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Impact of mobile phone use on car-following behaviour of young drivers

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ABSTRACT

Multitasking, such as the concurrent use of a mobile phone and operating a motor vehicle, is a significant distraction that impairs driving performance and is becoming a leading cause of motor vehicle crashes. This study investigates the impact of mobile phone conversations on car-following behaviour. The CARRS-Q Advanced Driving Simulator was used to test a group of young Australian drivers aged 18–26 years on a car-following task in three randomised phone conditions: baseline (no phone conversation), hands-free and handheld. Repeated measure ANOVA was applied to examine the effect of mobile phone distraction on selected car-following variables such as driving speed, spacing, and time headway. Overall, drivers tended to select slower driving speeds, larger vehicle spacings, and longer time headways when they were engaged in either hands-free or handheld phone conversations, suggesting possible risk compensatory behaviour. In addition, phone conversations while driving influenced car-following behaviour such that variability was increased in driving speeds, vehicle spacings, and acceleration and decelerations. To further investigate car-following behaviour of distracted drivers, driver time headways were modelled using Generalized Estimation Equation (GEE). After controlling for various exogenous factors, the model predicts an increase of 0.33 s in time headway when a driver is engaged in hands-free phone conversation and a 0.75 s increase for handheld phone conversation. The findings will improve the collective understanding of distraction on driving performance, in particular car following behaviour which is most critical in the determination of rear-end crashes.

1. Introduction

1.1. Distracted driving induced by mobile phone use

Driver distraction can be defined as a diversion of attention away from activities critical for safe driving to a competing activity (Lee et al., 2009). Distraction is also described as multi-task driving which reduces attention and cognitive resources allocated to the driving task. Studies have shown that multitasking while driving deteriorates driving performance, increases reaction time, and impacts lateral lane position and vision. This, in turn, poses serious safety concerns on the roads. A naturalistic driving study with 43,000 h of driving data from 241 drivers showed that the use of mobile phone while driving is associated with a higher number of crashes and incidents than driver interactions with any other source of distraction (Neale et al., 2005).

An extensive literature has empirically documented the risks associated with mobile phone use while driving (see Drews and Strayer (2009) for a detail review). Driving with phone conversation is considered as multitasking where a part of brain is occupied for the processing of the auditory sentences. An analysis using functional magnetic resonance imaging (fMRI) showed that, mobile phone distraction requiring the processing of auditory sentences decreases the brain activity by as much as 37% of the critical tasks associated with driving (Just et al., 2008). The increased cognitive load might cause a withdrawal of attention from the visual scene where not all the information a driver sees is processed; this phenomena is known as inattention blindness (Strayer et al., 2003).

Mobile phone use while driving is one of the most common distractions that motor vehicle drivers engage. In 2012 the National Highway Transportation Safety Administration estimates that 9% of drivers on the roadway at any given daylight moment are using some type of phone (either handheld or hands-free); for handheld

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phone use in particular, this estimate was 5% (NHTSA, 2014). White et al. (2010) observed 796 Australian drivers aged 17–76 years who owned mobile phones, and found that 43% of them reported answering calls while driving on a daily basis, followed by making calls (36%), reading text messages (27%), and sending text messages (18%). Mobile phone use while driving is more prevalent among young (and less experienced) drivers, who generally possess an elevated crash risk. A recent survey reported that almost one in two Australian drivers aged between 18 and 24 years used a handheld mobile phone while driving, nearly 60% of them sent text messages, and about 20% of them read emails and surfed the internet (AAMI, 2012).

In a naturalistic driving study Fitch et al. (2013) investigated the effects of distraction from the use of mobile phones while driving on 204 drivers. On average drivers were estimated to be talking on a mobile phone 10.6% of the time when they were driving with a mean call duration of 4.02 min. The study identifies that mobile phone subtask (locating, answering, dialing, browsing, text messaging and ending the call) can take driver's eyes off the forward roadway for up to 33.1–71.5% of time. Furthermore, locating/answering a handheld mobile phone was found to be associated with an increased safety risk (crash or near crash).

