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Effects of phone type on driving and eye glance behaviour while text-messaging

Kristie L. Young [a,*], Christina M. Rudin-Brown [a,1], Christopher Patten [b], Ruggero Ceci [c], Michael G. Lenné [a]

[a] Monash University Accident Research Centre, Monash Injury Research Institute, Monash University, Melbourne, Australia
[b] VTI, Borlange, Sweden
[c] Swedish Transport Administration, Stockholm, Sweden

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ABSTRACT

This study examined whether phone interface – touch screen keyboard vs. numeric keypad – moderates the impact of sending and receiving text messages on simulated driving performance and eye glance behaviour. The high visual–manual demands of text messaging are known to degrade driving performance and these effects may be exacerbated by the absence of tactile cues when using a touch screen phone. Twenty-four participants (25–50 years) sent and received text messages on either a touch screen or numeric keypad phone while driving a simulated freeway environment. As expected, compared to baseline, receiving and particularly sending text messages led to decrements in speed monitoring, decreased the amount of time spent looking at the forward roadway by up to 29%, and increased subjective workload. The performance degradations observed were similar across the numeric keypad and touch screen keyboard phones. Future research should further investigate the possible moderating effects of phone interface type on distraction using longer text message tasks and under more challenging driving conditions.

1. Introduction

The use of mobile phones while driving has been the topic of much research for more than a decade. This research has overwhelmingly found that mobile phone use can significantly degrade a range of driving performance measures including visual scanning, lateral and longitudinal vehicle control and cognitive processes such as decision making and hazard perception (Cooper and Zheng, 2002; Horrey and Wickens, 2004; Patten et al., 2004; Strayer et al., 2003; Tornros and Bolling, 2005).

In particular, the increasing popularity of using mobile phones for text messaging has become a concern for road safety authorities. The International Association for the Wireless Telecommunications Industry (CTIA) reports that 2.3 trillion text messages were sent worldwide in 2011, up from 158 billion in 2006 (CTIA, 2012). This popularity is reflected in the number of drivers texting while driving. In the Australian state of Victoria, the prevalence of sending and receiving text messages while driving is high, particularly among the young driver population (Young and Lenné, 2010; Young et al., 2010). In an online survey, Young and Lenné (2010) found that 88% of young drivers (18–25 years) who use a handheld mobile phone while driving reported *reading* text messages, while 77% admitted to *sending* text messages while driving. The prevalence of texting while driving is similarly high in other countries such as New Zealand, the United Kingdom and the United States. In New Zealand, in a typical week, 66.2% of (962) drivers (mean age = 31.5 years) report reading at least 1–5 text messages, and 52.3% report sending at least 1–5 text messages while driving (Hallett et al., 2012). Lansdown (2012) also found that 25% of (482) drivers in the UK reported that they read text messages daily or weekly while driving and 14% send text messages on a daily or weekly basis, despite rating these behaviours as highly distracting. The prevalence of text messaging was even higher in a sample of 91 college students in the US (mean age = 22.8 years), with 91% reporting that they have text messaged at least once while driving (Harrison, 2011).

Compared to conversing, relatively fewer studies have examined the safety aspects of using a mobile phone to send and receive text messages while driving. Those that have been done suggest that texting may be more distracting than other mobile phone tasks such as conversing (Alosco et al., 2012; Drews et al., 2009; Hosking et al., 2009; Owens et al., 2011; Reed and Robbins, 2008). Text messaging requires visual, manual and cognitive

* Corresponding author. Address: Building 70, Wellington Road, Clayton, VIC, 3800, Australia. Tel.: +61 3 9905 1258; fax: +61 3 9905 4363.
E-mail address: kristie.young@monash.edu (K.L. Young).
[1] Present address: The Transportation Safety Board, Ottawa, Canada.

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resources and the continuous high visual-manual demands of text messaging are of particular concern. Indeed, there is evidence that activities requiring high levels of visual-manual input lead to degraded driving performance and increased crash/near crash risk and that these risks are greater than for those tasks that are largely cognitive in nature, such as conversing on a phone (e.g., Klauer et al., 2006; Olson et al., 2009).

Driving simulation studies of text messaging have found that both sending and reading text messages negatively affects driving performance (Drews et al., 2009; Hosking et al., 2009). Hosking et al. examined the effects of text messaging on the driving performance of 20 young drivers with less than 6 months of solo driving experience. They found that retrieving and sending text messages impaired the driver's ability to maintain lateral vehicle position, following distance to a lead vehicle and response to lane change cues. Drivers also spent 4 times longer with their eyes off the roadway when texting compared to baseline. Also using a driving simulator, Drews et al. found that retrieving and sending text messages using their own phone resulted in impairments in drivers' lateral and longitudinal (following distance) control, slower reactions to the onset of brake lights and greater involvement in crashes.

