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Peripheral detection as a measure of driver distraction. A study of memory-based versus system-based navigation in a built-up area

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Abstract

The effect of in-vehicle information systems (IVIS) on traffic safety is currently under debate and suitable methods for measuring and comparing the impact of such devices on driver behaviour are urgently required. The secondary-task technique may be a good tool for objective measurement of driver distraction caused by IVIS.

The present study summarises previous results of secondary-task studies in traffic contexts and investigates the suitability of one secondary-task method, the peripheral detection task (PDT)-method, as a standard procedure for safety testing and evaluation of IVIS. The study was concerned with the effect of navigation messages on PDT-performance (reaction time and hit rate) taking into account also behavioural variables. Professional drivers served as subjects. They had extensive prior local-knowledge and experience of driving in the built-up area in which the experiment took place. They were required to drive two different routes, one after memory and the other in accordance with navigation messages a standard navigation system installed in the car. In the navigation system condition subjects were subdivided into three groups, receiving either verbal, visual or both visual and verbal (full) navigation messages.

Driving behaviour was virtually uninfluenced by navigation condition (memory versus navigation system) and message modality (full, visual or verbal) whereas PDT-performance, showed some effects of navigation condition on subjects' reaction times and hit rates. Pairwise comparison of message modality within each three groups showed a prolongation in reaction time and a marginally significant decrease in hit rate with full navigation messages (combined visual and verbal ones). Visual navigation messages affected only hit rate and no significant differences between navigation conditions were observed for the group presented with verbal messages. The pattern of results suggests that the PDT-method is biased toward

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visual sources of information from IVIS. As visual information processing is an important component in safe driving, the PDT-method is suitable as a predominant method in a test battery, but for unbiased measurement of distraction, methods less dependent on mode of presentation would be more appropriate.

Keywords: Driver distraction; In-vehicle information systems; Advanced driver support systems; Navigation systems; Secondary task; PDT; Capacity limitations

1. Introduction

New in-vehicle technologies such as navigation systems, vision enhancement systems and on-board Internet connections are presumed to increase in popularity and number in the not-so-far-away future vehicle. A subdivision has been made between advanced driver assistance systems (ADAS) with driving support functions and in-vehicle information systems (IVIS) that have other functions than those related to driving. Both car drivers and passengers may benefit from new technology, but some in-vehicle systems may not be suitable or appropriate for use in moving vehicles in the current road transport system. It is generally acknowledged that IVIS can cause distraction by diverting the driver's attention from the driving task. In fact, even some driver assistance systems may occasionally call for attention. However, being an integrated part of the driving task, their impact is usually not classified as distraction but as cognitive load. Regardless of type, IVIS and ADAS require drivers to sometimes divide their attention between in-vehicle information and information in the driving environment. The impact of these devices on attention may depend both on the design and on the function of such devices. Therefore it is possible that minor physical differences between devices with the same general functions affect driver attention, and methods sensitive for such differences would produce valuable information for safer IVIS design useful to authorities, users and producers of ADAS and IVIS.

The secondary-task method is a frequently used tool for the measurement of human capacity limitation. Although the theoretical status of dual-task and secondary-task methods has been under debate, many secondary tasks have been used (see Ogden, Levine, & Eisner, 1979; Wierwille & Gutman, 1978; Wierwille, Rahimi, & Casali, 1985) in the attempt to objectively measure cognitive load or "spare capacity" in applied contexts including driving in real traffic. The present paper outlines two main lines of research with secondary-task methods particularly in traffic-related contexts. Moreover, the sensitivity of the recently developed peripheral detection task (PDT)-method to the presence and to the modality of navigation messages during driving in a built-up area is tested.

1.1. Factors affecting processing efficiency under dual-task conditions: Automaticity, multiple resources and task priority

Time-sharing between concurrent tasks or components of a complex task is usually associated with a cost of concurrence assumed to reflect the limited capacity of the human information system (Broadbent, 1958; see also Broadbent, 1982). Exceptions are the concurrent performance of very easy tasks i.e. tasks with a small demand on processing resources or tasks that can be