To accord mobility and safety issues for elderly drivers : considerations on driving competency assessment, a pilot study

GABAUDE Catherine
INRETS – LESCOT,
catherine.gabaude@inrets.fr

Abstract

To have a greater knowledge of the real difficulties elderly drivers are confronted with, it is necessary to analyse their driving competencies within a framework which takes into account not only fitness to drive but also driving skills and driving behaviour. To pre-test the scoring grid of an assessment procedure developed at INRETS, a pilot study was conducted. The objective was to evaluate the impact of visual and cognitive declines on real road driving performance, focusing firstly on driving skills and fitness to drive before including driving behaviour in such an approach. This study was elaborated to identify tests which are shown to predict driving-related variables on either crash involvement or road test performance.
A case control study was conducted with 40 senior drivers (aged between 61 and 80 years old) recruited via their insurance company for a real road experiment (20 case volunteers having 3 at-fault accidents or more during a three year period and 20 control volunteers having no accidents during the same period). Non-driving tests included visual tests (visual acuity in far vision, movement perception and contrast vision) and cognitive tests (MMSE, Zazzo crossing-out test, Weschler digit symbol). The road test resulted in a driving performance evaluation conducted along a fixed route. The dependant variable studied was a penalty score.
Weschler digit symbol scoring shows a significant difference between case and control group and significant differences is observed between case and control groups for the total score and for the guided score. An analysis carried out on subtotals on height dimensions (mirror check, visual search, indicator use, lane choice, violation, positioning at intersection) shows a significant difference between Case and Control on violation criteria. Age, all visual tests, digit symbol scoring and Zazzo time are correlated with penalty score. 43% of the variation in the penalty score can be predicted based on age, group and scores obtained with 2 non-driving tests : movement perception and Zazzo time. The purpose of this pilot study was limited to suggesting a methodology for approaching older driver assessments.

Introduction

Concerning elderly drivers, all population forecasts in industrialised countries agree upon the fact that this part of the population is rapidly growing, due to demographic and cultural reasons. Strategies, policies and provision of services must be reconsidered in order to support the continued health and well-being of the elderly. To accord mobility and safety issues for elderly drivers, a compromise must be reached between too great a reduction in mobility (which will consequently increase the number of people becoming dependant in particular cases) and an increase in road unsecurity.

The ageing process is associated with a more or less severe modification of functional abilities. Impairments can be observed at sensori-motor and/or cognitive levels (Gabaude, 2003). Due to these varying levels, the elderly have very heterogeneous functional abilities and identifying people more at risk is a difficult challenge.

The French authorities have decided to set up a compulsory medical examination, after the age of 75, assessing the functional abilities necessary to drive. At present, we do not know the criteria and the threshold that will be used to to accompany the driver during all the ageing process and to decide if people are able or not to drive. Such a decision could have as a consequence a ban on driving if test results are under the level required. To avoid such a deprivation having important effects on mobility and not having an impact on driving risk exposure in the case of the criteria not being relevant (hakamies-Blomqvist, 1996), it is necessary to improve our knowledge of the impact of functional ability impairment on driving competency.

To have a greater knowledge of the real difficulties elderly drivers are confronted with, it is necessary to analyse their driving competency within a specific framework. According to Brouwer (2002), three aspects of driving competency exist. The first one concerns **driving skill**, in this case skill is acquired in a specific domain or activity. Arriving at this level the subject has learned how to evaluate, select or avoid some traffic situations and to drive in a smooth and safe way in these various situations. Driving skills of young drivers are assessed by a driving evaluator who rates various aspects of the task (like gap acceptance, limit line, observation, path, speed…). For experienced drivers the driving skill is rarely assessed except for research issues, and to compare driving skills of various drivers it is necessary to develop standardised methodologies. Results of on-road driving tests have frequently been used as criteria because they appear to be widely accepted as the most realistic measure of driving capacity, they have a good validity and efforts have been made to standardise their content and methods of evaluation (Lundberg and Hakamies-Blomqvist, 2003). The second aspect of driving competency is the **fitness to drive**, corresponding to a level of physical and mental abilities sufficient to be able to learn and to apply driving rules. Fitness to drive refers to those basic perceptual, cognitive, and psychomotor capabilities needed for driving (Eby et al., 2000). The third aspect is **driving behaviour**. It concerns what the driver is really doing when he is driving his car. Over the last decade several studies have reported on the development of a typology of aberrant driving behaviours using questionnaires. The most used questionnaire is the driving behaviour questionnaire (Reason et al., 1990; Parker et al., 1995).It is a survey instrument which covers three main types of bad driving: errors, lapses and violations.

