

the negative effect due to the extra workload. Finally, the acceptance and the perceived usefulness of assistive automotive technologies should also be considered, because the success of technologies critically depend on the broad acceptance and positive attitudes towards new technologies, especially in the older group.

The study's *aims* were twofold: (1) One aim was directed to the design of In Vehicle Information Systems, which may support older drivers in cognitive demanding traffic tasks. As intersections are known to be typical high-risk traffic situation, an intersection assistant was developed. The assistant informs drivers timely about the current traffic situation, which is to be expected in the upcoming intersection and also recalls the traffic rule, which has to be applied at the respective intersection. (2) The second aim of the study was the evaluation of the utility of the system for older drivers in terms of performance and acceptance.

2 Method

2.1 Variables

Two independent variables were under study. One is users' age, comparing younger (20-36 years) and older drivers (50-77 years). The second variable was the size of the displayed information on the IVIS interface, which was presented on a small display in the midconsole of a simulated car. Size variations were 185x186 pixels (5.5 x 5.5 cm; small display) vs. 370 x 372 pixels (11.2 x 11.2 cm; large display). Beyond the two conditions with IVIS support, there was a control group with no assistance. As performance measures, driving speed (km/h) and accuracy of lane tracking (radian, rad¹) were examined. Furthermore, participants rated the usefulness of the interface they were assisted by (1= very good, 6 = very inadequate).

2.2 Driving simulator, intersection assistant and driving task

Driving simulator. The driving simulator was composed of a truncated BMW car with an automatic gear shifting, placed in front of a projection screen. The car functioning concerning steering, accelerator and brake pedal was simulated (no tactile feedback). The screen had a 7,30 x 2,80 m size. Display resolution was 2048 x 768. The graphics were projected by two video projectors. The simulated environment was created with Pelops[®], a software developed at RWTH Aachen University. It allows to record online all interactions between driver, vehicle and traffic and to analyze driving parameters in a detailed manner.

IVIS Display. The visual display of the intersection assistant was presented on a 17-inch flat screen with 800 x 600 resolution in the midconsole of the simulator car. The interface design was developed in a pre-study. Older and younger participants were asked to graphically

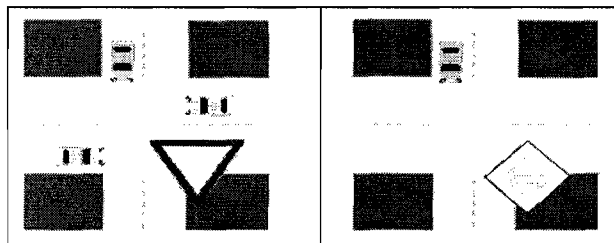


Figure 1: Visual interface of two intersection types

create the interface design without using text information (sign-production method). They were instructed that the intersection assistant would inform about the traffic rule and volume in the upcoming intersection. According to their proposals, the interface was finally developed (Figure 1). The created interfaces were very similar across participants, showing that there are interfaces feasible, which meet the mental interface model of a broad user group.

¹ Radian is a unit of angular measure equal to the angle subtended at the center of a circle by an arc equal in length to the radius of the circle. Example: A rad of 0,05 equals a steering angle accuracy of 2.9 deg.

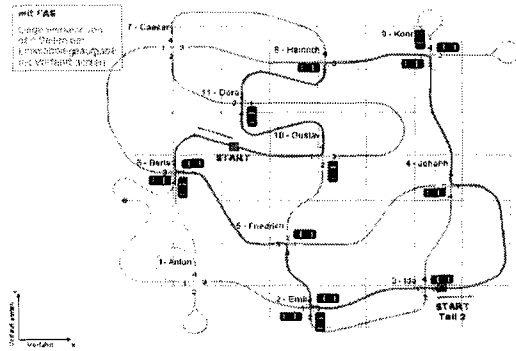


Figure 2: Schematic route

Task: An urban environment (speed limit of 50 km/h) was chosen as driving environment. The route included nine intersections with different volume of traffic and priority rule (Figure 2). Familiarizing participants with the simulated driving environment, a training route was to be completed. Participants were instructed to drive as natural as possible and to drive the car as accurate as possible and to keep the speed limit.

2.3 Participants

48 participants with valid drivers' licenses took part in the study. They had answered to announcements published in the local newspaper. All participants had (corrected to) normal visual acuity. For the younger group, 24 students, 13 males and 11 females (M = 26.7 years) volunteered. In the older adult group, another 24 drivers, 17 men and 7 women (M = 62.3 years) took part. The motivation to join the study was high; especially males were extremely attracted by the announcements. All participants were surveyed respecting their driving experience. Further, their verbal memory capacity, information processing speed and spatial ability were psychometrically assessed.

