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HUMAN VEHICLE INTERACTION FOR ELDERLY DRIVERS: THE MYTH AND THE CHALLENGE

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Abstract: This paper analyses the actual problems of elderly drivers in coping with certain driving tasks (i.e. changing lanes, merging or leaving from a parking position) from a structured state of the art and accident analysis and their impacts to the relevant design of telematic and other vehicle aids HMI. This work is part of AGILE project, co-funded by the Quality of Life programme of the European Commission, which aims at developing a better driving ability assessment and support framework for elderly drivers. *Copyright © 2002 IFAC*

Keywords: End users, Drivers, Evaluation, Information systems, Human Machine interface.

1. INTRODUCTION

In western society the older population is increasing both in absolute and relative terms (Transportation Research Board, 1988). These demographic trends alone will lead to a greater participation of older persons in traffic. In addition, future cohorts of older people will be different traffic participants from today's : in many European countries and in Japan (Hakamies-Blomqvist, 1996; Shimizu, 1992), mass motorization only developed in the 1960s. Generally, each family has had a car, usually driven by the man alone. Also, because of the generally smaller distances and the availability of alternative means of transportation, the car was not as necessary as it was in America or Australia. Therefore, many older Europeans and Japanese, particularly women, do not yet possess a driving license. For example, in the Netherlands 65% of older men, and only 21% of women aged 65 years and older, held a driving license in 1990 (Centraal Bureau voor de statistiek, 1992). The trend is that numbers of older drivers will become much greater (Finland reported a percentage growth of 89% for male elderly drivers and 269,3% for female elderly drivers between the years 1970 and 1990) with numbers more evenly distributed between the sexes. The mean number of elderly drivers on European roads can therefore be approximated to around 12% of all drivers today and around 20% by year 2010.

AGILE project (QLRT-2001-00118), co-funded by the Quality of Life programme of the European Commission, aims to develop a new set of training, information, counselling and driving ability assessment and support tools for the elderly, evaluating their full range of physical, cognitive, behavioural and interactional abilities and not just checking a few sensory and motor functions (as is currently the case). More specifically, the objectives of AGILE project are:

- To establish a clear identification of elderly problems in relation to various driving tasks and an aetiological classification of their traffic accidents.
- To select a proper set of elderly driving ability assessment criteria (using both neuropsychological, physiological and behavioural parameters) and quantifiable thresholds for them.

- To develop a low-cost pre-screening tool for rapid assessment of elderly drivers by themselves, their family doctors or other health care professionals either in interviews or even by mail.
- To develop an elderly drivers' assessment parameters database to be used as a knowledge repository and expertise basis for relevant assessment tools and decisions.
- To develop an integrated driving assessment system for the elderly, including all necessary assessment tools, such as a neuropsychological test battery, driving simulator scenarios and an on-road test, to be used in a modular way for elderly that seem to have particular difficulties in driving.
- To develop a reference test drive scheme to validate the reliability of the above tools.
- To develop a reliable and efficient decision and consultation expert tool, to assist the elderly driver evaluator to reach a decision and provide help to the elderly, by combining the outcome of various assessment tools.
- To develop a standardised pan-European elderly drivers assessment procedure.
- To develop quantifiable and precise, inclusive and permissive design guidelines for elderly compatible car design and the development of new, more appropriate driving aids for them.
- To develop appropriate training and consultation courses to help the elderly overcome their driving problems.

It should be emphasised that the assessment methods targeted are not meant to present a new barrier for elderly drivers. Instead, they should simplify the assessment process for most of them and help the rest to find appropriate methods and aids to allow them to remain safe drivers.

Of course, ultimately such an approach would still reasonably and fairly exclude from driving those elderly people that pose a risk to traffic safety and to themselves, while keeping their number to a minimum. For those excluded, it should offer support and access to alternative mobility policies (e.g. public transport passes).

To realise such a challenging task and achieve the targeted goals, a multi-disciplinary team of 13 Participants, representing 7 European countries, has been formulated. It includes participants with strong bioengineering/ clinical research that develop assessment methods and tools (AMAP, IFADO, COAT), elderly and disabled drivers' assessment centres (CARA, AV/GOCA, NIRH), Transport Research Institutes that specialise in E&D issues (HIT, IAT, VTI), a car manufacturer (CRFiat), assessment tools developers (PSYTEST, FOERST) and the European Federation of driving instructors (EFA).

