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Can strategic and tactical compensation reduce crash risk in older drivers?

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Abstract

Objective: to determine whether the use of strategic and tactical compensation can successfully improve safety in older drivers.
Methods: 84 healthy subjects aged between 65 and 96 were referred for a fitness-to-drive evaluation. Using ANOVA and contrast analysis, we tested the hypothesis that bad drivers who have had no car accidents use more active compensation strategies than bad drivers who have caused accidents in the previous 12 months. We classified drivers as bad, average or good, based on a structured road test.
Results: drivers who select driving tasks below their capacities and compensate by adapting their driving style cause fewer accidents than those who do not apply these strategies.
Conclusions: fitness-to-drive screening procedures need a broader perspective to prevent an over-emphasis on procedures which focus more on deficit than on capacities.

Keywords: *accidents, ageing, compensation, driving*

Introduction

We have observed that safe car driving—as evaluated by means of a road test in which subjects are forced into difficult situations—can be predicted reasonably well by neuropsychological tests. In our multiple regression model, four neuropsychological tests (movement perception, useful field of view, cognitive flexibility and selective attention) explained 64% of the variance in a road test score, while only 19% of the variance of 'at-fault' accidents in the previous 12 months could be explained by two tests (visuo-spatial function and cognitive flexibility). These results indicate that there is little correlation between driving-related abilities and accidents.

Many authors suggest that the use of compensation strategies can lower the increased accident risk when cognitive functioning is decreased [1]. However, the success of these strategies in preventing accidents has never been investigated and is not supported by empirical evidence. The objective of this project is to determine whether the use of active compensation strategies can lower accident risk. This means that, with a positive, constructive approach, we focus not on the disabilities of older people, but rather on their possibilities for maximum mobility.

'Compensation' in gerontology is related to the fact that age-related deterioration of function (often observed during laboratory assessment) does not have as great an effect on performance in everyday activities as one would expect [2]. In Baltes and Graf's model of successful ageing [3], selective optimization with compensation is defined as a general strategy of mastery describing the effective management of life in the face of age-related losses in mental and physical abilities. According to this model, successful ageing is based on the interplay between 'selection', 'optimization' and 'compensation'.

In the transposition of this model to the research project, selection is considered as a mechanism whereby older people have to adapt their aspiration of dealing with driving conditions to their altered cognitive resources.

The strategic level in Michon's model of driving behaviour [4] describes the way in which people carefully prepare their trips (destination, route, timing, etc.) as 'strategic compensation'. Avoiding complex traffic situations and avoiding driving in the dark or in rain or fog are examples of such compensation behaviour. Optimization provides a means of maintaining high levels of functioning in selected areas through practice and the acquisition of new bodies of knowledge.

Compensation (in the Baltes and Graf model) becomes relevant in situations involving high mental or physical demands, and alternative ways of achieving goals can be substituted by adaptive behaviour. This is described by Michon [4] as 'tactical compensation' and includes speed adaptation and anticipatory behaviour.

We assessed whether the use of compensation strategies is dependent on self-perception or self-insight (metacognition).

Methods

Subjects

The sample consisted of 84 elderly people (24 women and 60 men) ranging in age from 65 to 96 years (mean = 78.6, SD = 6.8) who came to the Belgian Road Safety Institute (CARA) for a fitness-to-drive evaluation. They had been referred by their insurance company (following one or more accidents or because they had changed insurance company) or by their physician. Since this is a study on normal ageing, selection of subjects to be evaluated was made beforehand. Based on a detailed medical questionnaire completed by the family doctor, subjects with a neurological disorder that could affect neuropsychological functioning as well as those suspected of having dementia were excluded. The mean Mini Mental State Examination (MMSE) score of the sample was 27 (SD = 3). Subjects volunteered to participate and signed informed consent forms (two refused to participate).

