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Mobile phone use during driving: Effects on speed and effectiveness of driver compensatory behaviour

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ABSTRACT

This study analysed and modelled the effects of conversation and texting (each with two difficulty levels) on driving performance of Indian drivers in terms of their mean speed and accident avoiding abilities; and further explored the relationship between speed reduction strategy of the drivers and their corresponding accident frequency. 100 drivers of three different age groups (young, mid-age and old-age) participated in the simulator study. Two sudden events of Indian context: unexpected crossing of pedestrians and joining of parked vehicles from road side, were simulated for estimating the accident probabilities. Generalized linear mixed models approach was used for developing linear regression models for mean speed and binary logistic regression models for accident probability. The results of the models showed that the drivers significantly compensated the increased workload by reducing their mean speed by 2.62 m/s and 5.29 m/s in the presence of conversation and texting tasks respectively. The logistic models for accident probabilities showed that the accident probabilities increased by 3 and 4 times respectively when the drivers were conversing or texting on a phone during driving. Further, the relationship between the speed reduction patterns and their corresponding accident frequencies showed that all the drivers compensated differently; but, among all the drivers, only few drivers, who compensated by reducing the speed by 30% or more, were able to fully offset the increased accident risk associated with the phone use.

1. Introduction

Driver distraction is defined as a situation when an explicit activity competes for a driver's attention; and it has been identified as one of the major contributing factors to the accidents (Lee et al., 2009). The main sources of driver distraction inside the vehicle are: mobile phone use (for conversing and texting), eating, conversing with passengers, operating in-vehicle digital devices (e.g., radio, CD-player etc.) while driving. Among all these distraction sources, mobile phone use is quite prevailing (Horberry et al., 2006; Urie et al., 2016; Choudhary and Velaga 2017a). A cross-sectional study conducted at 11 intersections in Alabama (US) by Huisingh et al. (2015) revealed that phone conversation during driving was the cause for 31.4% of the distracted driving. Similarly, it was reported that 14.1% and 3.4% of the drivers use mobile phone during driving in Spain and the United Kingdom respectively (Prat et al., 2015; Sullman et al., 2015). This increased prevalence of phone use during driving has caused a considerable number of accidents. For instance, NHTSA reported that mobile phone use during driving caused 12% of fatal crashes and 6% of injury crashes of all distraction affected crashes in the United States in 2014.

Attentional resources of a driver are limited, if the driver attempts to perform any secondary task, then the reallocation of the attentional sources may lead to deteriorated driving performance; which can be measured in terms of mean speed (Reimer et al., 2014), reaction time (Haque and Washington, 2015), situation awareness (Yannis et al., 2014) and lateral control (Peng et al., 2014) etc. But, research suggests that all these changes in performance may not be truly impairment; in fact some of these are the outcomes of driver's conscious or unconscious compensatory behaviours adopted for reducing the increased workload (Caird et al., 2014; Chiang et al., 2004). Mainly observed compensatory behaviours are: reduction in speed (Caird et al., 2014), change in the relative attention given to the driving task (Chiang et al., 2004) and maintaining larger headways from the front vehicles (Collet et al., 2010). Among all these compensatory measures, driver's behaviour alteration is generally seen in driver's mean speed selection during distracted driving conditions (Reimer et al., 2014). The speed of a driver is considered as one of the most important factors, which influences the accident occurring probability as well as severity. Therefore,

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any alteration in the speeding behaviour during distracted driving also affects the accident risk involved in driving.

Though distraction effects of phone use on mean speed and situation awareness are investigated by various researchers in the last two decades (Thapa et al., 2015; Yannis et al., 2014), very few studies have focused on both conversation and texting tasks. Moreover, effect of complexity levels of phone use is also not being studied well. The relationship between speed reduction strategies adopted during phone use while driving and the corresponding accident frequencies has to be explored (Young and Regan, 2007; Papantoniou, 2015). Therefore, the present study investigates and statistically models the impact of distraction due to both conversation and texting (each with two difficulty levels) on mean speed and accident involvement probability. All the factors such as: demographic characteristics, driving characteristics and distraction conditions, which can affect the driver behaviour are considered in the present study for analysing the performance of drivers. Further, the study aims to analyse how the changes in speed choices of drivers affect the risk of being involved in an accident for a sudden event while being distracted.

2. Literature review

Mobile phone use during driving is an ongoing safety problem; and vast literature is available on distraction effects of mobile phone use during driving. As, the present study concentrated on mean speed and accident risk associated with phone use, the following subsections of the paper summarize the literature reviewed on distraction effects of mobile phone use on mean speed, accident probability and drivers' behavioural adaptation for risk compensation. Then, the research gaps are highlighted in the last subsection.