2. TRAFFIC SAFETY AND EFFICIENCY OF ELDERLY DRIVERS

Older drivers as a group do not have higher accident frequencies than other groups, when the statistics are corrected for yearly mileage. In contrast, they have a much higher risk of injury or fatality in traffic. Indeed, statistics from the US show that older people made up 9% of the population but accounted for 13% of all traffic fatalities (U.S. Department of Transportation, 1996). This risk is, of course, higher in the less protected traffic modes. Driving a car is not only the most convenient but also the safest mode of travel for those older drivers who have intact driving ability.

However, ageing affects some capabilities that are important for driving. Both decrease in certain functions and increase in caution and wiseness show in older drivers' accident statistics. The most difficult situations are those demanding rapid processing of large amounts of simultaneously presented data. Thus, older drivers are over-represented in specific categories of traffic accidents, arising from actions such as failure to yield the right of way, turning improperly, ignoring stop signs and red lights and starting up improperly into traffic (Finesilver, 1969; Sttuts, and Mortell, 1992). Also when involved in an accident they are more usually than not at fault, as the following figures display (Hakamies – Blomqvist, 1994).

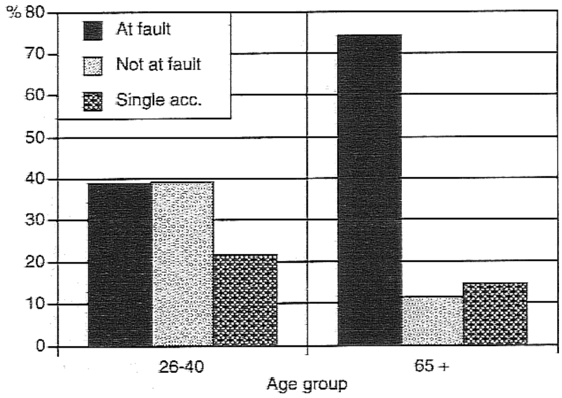

Fig. 1. Proportions of single-vehicle-accident drivers, drivers at fault in a collision and drivers not at fault in a collision by age group in Finland in the year 1984-1989, N=769.

Older drivers have no particular problem with automatic processes, which place limited demands on their attentional capacity and generally occur under highly predictable conditions of traffic and weather. Non-automatic processes, in use with unpredictable or unfamiliar demands such as turning, merging, collision avoidance or driving in adverse weather, are more challenging for older drivers. Therefore, elderly drivers are specifically over-represented in intersection accidents, such as turning left across a lane of traffic (turn right in left-driving countries), failing to yield the right-of-way and/or overlooking traffic signals (Garber, and Srinivasan, 1991; Viano, *et al*., 1990) and being hit at high speed by a vehicle coming from the drivers side. This trend is also represented in Figure 2.

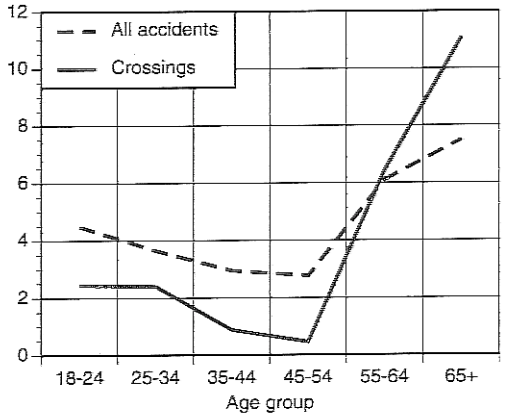

Fig. 2. Number of fatal accidents per 1000 accidents by age group for all accident categories at crossings for drivers legally at fault in Finland in the year 1990, N=41,617.

Other cognitive and behavioural problems related to elderly drivers that are reported in the literature include:

- stopping on green lights;
- making sudden stops without apparent reason;
- coasting to near stop in moving traffic;
- delay in changing lanes when an obstacle appeared;
- drifting into other lanes;
- misinterpretation of traffic signs;
- requirement of repeated step by step directions.

These types of error behaviours have mainly been associated with decline in sensory, perceptual and visuo-spatial functions as well as in attentional and executive functions (Johansson, 1997).

The elderly also tend to be overly involved in accidents resulting from changing lanes, merging or leaving from a parking position. The situation seems to be exacerbated when the driver reaches the age of 75 (Brainin, 1980).

