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Frequency of secondary tasks in driving – Results from naturalistic driving data

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ABSTRACT

Information regarding the overall frequency of secondary tasks while driving, as well as individual differences and situational influence on distraction frequency, is needed to understand the impact of distraction on driving behavior. Forty-nine drivers took part in a study that was based on naturalistic driving data and analyzed the frequency of secondary tasks while driving. Two approaches were used to assess secondary task interaction: the analysis of objective data from CAN for the full data set (∼370,000 km) and video analysis for a selected subset of 256 trips (∼20,000 km). Results regarding the duration of single secondary tasks and the proportion of driving time spent on the different secondary tasks are reported. Engagement in select secondary tasks (besides interaction with the passenger) was reduced when a passenger was in the car. Moreover, it was observed that especially demanding visual-manual secondary tasks were preferably performed when the car was at standstill and they were avoided when traveling at high speeds on the highway. In closing, the two measurement approaches mentioned above are directly compared and recommendations for future analyses are suggested.

1. Introduction

Recently, the impact of secondary tasks on driving safety has become a highly relevant issue in scientific discussion. One reason for this is that a new measurement approach called the naturalistic driving study (NDS). This type of approach can be used to gain insight into the frequency and impact of secondary tasks during daily, uninstructed drives. One important difference between NDS and experimental approaches is that drivers taking part in NDS can choose when and where to attend to secondary tasks while driving. In experiments on distraction, drivers are normally told by the experimenter when they have to perform pre-defined distracting activities and then the impact of distraction on driving is analyzed. Results from such experiments show that drivers compensate for the distraction by altering the stabilization level of the driving task, i.e. drivers slow down and increase their distance to the lead vehicle (e.g. Caird et al., 2008; Collet et al., 2010a,b). Experimental approaches normally do not study a potential compensation on the tactical level (Michon, 1985), which means compensation through choosing appropriate driving situations for interacting with secondary tasks (Bruyas et al., 2013). Schömig and Metz (2013) (see also Schömig et al., 2011) deviated from the norm in a study when they let the drivers decide whether or not to start a secondary task in a specific driving situation. In this study, drivers frequently attended to secondary tasks when the driving situation was less complex. Now, NDS make it possible to study the impact of situational factors on the frequency of distracted driving based on real life data.

Furthermore, NDS allow the overall frequency of distracted driving in real traffic to be estimated. This information is necessary to be able to interpret data from accident data bases. Analyses of accident data bases report varying figures regarding the frequency of distraction in accidents: e.g. 8.3% of accidents (Stutts et al., 2001) vs. 29% of accidents (Craft and Preslopsky, 2013). Reasons for the differing results from crash data bases are varying definitions of distraction, regional differences and differences in the quality of the information coded in the data base. But, as long as the exposure to distraction during non-critical driving is not known, the impact of distraction on accident risk is difficult to estimate using accident data bases. Distraction has to occur more frequently during crashes than during regular driving before it can be concluded that it is related to a disproportional high number of crashes.

Klauer et al. (2006) coded the occurrence of secondary tasks for 20,000 randomly selected periods of six seconds of driving that were chosen from the database recorded in the 100-car-study. In total, about 33 h of driving time were coded to assess the frequency of secondary tasks during driving. Unfortunately, the results that were reported regarding the base rate of distracted driving were limited. For instance, although the coding system

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used differentiated between different types of secondary tasks in a very fine grained way, distraction frequency was only reported for broad classes of distracting activities (e.g. drowsiness vs. secondary task in Klauer et al. (2006)). In Dingus et al. (2006), the results from distraction during non-critical driving were merged with the results from distraction during critical driving situations and then the impact of secondary tasks on the risk for critical driving situations were reported on. Detailed information about the frequency of secondary tasks cannot be derived from the odds ratios reported in the study. Sayer et al. (2005) used the data collected in a field operational test on the impact of a forward collision warning system. They coded the occurrence of secondary tasks for 1440 video sequences with a duration of five seconds each (in total two hours of driving). In 34% of the coded sequences, the drivers interacted with secondary tasks. The most frequent secondary tasks were interaction with the passenger (15.3%), secondary tasks related to the body (e.g. applying make-up, 6.5%) and the usage/handling of a mobile phone (5.3%). According to Toole et al. (2013), commercial drivers spent about 10% of driving time talking on the phone. Fitch et al. (2013) reported a similar proportion for car drivers. The approach of coding video sequences of a defined duration does not allow for the analysis of the duration of single secondary tasks, but it gives insight into the proportion of coded sequences with distraction.

