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Profile of older drivers at higher accident risk in a complex traffic situation.

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1. Introduction

Maintaining driving capability is important for guaranteeing the independence of older adults, especially for those in rural or remote areas. Individuals aged 65 years and over represent the most rapidly growing segment of the driving population, and they will become an increasing proportion of the overall motor vehicle crash problem (Lyman et al., 2002). Adjusted for distance travelled, motor vehicle crash rates are higher for elderly drivers, with an exponential increase above the age of 75.

Moreover, the types of crashes in which older adults are involved often occur in complex traffic situations. Drivers find it harder to negotiate in these situations as they grow older (Gandolfi and Dorn, 2009). The problem arises at intersections, more precisely when the older driver has to turn left across a lane of traffic (McGwin and Brown, 1999; Brouwer and Ponds, 1994). Therefore we are interested in the left turn task (a situation of particularly complex traffic in countries that use the right side of the road, right turns are analogous to left turns for left traffic countries). This maneuver was defined by Caird and Hancock (2002) as involving one vehicle traveling in a straight line that changes direction to the left at a junction of two or more roadways. Such intersections may be controlled or uncontrolled, situated in urban or rural areas, and vary in lane number and type. Turns can be made from two-way or one-way roads onto one-way or two-way roads.

Disabilities attributable to aging may impair driving. In her review, Janke (1994) presents an overview of the literature on normal age-related declines in physical, perceptual, cognitive and psychomotor abilities that are relevant to driving. Analyses of accidents report that inattention-related accidents are a frequent type of accident for older drivers (Shinar et al., 1978; Van Elslande, 2003). The age difference in reaction time is also particularly relevant for the complicated tasks and decisions that must be made quickly while driving (Eby et al., 1998). Besides, average visual acuity is declining as age increases (Janke, 1994), even if nowadays most of older people have a correction like surgery or glasses. Older adults, in comparison with young people, also show shrinkage of the useful or functional visual field, as noted in a review by Owsley and Ball (1993). The useful visual field or "useful field of view" (UFOV) has been defined as a measure of the spatial area within which a person can be alerted to visual stimuli in a variety of situations, and deficits in UFOV capacity have been related to crash experience in elderly drivers (Owsley et al., 1991; Owsley and Ball, 1993). Lastly, reduced head rotation may impair the ability of the driver to turn the head to see relevant stimuli necessary for safe driving in complex traffic situations and when changing lanes. In her study, Langevin et al. (2011) showed that limitations in physical abilities play an important role in explaining the high percentage of collisions in older pedestrians. The authors used a street-crossing simulation device to implement a street-crossing task with traffic approaching from one or two ways. In addition, the participants undertook a battery of

perceptual, cognitive and physical tests. A major finding was that slower walking speed being the strongest predictor of dangerous street-crossing decisions. Regarding drivers, motor abilities have rarely been taken into account. In our knowledge, only one study (Marotolli et al., 1998) included a neck rotation test in its battery of test. In this research, they compared an assessment of visual, cognitive and physical abilities with self report of histories of adverse driving events and concluded that it may be possible to identify individuals potentially at risk using simple tests of functional ability.

1.1. AIM OF THE STUDY

The main goal of our study was to describe the cognitive, perceptive and motor profile of older drivers with higher accident risk. For this, we compared cognitive, perceptive and motor abilities of three groups of drivers varying for age and driving capacity measured through their behaviour at a driving simulator task, involving a complex left turn situation.

One interest of our study was to examine in the same study measures of cognitive skills and a measure of driving using a simulator. We hypothesized that the older drivers with higher accident risk will present specific cognitive, perceptive and motor profiles.

2. Method

The study included 92 participants divided in three subgroups. They were tested individually, in a first session for the assessment of the participants' functional abilities, and in a second session for the assessment of driver behavior in a simulator left turn task.