3 Results

Data were analysed by MANOVAs assessing effects of the size of the displayed information and users' age on driving performance in terms of speed (km/h) and lane tracking accuracy (rad). The significance level was set at $p < 0,1$.

Size of the IVIS display: A first analysis was concerned with the question, if the bigger sized display led to a better driving performance compared to the smaller display and compared to the control group (having no IVIS). In order to consider route characteristics, intersection areas are differentiated from parts of the route without intersections. Generally, participants drove faster and more accurate in the routes without intersections (speed: 41.5 km/h; accuracy: 0.009 rad) compared to the intersection areas (speed: 24.5 km/h; accuracy: 0.05 rad). However, the driving speed in the simulation was generally lower than the speed limit of 50 km/h. For the *intersection areas*, a significant difference ($F(1,41)=2.4;p=0.061$) between conditions was found: Participants, who were supported by the IVIS, drove significantly slower and more accurate compared to the control group (Figure 3).

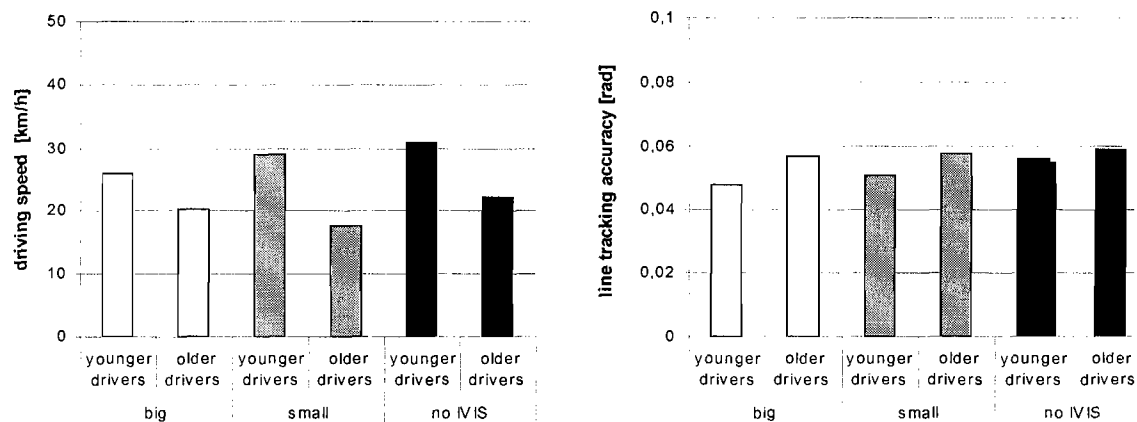


Figure 3: Driving performance for intersection areas in the three experimental conditions and age groups (left: driving speed; right: driving accuracy)

From the two display sizes, it was the bigger size of the displayed information, which led to a more careful and accurate driving style (large: speed: 23.3 km/h; accuracy: 0.052 rad; small: speed: 23.6 km/h; accuracy: 0.054 rad) and the control group (speed: 26.4 km/h; accuracy: 0.06 rad). However, there was no effect of assistance for the *route without intersections*: No performance difference occurred between the two IVIS conditions (large: speed: 40.9 km/h; accuracy: 0.009 rad; small: speed: 40.5 km/h; accuracy: 0.009 rad) and the control group (speed: 41.9 km/h; accuracy: 0.009 rad).

Users' age: Moreover, there was a significant age effect ($F(1,41)=12.7$; $p=0.000$). The older drivers were significantly slower in both, *the intersection areas* (young: speed: 28.6 km/h; accuracy: 0.06 rad; old: speed: 20.6 km/h; accuracy: 0.06) as well as in the *routes without intersections* (young: speed: 45.6 km/h; accuracy: 0.009 rad; old: speed: 36.9 km/h; accuracy: 0.009), however, equally accurate than the younger drivers.

Gender: Also, a significant ($F(1, 35)=6.9$; $p= 0.003$) was revealed. Women -independently of their age- drove more slowly in both, *the intersection areas* (males: speed: 42.4 km/h; accuracy: 0.009 rad; females: speed: 39.4 km/h; accuracy: 0.009) as well as in *routes without intersections* (males: speed: 26.6 km/h; accuracy: 0.05 rad; females: speed: 21.4 km/h; accuracy: 0.05). This is visualized in Figure 4.