The mentioned examples highlight one major drawback of most NDS reported in the literature. Results on distracted driving are completely based on video analysis. Therefore, although the data base collected in a study is enormous, the data on which the results are actually based is quite little. The small database makes it difficult to interpret individual differences in the frequency of distracted driving and to analyze the influence of situational factors (like road category or passenger in the car) on the frequency of distraction. The coded data points per driver or per situational category are normally not enough to reliably assess individual differences.

One aim of the presented research was to gain information on the frequency of distraction while driving for a German sample. In the analysis, solutions that provided a sufficient amount of analyzable data to investigate the overall frequency of distraction as well as individual differences and the impact of situational factors were looked for. It was assumed that this information would help to get a deeper understanding of the frequency of distracted driving and its impact on driving behavior.

The data analyzed was collected as part of the European project euroFOT (http://www.eurofot-ip.eu/). In this project, data was collected in a large-scale field-operational test (FOT) across Europe. For the present analysis, data from an FOT on navigation systems was used (for results see Benmimoun et al., 2012). In the FOT, the usage of the navigation system was instructed. Besides this, drivers could use their vehicles as they liked throughout the measurement period. Therefore, the data could be treated as naturalistic driving data if the frequency of distracted driving is analyzed.

The frequency of distraction was assessed using two approaches:

1. For some distracting activities (e.g. hands-free telephoning), continuous signals were directly available from the vehicle. These secondary tasks were automatically analyzed for the entire database.
2. For a selected subset of trips, the occurrence of other secondary tasks was coded based on the video. Care was taken to code a sufficient number of trips/kilometers per driver to be able to assess individual differences and the impact of situational factors.

With the first approach, individual differences and situational influences could be analyzed without a problem because the database was huge. However, the types of secondary tasks that could be investigated with an automated analysis were rather limited. To get a more complete picture on the frequency of secondary tasks while driving, the video was coded for a subsample of trips. The data from both approaches was combined to get a more complete picture of the frequency of distraction in driving. Furthermore, individual differences were analyzed. Lastly, it was assessed how situational factors, like having a passenger in the vehicle, road category or driving speed, impact the frequency of distraction.

2. Methods

2.1. Data collection and sample

The database contained data from 49 drivers who participated in the FOT over a three month period. In addition to the instruction regarding the usage of the navigation system, the FOT-vehicles could be used by the drivers as they liked throughout the three months. In order to be able to analyze safety related indicators, continuous information on the distance to the lead vehicle as well as on lane position was needed. To be able to log all of the needed information, vehicles had to be equipped with active cruise control (ACC) and lane assist (LDW). Thus, sensor technique was integrated in the vehicle that continuously measured lane position and following distance. In order to make all of the CAN-data needed for the analysis available for all of the vehicles, it was decided not to fit private cars with data loggers, but lend fully equipped FOT-vehicles to the drivers for the time of FOT-participation. All vehicles were equipped with a variety of on the market driver assistance systems, e.g. ACC, lane departure warning and blind spot monitoring. These system could be used by the participants as they liked throughout the FOT. The instructions used in the FOT.

The drivers in the FOT were customers of the car manufacturer participating in this study. Drivers received a vehicle for the duration of this study that was similar to the one they use on a daily basis. The BMW branch office in Munich was responsible for the recruitment of the drivers. The vehicles were given to premium customers free of charge. The sample was not representative of the German population, but rather reflected the customers of a specific vehicle brand. This had the advantage that the drivers did not need a lot of time to familiarize themselves with the new vehicle. All vehicles in the FOT were BMW 5 series fitted with a data logger that started and ended data collection automatically. For each trip, objective data from vehicle buses (CAN, Most, FlexRay) was logged continuously with the frequency available on CAN. For the analyses, all signals were converted into even-spaced, 20 Hz time-series data. Furthermore, continuous video was recorded with 5 Hz.

Only three of the 49 drivers were female. Table 1 gives descriptive values on the drivers' age and driving experience. For a more detailed description of the experimental setup and the data collected in the FOT, see Schoch et al. (2011). About 70% of the participants reported that they were highly experienced smartphone users. Only about 10% had no experience with a smartphone.

2.2. Analysis of CAN-data

In the objective data, signals were available that coded single button presses as well as the usage of the hands-free phone system. These signals were used to detect periods of distracted driving

Table 1
Description of driver sample.

	m	min	max	sd
Age (years)	43.8	25	66	10.1
Mileage last year (km)	37,373	10,000	90,000	19574.4
Driving experience (years)	25	6	45	10.0