The research community needs to develop new methodologies to evaluate the driving skills of older drivers and to ensure their fitness to drive. The introduction of standard assessment procedures will be particularly necessary for people suspected of having dementing illnesses. Moreover, assessment procedures which include different measurement levels can be interesting as they allow the drivers to be accompanied during the entire ageing process, helping them to anticipate the forthcoming difficulties, to start identifying functional limitations which can be overcome and to describe effective rehabilitation options.

To pre-test the scoring grid of an assessment procedure developed at INRETS, a pilot study was conducted. The objective was to evaluate the impact of visual and cognitive declines on real-road driving performance focusing firstly on driving skills and fitness to drive, adaptations carried out at the driving behaviour level will be studied later. A first test battery, which included brief and inexpensive screening tests was used to define functional impairements that are relevant to driving. As in Janke (2001) study, the objective of this first screening procedure is to determine if the functional abilities of a driver must be explored further through more intensive testing or if the driver is required take a road-test. This study was elaborated to identify tests that are shown to predict driving-related variables on either crash involvement or road tests performance.
Automobile insurance claims files were used to find drivers having more than three at fault accident during a certain period and control drivers. This research into age-related driving deficiencies is not employing accidents as a definitional criterion of unsafe driving but it was simply an opportunity to find people with heterogeneous driving habits to look for more valid criterions.

Method

A case control study was conducted with senior drivers (60 years old and more). Case and control volunteers were recruited via their insurance company. The French informatics and freedom committee impose that people agree to participate in this study by sending a letter to their insurance company. The study was also approved by the French human research ethics committee. Written consent was sought throughout the process and confidentiality of records was maintained. All participants were informed that they were free to terminate the study at any time without any negative consequences. Volunteers were paid a fee of € 100 for participating in the test program. This study is concerned with the effects of normal ageing on driving, only people without diagnosed neurological pathologies were included in the sample.

Participants

Two databases collected in the "Rhone" department of France were send by an insurance company. The first one concerned 3578 minor insurance claims (less than € 10 000, in order not to call up painful events) which happened during the last three years (representing 1372 members) and the second one, consisted of 7021 members not having any claim during the same period. A lot of information was not recorded in the databases.

Only 135 members had 3 at-fault accidents or more during the last three years. 527 members were presented in the control database. Case and control members interested in participating in the study were all contacted by mail. As the number of volunteers to do the experiment was not sufficient, the research was enlarged to the neighbouring department ("Isère" and "Ain"). 56 people from these departments were then contacted. Two months later, a second mail was sent to the non-respondent members of the case database.

Finally 40 senior drivers (aged between 61 and 80 years old) were recruited for the real road experiment. They were still driving at the time of the study, carrying out more than 3000 km per year. Matching parameters between the two groups was the sex, the age and the study level.

- 20 subjects were case volunteers having 3 at-fault accidents or more during a three year period (between 1998 and 2000).
- 20 subjects were control volunteers not having any accident during the same period.

All the participants agree to co-operate with the study and signed informed consent declaration after receiving a full explanation of the study.

Procedure

When people sent their agreement to participate in this study, they gave there address and phone number. Then INRETS contacted them by phone and asked them some information to check if inclusion criteria was correct (still driving at the time of the study, carrying out more than 3000 km per year, driving without an automatic transmission). Then an appointment for the experiment was arranged. Information to join INRETS and a questionnaire was sent to their address two weeks before the appointment. The questionnaire concerning the driving history and at-fault accidents had to be completed in advance by the driver.