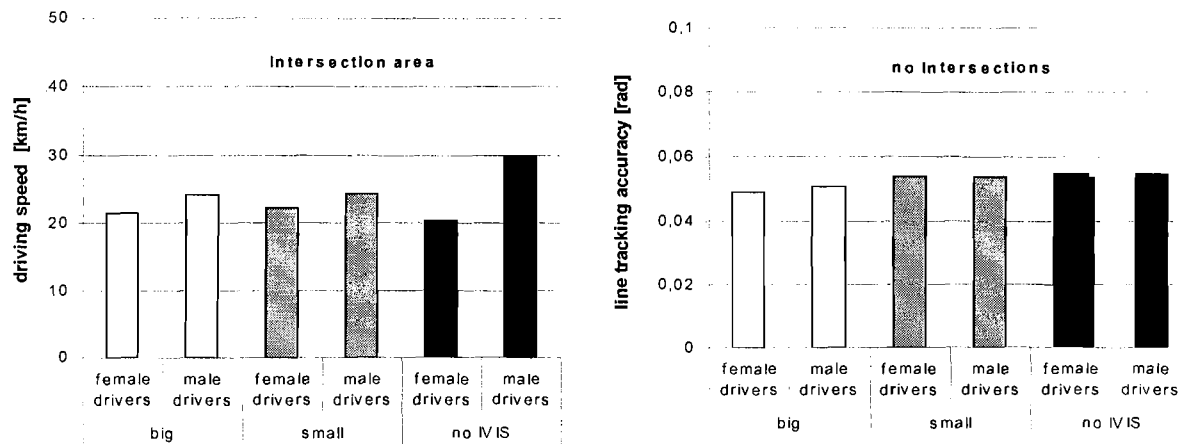


Figure 4: Driving performance in the three experimental conditions and gender groups (left: driving speed; right: driving accuracy)

Next, user ratings respecting the usefulness of the IVIS assistant are addressed. For the evaluation of the utility of the IVIS, a scale with 6 graduations (1: best, 6: worst) was provided. Outcomes are visualized in Figure 5. As can be seen there, overall, participants rated the usefulness of the IVIS system as “medium”, independently of users' age and gender. However, there is a clear age bias towards the bigger sized information in the IVIS. Older drivers rated the small sized display as rather low ($M = 4$), and clearly preferred the big sized display ($M = 2.3$). Younger adults had no preferences, but rather judged both display sizes as equally (Figure 5, left).

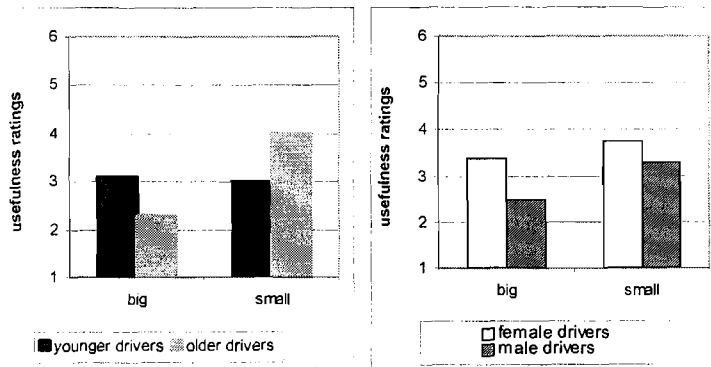


Figure 5: Ratings for the usefulness of the IVIS; best=1; worst=6

When looking on gender effects (Figure 5, right), male drivers preferred also the bigger sized display, while female drivers had no explicit preferences.

4 Discussion and Future Research

The key finding of the present research is that – indeed- there are technical developments in automotive technology, which have the potential to support older people while driving. Visual interfaces, which inform drivers timely about the traffic in upcoming intersections, can sufficiently support the driver and may lead to a careful driving behaviour. However, the visual interface of the IVIS has to be developed carefully. It should not contain too many details, but provide the most essential information clearly, and should meet participants' cognitive expectations of how interfaces should be alike. As participants developed the interface according to their mental models, this was guaranteed in the present research. Furthermore, the size of the displayed information should be also large enough. Though, some cautionary notes are concerned with the suitability of driving simulations as research setting. They often provoked the feeling of “artificial” driving and led to simulation sickness, especially in the older group. This might have been the reason for the comparably moderate judgements respecting the usefulness of the assistant in both age groups. Another possible source of the reluctant ratings may be older adults' disliking of being assisted. In post-experimental interviews, some of the older adults accentuated that they wanted to drive “on their own”, “without the need of getting help by a technical system”. However, the older drivers, who volunteered to take part in this study, may not be representative for the whole group of older adults. Older participants here were mentally fit, highly interested in automotive technology and extremely keen to get to know recent technical developments. Also, they had a high driving experience; therefore, they might be more self-confident even in high-risk traffic situations as intersections. Future studies should pursue in this line of research and should further examine how older adults can be supported by technology in complex traffic situations. Here, it would be insightful to learn if other IVIS modalities rather than the visual interface would be also beneficial for driving performance. At the moment we are examining the usefulness of auditory interfaces of the IVIS system. Moreover, further technical IVIS systems could be tested. As such, to back the car into a parking space or the overtaking processes on expressways are also highly demanding driving tasks, especially for older adults. Finally, more typically older adults should be examined.

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