

Covert Texting During Simulated Driving Maneuvers: Effects of Head-Up versus Head-Down Posture

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ABSTRACT

The deleterious effects of distracted driving are pushing lawmakers to enact legal prohibitions against the use of text messaging services while operating a motor vehicle. However, in states where such prohibitions have been enacted the crash rate has actually increased. One possible explanation of this paradox is that prohibition laws may cause many drivers to conceal their text messaging behavior rather than eliminate it. Holding a cell phone out-of-sight to conceal texting behavior may be accompanied by prolonged loss of visual contact with the road resulting in a concomitant reduction in driving performance. An exploratory study was conducted to assess the effects of text messaging upon simulated driving performance. Sixteen participants performed the *Lane Change Task* (LCT) in a driving simulator under three experimental conditions: (1) baseline driving without texting, (2) texting while holding the cell phone at steering wheel level (head-up condition) and (3) texting while holding the cell phone out-of-view from other drivers (head-down condition). The efficiency of the required lane change maneuvers was significantly degraded while participants were engaged in text messaging behavior relative to the baseline driving condition. However, no evidence was found to support the hypothesis that attempts to conceal text messaging behavior (head-down condition) resulted in greater decrements to driving performance than texting without attempts at concealment (head-up condition). An important limitation of this study was that driving behavior was assessed only in terms of the efficiency of steering maneuvers. More sophisticated simulation protocols that assess hazard detection and avoidance behaviors may be more sensitive to the loss of situation awareness hypothesized to accompany attempts to conceal text messaging behavior while driving.

INTRODUCTION

There is clear and mounting evidence from laboratory and simulation studies that texting-while-driving has strong negative impacts upon vehicular control and hazard detection (e.g., Drews, et al., 2009; Hosking, Young & Regan, 2009). Field studies have replicated and extended these findings (Owens, McLaughlin & Sudweeks, 2011; Yager, Cooper & Chrysler, 2012) and have made a strong case for linking texting behaviors to highly significant reductions in highway safety (Olson, et al., 2009).

It is hardly surprising that many states and local jurisdictions have attempted to mitigate the negative effects of texting behavior by adopting legislation banning hand-held cell phone use and/or texting while operating a motor vehicle. Follow-up epidemiological studies of crash statistics and/or insurance claims have revealed mixed results regarding the efficacy of these legislative actions on driving safety (Jacobson, et al., 2012; Harding, 2013). A counterintuitive effect of legislation designed to reduce texting while driving was reported by the Highway Loss Data Institute (2010).

Examination of insurance collision claims data in four states that adopted texting bans revealed that crash rates significantly increased in 3 of these states after the laws became effective (relative to matched control states). In fact, all four states demonstrated significant increases in crashes when analysis was limited to drivers under age 25 – the most prolific users of text message services (Tison, Chaudhary & Cosgrove, 2011).

The Insurance Institute for Highway Safety (2010) has speculated that such increases in crash rates could have resulted from noncompliance with the laws and the unanticipated effect of motivating those who do not comply to adopt a covert (hidden) posture when sending and receiving text messages while driving. That is, positioning the handheld device below the level of the instrument panel to conceal the visibility of the offending behavior from persons located outside of the vehicle (see Gauld, Lewis & White, 2013). Operating a texting device at such a low eye-level would result in longer and more complete eyes-off-the-road behavior than when holding the device at steering wheel level (where it might be observed by the public and/or

law enforcement personnel). Paradoxically, motivating drivers into adopting such a covert mode of texting behavior could potentially make a bad situation worse.

Current Investigation

If the conversion of overt texting behavior to covert texting behavior is a plausible explanation for the observed increase in vehicular collisions following enactment of laws banning texting while driving, then it follows that performance in a driving simulator should reveal decrements in vehicular control when texting with a head-down (covert) posture relative to texting with a head-up (overt) posture. The study reported here evaluated this claim using a validated simulation tool for assessing the intrusiveness of secondary tasks upon driving performance.