Testing occurred in Bron in the suburb of Lyon. The evaluation started with the visual tests or the medical exam, depending on the availability of the medical doctor (the French Human Research Ethics Committee required a medical exam to be sure that volunteers can participate in the experiment). Then, the neuropsychological assessment procedure was carried out. Subjects could ask to take as many breaks as they needed. At the last step of the day the road test was administered. Assessment of each individual took approximately 3 hours (more when adaptation period to an unfamiliar vehicle was long).

Non driving tests

Non driving tests, which took about 30 minutes to administer, included visual tests carried out with the "Ergovision" testing device. All tests are carried out in binocular vision:

- static visual acuity in far vision: differentiating stimuli in high contrast images (the visual acuity is defined when the subject is able to read 6 characters upon 8 without mistakes, it is assessed for 5 values: 2/10, 4/10, 6/10, 8/10 and 10/10).
- static visual acuity in intermediate vision (the score is assessed like the previous one).
- low contrast vision: differentiating stimuli in low contrast images, 9 levels are assessed. 3 visual acuity in intermediate vision (4/10, 6/10, 8/10) are presented for 3 contrast level (0.8, 0.6, 0.4). The level is reached when the subject is able to read 3 characters upon 4 without mistakes. (The score is the number of well identified levels).
- movement perception: indicating the direction of different arrow structures being in movement (the score is the number of well identified structures).

The neuropsychological examination consisted of tests chosen with the double aim of detecting severe cognitive impairment and exploring some of the functions altered during the ageing process. Three neurospychological tests were used: Mini-Mental Status Evaluation, Zazzo crossing-out test, digit symbol substitution test (WAIS subtest).

- Mini-Mental Status Evaluation (MMSE) : the test taps six general cognitive domains: orientation, registration, attention/calculation, recall, language and visuospatial perception/praxis. Conventional MMSE scoring gives no points for an error on an item and 1 point for correct performance. The MMSE yields a maximum score of 30.
- The Zazzo crossing-out test is a selective attention test where the task for the subject consists of crossing out target stimuli (squares with a line pointing upwards) distributed among a mass of distracting stimuli (squares with a line pointing downwards, to the right, to the left or diagonally). Inhibition mechanisms play a central role in taking the Zazzo crossing-out test. In order to selectively cross out target stimuli without making mistakes in the shortest possible time, the subject is required to effectively inhibit distracting stimuli. Two scores are measured, the total time and the number of good stimuli crossed-out (29 less the total number of targets' omission or crossing out of distracters).
- The digit symbol substitution test measures cognitive and perceptual-motor processing speed. The subject is given a code that pairs symbols with digits. The test consists of matching as many series of digits to their corresponding symbols as possible in 90 sec. The score is the total number of symbols drawn by the subject.

Road test

The road test results in a driving performance evaluation conducted along a fixed route (25 km). The participants had to drive, a test vehicle. The test times range from 35 min to 55 min according to familiarisation duration and speed on road.

<u>Vehicle description</u>

The test vehicle is a middle range Citroen model (ZX). The vehicle was equipped with video and computer systems in the most unobtrusive way. The installation of a dual command enables the investigator to help the driver to manage the critical situations that can occur during experiments. A multiple input display unit allows various synchronised scenes to be displayed on one video image. Angles chosen in this experiment are : the view as seen by the driver, the rear view, a tight view on the face of the driver and a broad plan including driver and the investigator. This data was recorded with a digital video recorder in order to be reviewed after the experiment.

<u>Route description</u>

Not to disadvantage people adapting slowly their behaviour to a new car and in order to be familiar with the test vehicle a trip (short or long) was carried out around INRETS site for each driver. At this step of the experiment the evaluation grid was not completed.

Then all volunteers had to drive along the same route travelling in and outside town areas and on motorways. The route was outlined to enable relevant information in different kinds of representative traffic situations (such as entering a roundabout, turning left, changing lanes, looking for directions …). Depending on the route portions the itinerary was given by the experimenter (guided journey) or the driver had to carry out a destination-finding task (non-guided journey). Indications were given without pointing out relevant infrastructure elements (for example: "as soon as you can, turn left"). The itinerary alternated between main roads and secondary roads to be sure that drivers did not know all the traffic situations travelled through. The structured road test, comprised of specified tasks in which drivers were scored on whether or not they met specific criteria. The participants were assessed at 45 pre-designated check-points on the test route (such as stop signs, traffic lights, lane change, roundabouts and T-junctions). For 19 check points the driver was also assessed while finding street using road signs only.

