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Workload of younger and elderly drivers in different infrastructural situations

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ABSTRACT

Based on the goal of forwarding an individualized navigation system for driving, the present work focuses on the examination of the workload of drivers of different age groups. The elderly drivers were 67–72 years old ($N = 8$, $m = 68.8$ years, sd = 1.6), the "younger drivers" 27–31 years ($N = 8$, $m = 29.0$, sd = 1.7). It was investigated whether in difficult situations the workload of elderly drivers is higher than the workload of younger drivers. The study was conducted in real, right-hand traffic using a test vehicle of the German Aerospace Center. The participants drove on a predefined track through the city of Braunschweig, Germany. Workload was assessed using multiple measures. Before, during and after the test drive, the participants rated the subjectively perceived effort. During the test drive, physiological data and driving speed were recorded. Results show that compared to younger drivers, elderly drivers reported less effort in most questionnaires. Four types of routing that are especially difficult for elderly drivers were identified on the basis of a cardiovascular measure (the inter-beat-interval). These were (a) two left-turn lanes at an intersection, (b) turning right when pedestrians, cyclists and cars were signaled "go" simultaneously, (c) driving through a complex intersection and (d) turning left without traffic signs. Probably caused by age-related deficits, the workload of elderly drivers was higher in these situations. With an individualized navigation, these situations could be avoided. As velocity was affected mainly by external conditions such as traffic light phases, this measure was not used as an indicator of workload.

1. Introduction

As the population of Germany is growing older, the proportion of elderly drivers is increasing, as well (Korner-Bitensky, Kua, von Zweck, & Van Benthem, 2009; Robertson & Vanlaar, 2008). Compared to 1960 the proportion of people older than 60 years was about 10% higher in 2010 and will increase by about 10% until 2060 (Bundeszentrale für politische Bildung, 2012, cp. Fig. 1).

Since 1955, the number of vehicles in Germany is continuously increasing; however, the road network has not expanded (Bundesministerium für Verkehr Bau- und Wohnungswesen, 2003). Especially the traffic volume on motorways has risen to such a large extent that crowded streets and traffic jams occur frequently. In the event of a traffic jam, navigation systems

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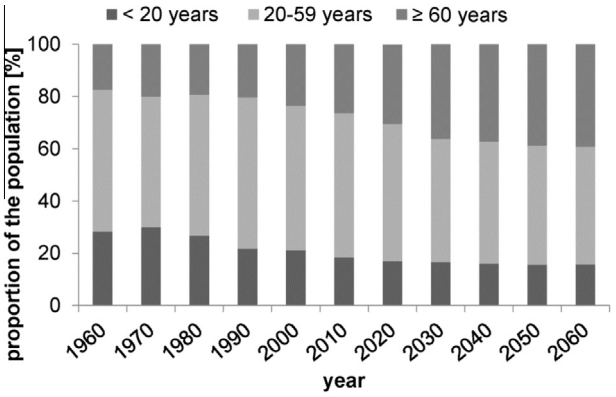

Fig. 1. Proportion of age groups of the German population (Bundeszentrale für politische Bildung, 2012).

can redirect the driver to an alternative route. However, since the first navigation systems for route planning have been developed, the basic algorithms have remained largely unchanged, thus traffic jams on alternative routes occur frequently as many drivers get the same suggestion (Ehrenpfordt & Rataj, 2005a).

Driver workload increases on crowded streets which specifically affects elderly drivers, e.g. by a higher attentional demand (Baldwin & Coyne, 2003). Furthermore, the geometry of the street and individual characteristics have an influence on the level of stimulation (Kantowitz & Simsek, 2001).Different types of drivers can be identified who are exposed to different stress levels in different traffic situations caused by individual strengths, weaknesses, preferences and aversions. In order to propose drivers routes that accord to the drivers' preferences, decrease traffic density and, thus, driver workload, Ehrenpfordt, Kullack, and Eggert (2008) developed an individualized navigation approach. A route from A to B can be calculated differently, meaning that different kinds of routes are proposed. For example, one route may lead the driver onto the motorway; another may lead him onto rural roads. With an individualized navigation system, the possibility exists to calculate a route which is optimal for an individual driver concerning the level of stimulation. That way, specific infrastructural conditions can be avoided or aimed for in order to make driving more comfortable and safe. Consequently, the traffic is distributed more evenly as different groups of drivers are recommended different types of routing. This leads to a reduction in traffic density which, in turn, can decrease the workload of all drivers.

The present study focuses on one group of drivers – the elderly. There is a special need for assistance systems in this group as elderly drivers want to maintain their mobility in spite of age-correlated deficits (Engeln, 2003). Especially elderly drivers can profit from an individualized navigation system as they already tend to avoid several traffic situations themselves (Ellinghaus, Schlag, & Steinbrecher, 1990). This behavior can be supported by the navigation system, especially in unfamiliar regions. As stressful situations are avoided, the occurrence of dangerous situations that cannot be dealt with is reduced and correspondingly the probability of a crash (Ehrenpfordt & Rataj, 2005b). When the driver even before starting a trip knows that specific situations will be avoided he might be more self-confident. Tränkle and Metker (1992) point to the conclusion that many difficulties of the elderly could be avoided if the drivers were assisted by navigation and guidance systems. Thus, elderly drivers can drive longer, enhancing their quality of life (Engeln, 2003).

In the light of the demographic development and the need for mobility of the older generation (Engeln, 2003), the group of elderly drivers ought to be examined more closely. Because of age-related deficits, driving could be more strenuous for older drivers than for younger drivers. For example, a simulator study by Cantin, Lavallière, Simoneau, and Teasdale (2009) showed that the workload of elderly drivers is especially high in complex situations. Whether elderly drivers are exposed to higher stress levels in difficult traffic situations than younger drivers needs to be investigated in a naturalistic driving study. Given an identification of situations which are especially difficult for elderly drivers, an individual navigation system could avoid these situations. Beforehand, the situations to be processed by the navigation system have to be defined in terms of specific infrastructural conditions. Although situations as "the following car tailgates" might be highly strenuous, they cannot be considered by the navigation system. If the situations are defined according to the infrastructural road conditions, the studied situations are a sample of all traffic situations of the same infrastructural conditions. In the following, the term 'situation' is thus used according to this definition. The present study aims at finding out which such situations are especially difficult and strenuous for elderly drivers.

2. Theoretical background

2.1. Definitions of "age" and theories of aging

Speaking of someone as being "old" requires a definition of this term. There is no general binding definition of "old age" in the academic literature but there are several attempts of a classification that involve different aspects and differ in the level