On the other hand, demented patients have been found to have 4,7 more times more chance of having a car accident than the rest of the population (Withaar, 1997). Also, a three-fold increased accident risk was found for persons over 60 suffering from cardiovascular diseases (Waller, 1967). Elderly drivers with diabetes were found to have a 2,6-fold increase in risk of a traffic accident; the risk increasing to 5,8 in insulin-treated diabetes (Koepsell, *et al.*, 1994). It has been calculated (Sjoergen, 1994) than in 1 out of 5 fatal crashes in the elderly, medical impairment - such as that caused by cardiovascular disease, diabetes or epilepsy - was probably an underlying cause. Still, current assessment tools do not allow the detection of people suffering from early dementia or silent stroke, thus leading to enhanced traffic risk for particular elderly drivers.

3. DEFINITION, CLASSIFICATION AND DRIVING COMPETENCE OF ELDERLY DRIVERS

Data in the literature suggest that decline in performance begins in the late 50's, and visual changes usually begin much earlier. 'Older' is probably most often defined as over 65, although some studies classify drivers in their late 40's or early 50's in this category. However, the 65-and-older category can be misleading. Because the curve showing increased crash risk is accelerating, it can be argued that drivers in their 60's are, as a group, qualitatively different from those in their 70's and certainly different from those in their 80's.

Consequently, some investigations have attempted to classify drivers into several older groups such as young-old (55-64), middle-old (65-74), old-old (75-84) and very-old (85 and older).

Such classifications can be useful as reminders of the differences among the various groups, but it is important to remember that individuals may or may not adhere to the group norms.

Many models have been constructed to explain the problems of elderly drivers (Brouwer, and Ponds , 1994; Hakamies – Blomqvist, 1994; NHTSA, 1989). The ageing process involves biological changes, which can have longer-term implications. As most of the information to be processed during driving a car is visual, it is important to know to what extent the different functions of the visual system change with age: the visuo-sensory function, the visuo-perceptual function and the visuo-spatial function.

The relevant problems may come from any of the domains below:

- Sensory and motor functions deteriorate with age. Static and dynamic visual sensitivity show an age-related decline, with the greatest effect on dynamic sensitivity. Although dynamic acuity is rarely considered in studies concerning ageing and driving, it has been found to be a better predictor of safe driving.
  Therefore, in case of an emergency, the reaction time to external stimuli (e.g. seeing the other car, moving foot from gas to break pedal) is higher. The average person in his/her 80s has a reaction time in response to light that is 7,6% slower than that of the average teenager. The response to sound is 9,2% slower for the aged and 11% for brake reaction time (Kent, and Novonty, 1961). Furthermore, a young driver can lift the foot from the gas and apply brake pressure a quarter- or a half-second faster than an older individual (Wellford, 1977).
- High order visual and cognitive impairments are also related to age. They are much more difficult to recognise and evaluate. They include, among others, deficits in visual perception, visual search and analysis, selective attention, divided attention and flexibility of attention. The elderly also seem

to exhibit poorer performance in synchronised tasks.
- Decline in psychomotor performance, information uptake speed and reaction time.
- Decision making impairments.
- Specific ageing-related cognitive and perceptual disabilities (such as Alzheimer's disease and cerebrovascular diseases, diabetes, renal disease) and multiple small cerebral infracts ('silent strokes').
- Confused messages to other driver cohorts.
  For example, elderly drivers often approach intersections slowly and decelerate almost to a halt before merging. This is most naturally interpreted by other drivers approaching on the main road as signalling an intention to stop and to respect right-of-way. Thus, they are completely unprepared to start avoidance manoeuvres when the elderly driver's vehicle nevertheless suddenly accelerates into the intersection area.

4. TOWARDS THE DESIGN OF APPROPRIATE TELEMATIC AIDS TO SUPPORT ELDERLY DRIVERS

Telematic researchers and industrial producers of these technologies have for too long assumed that E&D drivers will simply accept at face value, the products and technologies that are developed for them. However, a series of tests of Advanced Driver Assistance Systems (ADAS) using elderly drivers, conducted in EDDIT and TELSCAN EU-sponsored projects proved that the HMI but even the design aspects of these aids would make their use difficult, if not dangerous, for the elderly driver. Based on the problems and needs of elderly drivers, various specific ADAS have been conceptually designed for them.

4.1 T-junction aid

When a vehicle stops at a T-junction, it is difficult for the Elderly driver to see if there are other vehicles coming from the crossing lane. These situations are strongly felt in an urban traffic scenario. Previous tests have shown that the best technical approach to solve the problem is to detect the presence of crossing vehicles with the aid of an "eye" placed in the frontal part of the vehicle. A processing unit will give the driver a warning if a crossing vehicle is coming when it is 25-30 m. away from the T-junction.