<u>Road test scoring</u>

The driving performance evaluation was carried out into two steps. A road test observation grid was filled out during the experimentation (when it was not possible to do it in real time, videotape was later used to fill out the grid) and then a road test scoring grid was completed.

The observation grid was inspired by the Driving Performance Evaluation (DPE) developed by California DMV in Southern California (Hagge, 1994). The observation sheet for the road test was organised according to the sequence of the course. During the road test, the driving evaluator, sitting beside the driver, indicated on the observation sheet when certain structured manoeuvres at pre-designated points on the route were not performed. For this type of information the number of possible errors was fixed. For some actions, a qualitative judgement was recorded. The number of possible errors was fixed nevertheless critical errors were recorded as they occurred but they was not included in the driving score to be sure that all drivers have been observed in the same conditions.

A road test scoring grid was used to ensure uniformity and consistency in the data collection process. The dependant variable studied was a penalty score. It was defined as the total number of possible errors. Weighting of the more dangerous errors(cf. table 1) (hazardous or potentially critical) more heavily is consistent with the scoring method used by (Dobbs, 1997). The observation grid consists of height dimensions. In the road test scoring grid, each dimension was rated on 3 point subscales according to the situations.

Rated dimensions		*Observed dimensions*
Action	**Penalty (pt)**	**Action**
Mirror check: not done	2 or 1*	Direction following: question from the driver
Mirror check: late	0.5	Direction following: experimenter intervention
Visual search: not done	2	Speed : maladjusted
Visual search: incomplete	1	
Visual search: late	0.5	
Indicator use: absent	1	
Indicator use: late	0.25	
Lane choice: error	1	
Violation	3 or less**	
Positioning at intersection: dangerous	2	
Positioning at intersection: in the way	0.5	

*table 1: information included in the observation and the scoring grids (*only one point if a road separator exists, in the other case, a two-wheeled vehicle might be present, **according to the situation, 1.5 point was attributed when the manoeuvre was judged hazardous)*

Analysis
Several analysis were conducted such as frequencies, t-test and correlation to describe the data and make preliminary inferences. The study's main task was to distinguish subject group and predict road test score. Multiple regression analysis were conducted to predict driving penalty score from non driving test measures.

Results

The sample consist of 40 licensed active drivers from 61 to 80 years of age (case group mean age = 66.5, SD = 5.24; control group mean age = 65.6, SD =4.74). Matching parameters between the two groups was the sex, the age and the study level. All subjects except 4 (belonging to the women control group) have a high study level.

Visual tests
Mean visual acuity can not be calculated because visual acuity was measured for 5 values and progression between measures is logarithmic. In table 2 the number of subjects having or not the visual acuity required by the French driving legislation is presented. 3 individuals upon 40 are driving with a poor visual acuity. To know if drivers might be embarrassed when reading the dashboard, intermediate visual acuity was also measured. This criteria is not required by the French driving legislation. 6 drivers might have difficulties in reading information presented inside the vehicle.

	Case	Control
far vision acuity inferior or equal to 4/10	2	1
far vision acuity superior to 4/10	18	19
intermediate vision acuity inferior or equal to 4/10	1	5
intermediate vision acuity superior to 4/10	19	15

table 2: number of subjects having or not the far vision visual acuity required by the French driving legislation and subjects having more or less than 4/10 in intermediate vision acuity

The difference between the two groups is not significant for the movement perception test and for the contrast vision test (table 3). For the contrast vision test the score preconized by the Ergovision[1] handbook indicate that only one control subject have a good contrast vision, all others have a poor contrast vision.

