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Mutual interferences of driving and texting performance

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ABSTRACT

Despite legislative and social campaigns to reduce texting while driving, drivers continue to text behind the wheel. There is abundant evidence demonstrating that texting while driving impairs driving performance. While past driver distraction research has focused on how texting influences driving, the influence of driving on texting behaviors has been overlooked. This study used a Lane Change Task and a smartphone texting application to study the mutual influences of driving and texting. Results showed that concurrent texting impaired driving by increasing the lane deviation. Meanwhile, driving impaired texting by increasing texting completion time, texting errors, and key entry time intervals, and reduced key entry speed. In addition, we show that texting behavioral data collected can be used to distinguish texting while driving from texting-only condition with an accuracy of 88.5%. The mutual interferences of driving and texting inform the theory of dual-task performance and provide a scientific foundation to develop a smartphone-based technology to reduce the risky behavior of texting while driving.

1. Introduction

Texting while driving has become a widespread risky behavior and may impair driving performance more than talking on a cell phone (Caird, Johnston, Willness, Asbridge, & Steel, 2014; Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009; He et al., 2014; Hosking, Young, & Regan, 2009; Klauer et al., 2014; Wilson & Stimpson, 2010). As many as 281,000 to 786,000 crashes in 2012 may involve text messaging, according to the estimate of the United States National Safety Council (2012). Pickrell and Ye (2013) found 0.9% of drivers were visibly manipulating hand-held devices while driving in 2010, and this percentage increased to 1.3 percent in 2011. The risk and prevalence of texting while driving has attracted the attention of the general public, auto manufacturers, legislators and safety researchers (Jacobson & Gostin, 2010; Owens, McLaughlin, & Sudweeks, 2011).

Concurrent texting impairs driving in various ways. For example, texting while driving increases hazard response time (Burge & Chaparro, 2012; Drews et al., 2009; He et al., 2014; Leung, Croft, Jackson, Howard, & Mckenzie, 2012), increases lane deviations (the difference between the center of the vehicle and the center of the appropriate lane) and lane excursions (leaving the lane unintentionally) (Alosco et al., 2012; Crandall & Chaparro, 2012; Hosking et al., 2009; McKeever, Schultheis, Padmanaban, & Blasco, 2013; Rudin-Brown, Young, Patten, Lenné, & Ceci, 2013), increases mental demand (mental demands are psychological and mental stress experienced by an individual while completing one or more tasks) (Owens et al., 2011; Rudin-Brown et al., 2013), increases gaze-off-road durations (Hosking et al., 2009; Libby, Chaparro, & He, 2013; Owens et al., 2011), causes more collisions (Alosco et al., 2012; Drews et al., 2009), and raises the risks of traffic accident as many as 8–23 times (Olson, Hanowski, Hickman, & Bocanegra, 2009).

People have limited ability to perform two tasks simultaneously, such as texting and driving and doing so results in deficits on one or both of the tasks being performed (Allport, Antonis, & Reynolds, 1972). According to the theories of dual-task performance, when two tasks are carried out concurrently, the performances of one or both tasks may be impaired, causing a dual-task performance decrement (Wickens, 2002). For example, when performing a secondary auditory monitoring task (pressing a button when they hear a tone), drivers had slower reaction time when responding to a vehicle braking, compared to driving-only conditions, even when instructed to give the driving task priority (Levy & Pashler, 2008). While several studies have reported the effects of texting on driving performance, how driving affects texting performance has been ignored. Better understanding of changes in both driving and texting performance can inform theories of dual-task performance and contribute to the efforts to mitigate the risks of texting while driving.

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Researchers and practitioners have explored a variety of approaches to mitigate the risks of texting while driving, including legislation, social campaigns, and technological solutions. Legislative efforts have sought to discourage this behavior by making it illegal (McCartt & Geary, 2004; Mccartt, Hellinga, Strouse, & Farmer, 2010) and social campaigns have sought to educate drivers about the risks of texting while driving (Atchley, Hadlock, & Lane, 2012; Nemme & White, 2010). In addition, telecommunication companies including AT&T and T-Mobile have developed smartphone applications to discourage texting while driving, such as Drive Mode and DriveSmart. Smartphone users can enable these applications to delay or block incoming calls and messages when they drive, limiting their exposure to the dangers of texting while driving. However, despite the associated risks of texting while driving and these legislative, social, and technological efforts, drivers continue to text while driving. Ninety-one percent of college students reported having sent text messages while driving, even though they agreed or believed that texting while driving was dangerous and should be illegal (Atchley, Atwood, & Boulton, 2011; Harrison, 2011).