2.1. PARTICIPANTS

Participants consisted of thirty-three young (14 women, 19 men) between the ages of 25 and 37 (M: 30.63 years; SD: 3.64 years), thirty-four younger-old (18 women, 16 men) between the ages of 61 and 70 (M: 66.03 years; SD: 2.35 years) and twenty five older-old (10 women, 15 men) between the ages of 71 and 89 (M: 75.04 years; SD: 4.38 years). They were recruited by distributing flyers in the community, contacting senior-citizen organizations and due by word of mouth. They were paid for their participation. All participants reported they have driven at least 3000 km the last year. We used a self-report questionnaire to screen for taking drugs, cardiovascular disease, neurological disease, cerebrovascular accidents, diabetes, arthritis or osteoarthritis. If participants report an element from the list below, they were excluded from the study.

2.2. TESTS

2.2.1. Perceptual, cognitive, and motor measures

In the first part of the study, perceptual, cognitive, and motor abilities were assessed using the following order.

Perceptual abilities.

Visual Scanning task - In this task a matrix-like arrangement of 5 x 5 stimuli is used. The aim was to detect whether this arrangement includes a critical stimulus or not. Two reaction keys were used for the "present" and "not present" answers respectively. The measure used is reaction time in the presence of the critical stimulus (expressed in ms; 50 trials with the critical stimulus and 50 trials without the critical stimulus).

Vision measures - Measure by an Ergovision®, by reading letters at 33cm for the near vision and at 5m for the far vision. The results are expressed on a 12 points scale.

Cognitive abilities.

Useful Field Of View Test (UFOV) – This task involves three subtests (Ball et al., 1988). The first one (UFOV Part 1) measures the processing speed (Ball and Owsley, 1993) by determining a person's threshold for discriminating stimuli presented in central vision. The second one (UFOV Part 2) measures the divided attention ability. The procedure is similar to that of the UFOV Part 1 but with the addition of a concurrent peripheral target location task. The third one (UFOV Part 3) measures the selective attention ability, using a similar procedure of the UFOV Part 2 but with the addition of distracters. A threshold score on each subtest was considered here. It was equal to the display duration (express in ms) at which the participant could correctly perform the test 75% of the time.

Code task – This task was used to measure the processing speed. It consists in the presentation of digit-symbol pairs followed by a new presentation of the same digits, under which the participant should write down the corresponding symbol as fast as possible. The measure used was the number of correct symbols within the allowed time (e.g. 120 sec).

Reaction time Test – In this task, the participant should respond as quickly as possible by pressing a key to the presentation of a cross appearing on the monitor at randomly varying intervals. The measure used in this task is the reaction time (express in ms; 15 trials).

Working Memory Test – In this task, a sequence of numbers is presented on the monitor. The participant is required to determine whether each number - depending on the condition - corresponds with the previous number or the one before that. The outputs were the reaction time (express in ms) and the number of incorrect answers (upon 15 correct answers).

Motor abilities:

Flexibility Test - The participant has to turn his head to the right and to the left to read letters. The measure used is the largest angle formed by his head (express in degrees of angle).

2.2.2. Driving simulator: left turn intersections

The second part of the study took place on a driving simulator. Participants had to decide if they could perform a left turn at intersections. They started at the beginning of the intersection (see Figure 1) and had to look at the simulated road environment and the approaching files of vehicles.