	Case	Control	p: T-test
mouvement perception	10,05 (1,10)	10,35 (1,09)	0,391
contrast vision	3,90 (2,08)	3,25 (2,57)	0,385

table 3: visual quantitative measures - Group means (S.D.'s)

Neuropsychological tests

[1] a good vision contrast is observed when the subjects are able to read all levels, in the other case the contrast vision is poor

Only one neuropsychological test (digit symbol scoring) shows a significant difference between case and control group. This indicate that control subjects have a less important cognitive and motor slowing than case subjects.

	Case	Control	p: T-test
Digit symbol scoring: Symbols drawn	44,65 (9,08)	50,90 (8,26)	0,029
Zazzo scoring: good stimuli crossed-out	28,25 (0,97)	27,75 (2,02)	0,325
Zazzo scoring: time	56,05 (9,29)	49,80 (12,98)	0,088
MMSE scoring	28,30 (1,42)	27,85 (1,39)	0,317

table 4: Neuropsychological tests - Group means (S.D.'s)

Road test scores

The road test scores are firstly globally analysed. No significant difference (p=0.544) is observed on penalty score between man (mean=32.83, SD=15.54) and women (mean=35.48, SD= 11.59) and the study level is not correlated with the penalty score (r= -0,092, p = 0,572).

<u>Differences between case and control group</u>

Significant differences are observed between case and control group for the total score and for the guided score, Case individuals having a higher mean penalty score. When drivers were asked to choose their way by reading road signs, the penalty score was not significantly different between the two groups. Case individuals seems to be more cautious in this situation. An analysis realised on subtotals on the six rated dimensions (mirror check, visual search, indicator use, lane choice, violation, positioning at intersection) shows only a significant difference between Case and Control on violation criteria.

	Case	Control	p: T-test
Total score	38.87 (14,55)	29,55 (10,80)	0,027
guided score	20,57 (8,78)	14,24 (6,16)	0,012
non guided score	17,98 (7,84)	15,62 (6,92)	0,319
violation score	2,93 (3,72)	0,85 (1,32)	0,027

20 violations was observed in the case group and 5 in the control group. For the two groups, the more frequent violations was observed for left turn intersections.

	Case	Control
traffic light	5	0
priority	3	0
Left turn with traffic light	9	4
Left turn without traffic light	3	1

table 5: number of violations encountered in four situations.

For the other dimensions the difference between case and control group are not significant. Nevertheless, on the average for all drivers, the most part of the penalty points are attributed for Visual Search 29%, mirror check 24%, indicator use 24%, lane choice 14 %, violation 6% and positioning at intersection 5%.

Since the adoption of a yield-at-entry regulation in 1966 by Great Britain and in 1983 by France, the superior safety record of modern roundabouts was well-known in western Europe and in most British-influenced countries (Dearagao, 1992). Even if roundabouts are safer and more efficient intersections for drivers in general, in France, elderly drivers are not yet all accustomed to them. A subtotal of the penalty score was calculated for the roundabouts, difference between case and control was not significant. Nevertheless on the 45 check points of the test route, ten was located on roundabouts. On the average, 34% of the penalty points was attributed because of errors happened in such a situation.

<u>Predicting road test performance</u>
Results recorded from all drivers are included into the analysis. table 6 shows simple correlations between non driving measures and penalty score (*r* and *p*) and multiple regression analysis results (β, p). In this study it can be observed that the age factor is associated with the penalty score. Meaning that the penalty score of older drivers is higher than the others. All visual tests are correlated with the penalty score. Some variables are negatively correlated with the penalty score because the smaller test score indicated a bad performance. Moreover concerning the cognitive status of drivers, people having the worst results for the digit symbol scoring and taking time for the Zazzo crossing-out task have the higher penalty scores.

		r with penalty score	*p*	β	p
general	age	0,409	0,009	0.545	0.169
	group			5.251	0.150
visual status	visual acuity in far vision	-0,315	0,048	RV	RV
	movement perception	-0,385	0,014	-3.050	0.085
	contrast vision	-0,317	0,046	RV	RV
cognitive status	Digit symbol scoring: Symbols drawn	-0,463	0,003	RV	RV
	Zazzo scoring: good stimuli crossed-out	-0,247	0,124	RV	RV
	Zazzo scoring: time	0,498	0,001	0.427	0.012
	MMSE scoring	0,084	0,607	RV	RV

table 6 : simple correlations and multiple regression of non driving measures with penalty scores (RV=variable removed from the analysis)

