Text Messaging versus Talking on a Cell Phone: A Comparison of their Effects on Driving Performance

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This study compared the effects of texting to other modes of responding on driving performance. While driving a simulator participants were instructed to categorize words appearing on billboards as a state (e.g., Maine), fruit (e.g., kiwi) or drink (e.g., Pepsi). The word categories were reported by texting, phoning in or identifying them aloud. There was significant effect of response mode on measures of driving performance. Drivers in the texting condition had significantly slower reaction times to peripheral letter targets, drove more slowly, exhibited greater variance in their lane position and took their eyes off of the road more often than in either the cell phone condition or the verbal condition. Drivers in the cell phone condition often performed more poorly than in the verbal response condition.

INTRODUCTION

Drivers are faced with an increasing number of in-vehicle and personal information technologies that compete for their limited attentional abilities. These technologies include personal cellular phones, organizers, MP3 players, in-vehicle navigation systems, and radio/CD/DVD players. Use of these devices requires that drivers shift their attention and/or eyes from the roadway to the device, or attempt to currently perform both tasks by dividing their attention between the competing demands.

Over the last decade a growing body of research has shown that the costs of multi-tasking are manifest not only in poorer driving performance but also in an increased crash risk. Epidemiological studies have shown that talking on a cellular phone is associated with a fourfold increase in crash risk (McEovy et al., 2005; Redelmeier & Tibshirani, 1997). Experimental evidence obtained using simulators (Recarte & Nunes, 2003; Strayer, Drews, & Johnston, 2003; Strayer & Johnson, 2001) and close road driving (Chaparro, Wood, & Carberry, 2005) show that the effects are obtain for a variety of secondary tasks and indicate that the disrupting effects of secondary tasks may derive from a more general source of interference that hinders the attention-capturing properties of stimuli in the driving environment (Morris, Phillips, Thibault K, & Chaparro, 2008; Recarte & Nunes, 2000; Strayer et al., 2003). Meta-analyses show that the effects of secondary tasks on driving are robust (Caird, Willness, Steel, & Scialfa, 2008; Horrey & Wickens, 2006).

Many drivers report using cellular phones while driving (AAA Foundation for Traffic Safety, 2008) and an increasing number are using cellular phones to text message while driving. Intuitively texting while driving would appear to be more disruptive than talking on a cell phone because it shares the attentional demands of talking on a phone, with the associated perceptual motor demands of manipulating the device and visually confirming the correctness of the users input.

To date there have been few studies of the effects of texting on driving performance. Hosking Young and Regan (2006) used a driving simulator to investigate the effects of text messaging on the driving performance of young novice drivers. The drivers had 6 months or less of driving experience. They reported that the time drivers spent looking away from the roadway increased 4 fold when they were text messaging. They also reported an increase in the variability of lateral lane position and a greater number of lane excursions. Kircher et al. (2004) performed a small scale study (N = 10) of the effects of receiving and responding to text messages while driving using more experienced drivers (i.e., 10 years of driving experience). Their main finding was an effect of text messaging on driver brake reaction time. Braking reaction times were 35% greater when braking in response to a motorcycle that entered the roadway without yielding when they were reading a text message.

We sought to build on this earlier work by comparing the effects of texting, to other modes of responding on driving performance and by recruiting a larger pool of participants with a wider range of driving experience that would be more representative of the driving population. In this experiment participants navigated a road course in a driving simulator and were asked to categorize words appearing on billboards as a state (e.g., Maine), fruit (e.g., kiwi) or drink (e.g., Pepsi). Participants were instructed to report the word category by texting, phoning in or identifying them aloud.

METHODS

Participants

The study participants (N = 34; 5 male 29 female) ranged from 18 to 58 years of age (M = 23.26, SD=8.93). Data from two participants was excluded from the analyses because they were identified as outliers (± 3SD) on multiple dependent measures. Driving experience ranged from 2 to 35 years (M = 7.73, SD = 7.93). All were licensed drivers and had binocular visual acuity of (20/20) or better and normal color vision.

Survey

Participants completed a survey of driving, cell phone and texting experience. Twenty-three of the 34 participants reported that they received and or sent text messages while driving. Thirty-two participants reported talking on their cell phone while driving.

Only two of the participants reported a preference for the standard ABC method (e.g., full word spelling) of text entry that was used in the experiment. Nine participants reported a preference for t-9, 1 preferred using other variations of shortcuts within texting and 22 reported no preference.