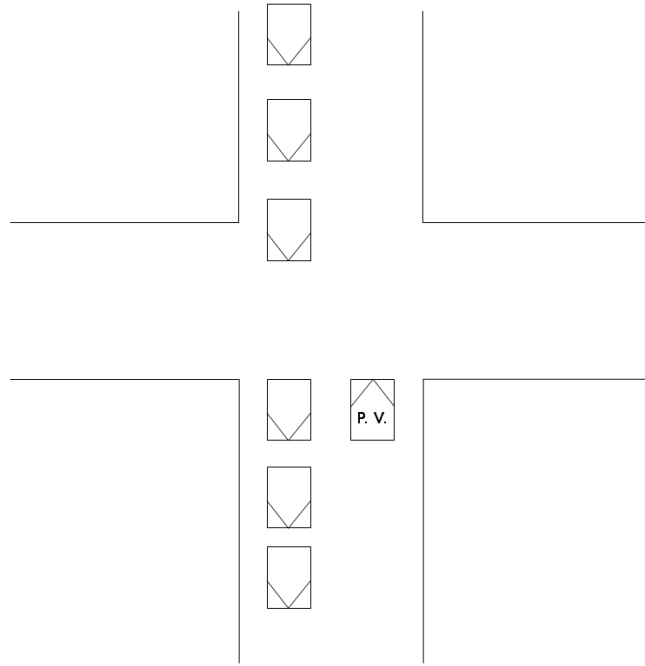


Figure 1: P. V. = Participant Vehicle. The participant has to turn left at the intersection.

Participants were instructed to turn left when they thought it was safe to do so. The participant's decision to turn or not to turn and his/her motion until reaching the end of the intersection were recorded. Three independent variables were manipulated, (1) speed of approaching vehicles (30 and 60 km/h), (2) complexity of the environment (simple = vehicles arriving only in front of the participant vs. complex = vehicles arriving in front of and from the right or the left of the participant), and experimental time gap defined as the gap between the third and the fourth car arriving in front of the participant (4 to 10 s, in 1-s increments).

The number of repetitions per time gap differed according to their probability of being accepted for turning. Therefore, time gaps of 4 and 10 s were presented once, time gaps of 5 and 9 s were shown twice, and the 'critical' time gaps of 6, 7, and 8 s were presented three times, making 15 trials in all. The combination of these 15 trials, the 2 speeds and the complexity (simple, complex with vehicles arriving from the left, complex with vehicles arriving from the right) resulted in a total of 90 trials. They were presented in random order in three blocks, with a break between the blocks.

The behavioral indicator of interest was the safety margin, corresponding to the time between the end of the maneuver and the end of the gap (see Figure 2).

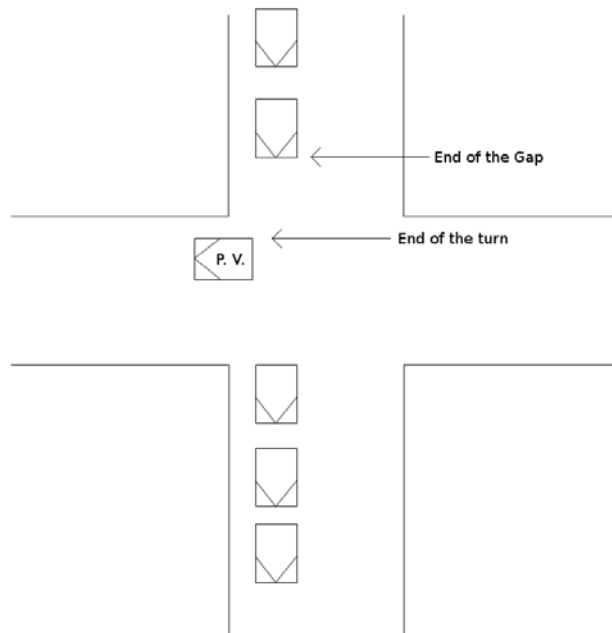


Figure 2: P. V. = Participant Vehicle. The safety margin was the time between the end of the maneuver and the end of the gap

2.3. DATA ANALYSIS

The safety margin measure was used to form three subgroups of young adults (n= 33), older adults (at no risk) (n = 45), and older adults at risk (n = 14). The group of young adults was considered as the control group. The two subgroups of older drivers were constituted using the quartiles of the safety margin. The older drivers under the first quartile with a low score of safety margin were classified as the older at risk. The older drivers above the first quartile with a higher score of safety margin were classified as the older not at risk. We conducted a one-way ANOVA with the perceptual, cognitive, and motor measures as dependent variables and the driver group as the independent variable. To compare the two groups of older drivers, post hoc comparisons were used (Tukey test). The significance level was set at 0.05.

3. Results

The results of the one-way ANOVA with the perceptual, cognitive, and motor measures as dependent variables and the driver group are presented in the Table 1.

