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A study of young adults examining phone dialing while driving using a touchscreen vs. a button style flip-phone

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ABSTRACT

A simulation study compared 36 young adult drivers' eye movements, driving behavior, and task completion time while dialing a flip-phone with tactile pushbuttons and an iPhone which provides a touchscreen interface. Once recruited, information on experience with different phone types was collected from each participant, which was then used as a covariate in statistical analysis. Participants who often use a traditional manual button phone completed the dialing task faster when using the flip-phone compared to touchscreen users using the iPhone. The flip phone, in general, resulted in fewer glances to the device than the iPhone. The mean number of glances greater than 1.6 s with the iPhone was 2.1 times the mean number with the flip phone. Further, females using the flip phone had the highest percentage of time spent with eyes on the road and the lowest likelihood of exhibiting long duration off-road glances (i.e., greater than 1.6 s and greater than 2 s). In terms of driving behavior, non-touchscreen users were found to slow down both when they were dialing on the flip phone and the iPhone, whereas touchscreen users slowed down only when they were dialing on the flip phone. Standard deviation of lane position was the highest when not dialing a phone, followed by when dialing the flip phone, and was the lowest when dialing the iPhone. Advantages appear to exist in a traditional tactile manual interface in terms of allocation of visual attention and possibly in compensatory behavior.

1. Introduction

The use of cellular technology in automobiles creates situations where drivers are required to balance driving, a primary task involving a high degree of learned behavior (Ranney, 1994) and a responsibility to public safety (Evans, 1991), with the seemingly simple activities involved with the use of cellular technologies, e.g., dialing, conversing, texting, browsing the web, etc. Interaction with a hand-held phone requires engagement of motor and cognitive resources that may interfere with the appropriate allocation of those resources to the driving task at critically inopportune times. Drivers appear to have limited awareness of the level of distraction involved with phone use (Horrey & Lesch, 2008) and are not curtailed by the perceived risks (Walsh, White, Hyde, & Watson, 2008). Early research on phone use reported that there is a four times increase in collision risk with phone use (McEvoy et al., 2005; Redelmeier & Tibshirani, 1997). It should be noted, however, that some more recent epidemiological assessments (Young, 2012, 2013; Young & Schreiner, 2009) and evaluations of naturalistic data (Fitch et al., 2013) suggest that the risk of phone use for conversational purposes is no greater than that of driving without conversation. The latter study does present data showing an elevated frequency of safety critical events (crashes, near-crashes,

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and crash-relevant conflicts) for visual–manual subtasks associated with phone use, further highlighting the complexity of assessing risk associated with interaction with the phone in a comprehensive manner. While some countries, as well a number of states and jurisdictions in the United States, have banned hand-held cellphone use, many others have not (IIHS, 2013; World Health Organization, 2011). Moreover, bans are difficult to enforce, with drivers often failing to comply with legislative efforts (McCartt, Braver, & Geary, 2003).

Numerous studies have assessed the impact of cell phones on the driving task (see Collet, Guillot, and Petit (2010a, 2010b) for a comprehensive review). A meta-analysis by Horrey and Wickens (2006) suggests that the act of conversing over a phone negatively impacts driver behavior. Manually dialing or texting on a phone involves substantive visual–manipulative interactions in combination with cognitive components (e.g., management of selective attention as it shifts from driving related activities back and forth to the dialing/texting task, memory recall of the number to be dialed) that are likely to be substantially more demanding on overall driver resources than the cognitive demands associated with maintaining most conversations. Several studies suggest that such visual–manual distractions can lead to dangerously long off-road glances and prolonged reaction times (Bayly, Young, & Regan, 2009; Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009; Hoffman, Lee, McGehee, Macias, & Gellatly, 2005; Hosking, Young, & Regan, 2009; Tsimhoni, Smith, & Green, 2004), as well as less precise lane keeping and speed control (Drews et al., 2009; Reed and Green, 1999). Although voice technology continues to evolve and has been suggested as an approach to reduce demand (Angell et al., 2006; Ranney, Harbluk, & Noy, 2005; Schreiner, 2006; Tsimhoni et al., 2004), many phone calls and other textual interactions with cellular technologies continue to rely on manual interactions with the keypad. In recent years, there has been a rapid transition from cellular devices with T9 based input systems and QWERTY keypads containing tactile buttons to touchscreens. Basacik, Reed, and Robbins (2012) have suggested that changes such as the move from physical keypads to touchscreens may change how individuals interact with the device and thus how distracting the different visual, cognitive, and motoric demands of these interface styles can be while driving. Yet there appears to be little research available that provides information regarding the extent to which different interface types may impact a driver's ability to enter information into the device.

Hoggan, Brewster, and Johnston (2008) summarize a number of design advantages inherent in mobile touchscreen interfaces but then point out that an important feature is lost, specifically that typical touchscreen buttons do not "provide the tactile response that physical buttons do when touched or clicked." They hypothesized that individuals would be able to enter text into a smartphone interface faster and with fewer errors using a physical keypad compared to a standard touchscreen. While they did not test this hypothesis in a driving context, they did obtain exactly these two findings in a modestly sized sample of 12 participants under the conditions of sitting stationary in a chair in the lab and while riding in a moving train. In a small driving simulation experiment involving 18 participants, Samuel, Pollatsek, and Fisher (2011) investigated glance behavior of frequent and infrequent text messagers that were distributed across two different phone conditions: a QWERTY keypad (Blackberry) and a touchscreen (iPhone). Although the mean number of glances over 2 s appeared to be larger for touchscreen text messaging, there was no statistical significance. A larger scale effort involving 100 participants assessed the distraction potential of contact selection, dialing, and text messaging using a QWERTY keypad (Blackerry) and a touchscreen (iPhone) (Ranney, Baldwin, Parmer, Martin, & Mazzae, 2011). Task performance and driving performance were reported, but eye glance measures were not investigated. In general, with the touchscreen, target detection during contact selection was lower, car-following delay during 10-digit dialing was greater, and the standard deviation of lane position during text messaging was higher.

In this paper, we aim to expand on previous efforts by exploring differences in self-reported workload, task completion time, glance behavior, and driving performance during 10-digit dialing with both a manual button style and a touchscreen phone interface. In line with Hoggan et al. (2008), we hypothesize that the more traditional tactile button interface has certain advantages over the touchscreen interface in a driving context in terms of lower visual demand due to the existence of enhanced tactile discrimination of key location and textual cues that are present on and between keys.

2. Methods

2.1. Participants

Recruitment methods and experimental content were approved by MIT's institutional review board. The sample was intentionally drawn from a younger age group (20–29 years) likely to have a high proportion of individuals with extensive experience using cell phones. Participants were required to be active, experienced drivers, defined as driving 3 or more times a week and having held a valid driver's license for 3+ years. Additionally, they needed to demonstrate a safe operating history by reporting a driving record free of accidents for the past year; these and health related criteria (detailed next) were included to maintain consistency of participant selection across this study and various on-road research conducted by the lab. In specific, the participant group was considered to be relatively healthy compared to an unscreened community sample based on self-report on the specified health exclusion criteria: major medical illness resulting in any hospitalization in the past 6 months, any neurological problems, treatment for a mental disorder, or regular use of a range of medications (e.g., anti-convulsant, immunosuppressive, cytotoxic, anti-depressant, anti-anxiety, anti-psychotics; medications for major medical conditions such as cancer, hypertension; medication to control heart rate or that causes drowsiness). Eye glasses were set as an exclusion criterion due to the use of eye tracking metrics as a primary dependent variable. Participants were drawn