Analysis and Examination on Cognitive Distraction for Travelers

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Abstract: Many see driving as a simple and straightforward process especially after having extended experience in driving. The process is more complex and is not without its risks as drivers utilize different sets of skills requiring a cooperative effort between the mind, body and cognition. A previous study illustrated that most of vehicle crashes and a large percentage of near-crashes were due to a lack of attention from the drivers' end. It was also found that the involvement of non-primary tasks which are not related directly to driving is among the most common types of inattention. In this article, we provide an overview on the concept of distraction for vehicle travelers. We go through the different variations of distraction as presented in the literature. Additionally, we explain how non-primary equipment in vehicles that are not related to driving may lead to distraction for humans. We present a categorization for the main types of distractions that may have an effect on vehicle travelers.
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Introduction

Driving is taken as granted by many people most of the time. It is however a complex and a risky task in which drivers employ simultaneously different sets of physical, psychological and cognitive skills. Even though complex skills are required for such an action, it is not unusual to see people being involved with other non-driving activities while they are in the same time driving. Such activities include talking to passengers, smoking, listening to the radio, eating or even reading. [2]. With the advance of incar technologies and wireless telecommunication, the use of devices such as cell phones, navigation systems, and other entertainment systems while driving is also becoming more and more common. In effect, the introduction of these activities to drivers is likely to introduce a risk to the safety of drivers while driving [3] [4]. Allowing drivers to effectively make use of the in-car technologies without negatively affecting their safety is considered a challenge that was addressed by many researchers [5] [6].

A realistic study that was conducted on 100 cars concluded that almost 65% of near-crashes and 80% of crashes were due to some form of inattention of the drivers [1]. Among the most common types of inattention are distractions caused by fatigue, and involvement with secondary tasks while driving. The same study indicated that 25% of all crash and nearcrash events were attributed to distraction of drivers. In [7], in-car entertainment systems and technologies were seen as distractions to the drivers while driving.

Driver Distraction

Drivers usually give their attentions while driving to both driving and non-driving tasks. With time and experience, drivers are usually able to segment some of their attention to tasks which are not-related to driving without seriously affecting the safety of their driving [2]. Drivers can also adjust to the driving environment or conditions they usually drive in [8]. For example, they may reduce their driving speed in specific risky areas and drive faster in other areas. It is possible that the drivers assign less attention to driving than is needed by focusing more on other tasks or activities leading to a risk in their safety or performance. This change in the focus balance between driving and other non-related tasks is usually caused by having complex secondary tasks or some very compelling ones. In some driving conditions, drivers may be required to channel all of their focus solely on driving without being occupied by any non-related tasks.

Many definitions for the phrase distraction of drivers have appeared in the literature. In, it was defined as having the drivers diverse their attention away from driving-related activities to other nonrelated tasks [7]. In [9], driver distraction is said to take place when a driver is delayed from identifying and recognizing important information that is required to drive safely. In the definition, this delay is said to occur due to other competing activities diverting the driver attention from the driving task.

Another definition given in [10] states that distraction is a process that draws the attention of the driver away from the road and negatively affect car control. These definitions share the claim that diverting the attention of the driver from driving to other secondary tasks is distraction. However, they do not note that not all the secondary tasks the driver may be involved in while driving may create a distraction.

A distraction should be probably be seen as an action or event that requires the driver to loss the necessary attention that he or she should divert to driving. In other words, if the secondary tasks do not negatively affect the focus and attention of the driver on driving safely, they should not be regarded as distractions.

In addition, the mentioned definitions do not take into account concurrent secondary tasks which take place all in the same time. Distraction in the literature has been classified into mainly four categories: physical, visual, auditory and cognitive distractions [2]. Physical distraction takes place when the driver hands are displaced from the steering wheel for a relatively long time. Visual distraction happens when the driver looks away from the road and shifts his attention on something else for a long period of time. Auditory distraction happens when the driver loses his hearing attention on the road environment and focuses instead on something else. Cognitive distraction happens when drivers think and focus on any subjects that effectively render them unable to drive safely.

Many in-car systems and technologies demand visual attention of the drivers to either input or read information from their displays. Sometimes, these in-car systems cause visual distraction to the drivers. In some cases, even physical distraction can take place when inputting data to the in-car systems. In an attempt to minimize visual distraction, new incar systems come embedded with speech recognition technologies which enable drivers to interact with the systems via spoken commands. Some researchers raised concerns about these speech-based systems by claiming that they can negatively affect the performance and safety of drivers on the road [11]. It is claimed that the change from visual displays to speech-based recognition system merely was a change in the interaction mode.

