The influence of road familiarity on distracted driving activities and driving operation using naturalistic driving study data

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A R T I C L E   I N F O

A B S T R A C T

This paper analyzed the influence of familiarity on the involvement of secondary tasks and driving operation using naturalistic driving study (NDS) data. Distracted driving activities were extracted from face videos captured in 557 trips, including 501 trips on familiar roads and 56 trips on unfamiliar roads. These trips were completed by 155 drivers using their own vehicles during daytime hours under good weather conditions. The data showed the frequency of distracted driving activities and duration time were higher on familiar roads compared to unfamiliar roads. More types of secondary tasks were found on familiar roads. Focusing on objects was the most common distracted driving activity on familiar roads. The average time drivers used to eat or drink was highest (8.67 s) on familiar roads. The time drivers spent checking their cell phone was high on both familiar roads and unfamiliar roads. Since driving operation is directly related to crash risk, this paper also analyzed the difference of driving operation on familiar roads and unfamiliar roads. The speed profiles were generated on well-known versus unfamiliar roads. It was shown that drivers were more likely to be speeding and select a short distance to deceleration near the intersections. The findings indicated that distracted driving phenomenon was more serious on familiar roads.

1. Introduction

There have been several different definitions of distraction over the last 20 years, which are consistent with considering distraction as a subset of inattention (Regan, Hallett, & Gordon, 2011). Distraction often occurs when driver’s attention is shifted away from the driving task by a secondary task that requires focusing on some event, activity, object or person within or outside the vehicle (Stutts, Reinfurt, Staplin, & Rodgman, 2001). As a result, drivers are delayed noticing the change of driving environment and may fail to react to the emergency situation. Driver distraction can be considered that the secondary tasks have the priority above actual vehicle control. It reflects a mismatch between the attention devoted to a safety-critical driving activity and the attention demanded by it (Young, Lee, & Regan, 2008). But it is not easy to exactly define whether driver distraction occurs. For distraction identification, two different methods (physiological measures and performance-based measures) were then developed to monitor driver distraction (Wu, 2009). Physiological methods are designed to measure specific physiological aspects of distraction, such as eye glance, visual occlusion and so on. Performance-based methods examine driving performance, such as maintenance of vehicle’s lateral position, speed control, gap acceptance and so on. The most widely used technique for distraction measurement is eye glance technique, which is...
also used by NHTSA to develop “Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices” (NHTSA, 2012). Eyes off road time (EORT) is a widely accepted and valid measure for visual related performance. Previous research has shown the evidence that crash risk increases with the increasing duration of eye glance away from the road (Simons-Morton, Guo, Klauer, Ehsani, & Pradhan, 2014). When drivers glance away from the forward roadway for greater than 2.0 s out of a 6-s period, their risk of experiencing an unsafe event substantially increases relative to the baseline (NHTSA, 2012). Tracking EORT needs high accuracy as EORT is usually very short which could not be precisely recorded by simple observing the eye movement of drivers manually. Additional efforts are needed to track EORT by involving head position, eye moving angle into eye tracker equipment. In most situation, the drivers still take driving as their primary task but just engage in one of ostensibly inappropriate behaviors within the driving task. In this case, “distracted driving” is more appropriate compared to “driver distraction”, which is detailed described in the book written by Young et al. (2008). Though some distracted driving activities, such as talking to passengers, may not take drivers’ eyes off the forward roadway, they can still increase cognitive load and reduce visual scan (Recarte & Nunes, 2003). Any secondary task found during driving task is defined as distracted driving activities. To be more accurate, this paper focus on distracted driving activities instead of defining these activities.

Driving a car has been a skill used every day for many people. Most drivers have their own familiar routes which are used repeatedly with very high frequency. Repeatedly engaging in a driving task can impact driving performance gradually by the change of driver behavior, resulting in possibly distracted driving. Some aspects of the environment may be unnoticed by drivers as they are too familiar with the road situation. It is recommended that drivers’ familiarity should be considered in practical matters of road engineering (Colonna, Intini, Berloco, & Ranieri, 2016; Read et al., 2011). The results from the previous study show that drivers are often at increased risk of crashing on roads they know well (Charlton & Starkey, 2012). Drivers driving on familiar roads are more likely to be distracted from driving task, which is a major cause of traffic crashes (Yanko & Spalek, 2013). Driver inattention, which is estimated as a contributing factor in 25% of crashes by the National Highway Traffic Safety Administration (NHTSA), has constituted a big issue for drivers on familiar roads (Wang, Knipling, & Goodman, 1996).

A significant proportion of studies have been conducted to identify the impact of familiarity on distracted driving. Driving simulation provides a low-cost method for driver behavior data collection. The difference of driver behavior on familiar and unfamiliar roads can be examined by changing the appearance of landscape, types of trees used and removing all landmarks in a driving simulator (Charlton & Starkey, 2013). In an experiment exploring the effect of practice and automaticity on attention and driving, participants were required to repeatedly drive a single road in a driving simulator spread over 12 weeks (Charlton & Starkey, 2011). It is shown that speed and lane position variability quickly decreased with practice. Yanko and Spalek (2013) analyzed the impact of road familiarity on driver inattention by asking 15 students to drive the simulator several times per week. It is found that familiar drivers take longer to respond to emergencies than unfamiliar drivers.

Driver behavior questionnaire (DBQ) can collect driver behavior in a relatively short period and provide big sample data, which is also widely used by researchers. In a DBQ study, a total of 502 participants were involved to answer different questions related to driving performance on familiar roads and unfamiliar roads (Burdett, Charlton, & Starkey, 2016). It is found that the phenomenon of mind wandering is more common while driving on familiar road based on drivers’ self-report. But many drivers did not consider inattention as critical based on the results from another DBQ study (Berthié, Lemercier, Paubel, Cour, Fort, & Galéra, 2015). And some participants may respond differently from what their real-world behavior would be in order to protect their privacy or escape responsibility. The abovementioned papers provided good practice of using driving simulation and DBQ to analyze the difference of driving performance on familiar routes and unfamiliar routes. But driver distraction, as one of the main subset of driver inattention is left unaddressed. The difference of driver distraction and inattention is that secondary activities are required to constitute driver distraction, but not necessary for driver inattention. The different types of distracted driving such as making up, eating, talking with passengers and checking cell phones are difficult to be obtained through driving simulation and DBQ.

Naturalistic driving studies (NDS) can provide a useful supplement to more controlled laboratory and field studies to further the understanding of driver distraction on familiar roads and unfamiliar roads (Stutts et al., 2005). NDS can collect driver observation and driving operation unobtrusively, which provides a good opportunity to analyze distracted driving activities. Table 1 summarizes the effectiveness of different methods for driver behavior analysis. As is shown in Table 1, only NDS method can collect detailed driver observation and driving operation at the same time. Though a significant proportion of the existing literatures are devoted to assessing the impact of distraction on driving performance (Hickman & Hanowski, 2012; Metz, Landau, & Just, 2014; Olson, Hanowski, Hickman, & Bocanegra, 2009; Wang et al., 1996), NDS studies related

<table>
<thead>
<tr>
<th>Method</th>
<th>Time used for data collection</th>
<th>Could detailed driver observation be obtained?</th>
<th>Could detailed driving operation be obtained?</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBQ</td>
<td>Relatively short</td>
<td>No</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Simulation</td>
<td>Neutral</td>
<td>No</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>NDS</td>
<td>Relatively long</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
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