Table 1: Means and standard deviations of perceptual, cognitive, and motor measures according to driver group

| | Older at risk 65-89 years n=14 | Older not at risk 61-84 years n=45 | Young adults 25-37 years n=33 | ANOVA F(2, 89) p-value |
|---|--------------------------------------|--|-------------------------------------|------------------------------|
| Visual Scanning (in ms) | 4263,14 (1168,51) | 3669,47 (1025,79) | 2964,76 (608,75) | <.01 |
| Near Vision (/12) | 7,86 (2,14) | 8,62 (2,21) | 11,52 (1,00) | <.01 |
| Far Vision (/12) | 8,43 (2,82) | 10,58 (1,98) | 11,94 (0,35) | <.01 |
| UFOV Part 1 (in ms) | 24,57 (13,80) | 20,12 (7,33) | 16,70 (0,00) | <.01 |
| UFOV Part 2 (in ms) | 92,91 (114,64) | 54,47 (76,51) | 22,75 (22,79) | <.01 |
| UFOV Part 3 (in ms) | 385,79 (531,67) | 179,81 (93,33) | 60,02 (46,90) | <.01 |
| Code (number of correct symbols) | 59,21 (11,58) | 65,56 (13,17) | 80,15 (15,68) | <.01 |
| Reaction Time (in ms) | 274,21 (51,56) | 267,27 (51,78) | 237,33 (27,30) | <.01 |
| Working Memory reaction time (in ms) | 784,36 (138,90) | 612,42 (183,35) | 633,52 (100,17) | <.01 |
| Working Memory incorrect answer (number of incorrect answer) | 5,79 (5,51) | 3,13 (6,18) | 1,06 (2,36) | <.02 |

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|--|------------------|-------------------|------------------|------|
| Flexibility to the left (degrees of angle) | 114,07 (9,60) | 114,60 (9,15) | 127,09 (9,50) | <.01 |
| Flexibility to the right (degrees of angle) | 110,71 (8,45) | 114,73 (10,02) | 128,27 (8,53) | <.01 |

The tests showed significant differences for all measures according to the driver group factor, indicating that in all measures, the young group was significantly different from the other two groups. Post hoc comparisons indicated that the older at risk group was significantly different from the other groups in only three measures; the UFOV Part 3 test, WM reaction time test, and the far vision test (see Table 2). In all other cases, the young group was significantly different from the other two groups.

Table 2: Post hoc results of perceptual, cognitive, and motor measures according to driver group

| | Older at risk 65-89 years n=14 | Older not at risk 61-84 years n=45 | Young adults 25-37 years n=33 |
|--------------------------------|--------------------------------------|--|-------------------------------------|
| Visual Scanning (in ms) | | | |
| Older at risk | - | | |
| Older not at risk | 0,095556 | - | |
| Young adults | 0,000185 | 0,003688 | - |
| Near Vision (/12) | | | |
| Older at risk | - | | |
| Older not at risk | 0,373239 | - | |
| Young adults | 0,000106 | 0,000106 | - |
| Far Vision (/12) | | | |
| Older at risk | - | | |
| Older not at risk | 0,000533 | - | |
| Young adults | 0,000106 | 0,003488 | - |
| UFOV Part 1 (in ms) | | | |
| Older at risk | - | | |
| Older not at risk | 0,124827 | - | |