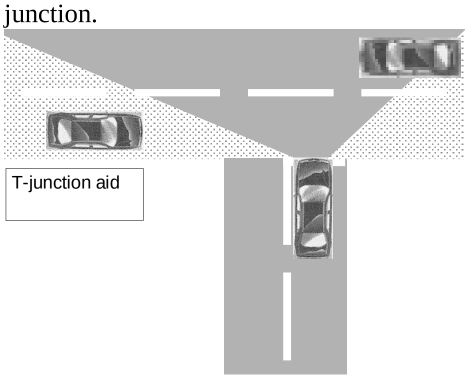

Fig. 3. Representation of T-junction aid functionality

4.2 Lane warning aid

Highway and extraurban roads are the typical environments where such a system is useful: Using a CCD camera and a processing device, observing the road in front of the vehicle, the system detects car position in the lane and warns the driver when lane markings are being crossed. When the car is near the lane border, an acoustic signal warns the driver of a potential dangerous situation. A larger effort is necessary to choose the right HMI approach for Elderly drivers, which is the key point for system acceptability.

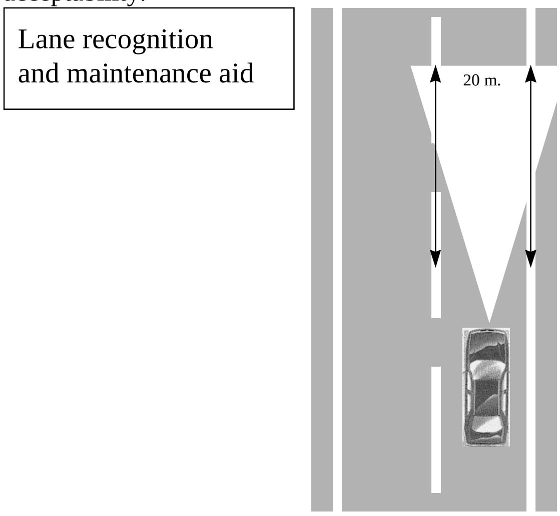

Fig.4. Lane warning aid functionality

4.3 Blind spot avoidance aid

Many elderly related road accidents are caused by lane changing manoeuvres while overtaking is in progress. This kind of situations can be detected by a dedicated sensor system able to produce a suitable warning information to the driver. The presence of "blind spots", areas in the lateral and backside zone not perceivable by the driver through the lateral mirrors, makes a device to detect the presence of overtaking vehicles being useful for car drivers, especially for those drivers, like elderly, whose level of attention decreases dangerously when driving time increases.

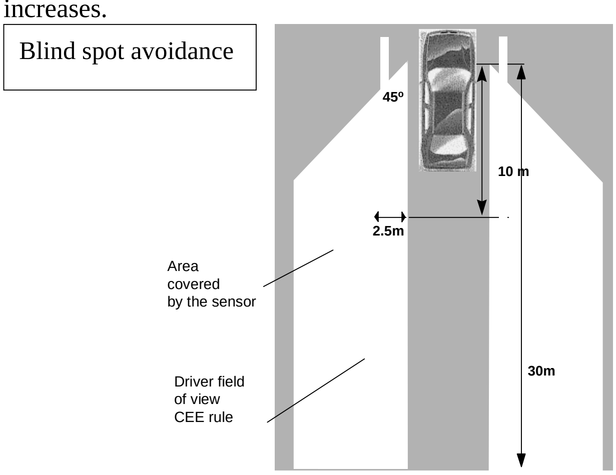

Fig. 5. Blind spot avoidance aid functionality

Selecting the appropriate type of devices for supporting the elderly driver as well as the necessary level of automation (i.e. full machine control or adaptive (user driven) as per intelligent cruise control, lane guidance, collision avoidance, etc.) may greatly benefit elderly drivers and demonstrate the capacity of IT to act as their companion rather than just another nuisance they have to cope with.