To reduce the negative effect of mobile phone use while driving, hands-free technology is widely used. However, conversation using both hands-free and handheld mobile phones has adverse effect on driving. A meta-analysis by Caird et al. (2008) reveals that the effect of hands-free vs. handheld phone studies did not differ appreciably from one another in terms of reaction time of the driver. Overall, a mean increase in reaction time of 0.25 s was reported for all phone-related tasks. A recent simulator study reported that both hands-free and handheld phone conversations are associated with about 40% increase in reaction times of drivers to peripheral traffic events (Haque and Washington, 2014). Overall, studies did not find any significant difference in relative risk of a crash for handheld and hands-free phones, both options individually associated with a fourfold increase in crash risk (McEvoy et al., 2005).

1.2. Impact of distracted driving on car-following

A few studies specifically have targeted to capture the adverse effect of mobile phone use on car-following behaviour. Car-following refers to the behaviour of a driver to follow a leading vehicle longitudinally. It is the most common routine driving situation and an important requirement for the safe driving (see Saifuzzaman and Zheng (2014) for the latest review).

In a driving simulator study, Alm and Nilsson (1995) observed the effects of hands-free mobile phone conversation on car-following behaviour. In their study, 40 participants drove a simulator vehicle for 80 km where a total of 16 car-following events occurred randomly. The participants were randomly exposed to a phone conversation task in 8 of these car-following situations. They observed an increased reaction time for phone conversation while driving. Furthermore, the participants did not compensate for their increased reaction time by increasing their headway during the phone task. However, later studies reported reduction in speed when driving with phone conversation, a behaviour known as risk compensation (Törnros and Bolling 2006). For example, Ranney et al. (2004) observed higher reduction of speed when driving with handheld phone conversation compared to other types of phone conversations (headset hands-free and voice dialing speaker kit hands-free) and baseline (no phone). Furthermore, drivers were found to increase their time headways during all types of phone conversations.

Drews and Strayer (2009) in their detail review about effect of mobile phone use on driving also reported increased reaction time and reduction of speed. Furthermore, an increase in lane deviation and fluctuation of speed are also reported which indicates less control over driving due to distraction caused by mobile phone use. A recent study by Stavrinos et al. (2013) also supports these findings by reporting significantly greater variability in driving speed, lower lane change frequency and higher lane deviations in distracted driving compared to baseline (no phone use while driving).

Strayer et al. (2011) in their study asked the participants to follow a pace car that was programmed to brake at 32 randomly distributed locations over a 24-mile multi-lane highway. They observed a slower brake reaction time for driver with mobile phone conversation compared to no phone driving. The distracted drivers also took longer time to recover their speed that was lost following braking. The drivers conversing on mobile phones tended to have a more cautious driving profile in terms of speed and following distance (i.e. maintaining lower speed and higher spacing) than non-distracted driving. However, crash rate was still higher compared to driving with no phone conversation. No significant difference was observed between driving with handheld and hands-free phone conversations.

Driver reaction time, speed, and following distance are considered key variables in describing the stability and flow of traffic. Driver engaging in phone conversations while driving can significantly influence these variables, thus, performs poorly in following the preceding vehicle. Although aforementioned studies have attempted to document the risk of mobile phone use in car-following situation, overall the literature is scarce, and our understanding on this important issue remains elusive. For instance, fluctuations in speed and spacing and acceleration noise have been seldom measured, which could give valuable insight about driver's control over car-following in distracted situations. Driver demographics could also influence car-following behaviour in distracted situation, which needs to be explored.

1.3. Research objective

This study aims to investigate the effect of both hands-free and handheld mobile phone conversation on car-following behaviour of young drivers. A simulator experiment was designed where a participant drove a simulator vehicle in three different phone conditions: baseline (no-phone conversation), hands-free phone conversation and handheld phone conversation. A wide range of variables (such as driving speed, spacing, speed difference, time headway and acceleration noise) were considered to examine car-following behaviour of distracted drivers. The effects of distraction on the car following behaviour were mainly identified by comparing the driving performances in distracted and non-distracted (no-phone conversation) conditions. In addition, driver's time headway was modelled using the Generalized Estimation Equation (GEE) to develop further insights into the car-following behaviour of distracted drivers.

2. Driving simulator experiment

2.1. Driving simulator

To accomplish this study, an experimental driving simulator study was conducted at the Centre for Accident Research and Road Safety-Queensland (CARRS-Q), Queensland University of Technology (QUT). In this experiment a group of distracted drivers were

[1] Detail about the simulator can be found at http://www.carrsq.qut.edu.au/simulator/.