Road test

Specialized driving instructors responsible for fitness-to-drive evaluation at the CARA centre administered the road test without being informed of the subjects' accident record or cognitive status. This road test consisted of a standardized 35-km route in and around Brussels, during which many different traffic situations were encountered. We evaluated the driving test on the basis of a detailed structured evaluation grid consisting of 11 scales, each rated on two or more three- or four-point scaled items. This instrument (the 'TRIP—Belgian version') was developed at the neuropsychology/gerontology department of the University of Groningen by Brouwer *et al.* in co-operation with the CBR and CARA fitness-to-drive assessment centres. We divided the scores into three categories using quartile scores ($<25\%$; 25–75%; $>75\%$) to distinguish between bad drivers, average drivers and good drivers.

Accidents

This independent variable refers to the occurrence or non-occurrence of self-reported 'at-fault' accidents in the previous 12 months. We assessed it by a questionnaire, completed in advance, followed by an in-depth interview at the start of the evaluation. Of the subjects, 63% reported 'at-fault' accidents in the previous year. This over-representation, which was due to the sampling procedure in which many subjects were referred because of accidents, is essential to ensure reliable comparability of groups with and without accidents.

Evaluation of compensation strategies

To evaluate strategic compensation, we devised a questionnaire to be completed beforehand. The participants indicated which of 16 difficult traffic situations (driving in the rush hour, in complex environments etc.) they avoided while driving.

To evaluate tactical compensation, we used four specific observations during the road test: distance from the car in front (on a five-point scale from 'too close' to 'too far'); choice of speed (on a five-point scale from 'too fast' to 'too slow'); and anticipation behaviour both in changing traffic situations and during changing road situations (each on a four-point scale from 'unsatisfactory' to 'good'). We transposed all scales to a five-point score to obtain equal weighting for each item.

Evaluation of planning functions

To evaluate the executive planning function we used a random-number generation [5] task. The subject had to generate 100 numbers from 1 to 10 in maximum random order. In this task, a new strategy (generating random numbers) has to be implemented and a routine task (counting) must be suppressed. We used the mean successive difference as a dependent variable. Mean successive difference $= \sqrt{[\text{sum}(x_1 - x_{1+1})^2/(n-1)]}$, where $n = 100$ and x are the consecutive numbers. This formula detects the tendency to count. A trend toward counting yields a lower mean successive difference.

Evaluation of metacognition

To evaluate metacognition, we asked four questions, followed by relevant items (78 items in total).

1. What do you find the most difficult to do (with respect to the driving task)?
2. With what do you have most problems while driving?
3. What driving conditions do you find most difficult (even if you usually avoid them)?
4. In your view, what causes most problems while you are driving?

This questionnaire was filled in beforehand. We asked subjects to underline on each list of 13 items the three items that applied most to them. On the day of the evaluation, each item was scored by means of a five-point Likert scale (from 'not really' to 'exceedingly'). In this way, subjects could illustrate their answers in more detail. Since subjects were initially expected to underline three items, they could indicate afterwards whether 'not really' applied (scored as 0).

MMSE

General cognitive decline could adversely affect the reporting of driving-related problems as well as the reporting of the number of difficult situations that are avoided (metacognition and strategic compensation), we therefore calculated the correlation of these questionnaires with MMSE scores [6].

Statistical methods

Analyses were performed with Statistica for Windows 5.1.

Results

Strategic and tactical compensation

We analysed the effect of strategic compensation on the occurrence of accidents by a two-way between-subjects ANOVA with the 'strategic compensation score' as a dependent variable and the 'road test score' (<25%/25–75%/75%) and the occurrence of 'accidents' (accidents/no accidents) as factors (see Figure 1).

This analysis yielded a significant main effect for the 'road test score' [$F(2,78) = 12.4$, $P < 0.0001$], indicating a higher strategic compensation score for bad drivers. A significant main effect was found for the occurrence of accidents [$F(1,78) = 4.8$, $P < 0.04$], indicating more compensation in the no-accident group. A significant interaction effect was observed between the 'road test score' and 'accidents' [$F(2,78) = 5.9$, $P < 0.005$].

