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Understanding the impacts of mobile phone distraction on driving performance: A systematic review

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ABSTRACT

The use of mobile phones while driving—one of the most common driver distractions—has been a significant research interest during the most recent decade. While there has been a considerable amount research and excellent reviews on how mobile phone distractions influence various aspects of driving performance, the mechanisms by which the interactions with mobile phone affect driver performance is relatively unexamined. As such, the aim of this study is to examine the mechanisms involved with mobile phone distractions such as conversing, texting, and reading and the driving task, and subsequent outcomes. A novel human-machine framework is proposed to isolate the components and various interactions associated with mobile phone distracted driving. The proposed framework specifies the impacts of mobile phone distraction as an inter-related system of outcomes such as speed selection, lane deviations and crashes; human-car controls such as steering control and brake pedal use and human-environment interactions such as visual scanning and navigation. Eleven literature-review/meta-analyses papers and 62 recent research articles from 2005 to 2015 are critically reviewed and synthesised following a systematic classification scheme derived from the human-machine system framework. The analysis shows that while many studies have attempted to measure system outcomes or driving performance, research on how drivers interactively manage in-vehicle secondary tasks and adapt their driving behaviour while distracted is scant. A systematic approach may bolster efforts to examine comprehensively the performance of distracted drivers and their impact over the transportation system by considering all system components and interactions of drivers with mobile phones and vehicles. The proposed human-machine framework not only contributes to the literature on mobile phone distraction and safety, but also assists in identifying the research needs and promising strategies for mitigating mobile phone-related safety issues. Technology based countermeasures that can provide real-time feedback or alerts to drivers based on eye/head movements in conjunction with vehicle dynamics should be an important research direction.

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1. Introduction

Mobile phone distracted driving (MPDD) is an ongoing challenge for transport network managers. Observational studies conducted in the United States reveal that 31.4% of drivers talk on phone and 16.6% text or dial (Huisingh et al., 2015). Hickman and Hanowski (2012) reported that about 2.2% of commercial motor vehicle drivers were observed using mobile phones while driving. In Australia about 5% of drivers use handheld mobile phones whilst driving (Young et al., 2010), 3.4% in the United Kingdom (Sullman et al., 2014), and 14.1% in Spain (Prat et al., 2015). In an epidemiological study in the United States, about 69% of drivers aged between 18 and 64 years reported having engaged in a mobile phone conversation at least once in the past month (Overton et al., 2014). Meanwhile, about 60.4% drivers in New Zealand reported being involved in mobile phone conversations in a typical week, about 66.2% read 1–5 text messages while driving, and about 52.3% sent 1–5 text messages while driving (Hallett et al., 2011, 2012). Similarly, in Portugal, about 28.5% of a web-based sample of drivers reported using a mobile phone at least once a day (Ferreira et al., 2013). A survey conducted in Australia reported that almost one in two Australian drivers aged between 18 and 24 years use handheld mobile phones while driving, nearly 60% of them send text messages, and about 20% of them read emails and navigate (AAMI, 2012). Brace et al. (2007) argued that mobile phone usage while driving will remain stable (or even increase) due to the high degree of integration of this technology into society, whether it is lawful or not.

Different studies report varying effects of MPDD on crash risk. An epidemiological study found that mobile phone conversations increase crash risk by a factor of four (Redelmeier and Tibshirani, 1997). Asbridge et al. (2013) reported that the odds of a culpable crash increase by 70% when the driver is using mobile phone. In the United States, an study of police crash reports showed that mobile phone distraction resulted in 18% of fatal crashes and 5% of injury crashes (Overton et al., 2014). Epidemiological studies and police reported data, however, often suffer from underreporting problems and do not record the exposure to mobile phone use, and therefore these estimates may be inaccurate. Experimental and/or naturalistic studies, on the other hand, are not suitable for estimating actual crash risk as crashes are rarely observed within the study design (Caird et al., 2008). Hence, the use of surrogate measures of safe driving performance has been common, but the variety of these measures and the irregular results obtained has impeded a better understanding of the risk of using mobile phones while driving (Caird et al., 2014a). Moreover, the nature of the relationship between surrogate measures and actual crash risk is poorly understood and evidence is lacking.

Surrogate measures for safety evaluation of MPDD often compare various driving performance metrics such as speed, lateral control and braking between baseline (no distraction) and distracted conditions. By observing these metrics, self-regulation of driving or mobile phone usage has been reported in naturalistic driving and simulator studies as a potential risk compensatory factor (Hickman and Hanowski, 2012). Yet, it remains unclear whether this phenomenon has implications on safety (Yannis et al., 2010). The behavioural alterations in driver behaviour, in response to changing external physical conditions, are often gauged in terms of speed selection (Reimer et al., 2014), response time to a mobile phone call (Tractinsky et al., 2013), deceleration and reaction time (Benedetto et al., 2012), following distance (Kass et al., 2010), use regulation (Hickman and Hanowski, 2012), stopping behaviour at the onset of yellow light (Haque et al., 2015), braking behaviour (Haque and Washington, 2014a) and reaction time (Haque and Washington, 2013, 2014b), among others.

The trend in literature has been to apply reductionist methodologies for analysing the impact of particular distractive conditions (i.e. dialling, texting, ringing, etc.) on driving performance. Results obtained from these studies may not be conclusive because they typically do not consider different distractive conditions simultaneously, leaving their combined effects on driving performance and safety largely unknown.

Knowledge of the underlying mechanisms of the human-machine system and their interactions is needed. The lack of this knowledge has hampered the formulation of more effective strategies for coping with MPDD (Young and Regan, 2008; Young and Salmon, 2012). More importantly, this information is vital for parameterization of driver behaviour and for the development of technology-based interventions and system architectures. It is therefore very important to develop an integrated framework that helps to identify how different distractive conditions lead to different driving performance and outcomes.

The relationship between MPDD and safety has fuelled a dialogue that includes psychological, medical, engineering, economic, political and social points of view. This dialogue has resulted in the total or partial ban of the use of mobile phones while driving in many places around the world. However, uncertainty remains about how mobile phone use independently or in association with other factors affects driving performance. This article proposes a systematic framework based on a human-machine system approach to identify all of the components and interactions of MPDD so the effects of mobile phone use can be systematically analysed.

The paper is organized as follows. The next section presents a new systemic approach for understanding the interactions among the driver, the car, and the mobile phone. Next, a research methodology and the search protocols for collecting relevant literature are discussed. This section is followed by a systematic analysis of the literature that is consistent with the proposed classification scheme. The paper concludes with a theoretical discussion on the appropriateness of the proposed model and highlights the research path moving forward.

2. Mobile phone distracted driving (MPDD) as a human-machine system

A systems approach is one of the most robust methods for analysing configurations with high structural complexity (Leveson, 2011). This robustness is enabled through the use of a line-base language for isolating system components and