METHOD

Participants. A sample of 16 young adults (ages 18-24 years) was recruited from undergraduate university classes. All participants held a valid driver's license, owned a "smartphone", were highly experienced with texting on their phone and had a corrected visual acuity of 20/25 or better. The experimental protocol was approved by the university's Institutional Review Board prior to initiation of the study.

Apparatus. The driving task was implemented using a previously validated, PC-based part-task driving simulation platform known as the *Lane Change Task* (LCT) (see Mattes, 2003; ISO-26022, 2010). The LCT simulated a three-lane highway (on a 24-in LCD color display) and was fully interactive with a steering wheel, brake pedal and accelerator pedal (Logitech Model G25). Each "circuit" of the LCT's virtual track was approximately 3000 m in length and contained 18 roadside signs which instructed the driver to change their lateral position to a newly specified lane. Longitudinal spacing of sign location was varied to mitigate the role of anticipatory timing strategies. The content of each sign remained blank until 1.25 seconds prior to the signaled lane change maneuver (at which point the lane change instructions appeared). In addition to logging vehicle speed,

longitudinal position and lateral position (at 60 Hz), the "goodness of fit" of each lane change maneuver was quantified by its deviation from an ideal lane change maneuver template (i.e., the LCT error metric).

Procedure. Each experimental session began with a seven minute practice period in which the participant had the opportunity to drive the simulator and get acquainted with the demands of the lane change maneuver that was required upon encountering each roadside sign. The practice session included the completion of one test lap during which the participant texted interactively with the experimenter while simultaneously operating the LCT driving simulator. All participants used their own phones in order to ensure enhanced familiarity with the text messaging device. Immediately following the practice session, baseline driving-only performance was collected for one lap of the test circuit. Next, each participant was required to read and respond to text messages sent by the experimenter while completing two laps of the LCT driving circuit. On one lap the participant held the mobile phone below the level of the steering wheel (head-down condition) and on the adjoining lap the phone was held near the top of the steering wheel (head-up condition). The order of the head-up versus head-down experimental manipulation was counterbalanced across participants. Following completion of the experimental laps of the test circuit, a second driving-only baseline lap was completed. Holding the phone in the head-down posture required the participants to divert central vision completely from the road, while the head-up posture enabled the driver to maintain more complete visual access to the roadway environment.

Four text message inquiries (with responses) occurred during each of the experimental conditions (head-up versus head-down). Half of the text message inquiries required high-levels of cognitive processing demand while the remaining two inquiries involved routine requests for information that resulted in low-levels of cognitive processing demand. The length of the anticipated response to each test inquiry was either short or long. Hence, the nature of the text message interactions in each

experimental condition consisted of two levels of cognitive processing demand (low; high) crossed with two levels of anticipated response length (short; long number of text characters). The actual questions used for each of these stimulus conditions are listed in Table 1 (below).

Table 1.
Interactive Texting Stimulus Questions:
Cognitive Processing Demands vs.
Anticipated Length of Reply

Low Processing Demand / Short Reply Demand

What are the colors of the American Flag?
What day of the week is it?

Higher Processing Demand / Short Reply Demand

What's the 14th letter of the alphabet?
What is half of 8 times 4?

Low Processing Demand / Long Reply Demand

What is your full home address?
Describe what you did last weekend in detail.

Higher Processing Demand / Long Reply Demand

What classes are you taking next semester?
What type of Subway sandwich do you get and
what fixings do you put on it?

RESULTS

The main experimental hypotheses were evaluated via statistical analysis of the LCT lane change error metric (i.e., cumulative lane position deviation from an ideal spatial template). An analysis of variance revealed a highly significant effect of the texting condition manipulation ($F(2,30)=26.75$, $p < 0.001$). Relative to the pooled baseline condition, lane change performance was significantly degraded in the head-up ($p < 0.001$) and head-down ($p < 0.001$) texting-while-driving conditions (see Figure 1). However, no reliable difference in lane change performance was found between the head-up and head-down texting conditions ($p < 0.58$).