As the number of observations was relatively low (40) it was choosen to integrate only 5 variables in the model to be sure that the estimates of the regression line will be quite stable and replicable. Age and group was not removed to enter these variables in the model and the more correlated variables was also entered (movement perception, digit symbol and Zazzo time). Independent variables were removed one at a time according to the effect on the regression coefficient. 43% of the variation of the penalty score can be predicted based on age, group and scores obtained with 2 non driving tests : movement perception and Zazzo time (R^2= 43 %, R^2 adjusted= 36 %,F= 6.55, p= .0005).

Discussion

As mentioned by Elliott and Grayson (2001) there is a need to clarify the relationship between performance on tests of cognitive ability and driving performance. The aim of this pilot study was to identify non driving tests that would predict driving performance. The multiple regression analysis shows that the two measures entering the model after forced entry of age and group were Zazzo time and movement perception. These two tests demand little in the way of equipment or examiner time and this study shows that there measurements are linked with driving ability. As the volunteers were recruited via an insurance company with a great majority of people having a high study level, it is possible that the others neuropsychological tests should have also been relevant in predicting driving performance in another context.

Because of an increasing prevalence of dementia of the Alzheimer type (DAT) and the observation of greater impairement of road skills in subjects with DAT compared with older drivers who were controls (Fox and others, 1997) a systematic emphasis should be given to the detection of severe cognitive impairment in the assessment of older driver fitness. For some visual decline there is a need to inform the drivers on the consequences they have and on how drivers can cope with these declines. For these reasons, their is a need to introduce standard screening tests, to identify drivers suspected of having sensorial or cognitive deficits who need to change their behaviour or re-learn various skills, or those who are unsafe to continue driving. Sensorial and cognitive screening tests could determine the need for more in-depth performance based methods of screening when deciding fitness to drive. But it is difficult to decide what the cut-off points on sensorial or cognitive tests should be. More experimental researches are needed to define them.

But before developing such studies a standardised methodology should be adopted to assess the driving competency. As mentioned by De Raedt and Ponjaert-Kristoffersen (2001), predicting driving ability as observed on road test is less problematic than predicting real-world accident involvement. The type of route used in this study seems to be long and varied enough to permit the evaluation of volunteers' driving skills. The penalty scores rated by the examiner will be rated a second time by another person, using the video, to evaluate the reliability of the evaluation grid.

Brouwer (2002) indicate that consequence of impairments of perception or cognition is that the afflicted person needs more time to identify and respond to an object or situation. This study shows that under time pressure the driving skills realised on the operational level are altered for some experienced drivers. This study is only indicating preliminary results concerning the operational level of the driving task. As mentioned by Hakamies-Blomqvist (1994), caution is warranted when using measures assessing mainly operational aspects of the driving task because compensatory behaviour appears at a strategic levels and problems at subsequent levels may be avoided. The existence of such opportunities for compensation in the driving task must be taken into account when formulating the ability requirements. So, at the tactical or strategical levels, adaptative strategies must be explored even if they are not yet concerned. In this study a further analysis of the data collected by questionnaire will be done later on, to search some compensations or accommodations. This study confirm also a result obtain by Brouwer and Ponds (1994) indicating that compensation breaks down in complex and ambiguous traffic situations. In fact, five quite safe drivers (having less than 30 penalty points) encountered severe difficulties (i.e. having more than 3 penalty points at the check point) in three part of the route especially ambiguous. Nevertheless some behavioural problems seems to be existing in the case group as their violation score is significantly different from the control group. When analysing the questionnaire the behavioural difference between these two groups will be studied.

