Self-regulation of Drivers' Mobile Phone Use: The Influence of Driving Context

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ABSTRACT

Mobile phone use while driving is considered as a major concern for traffic safety. Various studies indicate negative effects of distracted driving and recent Naturalistic Driving studies report substantial increases in crash risk of mobile phone use while driving. The objective of this study was to investigate what mechanism related to self-regulation underlies drivers' decision to engage in mobile phone activity while driving. This study focussed on the effect of driving context. For this study naturalistic driving data collected in the UDRIVE project was analysed. Dutch drivers spent over 9% of all driving time engaging in mobile phone related tasks. Drivers used their mobile phone significantly less when a passenger was present. Also a significant overrepresentation of visual-manual (VM) tasks initiated during standstill was observed, for the other speed categories significantly less VM tasks than expected were initiated. In addition significantly more time was spend engaged in VM tasks on urban roads than expected. On rural roads and highways significantly less time was spend on VM tasks than expected. The analysis clearly shows indications of drivers' self-regulatory behaviour.

Keywords: Distraction, Mobile phone, Driving context, Self-regulation, Naturalistic Driving.

1 INTRODUCTION

In 2017, 89% of all Dutch inhabitants of twelve years and older own a smartphone (CBS, 2018). The rapid penetration and use of mobile phones in the last decade generated a wide interest in safety issues related to mobile phone use while driving (SWOV, 2017). Various (review) studies investigated the behavioural effects of the use of a mobile phone while driving (Basacik, Reed & Robbins, 2011; Collet, Guillot & Petit, 2010a; 2010b; Dingus, 2016; Stelling-Konczak & Hagenzieker, 2012). Based on the results of behavioural studies, we can conclude that using a mobile phone has a negative effect on driving behaviour indicating that mobile phone use while driving is a problem for traffic safety. In order to understand the magnitude of this problem better, this study investigated the prevalence of mobile phone use of Dutch car drivers. In addition, driving context when using the mobile phone was analysed in order to explore mechanisms of self-regulatory behaviour.

In the last decade several studies using different methodologies researched prevalence of mobile phone use while driving. Recent studies using Naturalistic Driving (ND) data show large differences in prevalence of mobile phone use between countries. A recent US study based on ND data reports (hand-held) mobile phone use of over six percent of all driving time (Dingus et al., 2016). Results of the recent European ND project UDRIVE show large differences between different European countries (Carsten et al., 2017) ranging from below one percent to above nine percent of all driving time. While these differences remain largely unexplained yet, it highlights the importance of obtaining national or regional data on prevalence of mobile phone use.

Mobile phone-related accidents have not increased in line with the use of the mobile phones suggesting that the potential risks of mobile phones use are regulated at many levels (Pöysti, 2005). Drivers self-regulatory behaviour of mobile phone use while driving can occur at different levels: strategic level (e.g. deciding not to use a mobile phone while driving), tactical level (e.g. the timing of engagement in the mobile phone task) or at the operational level (e.g. slowing down, often referred to as compensatory behaviour). This study aims to explore how driving context influences the drivers' decision to use the mobile phone on a tactical level. The focus will be on visual-manual (VM) phone tasks such as dialling, sending a text message or reading as they are commonly associated with increased risk (Klauer et al., 2006; Olson, Hanowski, Hickman & Bocanegra, 2009). Holding a mobile phone (including hand-held calling, texting) while driving is prohibited by law in the Netherlands, hands-free calling however is allowed.

2 METHOD

2.1 The UDRIVE database of Dutch car drivers

Naturalistic driving data of Dutch drivers collected in the UDRIVE project between 2015 and 2017 was used for analysis in this study. Thirty-three drivers participated in the Dutch car study; 3727 hours of data was collected and in total 230,842 kilometres were driven by the drivers. Data of 28 participants were included in this study. The average age of participants was 44.5 years (SD=12.9; range 26-70), of one participant age was unknown. An equal amount of women and man participated.