| | | | |
|--|----------|----------|---|
| Young adults | 0,003517 | 0,113416 | - |
| UFOV Part 2 (in ms) | | | |
| Older at risk | - | | |
| Older not at risk | 0,183477 | - | |
| Young adults | 0,007116 | 0,129004 | - |
| UFOV Part 3 (in ms) | | | |
| Older at risk | - | | |
| Older not at risk | 0,006825 | - | |
| Young adults | 0,000127 | 0,045101 | - |
| Code (number of correct symbols) | | | |
| Older at risk | - | | |
| Older not at risk | 0,301183 | - | |
| Young adults | 0,000129 | 0,000146 | - |
| Reaction Time (in ms) | | | |
| Older at risk | - | | |
| Older not at risk | 0,866746 | - | |
| Young adults | 0,029403 | 0,011832 | - |
| Working Memory reaction time (in ms) | | | |
| Older at risk | - | | |
| Older not at risk | 0,001169 | - | |
| Young adults | 0,007024 | 0,817149 | - |
| Working Memory incorrect answer (number of incorrect answer) | | | |
| Older at risk | - | | |
| Older not at risk | 0,202294 | - | |
| Young adults | 0,011453 | 0,176168 | - |
| Flexibility to the left (degrees of angle) | | | |
| Older at risk | - | | |
| Older not at risk | 0,981414 | - | |
| Young adults | 0,000198 | 0,000107 | - |
| Flexibility to the right (degrees of angle) | | | |

| | | | |
|-------------------|----------|----------|---|
| Older at risk | - | | |
| Older not at risk | 0,337920 | - | |
| Young adults | 0,000106 | 0,000106 | - |

4. Discussion

The goal of this study was to describe the cognitive, perceptual and motor characteristics of most at risk older drivers.

Regarding cognitive, perceptual and motor abilities, significant age group-related differences were found indicating that older adults have a lower level for all measured abilities, a result found in the literature (Anstey et al. 2005; Drag and Bieliauskas, 2010). Such a result allowed supposing that such difficulties in older adults may increase crash risk. Age itself does not reliably impact fitness to drive but declining physical and cognitive functions typically associated with ageing have been found to increase crash risk. This idea was put forward by Matas et al. (2014).

In order to describe the cognitive, perceptive and motor profile of older drivers with higher accident risk, we look at the differences between the older at higher accident risk and the two other groups. Comparing the subgroup of older drivers at higher accident risk to the subgroup of older drivers which does not have this risk we found that older adults at risk group had worse performance in three tests; the Far Vision test which assessed the far vision capacity, the UFOV Part 3 which assessed selective attention ability and speed of visual processing, and the Working Memory reaction time which assessed the working memory ability. This result supports the idea that these three abilities play an important role in the older adults risk behavior.

Decline in the far vision ability could cause difficulties in perceiving the vehicles and estimating their speed. These capacities are crucial for the evaluation of the time to arrival of the cars. In our study, the near vision was not different between the older drivers at risk and the other older drivers. This may be explained by the fact that nowadays majority of older drivers take an early screening test of near visual acuity, and that improving vision surgery become more and more common. Attention ability has also been described as one of the more crucial abilities involved in driving behavior, particularly in left turn complex situations that can be referred to as a cognitively highly demand task. Hancock and Caird (1991) point out there is a rising of information processing in intersection to which the drivers have to adapt by performing the maneuver while remaining attentive to the traffic. Working memory also appeared linked to the at risk driving behavior in older adults. This suggests that higher-level functions, such as executive functions, or control functions, are cognitive resources involved in the older adults risk behavior.

Finally, it is interesting to note that studies about older pedestrians' street crossing have highlighted the importance of motor functions in at risk behavior, which does not appear to play a major role in the driving task. A possible main difference is that, for crossing the street, the pedestrian needs to be largely concentrated in his walk that is an important part of the achievement. While in driving, one may suppose that the car plays the role of a facilitator. As

a consequence, the driver behavior is much less dependent of motor abilities to perform the task.

Notwithstanding, there are several limitations to the present study. First, in the participant recruitment methods; the drivers who volunteered for this study cannot be taken as representative of the target population because sample was not randomly selected but only came from some sectors of the community. It should also be remarked the relatively small samples of older at risk. It's possible that it did not allow to bring out all the inter-group differences significant.

It is also interesting to note that, since our study has highlighted clear differences in cognitive and perceptual abilities between older driver and older driver at risk, which may explain their at risk behavior, other studies have also shown the impact of the self monitoring in the driving behavior (Anstey et al., 2005). In future research it may be interesting to investigate the impact of the self evaluation and the self regulation in the driving behavior of older drivers at risk.

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