More recently, in a controlled closed-road study, Owens et al., 2011 evaluated the effects of text messaging on either a handheld phone or an in-vehicle system on driving performance. They found that sending and receiving text messages on a handheld phone resulted in higher subjective mental workload, more frequent and longer glances away from the roadway, and impaired steering performance compared to baseline driving. Use of the in-vehicle system revealed less performance degradation than the handheld phone, but was still associated with greater glances to the device and higher mental workload.

All of these studies demonstrate that text messaging can be highly detrimental to the driving task. However, while some of these previous studies (e.g., Owens et al., 2011) have allowed drivers to use their own phone which include a range of interface types (e.g., numeric keypad, QWERTY, touch screen), none have specifically examined differences in texting across these phone types. To date, there remains little research available examining how the type of phone interface might moderate the distracting effects of text messaging.

The popularity of the 'smartphone' has exploded in the past few years. As well as offering increased functionality, the use of smartphones in vehicles has raised concern because of their use of touch screen, or direct input, technology. While touch screens can offer a range of advantages such as direct and intuitive (pointing) input, their use by drivers has raised alarm primarily because they can place significant visual demand on the driver due to the absence of tactile feedback (Pitts et al., 2010). The lack of tactile and haptic cues on touch screen interfaces can lead to greater visual demand and a higher number of longer glances to the interface to guide the user's fingers and to confirm selections (e.g., Allen et al., 2008; Harrison and Hudson, 2009; Pitts et al., 2012).

Under static (no driving) conditions, Allen et al. (2008) examined text entry performance on touch screen vs. keypad phones. When entering text, users made a greater number of errors on the touch screen compared to the keypad phone, which the researchers concluded was due to the lack of tactile cues present on the touch screen interface. Under simulated driving conditions, Reimer et al. (2012) found that dialling phone numbers on a touch screen phone resulted in longer completion times and less time looking at the forward roadway compared to a flip-phone with tactile buttons. Another simulator study (Ranney et al., 2011) examined text messaging (among other tasks) using tactile (Blackberry) and touch screen (iPhone) phones with QWERTY keyboards. They found modest differences between phone types, including increased driving performance degradation with the touch screen relative to the tactile phone; however, they did not examine the impact of phone type on eye glance behaviour. Given the increased visual demands of touch screen interfaces, it is possible that the use of touch technology may exacerbate the already high levels of distraction associated with text messaging while driving.

The current study sought to examine the impact of using a smartphone with a touch screen QWERTY keyboard vs. a tactile numeric keypad phone to send and receive text messages on simulated freeway driving performance and eye glance behaviour. The tactile numeric keypad interface was selected to compare against touch screen keyboard interfaces as, at the time of the study, numeric keypad phones made up 73% of all mobile phones sold (TomiAhonen Consulting, 2010) and, thus, represented the tactile phone interface used by the majority of drivers. This paper extends the results from the same simulator study that were published previously by Rudin-Brown et al. (2013). The paper by Rudin-Brown et al. examined differences in the effects of text messaging across the freeway and tunnel environments. The current study focusses on differences in text messaging across the two phone modes for the freeway environment only.

It was hypothesised that, compared to driving alone, driving while text messaging would be associated with more variable lateral control, slower and more variable vehicle speeds, greater eyes-off-road time, and increased subjective workload. It was also expected that, compared to *reading* a text message, *writing* a text message while driving would result in greater driving performance decrements and higher subjective workload. Finally, it was predicted that, compared to numeric keypad phones, writing text messages on a touch screen phone would exacerbate the expected impairments in driving and visual performance and workload due to their lack of tactile feedback.

2. Method

2.1. Experimental design

The study used a two-way (2×3) mixed design with phone type (touch screen keyboard vs. numeric keypad) as a between-subjects factor and task (Baseline, Texting—read only, and Texting—read and write) as a repeated-measures factor. Dependant variables examined included those related to the primary (driving) and secondary (texting) tasks. To assess drivers' performance on the text-messaging tasks, the speed of text-messaging and any errors made served as dependent variables. To assess driver performance, the dependent variables examined included vehicle speed and speed variability, standard deviation of lane position (SDLP), the percent of drivers' total gaze time to the road centre (during text-messaging conditions), frequency and duration of glances to the phone, and ratings of subjective workload. The order of task presentation was counterbalanced within each drive.

2.2. Participants

Twenty-four licensed drivers (12 male; 12 female) aged 25–50 years ($M = 33.4$, SD = 9.9) participated in the study. Table 1 provides brief demographic details of the sample by phone user type. All participants were required to have held a valid driver's license for at least three years and to have normal or corrected-to-normal visual acuity. All participants reported regularly text messaging and a large proportion reported reading and writing text messages while driving. Participant age, driving experience, kilometres travelled each week and mobile phone use in and outside the vehicle did not vary significantly across the two phone type users (all