Is it possible to develop a smartphone application to monitor texting while driving, and prevent or discourage drivers from engaging in such risk behavior? If an application can monitor texting while driving, it can potentially be easier to implement, and can complement current efforts in law enforcement or social campaigns. Researchers have attempted to detect drunk driving (Dai, Teng, Bai, Shen, & Xuan, 2010), cognitively distracted driving (Liang, Lee, & Reyes, 2007), aggressive driving (Johnson & Trivedi, 2011; Zeeman & Booysen, 2013), and drowsy driving (Hammoud & Zhang, 2008; He et al., 2013). However, to our best knowledge, no application has been developed that detects texting while driving. Thus, this study also explores the possibility using texting behavioral data to identify whether a driver is texting while driving.

The popularity and risks of texting while driving highlight the continuing need for research and understanding of how texting influences driving and vice versa, and how drivers coordinate performance of both tasks (Atchley et al., 2011; Harrison, 2011). Most driving studies focus on driving performance, while texting performance is mostly ignored or less emphasized. Smartphones allow the collection of detailed data on secondary texting performance. In this study, we utilize the capability of smartphones to capture texting performance and describe the mutual interferences of texting and driving. The goal of this paper is to discover the mutual influences of concurrent texting and driving, and sought the possibility to detect texting while driving and reduce its risks. It is predicted that participants will show greater lane deviation while driving and texting compared to the drive-only condition. It is also hypothesized that participants will take longer to complete the texting task and make more errors when driving and texting than when driving-only.

2. Materials and methods

2.1. Participants

Twenty-eight participants (12 men, 16 women) from a university community ages 18–35 years ($M = 22.14$ years, $SD = 4.64$ years) volunteered to participate in this driving experiment. All participants were screened prior to participation to ensure normal or corrected-to-normal vision using the Snellen Visual Acuity chart (Ferris, Kassoff, Bresnick, & Bailey, 1982). All participants completed a survey to ensure they were right-handed, active drivers, with at least two years of driving experience ($M = 6.29$ years; $SD = 4.51$ years). They all owned a touchscreen smartphone and on average, reported sending 83 text messages per day (*median* = 70, $SD = 86.06$).

2.2. Apparatus and stimuli

Driving performance was assessed using a driving simulator consisting of a General Motors car seat and Logitech Driving Force GT steering wheel and pedals. The Lane Change Task (LCT) version 1.2 software simulated the driving task using a 60 inch-Sharp Aquos 3D HD LCD display.

A 4.3″ HTC ThunderBolt touch-screen smartphone running the Android 2.3.4 operating system was used for the texting task. The buttons on the keyboard of the smartphone were arranged in a QWERTY layout.

2.3. Experimental design

There were five counterbalanced experimental conditions, including driving-only condition, two dual-task conditions, in which participants either drove while texting with one hand (drive + text one hand) or two hands (drive + text two hands), and two texting-only conditions in which participants completed the texting task with either one or two hands. We employed a within-subject design. Participants finished all the task conditions.

The dependent variables measured for the driving task were mean lane deviation and standard deviation of lane deviation. Lane deviation refers to the difference between the center of the vehicle and the center of the appropriate lane. For the texting task, the dependent variables consisted of task completion time, key entry per second, texting task completion time, texting errors, input time interval, standard deviation of input time interval, and device stability (He et al., 2014).

2.4. Experiment tasks

2.4.1. Lane Change Task (LCT)

In the LCT, participants were required to drive down a straight section of road with three lanes and were prompted to change lanes according to directions on signs, which appeared on both sides of the roadway. An arrow on the sign, shown in Fig. 1, indicated which lane the driver supposed to maneuver into. Participants were instructed to change from their current lane in a deliberate manner, and to do so as quickly and efficiently as possible.

Participants maintained a constant speed of 60 km/h and were instructed to make lane changes as quickly and accurately as possible when they saw the lane change sign. The LCT was developed by Daimler Chrysler AG Research and Technology to test driver distraction (Hofmann, Rinkenauer, & Gude, 2008; Huemer & Vollrath, 2010; Mattes & Hallén, 2008).

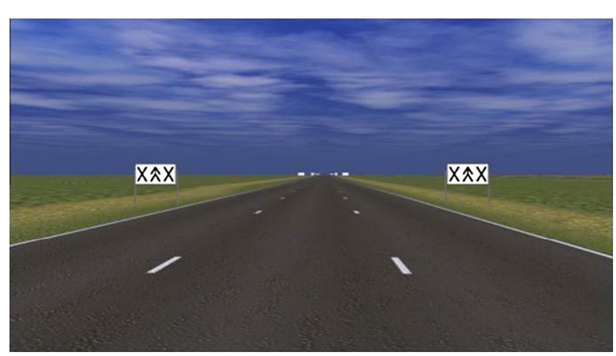

Fig. 1. Screenshot of driving simulator environment.