All participants were provided with a leased Renault Clio IV which they drove in during their participation. The cars were equipped with seven cameras and a data acquisition system able to log CAN-bus data, GPS-data, Mobileye data and video footage (more information on the UDRIVE data collection see Bärgman et al., 2017). In this study video images were analysed to observe mobile phone usage. Map matched GPS-data and CAN-bus data were used to determine driving speed, road type and speed limit.

2.2 Data sample and annotations

A random sample of trips was selected of the 28 participants out of the available data. Two inclusion criteria for trip inclusion were used; a trip duration was at least three minutes and 50% of the trip duration driving speed had to be above 5 km/h. A team of five video annotators manually inspected trips from start to end for episodes of mobile phone use. The following subtasks were annotated: hand-held conversation, hands-free conversation, hand-held interaction, hand-held reading, hands-free interaction, holding (without interaction), searching for the mobile phone and any other activities related to the mobile phone (other). The presence of passengers was annotated as well. When the quality of the inward camera was not sufficient the trip was excluded and a different random trip was selected. Consequently, 656 trips were annotated and 225 hours of video material, including 14159 driven kilometres of 28 participants. Per participant a minimum of 10 and a maximum of 36 trips were annotated.

2.3 Data analysis

Prevalence of mobile phone engagement, the effect of passenger presence and the influence of speed and driving context on the engagement in VM tasks were analysed in detail. VM tasks were defined as the subtasks hand-held interaction and hand-held reading. If there were less than three seconds between VM tasks, the VM task was annotated as one.

3 RESULTS

3.1 Prevalence of mobile phone engagement

Prevalence of the aforementioned categories of mobile phone engagement was determined per participant. Averages over participants were then calculated. In 32% (SD=25.6) of the trips a mobile phone was used. Differences amongst participants were large. One participant never used the mobile phone in the car while another participant used the mobile phone in all of the trips that were annotated. Drivers spend 9.3% of all driving time engaged in mobile phone related tasks. One driver was even engaged in mobile phone related tasks during 74% of the driving time. Table 1 gives an overview of the percentage of time that was spend on a specific task related to mobile phone use. Drivers rarely called hand-held, while hands-free calling happened more often, 2.1% of all driving time. Drivers were engaged in a VM task (hand-held interaction and hand-held reading) in 1.7% (SD=2.5) of all driving time.

Table 1 – Average, standard deviation and maximum percentage of the time wherein drivers are engaged in mobile phone related tasks

Task	Average percentage	Standard deviation	Maximum percentage
Total phone engagement	9.3	16.1	73.7
Hand-held conversation	0	0	0.02
Hands-free conversation	2.1	3.1	12.2
Hand-held interaction	1.5	2.2	10.4
Hand-held reading	0.2	0.4	1.8
Hands-free interaction	0.6	1.5	7.1
Holding (without interaction)	4.5	12.3	56.8
Searching for the mobile phone	0.2	0.2	0.7
Other	0.02	0	0.1

The effect of passenger presence was determined with a paired-sample t-test. The percentage of trips with passengers present was compared with trips wherein the mobile phone was used and passengers were present. In 26% of all the trips (SD=18.3) a passenger was present during the major part of the trip. For trips where a mobile phone was used this was 16% (SD=23.8), significantly less than the overall percentage ($t(26)=2.973$, $p=0.006$, $d=0.57$). This indicates that drivers used their mobile phone less often when there was a passenger present. When only looking at visual-manual interactions in 6.9% (SD=19.6) of the trips where a mobile phone was used a passenger was present, also significantly less than the overall percentage of 26% ($t(26)=7.767$, $p<0.001$, $d=-1.493$).

3.2 Visual-manual tasks, speed and driving context

1058 visual-manual tasks were identified, drivers were engaged in a VM task 3.9 hours of the driving time. The speed with which drivers initiated a VM task was analysed. To do so, the percentage of VM tasks initiated at a certain speed was compared to the overall percentage of time driven at a certain speed in speed bins of 10 km/h (conform Tivesten and Dozza, 2015). The results are shown in Figure 1. Clearly, most of the tasks were initiated when standing still.

