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Drivers' phone use at red traffic lights: A roadside observation study comparing calls and visual–manual interactions

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ABSTRACT

Phone use while driving has become one of the priority issues in road safety, given that it may lead to decreased situation awareness and deteriorated driving performance. It has been suggested that drivers can regulate their exposure to secondary tasks and seek for compatibility of phone use and driving. Phone use strategies include the choice of driving situations with low demands and interruptions of the interaction when the context changes. Traffic light situations at urban intersections imply both a temptation to use the phone while waiting at the red traffic light and a potential threat due to the incompatibility of phone use and driving when the traffic light turns green. These two situations were targeted in a roadside observation study, with the aim to investigate the existence of a phone use strategy at the red traffic light and to test its effectiveness. $N = 124$ phone users and a corresponding control group of non-users were observed. Strategic phone use behaviour was detected for visual–manual interactions, which are more likely to be initiated at the red traffic light and tend to be stopped before the vehicle moves off, while calls are less likely to be limited to the red traffic light situation. As an indicator of impaired situation awareness, delayed start was associated to phone use and in particular to visual–manual interactions, whether phone use was interrupted before moving off or not. Traffic light situations do not seem to allow effective application of phone use strategies, although drivers attempt to do so for the most demanding phone use mode. The underlying factors of phone use need to be studied so as to reduce the temptation of phone use and facilitate exposure regulation strategies.

1. Introduction

Communication is a central element of the digital age, and phone use has evolved into a habit for many people. The statistics of the International Telecommunication Union show that mobile phone subscriptions have dramatically increased over the last decade (International Telecommunication Union (ITU), 2014). Inevitably, phone use is also taking place in road traffic and driver distraction by mobile phones has become one of the priority issues in road safety (World Health Organization (WHO), 2011). In a survey conducted in 2012 with a representative sample of the French driver population, 23% of the respondents indicated to use the phone with a hands-free kit while driving and 11% admitted to use the phone hand-held. 13% of the respondents said to read text (messages, mails or websites) and 11% to write text while driving (ONISR, 2013). Accident analyses conducted in 2010 revealed that close to 10% of injury crashes in France could be attributed to mobile phone use while driving (OECD/ITF, 2014). On an international level, reviews of the effects of phone use on driving performance keep raising concerns on the cognitive, visual and manual distraction provoked by calls or other interactions with the phone, and they highlight the corresponding increase in crash risk (McCartt et al., 2006; Brace et al., 2007; Kircher et al., 2011; Bruyas, 2013). Given that they provoke interruptions of drivers' visual sampling of the driving environment, distracting activities with high visual demand are associated to higher crash risk than those that only imply cognitive distraction (Young and Salmon, 2012). Simulated as well as naturalistic driving studies revealed a relationship between crashes and glances inside the vehicle that lasted more than 1.6 or 2 s, respectively (Horrey and Wickens, 2007; Klauer et al., 2006). Related to phone use, the greatest increases in the odds for drivers to be involved in safety-critical events have been detected for text messaging, followed by dialling a number and reaching for a mobile device (Hickman et al., 2010; Olson et al., 2009).

While drivers used a mobile phone, failures to perceive and process traffic signs and hazards that are present on the road have

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been found (McKnight and McKnight, 1993) and longer reaction times to traffic signals and events have been observed (Strayer et al., 2003; Charlton, 2009). Hence, phone use can lead to a general decrease in situation awareness, as defined by Endsley (1988), and to violations of traffic rules (Caird et al., 2008). These effects are amplified if the drivers' use of the mobile phone implies a diversion of the gaze towards the phone. For example, while texting drivers make more in-vehicle glances and reduce their visual attention to the environment, which has proven to be associated to impaired lateral vehicle control (Hosking et al., 2009; Drews et al., 2009). In addition to their decreased awareness of changing events in the road scene, drivers might not concentrate on the traffic situation for long enough between their off-road glances so as to get back 'in-the-loop' (Senders et al., 1967 cited in Young and Salmon, 2012). As a consequence, drivers suffer from delayed detection of relevant information or complete hazard identification failures. Thus, a major issue of concern lies in the alteration of visual information uptake when using the phone.

The latest generations of mobile phones feature a wide range of use options, with a growing number of mobile phone applications that require visual–manual interactions. Smartphones are not only increasingly popular; they also tend to become an essential device in everyday life and imply strong temptations for visual–manual interactions. Their use can become an automated habit, driven by internal factors, such as the need to constantly stay informed and in touch with the social network, or by external triggers, i.e. a sound emitted by the phone. These triggers can appear at any time and in any situation, and consequently also while driving (Bayer and Campbell, 2012).

