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Modeling safety risk perception due to mobile phone distraction among four wheeler drivers

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ABSTRACT

Nowadays, there is an increasing trend in the use of information and communication technology devices in new vehicles. Due to these increasing service facilities, driver distraction has become a major concern for transportation safety. To reduce safety risks, it is crucial to understand how distracting activities affect driver behavior at different levels of vehicle control. The objective of this work is to understand how the vehicle and driver characteristics influence mobile phone usage while driving and associated risk perception of road safety incidents. Based on literature review, a man–machine framework for distracted driving and a mobile phone distraction model is presented. The study highlights the findings from a questionnaire survey conducted in Kerala, India. The questionnaire uses a 5-point Likert scale. Responses from 1203 four-wheeler drivers are collected using random sampling approach. The questionnaire items associated with three driver-drive characteristics are: (i) Human Factors (age, experience, emotional state, behavior of driver), (ii) Driver space (meter, controls, light, heat, steering, actuators of vehicle), (iii) Driving conditions (speed, distance, duration, traffic, signals). This mobile phone distraction model is tested using structural equation modeling procedure. The study indicates that among the three characteristics, 'Human Factors' has the highest influence on perceived distraction due to mobile phones. It is also observed that safety risk perception due to mobile phone usage while driving is moderate. The practical relevance of the study is to place emphasis on behavior-based controls and to focus on strategies leveraging perception of distraction due to mobile phones while driving.

1. Introduction

The use of information and communication technology devices in four wheelers is on the rise. Such technological developments, while adding ease to life, increase the potential for drivers to engage in secondary tasks while driving [1,2]. Recent studies report phone use exposure estimates in the range 30–60% in a few developed countries [3]. The proportion of drivers using mobile phones has been increased over the past 5–10 years [4]. Driver distraction has become a major concern for transportation safety.

Nature, severity, and frequency of distractions affect the safety of drivers, passengers, and vulnerable road users [5]. There is a growing body of evidence which shows that the distraction caused by mobile phones can impair performance in a number of ways, e.g., longer reaction time to external stimuli (notably braking time, response to traffic signals), impaired ability to maintain the correct lane, shorter following distances and an overall reduction in awareness of the driving situation [4,6]. Most secondary tasks lead to a decrease in driving speed, while visual–manual tasks additionally take driver's eyes of the road, deteriorating the lateral performance [2]. The impact of using a mobile phone on crash risk is difficult to ascertain, but studies suggest that drivers using mobile phones are approximately four times more likely to be involved in crashes [4].

To reduce safety risks, it is crucial to understand how distracting activities affect driver behavior at different levels of vehicle control. There may be more than one reason or factor that motivates a person to involve in some secondary activity. The objective of the paper is to examine the role of vehicle and driver factors on risk perception of road safety incidents arising from the use of mobile phones while driving. First, a short literature review of a man–machine framework for distracted driving is presented (Section 2). Next section deals with distracted driving due to mobile phones by proposing a 'mobile phone distraction model'. In Section 3, the study methodology highlighting 'mobile phone distraction model', questionnaire survey and the analysis procedure are presented.

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Results and discussion from the structural equation model (SEM) are shown in Sections 4 and 5 respectively. Finally, the conclusions of this study are presented in Section 6.

2. Literature review

Driving is a very critical task that requires undivided attention and complete commitment of associated skills of the driver. Driver distraction is defined as a diversion of attention from activities critical to safe-driving for performing any secondary competing activity [2]. Distraction to the driver occurs from any secondary physical or mental activity that shifts the attention of the driver from safe handling of the automobile [7]. Some distractions are initiated by the driver, and others are acute situations that demand a quick response from the driver [8]. Most in-vehicle distractions belong to the former, whereas most outside vehicle distractions are of the latter.

Man–machine interactions between the driver and device may involve inputs such as visual, audio, or tactile inputs from the driver; and outputs like manual or voice responses. The secondary tasks which potentially distract the driver from the safe operation of the vehicle include interacting with a passenger, conversing on mobile phone, text messaging, use of smartphones and other office devices, navigation aids, background music, adjusting audio-video players, eating and drinking, manipulating in-vehicle environmental attributes, and seeking for objects. Fig. 1 presents the man–machine framework [9] for distracted driving. The major four-wheeler driver and driving characteristics that affect safety include 'Human characteristics', 'Driving Conditions', 'Driver Space' and 'Interaction characteristics' due to in-vehicle device and their use (Table 1).