The involvement of the driver with the speech-based system may still lead a significant workload on the driver side which may cause a distraction. This possible distraction was attributed in the literature [1] to two main sources: First is that drivers must preserve a cognitive model for the system they are using. Second aspect is the workload required from the driver during the interaction with the device. In some cases, conversations about exciting topics or business-related actions may absorb more concentration and attention from the driver leading to a distraction. It was reported in [12] that during phone conversations, drivers reactions were reduced to unexpected events.

The above-mentioned studies and others too as in [13] and [14] show that the type of cognitive task that is performed by drivers while driving can have an important effect on their driving precaution, safety and behavior. Even though in-car systems supported by voice-recognition technologies can help drivers reduce physical distraction by allowing their hands to be on the wheels most of the time, the cognitive demand by such devices can still be significant.

Cognitive Distraction for Drivers

Cognitive distraction can be described with the phrase “mind-off-road” while vision distraction is viewed as “eyes-off-road”, according to [15]. Both are significant and can degrade the performance and safety of the driver, as described previously above. Among the open questions in this subject is how drivers regulate their driving to compensate any decrease in their focus and attention while driving [2]. Only limited research was found in the literature addressing this question. Most of the previous work in the literature has focused on identifying how the performance of drivers driving is affected with the usage of in-car systems and technologies. According to [8], not all of the secondary and non-driving related activities cause degradation to the performance of drivers. It was found that sometimes drivers get involved with secondary complementing tasks and activities to help them stay stimulated and keep a safe level of consciousness while driving.

It is possible to segment the level at which drivers choose to mitigate their risk for usage of incar systems into two main classes: high level decision and operational-related activities [16]. High-level decisions that can be made by drivers include for example choosing not to answer mobile phones while driving. Operational activities are such that driving slowly, increasing the distance between the car and others preceding or proceeding it, or moving to a slower lane [17] while involved with secondary activities. Age, sex and experience of the drivers were found to be some of the factors affecting which risk mitigation classes drivers choose to adopt [18].

According to [19], the most common types of distractions for drivers is visual and cognitive distractions. Visual distraction usually happens when the driver looks away from the road. This form of distraction can be quantified by measuring the length and the number of glances away from the road [20]. Cognitive distraction on the other hand takes place when the driver shifts his attention to something not related to the driving he or she is involved in. It can simply due to a deep concentration on a specific thought affecting the attention being paid on the road.

There are several types of measures surveyed in the literature for detection of distraction by drivers [21]. There are subjective report measures such as Subjective Social Status (SSS). There are also driver biological measures. These rely on modalities such as Electroencephalography (EEG), Electromyography (EMG) and Electrocardiography (ECG). There are driver physical measures employing methods such as gaze direction. In addition, there are driving

performance measures utilizing methods such as monitoring the yaw angle. There are also hybrid measures.

It can be noted from the above mentioned measures that they vary in how they are performed, monitored and reported and in how intrusively they are. It was reported in [19] that cognitive distraction needs to be reported and measured in real-time and in a non-intrusive way. Therefore, they suggested that the biological measures and the subjective report measures are not suitable for the task. However, in [22] a method was explored for monitoring EEG indices of workload and engagement which were acquired unobtrusively. Their method was utilized to predict the cognitive state transition in a person ranging from alertness, to weakness and drowsiness.

We highlight in this paper that the reported accuracy by the mentioned methods above is not relatively high. It is thus useful to identify measures or rather features that can help in boosting the accuracy of such methods. With all of the studied methods which are reported in the literature, it is noted that there is also a lack of a precise measurement that can aid in providing quantitative assessment of the cognitive state of the driver during a distraction taking into account the distractions inside and outside the car. In addition, we emphasize the need for identifying and studying the conditions under which drivers are less affected by cognitive distraction. There is also a need to identify and then attempt to imitate the driving conditions in which drivers are at greatest risk while taking the measurements.

Conclusion

In this paper, we give an overview on what is meant by driver distraction. We illustrate the various definitions of the phrase "driver distraction" in the literature. We describe how in-car systems and technologies which are not related to driving can cause distraction to drivers. We report the five main categories of distractions affecting drivers while driving. We then describe what is meant by cognitive distraction, its risks and how it can occur. We present the main measures used in the literature for the detection of distractions. We then report the main ones used for cognitive distraction. Afterwards, we highlight areas for further research in the field.

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