2.1. Effect of mobile phone use on mean speed

Drivers generally try to compensate for additional workload due to any driver distractions (e.g., sending a text message while driving) by reducing their speed (Peng et al., 2014; Thapa et al., 2015). In large number of studies, speed reduction is a commonly documented trend when drivers use mobile phones during driving (Charlton, 2009; Leung et al., 2012; Caird et al., 2014). Various factors can influence driver's mean speed behaviour in distracted driving conditions. Type of distraction (visual, cognitive or visual-manual) is the most influencing factor for the compensatory behaviour (i.e., speed reduction) (Engstrom et al., 2005; Jamson and Merat, 2005). The compensatory behaviour of reducing the speed is observed in all the distraction types: conversation (Tractinsky et al., 2013; Metz et al., 2015; Leung et al., 2012; Tornros and Bolling, 2006), texting (Yannis et al., 2014; Yannis et al., 2014; Mckeever et al., 2012) and visual-manual tasks (such as: initiate and/or end the phone conversation) (Young et al., 2013). The time spent in visual-manual tasks is lesser compared to conversation and texting tasks, therefore, very few studies have analysed these distraction effects (Young et al., 2013 and Fitch et al., 2013). Visual scanning of the roadway is reduced considerably in the texting tasks (Young et al., 2012; Peng et al., 2014) which results in higher workload and therefore, larger speed reductions are observed (McKeever et al., 2013; Thapa et al., 2014; Caird et al., 2014). Some of the studies also accounted for the effect of age on speed of the driver (Reamer et al., 2011; Liu and Ou 2011 Liu and Ou 2011). The overall results of these studies show that, in distracted driving conditions older drivers tend to drive slower when compared to young drivers. Additionally, it is shown that female drivers drive slowly when compared to male drivers (Reimer et al., 2014; Leung et al., 2012) in distracted driving conditions. The other widely studied factor which affects the mean speed of the driver is the phone use modality: hands free and hand held, and it has been proven in some of the studies that the detrimental effects of phone use on lane deviation and situation awareness are equal for both the phone modes; but, the effects on speed is more significant for hand-held phones (Tornros and Bolling, 2006; Patten et al., 2004). Complexity of road environment also affects the speed of the drivers. It is observed that as the complexity of the road environment increases, the compensation for increased workload also increases i.e., more speed reduction is observed in complex road scenarios such as: urban area (Tornros and Bolling, 2006; Yannis et al., 2014), windy road (Metz et al., 2015) etc. Further, the interaction effects of these complex scenarios with conversation and texting tasks result in speed reduction (Tornros and Bolling, 2006; Metz et al., 2015). From the above mentioned review of existing literature, it is understood that drivers compensate distractions by reducing their speed for the perceived increased workload in order to maintain the adequate safety levels. But, still it is unclear that whether this speed reduction strategy is actually helping in maintaining the same level of accident risk as present in non-distracted driving.

2.2. Effects of mobile phone use on accident probabilities

A simulator study by Yannis et al. (2014) compared the accident frequencies in distracted and non-distracted driving and found that if the driver's visual attention is shifted away from driving to perform texting tasks on the phone, then the accident probabilities increases to 8.3 times in comparison to the non-distracted driving. Similarly, a study by Alosco et al. (2012) also showed that texting tasks increased the crash frequency when compared to control condition (no phone use). Increase in accident risk is also documented in existing literature when the drivers are indulged in conversation task (Charlton, 2009; Collet et al., 2010). The accident risk associated with the phone use is assessed in terms of surrogate measures; for example, Fitch et al. (2013) investigated the risk of a safety critical event (SCE) caused by phone use during driving and the results showed significant increment in SCE associated with phone use during driving. One of the possible reasons behind the increased crash rates is that the drivers are less likely to initiate the deceleration process as they approach a hazardous situation when they are conversing over the phone (Charlton, 2009). A review study by Collet et al. (2010) concluded that the reduction in speed is the subconscious outcome of managing the supplementary load produced by phone use but still impairing situation awareness abilities.

2.3. Behavioural adaptation for risk compensation

Behavioural adaptations are the common alterations in the driver behaviour to compensate for the changes in perceived risk (Rudin-Brown and Jamson, 2013). In the context of distraction, Young et al. (2009a) developed a model mentioning all the factors which moderate the impact of distraction on safety. Young et al. (2009a) described the compensatory strategies (self-regulation by drivers) adopted for risk compensation into three types: strategic, tactical and operational. Driver's decision to engage in the secondary task (e.g., switching off phone before the drive) comes under strategic level control, while adjustment in the timing of engagement (e.g., stop using phone or adjusting the timing of talking) comes under tactical control and adjustment in the resource allocation in the task engagement (e.g., reducing speed, increasing headway) comes under operational control (Young et al., 2009a). Some of the previous studies show that the compensatory strategies are not fully helpful in reducing the accident risk (Caird et al., 2008; Taylor et al., 2000). For instance, Rudin-Brown and Jamson (2013) stated that the self-regulation by drivers may not always be sufficient for offsetting the risk associated with the distraction tasks, especially in case of a sudden/unexpected event.

2.4. Research gap

Overall, the studies have documented the observed speed reduction during distracted driving as a compensating behaviour for the increased workload. It has also been recorded that the speed reduction strategies