Since we hypothesized that bad drivers could lower their accident risk by strategic compensation, we used contrast analysis on this part of the design. This analysis showed that drivers in the bad driving group who were free of accidents used significantly more compensation than bad drivers with an accident history in the previous 12 months [$F(1,78) = 7.8$, $P < 0.01$]. The groups of average and good drivers showed no significant difference between subjects with and without accidents (see Table 1).

We analysed the effect of tactical compensation on the occurrence of accidents by the same type of ANOVA with the tactical compensation score as a dependent variable (Figure 2). This analysis yielded a significant main effect for the 'road test score' [$F(2,78) = 13.1$, $P < 0.0001$], indicating less tactical compensation for bad drivers. Moreover, a significant main effect was found for 'accidents' [$F(1,78) = 5.1$, $P < 0.03$], indicating more tactical compensation in the no-accident group. Contrast analysis showed that drivers in the bad driving group who were free of accidents used significantly more tactical compensation than bad drivers with accidents

Table 1. Mean tactical and the strategic compensation scores and standard deviations, by group

		Compensation score			
		Tactical		Strategic	
Group	*n*	Mean	SD	Mean	SD
Bad drivers					
No accidents	5	14	1.5	10.8	4.4
Accidents	16	11.6	3	6.3	2.8
Average drivers					
No accidents	16	14.5	1.4	3.6	3.2
Accidents	26	14	1.7	5.2	3.7
Good drivers					
No accidents	10	15.9	0.3	4.6	3
Accidents	11	15.7	0.5	2.4	1.4

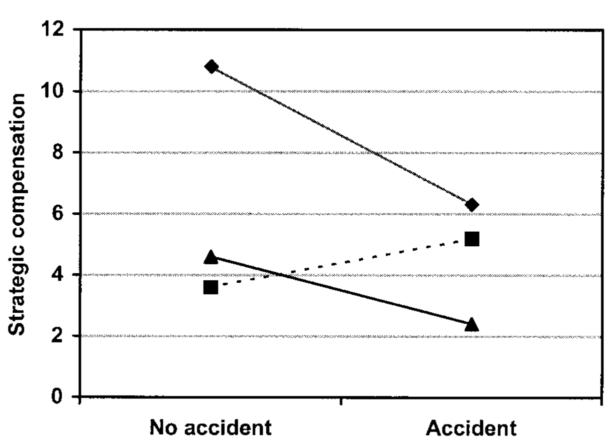

Figure 1. Strategic compensation scores for bad (◆), average (■) and good (▲) drivers with and without a history of accident.

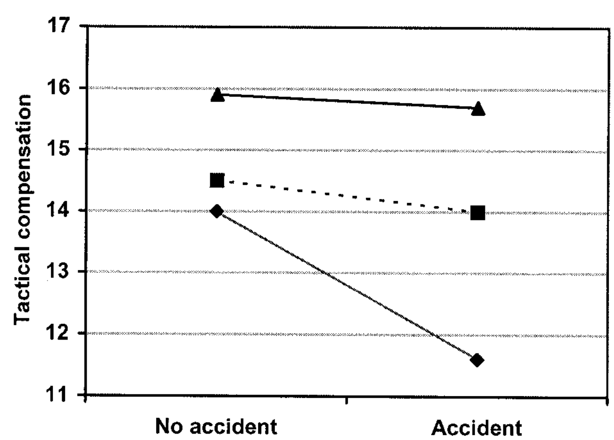

Figure 2. Tactical compensation scores for bad (◆), average (■) and good (▲) drivers with and without a history of accident.

[$F(1,78) = 6.7$, $P < 0.02$]. Among the average and good drivers, there was no significant difference between those with and those without accidents (Table 1).

Metacognition and planning

Metacognition (self-insight) showed no correlation with tactical or strategic compensation ($r = 0.09$ and $r = 0.04$). Concerning the 'random number generation' task, we observed no significant correlation with strategic compensation ($r = 0.18$), and observed a significant correlation of $r = 0.27$ with tactical compensation.