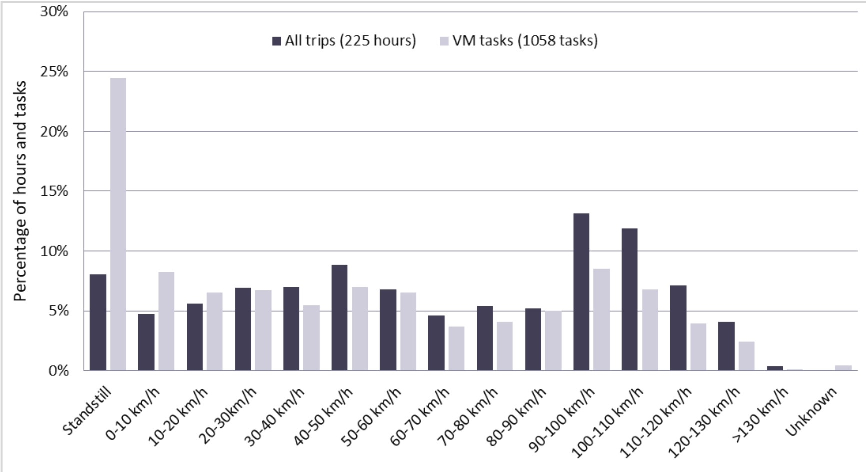

Figure 1 - The percentage of driving time in speed bins of 10 km/h for all annotated trips (225 hours) and the percentage of visual-manual tasks initiated at a certain speed

To gain understanding of the relation between speed driven and VM task engagement, the number of observed VM tasks initiated in a certain speed bin was compared to the expected number of VM tasks based on the distribution of driving time in a certain speed bin. Figure 2 shows the difference between the observed and expected values. An overrepresentation of VM tasks initiated during standstill was observed, for the other speed categories an underrepresentation was observed. A chi-square goodness of fit test was used to compare the occurrence of VM tasks with the hypothesized occurrence. Significant deviations from the hypothesized values were found for all categories (Standstill: $\chi 2(1)=358.1$, $p<0.001$; 0-50 km/h: $\chi 2(1)=11.7$, $p<0.001$;50-100 km/h: $\chi 2(1)=22.9$, $p<0.001$;100>km/h: $\chi 2(1)=46.2$, $p<0.001$).

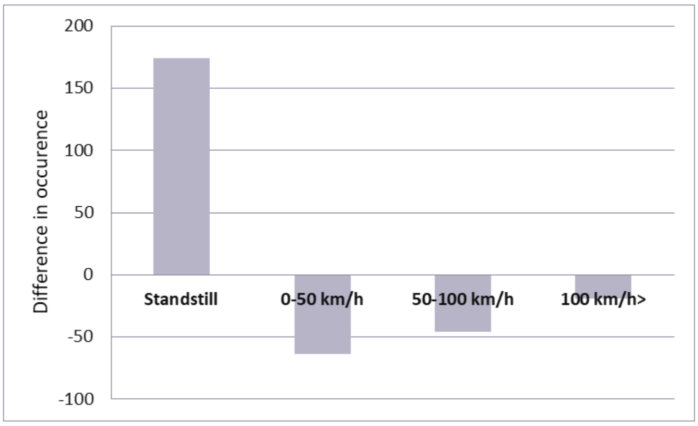

Figure 2 - The difference between observed and expected number of initiated VM tasks for speed categories; standstill, 0-50 km/h and more than 100 km/h (N=1058)