Driving Simulator

A STISIM Version 8 driving simulator was used to assess driving performance. The driving simulator console consisted of a monitor, steering wheel, turn indicator, brake and accelerator pedals. Nine comparable driving courses were developed for the experiment; three for each of the following conditions: driving with no cell phone, driving while talking on a cell phone and driving while texting on a cell phone. Three courses were used only for training on each of the tasks and the other six courses were used for data collection. Each course was 12,500 ft. in length and was comprised of a four-lane road, with both in-lane and on-coming traffic. The course took approximately five minutes to complete when maintaining the posted 40 mph speed limit. A police siren was used to alert the participant when they had exceeded the speed limit by 5 mph. Each course contained six stop lights including four that required the participant to stop for crossing vehicular traffic and pedestrians. Six billboards with the name of a drink, fruit or state were randomly placed throughout the course on the left and right hand sides of the road. Nine random letters were also randomly positioned on the right and left hand sides of the road throughout the course.

Driver Communication Tasks

A Samsung sch-u340 cell phone was used in the experiment. The participants' texting ability using the standard ABC method was assessed in a preliminary task by having them type "The quick brown fox jumps over the lazy dog" as fast and accurately as possible. Participants were given time before the experiment to familiarize themselves with the phone and its operations.

While driving, participants were instructed to categorize the words appearing on the billboards as a state (e.g., Maine), fruit (e.g., kiwi) or drink (e.g., Pepsi). Participants were instructed to report the word category by identifying them aloud, phoning in or texting the response.

Verbal Report: Participants reported aloud the word category which was then recorded by the experimenter.

Cell Phone: Participants were instructed to open the cell phone and dial the most recent number in the call log and report the category to an experimenter located in another room.

Texting: Prior to starting the road course the experimenter sent a text message to the participant. When reporting the first word billboard, the participant simply replied to the waiting text message. The participant was instructed to continue driving and wait for a response text message from the experimenter before reporting the category of the next billboard. After receiving a second text message, the participant would report the category of the second billboard and again wait for a response from the experimenter before sending their report of the third billboard. Participants were not allowed to use abbreviations, t-9 or other word spelling shortcuts in the experiment.

Procedures

Participants drove a practice course for each test condition that familiarized them with the communication tasks. They were instructed to obey all traffic laws, observe a 40 MPH speed limit and to drive in the left "passing" lane when possible. The participants were instructed to indicate when they detected a peripheral letter on the side of the road as quickly as possible by pressing the turn indicator. The peripheral letter targets subtended between ~.38 and.56 degrees of visual angle. After completing the three practice courses, participants performed six more courses, two for each condition. The order of the courses was counterbalanced throughout all conditions and participants.

The simulator measured the participants driving performance by recording reaction time, mean speed, and lane deviation. The participants eye glances were recorded on video tape and were reviewed to measure the number of times a participants' eye left the roadway while driving each course.

RESULTS

A one way repeated measures ANOVA was conducted to evaluate the effects of the response mode (i.e., response via verbal report (VR), via cell phone (CP), or texting the response, (TXT)) on measures of driving performance and detection of peripheral letter targets. A Bonferroni adjusted alpha level was used for all post hoc comparisons. The driving dependent measures included mean driving speed, reaction time, deviation and the number of times the driver's eyes left the roadway. Data were transformed using the procedures recommended by Kirk (1995) when the data were not normally distributed.

Statistical analyses indicate there was a main effect of response mode on all the dependent measures ($p<.05$). Figure 1 shows the results for reaction time (Log_{10} X) to the letter targets

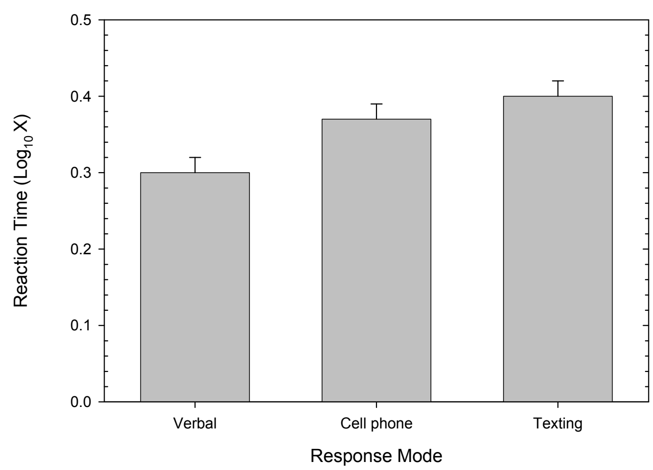

FIGURE 1.
Transformed (Log_{10} X) reactn times (sec) to peripheral letter targets as a function of response mode. The error bars represent 1 SEM.

positioned alongside of the road. Participants had to hit the turn signal when they first saw the peripheral letter targets. The ANOVA showed a significant main effect of response mode, $F(2, 66) = 14.79$, $p < .001$. Post hoc paired comparison show that participants responded faster in the VR condition (M = .3, SD =.14) relative to either the CP (M = .37, SD = .11) and the TXT condition (M = .40, SD = .12), which did not differ from each other.

