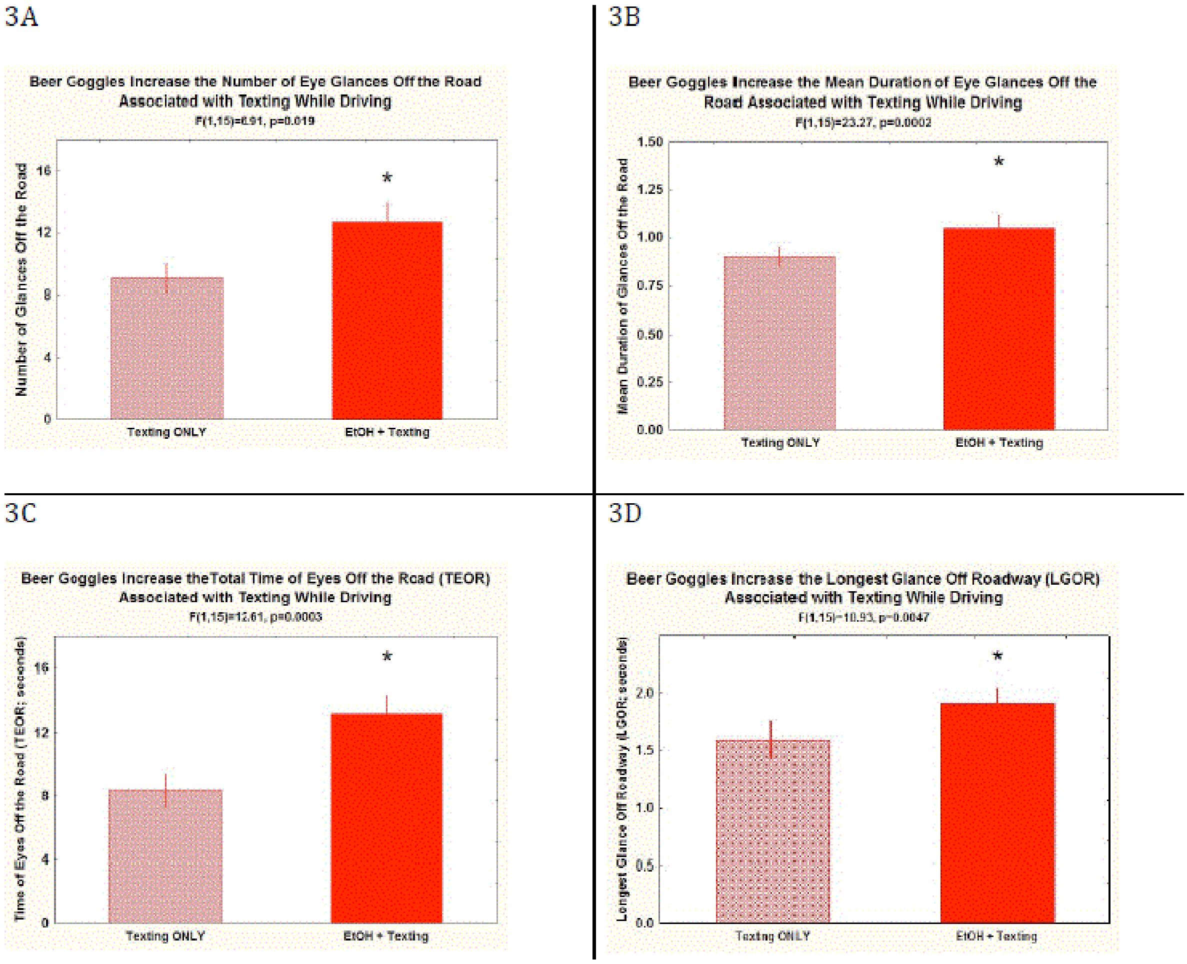


**Figure 3:** The effects of texting while driving on eye glances away from the roadway under Control Goggles versus Beer Goggles.

Multiple regression analyses examining the possible relationship between driver demographic variables, including typical driving and texting behaviors (Driver Gender, Driver Age, Years of Driving, Hours of Driving per Week, Number of Texts per Day, Texting Skill Assessment, Average Driving Speed; Average Alcohol Intake) and the effects of Texting on Driving Performance (with or without Beer Goggles) were not statistically significant. Similarly, multiple regression analyses examining the possible relationship between eye glance measures (Mean Glance Duration, Median Glance Duration, Mean Number of Glances, TEOR, LGOR) and the effects of Texting on Driving Performance (with or without Beer Goggles) were not statistically significant (data not shown).

## Discussion and Conclusions

The present studies confirmed past reports that texting impairs driving simulator performance (see Introduction). In the present study, a text conversation (i.e., message and reply) was characterized by a series of glances back and forth between the phone and the roadway. Control subjects made slightly fewer than ten glances away from the roadway and to the phone, with an average glance duration of approximately 1.0 seconds, for a TEOR of approximately 10 seconds; these values are consistent with the eye glance data reported by other investigators [6,10-12,14,15].

Wearing the Beer Goggles did not affect driving performance during the pre-text period. This is most likely because the pre-text roadway was straight and easy to drive. In a pilot study on a more challenging roadway (with curves and traffic, etc.), Beer Goggles did indeed negatively affect driving performance (data not shown). Thus, lack of effect of Beer Goggles on the pre- text driving in the present study does NOT mean that Beer Goggles have no effect on driving performance. In a similar manner, moderate doses of alcohol have an effect on some, but not all, measures of driving performance in a simulator [21-24].

Wearing Beer Goggles potentiated the disruptive effects of texting on driving performance. In terms of the possible real-world impact, the effect observed is comparable to going from weaving in your own lane when texting while wearing the control goggles (which is of course unsafe) to having lane excursions when texting while wearing the beer goggles (much more dangerous indeed). Beer Goggles also increased all of the eye glance measures which might lead to impaired driving (number of glances, mean/median glance duration, TEOR).

As mentioned in the Introduction, Beer Goggles produce alcohol-like visual disturbances only, and they do not produce many other effects typically associated with ethanol intoxication, e.g., impaired judgment, diminished reaction time, increased aggression. These effects of ethanol would be predicted to further disrupt driving and to potentiate the disruptive effects of texting on driving. It is quite possible; therefore, that the present dramatic effects observed with Beer Goggles may actually underestimate the full effect of the negative interaction between alcohol and texting on driving performance.

The present findings suggest that texting while driving drunk might be more dangerous than either texting while driving or drunk driving alone. Given the relatively high likelihood of texting while drunk, and the possibility that drunk texters may get behind the wheel, recent newspaper reports regarding texting while driving drunk (see Introduction) may represent only the ‘tip of the iceberg’ regarding this danger.

In summary, texting significantly disrupted simulator driving performance; this effect was made dramatically worse by the visual disturbance produced by Beer Goggles. Given the likelihood of texting while driving after drinking, these data suggest that ‘No Texting While Driving’ education and public service messages need to be continued, and they should be expanded to focus on the negative interaction between texting, drinking and driving.

## Acknowledgements

These studies were supported in part by an EACPHS grant (Faculty Research Award Program [FRAP]) award to DH and RLC. The authors are grateful to the EACPHS students, faculty and staff who participated as subjects. TP was supported in part by a FRAP Award to DH and RLC. These studies were approved by the WSU Behavioral IRB (#063413B3X).

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This article was originally published in a special issue, entitled: **"Driver Safety",** Edited by Jibo He