4. CONCLUSIONS

The importance of driving for elderly people is not self-evident and may be perceived, only when comparing it to the other modes of transportation. Driving is a user friendly transport mode for elderly people, as shown in Table 1. Many of them are not able to walk the required distance, stand for a long time or have the overall physical endurance to use public transportation means. Over 25% of elderly Americans are not able to use public transport (Waller, and Goo, 1969). Thus, enabling older people to drive has practical, social and personal value with significant implications for their quality of life through sustaining their independent mobility. As manifested by the American Association of Retired Persons, "For the average older driver, losing a license is like breaking a hip and having to go into a nursing home: Suddenly you are immobile, you can't go anywhere. Even if you limit yourself to sunny days and certain hours, you want that independence".

Table 1 Comfort features of the private car and traditional public transport (when a mode has an advantage for older persons, the feature is italicised) (Brouwer, and Ponds, 1994).

Private car	***Public transport***
Luggage transportation easy	Luggage transportation difficult
High psychosocial safety	Low psychosocial safety
Much privacy	Little privacy
Seat assured	Seat uncertain
Parking necessary	*No parking problems*
Weather protection good	Cold and windy stations
Walking distance <400 m	Walking distance >400 m
Entrance easy	Entrance difficult
Moderate casualty risk	*Low casualty risk*

One of the new scientific challenges will thus concern the older car driver. Car driving is a very complex cognitive activity, even if many of its aspects are automated. Since, during the normal ageing process several cognitive functions may decline, it is very important to identify those that are related to driving. In addition to the normal cognitive decline, some chronic illnesses may also present aggravating factors, especially when different kinds of medication are involved, which can have secondary effects on some cognitive functions that are important for safe driving. Among the most frequent diseases are visual impairments, cardiovascular diseases (CVA), diabetes and different dementing diseases, especially of the Alzheimer type (DAT) (Waller, and Goo, 1969). Conservative estimates of the prevalence of different dementing illnesses among elderly drivers raise the number to 5%-7% of all elderly drivers (around 40,000 people in Sweden alone) [Hakamies-Blomqvist, 1994].

In 1986 in the US traffic deaths of those aged 65+ accounted for about 13% of all traffic fatalities, which was roughly in proportion to their share of the population (12.1%). However, only ten years later, in 1996, elderly persons' share of fatalities already had reached 16.9% [FARS for traffic fatalities, US Bureau of Census for population estimates], while their share in the population did not increase markedly from 1986 (12.8% in 1996 as compared to 12.1% in 1986).

The situation in Europe seems to be the same. In response to this problem, different European countries adopted different policies, from neglecting it (keeping driving license validity unlimited, such as in Belgium, France and Germany) to imposing general screening of the population by inadequately trained GP's, without specific tools and at arbitrary ages (i.e. at 45 in Spain!, 65 in Greece, 70 in the Netherlands and Finland, etc.). The medical checks to renew them vary between 2 (for Switzerland, after 70 years of age) to 3 (for Luxembourg) and 5 (for Finland, Spain, etc.) years.

These random and differentiated policies lead either to the inclusion of few dangerous elderly drivers on the road or to the unnecessary limitation of the mobility and autonomy of others, who just can not sustain the psychological and other burden of too frequent and/or too complex assessment. It should be underlined that more than half of the people over 75 tend to lose their driving license today in countries with the periodic renewal system (Hakamies-Blomqvist, *et al.*, 1995).

Nevertheless, many older people remain very good drivers which means that age per se should not be the ad hoc criterion used to differentiate between safe and unsafe older drivers. Consequently, and in light of the age-related cognitive problems described above, it is important to study in depth the factors that influence driving behaviour in older people.

Although licensing authorities have extensive experience in assessing the fitness to drive of physically impaired drivers, (Withaar, 1997) there is a lack of standardized systematic procedures for assessing the fitness to drive of cognitively impaired persons. Assessment procedures indeed vary among countries and include either off-road or on-road assessments or both. However, there is a risk that the strengths and limitations of tests in use are not adequately recognised by assessors, potentially leading to errors in decisions about fitness to drive, either by allowing unsafe drivers to continue driving, or by recommending that safe drivers do not drive. There also exist risks of litigation that can emanate from inappropriate recommendations.

In conclusion, there is a disturbing lack of basic information with which to develop rational policies for deciding who is, or is not, qualified for licensure among the elderly population (Waller, 1991). It is generally acknowledged that limitation of the privilege to drive should be based on the demonstration of impaired driving competence, rather than on a stigmatising label, such as being elderly (Drachman, 1979).

AGILE project aims to rationalize and standardise Europewide such policies by providing the necessary scientific tools and data to find “whose accidents are older drivers accidents?”, in other words the few ones among the elderly group that really need help and further assessment.

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