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How do drivers interact with navigation systems in real life conditions? Results of a field-operational-test on navigation systems

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ABSTRACT

As part of the project euroFOT, the impact and usage of navigation systems was studied in a Field-Operational Test (FOT). The usage and handling of two HMI-solutions for navigation systems – one was nomadic and the other integrated – were investigated during daily drives. For $N = 99$ drivers, data was recorded whenever drivers used their vehicles during a three month period. During these three months, drivers used an integrated navigation system for a month and a nomadic device for a month. In the third month, they did not use a navigation system at all (baseline). Drivers preferred system handling in low demanding driving situations, like standstill or at very low speeds. If system handling occurred while the vehicle was moving, then an adaption of speed and following distance was observed. No increase of critical driving situations, like very close distances, could be found during system inputs. Results indicated that drivers were cautious when they interacted with the navigation systems. They adapted their system handling to the demands of driving and there is no indication that driving safety was jeopardized. These results help to gain a better understanding of how experimental results on driver distraction relate to unobserved driver behavior during daily drives.

1. Introduction

1.1. Background

Recently, Field-Operational-Tests (FOT) have been increasingly used to study the impact of various driver assistant systems on driving. According to the FOT-Net Wiki (FOT-Net consortium, 2011) "Field Operational Tests (FOT) are large-scale testing programmes aiming at a comprehensive assessment of the efficiency, quality, robustness and acceptance of ICT solutions used for smarter, safer and cleaner and more comfortable transport solutions, such as navigation and traffic information, advanced driver assistance – and cooperative system." In general, the aim of a FOT is to measure the acceptability to the user, to evaluate how the system is used in real-life conditions, and to project potential impacts on safety, mobility, and the environment for a specific assistant system (Najm, Stearns, Howarth, Koopmann, & Hitz, 2006).

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To do so, data are collected during daily drives of non-professional drivers. Data loggers are installed in series – and very often private – vehicles. Data logging starts automatically at the beginning of each drive. The aim is to collect data for every drive made with the vehicle during the period of the FOT. The advantages of FOTs compared to more standardized laboratory setups (e.g. test track, driving simulator) are that no experimenters are present during the drives and that the recorded drives reflect driver behavior in real-life conditions with real-life pressures. Accordingly, it is assumed that drivers are less influenced by the measurement conditions than in other study designs and that recorded data reflect ''naturalistic driving''. In an FOT, driving data are collected to show the usage of the assistance systems as well as the adaptation of driving to the tested functions in real-life driving conditions.

1.2. Impact of navigation systems

The navigation system is one of the most widely used driver assistant systems. The aim of navigation systems is to provide the driver with turn-by-turn route information. In turn, it can be assumed that navigation systems are useful and enhance route finding performance, especially on unfamiliar roads. Furthermore, most navigation systems offer a dynamic route guiding function. Based on TMC, up-to-date information regarding the current traffic situation is used by the system to guide drivers around traffic jams and to find the most time efficient route. In a field-test by Inman, Sanchez, Bernstein, and Porter (1996), a reduction of average planning time and reduced travel times was reported when integrated navigation systems were used. In this study, navigation systems did not affect travel distance, nor did they influence the likelihood of congestion during a trip.

Navigation systems are available with different solutions for the human–machine-interface (HMI). Some systems are fitted directly into the vehicle (normally by the car manufacturer) and consist of a display placed somewhere in the middle console plus input devices integrated in the overall HMI-concept. Others are nomadic devices that can be brought into the vehicle and usually attach to the windscreen. Recently, navigation apps for smartphones have also been made available.

1.3. Influence of distraction on driving performance

The main focus of experimental studies on navigation systems is on the potentially distracting effect of such systems. According to Young, Regan, and Hammer (2003), entering destination information is considered to be the most distracting task associated with the use of navigation systems. The handling of a navigation system normally requires manual input, but sometimes speech input is also possible. During system inputs, feedback about the state of the system is visually provided on the display. The main differences between the different HMI-solutions are the position and size of the screen used, as well as the position and the device used for inputs (e.g. touchscreen, buttons). Normally, the handling of a navigation system – like entering destinations – leads to visual–manual distraction which is known to interfere with driving performance (Wickens, 2002). In experiments, participants are normally instructed to solve the distracting task, e.g. entering a destination into a navigation system, in an experimentally-defined driving situation. Such tasks help investigate the impact of system handling on driving. Tsimhoni, Smith, and Green (2004) report degraded lane performance, a decrease in speed and an increase in following distance while entering destinations to a navigation system via a keyboard during driving. This is in line with results on other visual–manual distractions. Often a decrease in lateral performance is reported with a decrease in speed and an increase in following distance during visual–manual distraction (see Bayly, Young, & Regan, 2009, chap. 12 for a summary). The experimental results on the impact of visual–manual distraction are often interpreted as an attempt of the driver to compensate for the extra load by reducing speed and enhancing distance.

In qualitative surveys, drivers reported that they preferred to attend to distracting activities in driving situations that are less demanding (e.g. standstill, driving on highways) and tried to avoid being distracted in driving situations that were more demanding (e.g. Boyle & Vanderwolf, 2005; Kern, Schmidt, Pitz, & Bengler, 2007; Thulin & Gustafsson, 2004). This is partly supported by a study that Lerner, Singer, and Huey (2008) did in which drivers rated their willingness to engage in secondary tasks in different driving situations. As soon as the driving situation involved specific maneuvers, like turning left, drivers were less willing to engage in the demanding tasks of entering a destination into the navigation system. The influence of driving maneuvers was less pronounced for simple secondary tasks like telephoning. The influence of situational demands on the willingness to engage in distracting activities was confirmed by an experiment in the driving simulator by Schömig, Metz, and Krüger (2011) (see also Metz, Schömig, Krüger, & Bengler, 2010b). In this study, drivers solved more visual secondary tasks in less demanding driving situations than in more complex driving situations. Both the adaption of driving behavior and the avoidance of distraction in demanding driving situations can be understood as attempts of the driver to compensate for possible distracting effects (Young, Regan, & Lee, 2009).

More recently, the frequency and impact of distraction on driving has been studied using data collected in naturalistic driving studies (NDS, e.g. Dingus et al. 2006; Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006) and FOTs (e.g. Sayer, Devonshire, & Flannagan, 2005). In these studies, distraction was assessed via video coding. The most common approach was to randomly select video clips of a defined length (e.g. 5 s, Sayer et al., 2005) from all available data and to code driver state, distraction and other relevant situational variables in each video clip. Here, only data where video coding was available was used in the analysis. This is often a rather limited amount of data. For instance, Sayer et al. (2005) coded 1440 video sequences that lasted 5 s each (in total 2 h of driving time for 36 drivers). They then analyzed objective driving parameters