In their deciding-to-be-distracted approach, Lerner and Boyd (2005) argue that the risk of secondary tasks while driving is not only determined by the distractive potential of the activity itself but also by the driver's exposure to the task, and that drivers can influence their risk by actively regulating exposure to secondary tasks. This regulation is based on higher-level decisions, which depend on motivational and cognitive factors (Summala, 1997). It can either be achieved by exposure limitation or by seeking for compatibility of the secondary task and driving, i.e. by choosing traffic situations in which the demands of the driving tasks leave enough attentional resources for the phone use (Huth and Brusque, 2013). In a simulator study, Schömig et al. (2011) observed that drivers took the deliberate decision to engage in the secondary task based on an anticipation of the development of situational demands and the judgement of their compatibility with the execution of a concurrent task. Specifically, Stutts et al. (2005) found that the most prominent factor influencing the decision to engage in a secondary task is whether the vehicle is moving or not. The compatibility of phone use with the driving task can vary dramatically, since the demands of driving can be relatively low or extremely high, according to the driving situation and the manoeuvre the driver is carrying out. The traffic context is dynamic and can evolve quickly, and drivers will have to apply phone use strategies that are adapted to these changing conditions.

Interactions with the phone that last longer than a few seconds are thus susceptible to take place in a context that does not correspond to the one initially chosen by the driver. In this regard, the possibility to interrupt the phone interaction plays a crucial role (Huth and Brusque, 2013). Interruptions of secondary tasks in order to execute controls of the primary task have been described as an interaction strategy with in-vehicle devices (Rauch et al., 2008). However, phone interactions might not always be easily dividable into several chunks that allow the driver to pay attention to the traffic situations at regular and appropriate intervals. Calls might be difficult to interrupt quickly, given that the conversation partner is not witnessing the traffic situation, whereas interruptions of visual–manual phone use can lead to interaction errors, which can also extend the interaction beyond the drivers' intentions.

In this regard, intersections represent a particularly interesting location due to the dynamic driving context that can considerably evolve within short periods of time (Sandin, 2009). Driving through an intersection implies different phases that are associated to driving tasks of different difficulty levels (Cooper et al., 2003). Furthermore, intersections are locations where the paths of several types of road users cross, which can lead to conflicts with potentially severe outcomes (Habibovic and Davidsson, 2012). At the same time, intersections controlled by traffic lights can induce drivers to engage in phone use while safely stopped at a red traffic light. In this situation, drivers may take the chance to use the phone out of necessity or boredom, including highly demanding phone use modes such as texting or checking emails. However, once the traffic light turns green, the driver enters a potentially complex situation with high attentional demands. Negative consequences of phone use could appear in this situation if the phone interaction was not interrupted when starting to move the vehicle or if the driver is still cognitively distracted by the recent phone use.

In sum, traffic light situations at urban intersections imply both a temptation to use the phone at the red traffic light and a potential threat due to the incompatibility of phone use and the driving task when the traffic signal turns green and the vehicle moves off. The aim of this study was to observe phone use at urban intersections during these two situations and to address the following two research questions:

1. The first research question focussed on the existence of a phone use strategy. The aim was to determine if drivers took the chance to use their phone when waiting at the red traffic light by observing the initiation of phone use in this situation.
2. The second research question concerned the effectiveness of the phone use strategy. It was addressed in two parts. Firstly, the cessation of phone use at traffic lights was observed in order to examine if drivers limit the phone use to the safe stopping situation. Secondly, the relationship between phone use and delayed starts when the traffic signal turns green was tested.

Given that phone calls and visual–manual interactions affect driving to a different extent, the existence and effectiveness of a phone use strategy were tested for differences between these two phone use modes.

2. Method

2.1. Observations

The method applied in this study is based on traffic observation techniques, which have previously been used in studies related to the prevalence of distracting secondary activities while driving (Sullman, 2012), and in particular regarding mobile phone use (Walker et al., 2006; Pickrell and Ye, 2010). In these studies, trained observers collect information on driver characteristics and predefined target behaviours in the setting where they naturally occur. Behaviour is measured directly, avoiding possible biases of self-reports, and the non-invasiveness of this research method makes for high construct and face validity (Eby, 2011). According to the research questions, the present study collected information on drivers who used their mobile phone while waiting at a red traffic light. With the aim to compare driver behaviour of mobile phone users and non-users, a control group of non-users was created in parallel.

Three urban intersections that are controlled by traffic lights were selected in Lyon, France. At each intersection, the traffic light