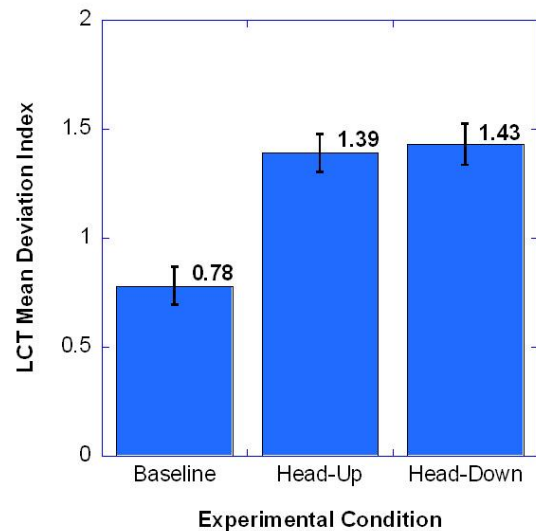


Figure 1.
Mean LCT deviation as a function of
experimental driving condition.
(Error bars denote standard deviations)

Exploratory analyses were also conducted to evaluate effects due to the cognitive demands of the text inquiries (low versus high) and the length of the reply required to answer the inquiry (short versus long). The cognitive demand manipulation did not influence the overall quality of the lane change maneuvers ($F(1,15)=0.04$, $p < 0.84$). Text message inquiries designed to elicit lengthy replies tended to yield decrements in lane change performance. However, this trend could not be strongly supported on the basis of the statistical analysis ($F(1,15)=2.79$, $p < 0.12$, observed power = 0.4).

DISCUSSION

Clear, sizable and statistically reliable increases in lane change performance errors were observed when operating the LCT simulator while simultaneously engaged in controlled texting behavior. This result is consistent with expectations and a growing literature describing the costs of texting while driving. However, the main hypothesis that head-down (covert) texting postures would have a greater deleterious impact on driving performance than head-up (overt) texting postures

was not supported by the analyses of the lane change error data.

Yet, this null finding cannot be offered as strong support for the interpretation that head-down postures are no more harmful than head-up texting postures. The LCT driving simulator focuses mainly upon vehicle control parameters such as lane position and speed and related-measures derived from these variables. No competing vehicular traffic, pedestrians or other dynamic objects are rendered as part of the LCT simulated roadway environment. The need to anticipate and/or detect hazards (other vehicles; pedestrians; challenging roadway geometries, etc.) and appropriately react to them is never assessed. Yet, it is just these types of unanticipated detection/reaction scenarios that one would expect to be especially vulnerable to the increased loss of visual contact with the roadway environment associated with head-down postures while texting (Burge & Chaparro, 2012).

There is some indirect evidence from the present experiment that supports the notion that head-down postures are more likely to interfere with the situation awareness necessary for high-levels of driving safety and performance. On numerous occasions, the participants in the current study failed to respond to the lane change prompt signaled by a roadway sign (i.e., they completely missed the sign and never executed the requisite lane change maneuver). Such errors of omission were not included in the analysis of the lane change error data. It is interesting to note that 23 such “misses” occurred during head-down texting compared to only 17 during head-up texting (Across the entire experiment there was only 1 omission error observed during the no-texting baseline condition). This 35% increase in omission errors suggests that situation awareness may be more vulnerable during covert/head-down texting.

In order to more thoroughly evaluate the potential costs of covert/head-down texting postures a more dynamic driving simulator with scriptable environmental hazards and a wide field-of-view (120+ degrees) will need to be employed (Kemeny & Panerai, 2003). Our laboratory is currently in the process of re-evaluating the head-up versus head-

down texting issue using such a dynamic driving simulation platform as part of the second author’s M.A. thesis project.

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Acknowledgments

Special thanks to Maegan Nimick and Kaitlin Gebhart for their assistance collecting the experimental data.

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