The data was further analysed to explore the relation between road type and engagement in VM tasks, focussing on urban areas (30-50 km/h speed limit), rural areas (60-90 km/h speed limit) and highway (100> km/h speed limit). For 74% of the visual-manual tasks (787 tasks) speed limit information was available, corresponding to 2.1 hours of the VM tasks (53% of the total duration of VM tasks). For these tasks the percentage of time driven on a road with a certain speed limit was calculated. Most of the time engaged in a VM task was spend on highways (50%), 17% of the time engaged was spend on rural roads and 33% of the time engaged was spend on urban roads. As drivers do not spend an equal amount of time on the different road types, we again compared the observed and expected time spend on VM tasks based on the distribution of driving time on the different road types. A chi-square goodness of fit test was used to compare the total duration of VM tasks per road category with the expected total duration of VM tasks per road category. Significant deviations from the hypothesized values were found for all categories (urban: $\chi 2(1)=155.6$, $p<0.001$; rural: $\chi 2(1)=20.9$, $p<0.001$; highway: $\chi 2(1)=55.0$, $p<0.001$). The results presented in 3 show that given the distribution of time driven on a certain road type, more time was spend engaged in VM tasks in urban roads than would be expected, on rural roads and highways less time was spend than would be expected.

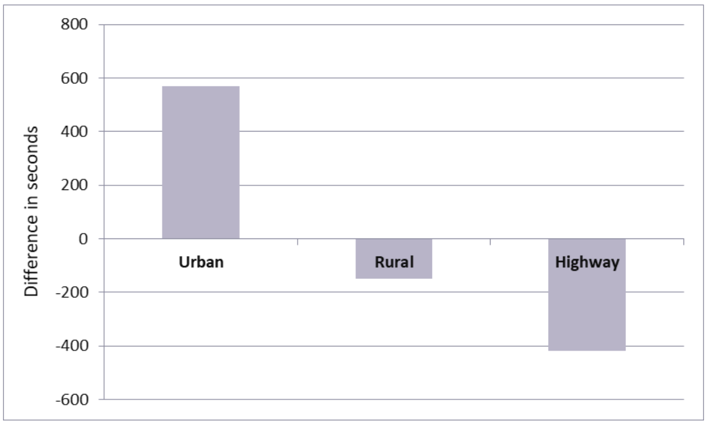

Figure 3 - The difference between observed and expected duration of VM tasks in seconds in urban, rural and highway driving context (N=787)

4 DISCUSSION AND CONCLUION

On average, Dutch drivers spend 9% of all driving using their mobile phones. Prevalence in the Netherlands is high, compared to the prevalence of mobile phone use in other European countries determined using the same methodology (Carsten et al., 2017): 3.5% in France, 1% in Germany, 9.8% in Poland and 2.9% in the UK. Further analysis is needed to explain these large differences. Methodological aspects such as participant sample could partly explain the differences, but also cultural differences, differences in legislation and enforcement could be related to the observed results. Better understanding of the observed differences between European countries could facilitate the development of countermeasures and support decision making.

Drivers used their mobile phone significantly less when a passenger was present. Also a significant overrepresentation of VM tasks initiated during standstill was observed, for the other speed categories significantly less VM tasks than expected were initiated. In addition significantly more time was spend on VM tasks on urban roads than expected. On rural roads and highways significantly less time than expected was spend on VM tasks.

Although the results presented in this paper are limited and the participant sample cannot be considered as representative for the Netherlands, there are clearly some indications of drivers' self-regulatory behaviour. This paper describes the intermittent results of a currently ongoing analysis. More factors of driving context such as driving manoeuvre, road curvature, weather/light conditions and lead vehicle presence will be included in the analysis. In addition, a 15-second baseline period preceding the engagement of a VM task will be compared to driving during VM task engagement on several factors.

The majority of drivers are likely to be aware of the dangers of mobile phone use behind the wheel, partly because of public campaigns. It would be a reasonable assumption that one of the drivers' goals is to drive safely and avoid crashes. If self-regulatory behaviour related to mobile phone use of drivers would be perfect, this goal would be reached and no mobile phone use related accidents would happen. The literature describes different patterns of self-regulation failure such as underregulation (deficient standards, inadequate monitoring, or inadequate strength) and misregulation (false assumptions or misdirected efforts) (Baumeister & Heatherton, 2009). Self-regulatory behaviour related to mobile phone use of drivers placed against this theoretical background helps understanding drivers' decisions to engage in mobile phone activity while driving but most importantly it increases understanding of self-regulation failure that leads to unsafe driving.

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