It is clear that this study is not very predictive because subjects are not driving their own car an moreover they are driving in an unfamiliar sector. This problems was called up by various authors (Lundberg and Hakamies-Blomqvist, 2003; De Raedt and Ponjaert-Kristoffersen, 2001). In this study, in an attempt to standardise the test situation (to enhance compatibility across subjects and to ensure uniform scoring) a fixed route for the road test was used. It might be interesting to assess the same drivers using their own car on a current route to see if their driving skills (assessed with the same methodology standardised as many as possible) are also altered or not.

It is also interesting to observe that elderly drivers encountered difficulties with left turns and in particular left turns with traffic lights. Adapted intersections should be designed such that decision can be required sequentially. In general manner, traffic situation should be as predictable as possible to maximise the opportunity for anticipation for the older drivers. If the infrastructure was more standardised, especially the layout of roundabout and intersections, elderly drivers will be more at ease using them.

Conclusion

Two issues are important to consider with regard to monitor older drivers: the attempt to identify individuals with an excess risk of accident involvement and the attempt to find ways of maintaining or restoring functional capabilities.

If one day an elderly driver screening is compulsory as it will be the case in France in the next future because a legislative proposal is under study, such a regression equation (after being tested on a larger group of driver) can allow to estimate the driving skills of drivers not to deliver an aptitude or inaptitude certificate but it can allow to adapt the advice given to drivers and a lot of work need to be done in this framework.

The driving tests might be used to assess also compensatory behaviour using the scales to measure tactical compensation in a more specific way and an instrument to evaluate strategic compensation might be very useful. Such researches must stimulate rehabilitation programmes to train drivers with more adapted behaviours.

References

Brouwer, W. H., 2002, Attention and driving: A cognitive neuropsychological approach, *in* Zimmermann, P., and Leclercq, M., editors, Applied Neuropsychology of Attention: Hove, Psychology Press, p. 223-248.

Brouwer, W. H., and Ponds, R. W., 1994, Driving competence in older persons: Disabil Rehabil, v. 16, p. 149-61.

De Raedt, R., and Ponjaert-Kristoffersen, I., 2001, Predicting at-fault car accidents of older drivers: Accident Analysis and Prevention, v. 33, p. 809-819.

Dearagao, P., 1992, Circles and Roundabouts : An historic review, Actes du séminaire "Giratoires 92": Nantes - France.

Dobbs, A. R., 1997, Evaluating the driving competence of dementia patients: Alzheimer Dis Assoc Disord, v. 11 Suppl 1, p. 8-12.

Eby, D., Shope, J. T., Molnar, L. J., Vivoda, J. M., and Fordyce, T. A., 2000, Improvement of older driver safety through self evaluation: The development of a self-evaluation instrument, The University of Michigan.

Elliott, M., and Grayson, G., 2001, Dementia and driving, Transed, p. 278-287.

Fox, G. K., Bowden, S. C., Bashford, G. M., and Smith, D. S., 1997, Alzheimer's disease and driving: prediction and assessment of driving performance: J Am Geriatr Soc, v. 45, p. 949-53.
Gabaude, C., 2003, Exploration des capacités visuelles et attentionnelles des conducteurs âgés: Intérêts et techniques: RTS, numéro spécial conduite automobile et vieillissement.
Hagge, R. A., 1994, the California driver performance evaluation project : an evaluation of a new driver licensing road test: Sacramento, California department of motor vehicles.
Hakamies-Blomqvist, L., 1994, Compensation in older drivers as reflected in their fatal accidents: Accident Analysis and Prevention, v. 26, p. 107-112.
Janke, M. K., 2001, Assessing older drivers: Two studies: Journal of Safety Research, v. 32, p. 43-74.
Lundberg, C., and Hakamies-Blomqvist, L., 2003, Driving tests with older patients: effect of unfamiliar versus familiar vehicle: Transportation Research Part F: Traffic Psychology and Behaviour, v. 6, p. 163-173.
Parker, D., Reason, J., Manstead, A., and Stradling, S., 1995, Driving errors, driving violations and accident involvement: Ergonomics, v. 38, p. 1036-1048.
Reason, J., Manstead, A., Stradling, S., Baxter, J., and Campbell, K. L., 1990, Errors and violations on the roads: A real distinction?: Ergonomics, v. 33, p. 1315-1332.