Longer-term effects of ADAS use on driving performance of healthy older drivers and drivers diagnosed with Parkinson’s disease
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Chapter 1

INTRODUCTION
As demographic studies revealed, the population is becoming older due to increasing life expectancy. The number of persons aged 65 and above will increase rapidly over the next few decades and, in particular, ‘older old’ persons over 75 (Demography Report, 2011). Driving is probably going to be a more preferred and a more frequently used mode of transportation for future older persons than it is for the present ones. We see, for example, an increasing proportion of this population possessing driver licenses, especially women, than previous generations. Therefore, the number of older persons holding a valid driver’s license and being active drivers will probably rise substantially (OECD, 2001). Because of age-related visual, cognitive, and motor impairments, older drivers have a higher risk of being involved in a crash. Due to their increased physical vulnerability, those crashes lead to severe injuries which may prove fatal (Evans, 2004; Hewson, 2006). But also, through driving, older persons can maintain a high sense of independence enabling them to participate in various activities ranging from shopping for groceries to attending social events (Houser, 2005). Refraining from driving or having a driver’s license revoked may lead to faster aging, depression, and solitude (Carp, 1988; Kaplan, 1995). Restricting and compensating are not the most favorable solutions to the problem because driving contributes to independent living and subjective well-being (Fonda et al., 2001; Marottoli, et al., 2000), particularly, if accessible public transport is not available.

Even though road traffic fatalities have decreased substantially over the last decades due to the implementation of road traffic safety strategies and policies throughout Europe and other industrialized countries (IRTAD, 2011), older people need special attention within the road traffic network because of their unique characteristics and needs. Especially for older drivers, it is important to not only prevent crashes from occurring, but also to minimize the negative effects of crashes. For example, an 80 year old female driver is seven times more likely to be killed compared with a 45 year old female driver when experiencing the same severity of the crash due to the increased fragility with increasing age (Evans, 2004). Because of their physical vulnerability, extensive measures for bodily protection would be required. Bodily protection in form of crash zones and airbags is provided to drivers and passengers in the event of a crash, but they do not fully compensate for the vulnerability of older persons.

In addition, older drivers experience declines in visual, cognitive, and motor functions as a result of aging (Davidse, 2007). The most critical impairments which are crucial for
road traffic safety are divided/selective attention and decision making under time pressure (Brouwer & Ponds, 1994). Limitations in these two domains are manifested in the driving tasks, both on the tactical level (i.e. speed control, headway control, lane position) and the operational level (e.g. lateral position control and e reactions to unexpected changes in the road and traffic situation).

Nonetheless, older drivers may profit from a tremendous amount of driving experience that may have prepared them for a wide range of road and traffic situations. However, situations do not always develop as expected and predictive cues are not always interpreted correctly or more important timely. Therefore, based on their specific crash profile and unique characteristics, older drivers might be helped by the provision of relevant traffic information in advance reducing the time pressure and divided attention requirements. In this thesis an Advanced Driver Assistant System (ADAS) providing information about traffic and speed limit signs, speeding, and following distance has been proposed and tested in a longer-term driving simulator study with a group of healthy older drivers, drivers diagnosed with Parkinson’s disease (PD), and young inexperienced drivers. Changes in driving performance and in subjective ratings in response to ADAS use are investigated with respect to effects of short-term and longer-term practice, but also with respect to ADAS removal after completing several consecutive sessions with ADAS.

In Chapter 2, the concept “road traffic safety” is explained. It is also described what has been done in the past to improve road traffic safety and what will be the focus of research in the future. In addition, the chapter provides a brief overview of the demographic change in age structure, struggles of older drivers in traffic and why it is important to allocate resources to the investigation of older drivers and road traffic safety.

In Chapter 3, different ADAS functions, which have been proposed as suitable for older drivers, are explained in more detail and results of a literature review on these functions are summarized and critically reviewed as studies presented in this chapter have a few drawbacks and shortcomings. In addition, the experimental setup used to investigate longer-term effects of ADAS use on performance is briefly explained as well as the functioning of the proposed and implemented ADAS.

Chapter 4 contains an experiment designed to test the effects of an intersection assistant on crossing performance of 18 healthy older drivers in a driving simulator. Intersection
time, maximum speed on intersections, number of stops before crossing an intersection, and time-to-collision served as performance measures used to assess performance and changes of performance over a period of several sessions. Gaze behavior was also used to gain some insight in attention allocation. Drivers were randomly assigned to either a control (driving without assistance) or treatment group (driving with assistance). Differences between a control group and a treatment group were compared as well as changes over time within groups analyzed.

In Chapter 5, older drivers are compared with 18 inexperienced young drivers. Driving performance data were again collected over several sessions. Young drivers were also randomly assigned to a control and a treatment group. The aim of the second experiment was to test whether support given to older drivers might be helpful for young drivers as well. In addition to intersection performance, young and older drivers’ performance with regard to speed and headway control was analyzed in response to ADAS use.

As neurodegenerative diseases are not uncommon when getting older, a group of drivers diagnosed with Parkinson’s disease (PD) was recruited for the third experiment. In Chapter 6 results of the intersection assistant as well as subjective measures such as trust in and acceptance of gap advice, and perceived workload are reported. Nine drivers diagnosed with PD completed the experiment with the assistant system. Results were compared with healthy older drivers of the treatment group. Changes in performance and perception as a result of short- and longer-term practice were analyzed, but also the effects of ADAS removal after having completed several sessions with ADAS.

Chapter 7 contains additional results of the third study. The implemented ADAS was also intended to support drivers with speed and headway control. Effects as a response to ADAS use were examined for short-term and longer-term practice but also for ADAS removal. Speed and headway data of drivers diagnosed with PD and healthy older drivers, who received the same treatment, were extracted and analyzed.

In Chapter 8, the result of the four empirical studies presented in Chapters 4 through 7 are summarized and discussed. The significance of the findings with respect to road traffic safety, particularly for older drivers diagnosed with PD, will be outlined.

Because Chapters 4 through 7 are based on previously published journal articles, some overlap between those chapters can be found. In addition, the content of these chapters
may also overlap with content of Chapters 2, 3, and the discussion in Chapter 8. However, this overlap has been attempted to keep to a minimum while providing a comprehensive overview of the issue.