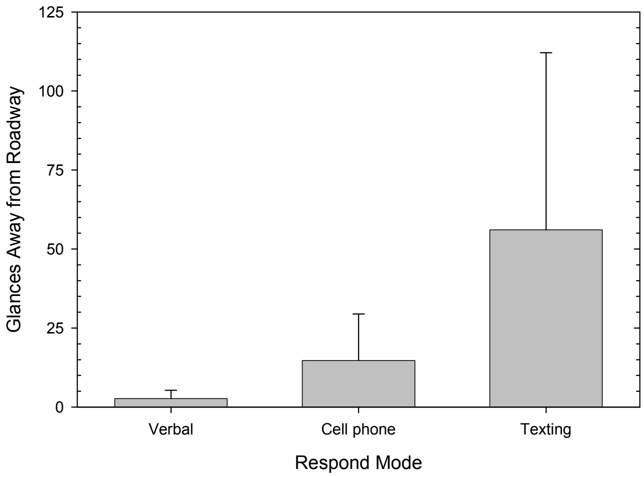

FIGURE 2.
Cumulative number of eye movements away from the roadway as a function of response mode. The error bars represent 1 SEM.

Figure 2 shows the raw untransformed data for the number of times drivers glanced away from the roadway. The ANOVA was performed on transformed (Log_{10} X+1) data (Kirk, 1995). The main effect of response mode was significant, F (2, 66) = 364.71, $p < .001$). Driver's looked away from the roadway significantly fewer times in the VR condition (M = .49, SD = .27) relative to either the TXT (M = 1.74, SD = .10) or the CP condition, (M = 1.14, SD = .26). Drivers looked away from the roadway more frequently in the TXT condition relative to the CP condition.

The ANOVA on lane deviation was significant, F (1.63, 53.8) = 12.25, $p < .001$) A Greenhouse Geisser correction was used in this analysis. Lateral control was poorer in the TXT condition (M = 11.85, SD =. 13) relative to the CP, (M = 11.78, SD =.15) and VR (M = 11.75, SD = .12) conditions which did not differ significantly from each other. Finally, drivers drove significantly more slowly, F (2, 66) = 7.72, $p < .001$), when texting (TXT) (M = 25.08, SD = 1.21) then when they responded verbally (VR), (M= 25.90, SD = 1.53), or via a cell phone (CP), (M = 25.64, SD = 1.32). Driving speed for the VR and CP conditions did not differ significantly from each other.

DISCUSSION

We investigated the effects of text messaging, phoning in and responding aloud on driving performance. Drivers in the text messaging condition had significantly slower reaction times to peripheral letter targets, drove more slowly, exhibited greater variance in their lane position and took their eyes off of the road more often than in either the cell phone condition or the verbal response condition. While our results for variability in lane position agree with the findings of Hosking et al. the results for mean speed do not. Hosking found no effect of texting on mean speed whereas we found that drivers slowed down when texting. It is likely that differences in the driving experienced of the participants recruited for the two studies may account for the different results.

The poorer driving performance in the texting condition is not a result of the participant's lack of familiarity with the cell phone used in the experiment. We found that performance on the texting assessment was not significantly correlated with any of the driving measures. Performance on the texting assessment was however, positively correlated with the drivers age (r =.753, p<.001) and with years of driving experience (r =.689, p<.001).

Texting had a significant impact on eye movement patterns and there was considerable heterogeneity in these patterns across participants. When texting, participants looked away from the roadway 4 times more frequently than in the cell phone condition. Similarly, glances away from the roadway were 6 times more frequent in the cell phone condition relative to the verbal response condition. Some participants in the texting condition looked away from the roadway over 100 times when completing the ~5 to 7 min driving simulation. These results likely reflect different strategies for interleaving the demands of texting with those of driving (Brumby, Salvucci, & Howes, 2007). Kircher et al. (2004) also noted large individual differences in the strategies for reading text messages and interleaving it with the ongoing driving demands.

The correlation between the number glances away from the roadway and collisions in the texting condition indicates a significant positive association (r = .451, p = .007). Drivers who frequently looked away from the roadway also drove more slowly (r = -.386, p = .022) but driving more slowly was not associated with fewer collisions. The frequency of glances and glance duration away from the roadway may increase crash risk (Wierville, 1993; Wierville & Tigerina, 1998). Data from the 100-Car Naturalistic Driving Study (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006) indicates that short glances while engaged in a secondary task elevates risk slightly or not at all, but longer glances of two or more seconds increase crash/near-crash risk two fold.

In summary, texting was found to be as or more disruptive than talking on the cell phone. Drivers showed poorer lateral control, drove more slowly, glanced away from the roadway more frequently and were slower to respond to environmental stimuli. These data suggest that texting is potentially even more distracting and dangerous than talking on a cellular phone. This can be attributed to the increased physical and visuo-motor requirements associated with texting.

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