The chain of events in the man–machine model are factors affecting the driving task (Human Factors, Driver space and Driving conditions), immediate-state and end-state (Fig. 1). 'Driver Space' is part of driver-vehicle interaction (inside vehicle) and 'Driving Conditions' is a part of vehicle-environment interaction (outside vehicle). Driver–vehicle interactions along with secondary tasks cause driving distraction and result in the immediate-state (loss of focus, steering control or pedal response). Driving distraction occurs in visual, manual, cognitive and audio forms [1], and can be studied through the multiple resource theory to examine the driver performance decrement [2]. According to the multiple resource theory, the resources allocated for visual attention and central processing while driving are forced to be divided by secondary tasks. Secondary tasks demanding these two types of resources (e.g., use of cell phone and navigation aid) pose visual and cognitive distractions while driving. Both visual and cognitive distractions increase driver workload and thereby influence the vehicle control and gaze behavior [2]. When distracted, drivers tend to place less emphasis on the visual scanning in favor of activities related to vehicle control [32]. Distraction enhances the chance of driving errors [33] and reduces situational awareness [34]. The man–machine interactions are indicated by the immediate states or driver performance indicators such as number of glances & glance time, speed, lateral position, posture, steering error, mental effort, NASA Task Load Index, time for detection of information, reaction time, lag distance, heart rate and committing errors. The end states are events or conditions that reflect a state of higher safety risk.

Intervention strategies to address distracted driving include legislation, enforcement, blocking technologies, using social media, education and transforming social norms [31,35–37]. Education related intervention strategy is based on risk perception of drivers who undertake distracted driving. Numerous literature indicate the difference in risk perception by different age groups, gender, in-vehicle devices or nature of secondary tasks [3,38,39]. Overall, the Man–machine model for distracted driving provides a useful framework for examining the role of major dimensions of driver-drive characteristics on distraction due to secondary tasks while driving.

3. Methodology

Considering the Man–machine model this paper specifically focuses on one of the secondary tasks, i.e., use of mobile phones. A mobile phone distraction model is proposed and validated.

3.1. Mobile phone distraction model

The mobile phone distraction model shown in Fig. 2 has three constructs, 'Human Factors', 'Driver Space' and 'Driving Conditions' that influence the driver's distraction due to a secondary task, i.e., 'Distraction_Mobile'. The focus in 'Distraction_Mobile' is on the immediate effect due to its use, i.e., loss of focus or steering control. This is represented as the immediate-state in Fig. 1. The driver's response while driving with secondary tasks results in end states such as 'accidents', 'near miss' and 'erratic driving'. Overall the model represents the influence of 'Human Factors', 'Driver Space' and 'Driving Conditions' on the risk perception of the driver towards safety incidents arising from the use of mobile phones while driving (i.e., 'Mobile Use'). Four hypotheses are tested in the mobile distraction model. First, the model

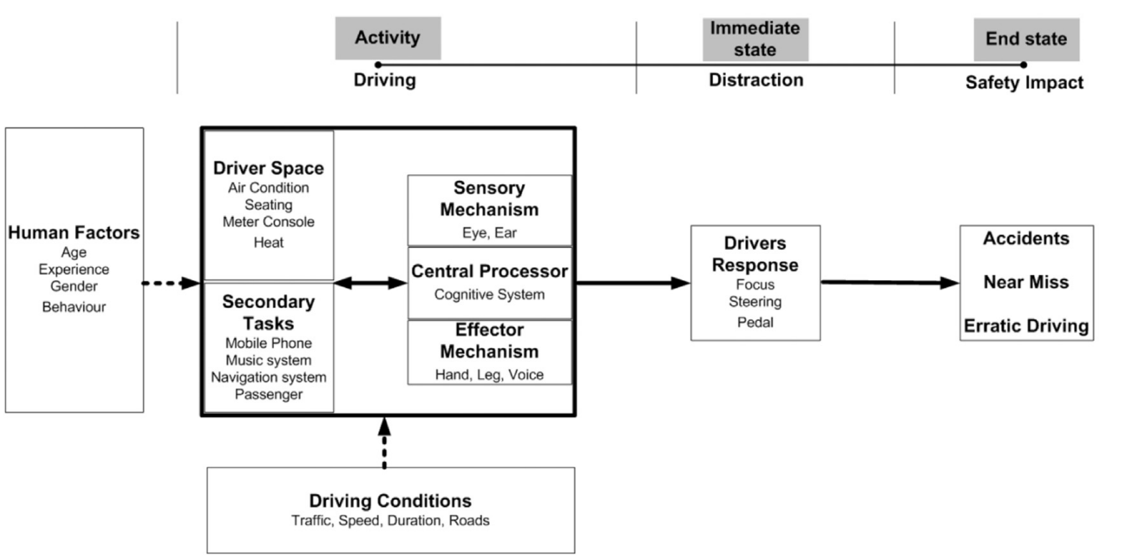

Fig. 1. Man–machine model for distracted driving.

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