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Modelling driver distraction effects due to mobile phone use on reaction time

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ABSTRACT

Phone use during driving causes decrease in situation awareness and delays response to the events happening in driving environment which may lead to accidents. Reaction time is one of the most suitable parameters to measure the effect of distraction on event detection performance. Therefore, this paper reports the results of a simulator study which analysed and modelled the effects of mobile phone distraction upon reaction time of the Indian drivers belonging to three different age groups. Two different types of hazardous events: (1) pedestrian crossing event and (2) road crossing event by parked vehicles were included for measuring drivers' reaction times. Four types of mobile phone distraction tasks: simple conversation, complex conversation, simple texting and complex texting were included in the experiment. Two Weibull AFT (Accelerated Failure Time) models were developed for the reaction times against both the events separately, by taking all the phone use conditions and various other factors (such as age, gender, and phone use habits during driving) as explanatory variables. The developed models showed that in case of pedestrian crossing event, the phone use tasks: simple conversation, complex conversation, simple texting and complex texting caused 40%, 95%, 137% and 204% increment in the reaction times and in case of road crossing event by parked vehicles, the tasks caused 48%, 65%, 121% and 171% increment in reaction times respectively. Thus all the phone use conditions proved to be the most significant factors in degrading the driving performance.

1. Introduction

The World Health Organization (WHO) recognizes road accidents as the 9th leading cause of deaths, which accounts for 2.2% of the total deaths worldwide (WHO fact sheets, 2014). In India, the road accident statistics reveal that there is an accident happening every minute and causing a loss of life in every four minutes (MRTH, 2013). There are evidences that indicate driver distraction (caused by digital communication devices such as Mobile phones or in-vehicle devices such as GPS) as one of the main reasons of accidents; for instance McEvoy and Stevenson (2007) conducted a case crossover study in two years of time span in Perth, Western Australia and found that driver distraction due to phone use, contributed to 14% of the road crashes. Similarly it was reported that 10%, 37%, 10.7% and 16% accidents in New Zeeland, Spain, Canada and US were caused by driver distractions (NRSC, 2010; DGT, 2008; World Health Organization, 2011 and Ascone et al., 2009). In India one online survey conducted on risk assessment of mobile phone use by Shabeer and Banu (2012) revealed that 31% of the drivers who used a mobile phone during driving met with accidents. Further, analysis on sources of these distractions showed that use of

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digital devices such as: mobile phones, GPS and handling of entertainment devices are the commonly prevailing sources of distraction; however, among all the distractions, mobile phone use is the most common one while driving (Horberry et al., 2006). Despite the ban on mobile phone use during driving, the proportion of drivers with mobile phone use is reasonably high; for example, in some metro cities in Australia, US, UK, Spain, Canada and Sweden it is 4.75%, 5.8%, 3.7%, 1.3%, 5.9% and 30% respectively (Young et al., 2010; Eby et al., 2006; Sullman et al., 2015; Prat et al., 2015; Burns et al., 2008; Thulin and Gustafsson, 2004). The use of mobile phone is not only limited to talking, but also extended to sending (or reading) messages and emails. In fact, it has been reported that mobile phone usage for texting while driving is as high as, 45%, 16.67%, and 27% in the United Kingdom, Australia and US respectively (World Health Organization, 2011). This trend is more common in young drivers; for example, a study in Australia showed that 58% of young drivers read text messages and 37% of them send the messages during driving (World Health Organization, 2011).

Driving performance, particularly reaction time (response to the events happening in driving environment), is adversely affected by mobile phone usage during driving and results in increased risk of accident involvement. Redelmeier and Tibshirani (1997) showed that if a driver is talking on a phone during driving then accident occurring probability increases four times compared to without phone use driving condition. McKnight and McKnight (1993) speculated that demands on the driver's attention and skill gets increased due to mobile phone use, which results in increased reaction time and increased failure rates to detect and react according to the traffic signals and hazardous events happening on the road.

As summarized above, distraction has become major road safety issue in the last two decades and many studies have been conducted in this direction world-wide. Present study aims to investigate the distraction effects due to mobile phone use for Indian driving conditions, where the driving conditions and driver behaviours are completely different from others. The study examines both, cognitive and visual distraction effects (with different level of complexities) on driver reaction time.

2. Literature review

Lee et al. (2008) defined driver distraction as diversion of attention away from activities critical for safe driving towards a competing activity. Existing literature has shown that both cognitive and visual distraction can impair the driver's reaction time behaviour (Bellinger et al., 2009). Following subsections summarize the previous study results of mobile phone use on reaction time of a driver, followed by different experimental setups and analysis methods adopted by previous studies.

2.1. Effects of phone use on reaction time

Many studies illustrated about the increase in reaction time due to phone usage (Al-Darrab et al., 2009; Alm and Nilsson, 1994; Brookhuis et al., 1991; Strayer and Drew, 2004). Literature has showed that both conversation and texting impair the event perceiving abilities of drivers, which leads to unsafe driving conditions (Bellinger et al., 2009; Redelmeier and Tibshirani, 1997; Lamble et Al., 1999). meta-analysis studies conducted on effects of mobile phone use during driving, strongly emphasized on the fact that reaction time significantly increases if a driver is concurrently involved in conversation (Horrey and Wickens, 2006) or texting (Caird et al., 2014).

Caird et al. (2008) critically reviewed 33 studies on effects of phone use and concluded that reaction time increases by 0.25 s while talking on phone during driving. Lee et al. (2001) analysed the effects of cognitive loading of a speech based e-mail system on driving performance and found that there is 30% increment in reaction-time. Cooper et al. (2011) observed that reaction time increases to two folds if a phone is used for texting while driving. Klauer et al. (2006) and Yannis et al. (2014) observed increment in accident probabilities when texting on phone during driving.

Various experimental designs have been used for estimating the reaction time, for example, Haque and Washington (2014) analysed driver's reaction time against a simulated event, where a pedestrian entered a zebra crossing from a sidewalk. Results of the study exhibited 40% increment in reaction time when the drivers were talking on the phone during driving. Leung et al. (2012) examined the reaction time against a hazardous event of sudden appearance of a truck in front of the subject vehicle and found significant increment in reaction time while conversing on phone. Consiglio et al. (2003) measured the reaction time for critical traffic signals and reported that 72 ms increment happened in reaction time of the drivers when they were engaged in phone conversation. Patten et al. (2004) used Peripheral Detection Task (PDT) for examining driver's reaction time and found that detection of peripheral stimuli got delayed 72 ms and 261 ms when the driver was involved in simple and complex conversation on phone during driving respectively. Recarte and Nunes (2003) measured drivers' response by a simultaneous visual-detection and discrimination test and observed significant reduction in event detection performance.

Driver's demographic characteristics (age and gender) have also been considered while analysing the reaction time in distracted driving conditions. Haque and Washington (2014) observed that one year increment in driver's age caused 12% increment in driver's reaction time. In a meta-analysis study by Caird et al. (2008) it was concluded that older drivers were more affected (reaction time increment was 0.46 s) when compared to younger drivers (reaction time increment was 0.19 s) while conversing on a phone during driving. Similarly, in a field study, Hancock et al. (2003) showed that the impairment in reaction time was 0.18 s higher for older drivers than the younger drivers. This study also showed that the reaction time increased by 0.25 s for female drivers while for male drivers the increment observed was 0.14 s. Several studies have also