MMSE scores

There was no significant correlation between MMSE and metacognition ($r = 0.12$) or between MMSE and the strategic compensation score ($r = -0.19$). The mean MMSE scores for the different subgroups (accident/no accident, bad/average/good driver) ranged between 24 and 28. (The lowest scoring group were bad drivers with a history of accident, the highest were average drivers without and good drivers with or without a history of accident.)

Discussion

Elderly people assessed as being bad drivers (as observed during a road test where the subject is placed in complex and tricky situations) seem to be able to avoid accidents using strategic and tactical compensation mechanisms. The absence of a correlation between strategic compensation and mileage in the group of bad drivers highlights the fact that successful compensation does not mean reduced mobility, but only reduced exposure to difficult situations. The self-reporting reliability of our metacognition and strategic compensation questionnaires could be adversely influenced by cognitive decline: the MMSE scores of our population did not indicate pathological cognitive decline and there was no correlation between MMSE scores and the number of items reported on both questionnaires.

The bad driver group yielded the highest scores for strategic compensation, indicating that only bad drivers select traffic situations below their capacities. Moreover, in the groups of better drivers, no difference in strategic compensation score was found between people with and people without accidents, indicating that they do not resort to strategic compensation strategies to avoid accidents. Better drivers use less strategic compensation, although they too might benefit from it. Indeed, more than half of the subjects in the group of good drivers with low strategic compensation scores had a history of accidents. Nevertheless, the strategic compensation score shows higher scores for the accident-free group, indicating the usefulness of these strategies as a means of avoiding accidents. However, the tactical compensation scores were quite high for all groups, except for the bad driver group, which had a markedly lower score. Moreover, the bad driver group was the only group with a significantly lower tactical compensation score among those who had had accidents compared with those who had not had accidents.

These results indicate that average and good drivers (as rated by experts) use more tactical compensation (driving slow, keeping further away from the car in front, anticipation) than bad drivers and that tactical driving style adaptations seem to be successful in avoiding accidents. In fact, a main effect was observed of the tactical compensation score for 'accidents', with higher scores for the accident-free group. There is consensus that age-related decline of driving-related neuropsychological functions at an operational level may be compensated by strategies at a strategic and tactical level [e.g. 7], although this had never been tested directly. However, self-insight does not appear to be related to the use of such strategies. In a recent study involving older drivers, indications were found for a general lack of awareness concerning driving problems [8]. It is probable that the immediate goal of compensation behaviour of older drivers is to reduce mental load, with increased safety a by-product rather than the main goal of the behaviour [9]. This could be the reason for the absence of a correlation between compensation and self-insight. Compensation might occur automatically to eliminate cognitive load rather than because a person perceives a potential danger or a decline in his capacities. This idea is also supported by the observation that compensation occurs also in complex tasks without safety risks [10].

On the other hand, a cognitive measure of planning function has been correlated to some extent to the use of tactical compensatory mechanisms. We chose the 'random generation task' as a measure of driving-related planning abilities because this task requires the implementation of a new strategy with suppression of automatic repertories (the counting trend): as Hakamies-Blomqvist has said, "The execution of any highly over-learned skills with large automatic subroutines must be modified according to the functional changes of the ageing performer" [9]. Suppressing automatic actions is important while driving, but may be less relevant to strategic compensation, which can be organized beforehand without time pressure. This might explain the absence of a significant correlation between the 'random generation task' and strategic compensation.

These results indicate the importance of focusing not only on shortcomings during assessment but also on possibilities of maintaining safe driving standards, in spite of certain problems. Although there has been, until now, no direct evidence to support the usefulness of compensation, there is some indirect evidence. For example, Hakamies-Blomqvist found fewer accidents occurred under difficult situations with older drivers than with younger drivers [9]. However, why many older drivers do not use compensation strategies remains unresolved. The group of bad drivers with an accident history was three times larger than the group without accidents. It would therefore be advisable to include an evaluation of compensatory abilities in fitness-to-drive assessment procedures. Special courses could be developed to enhance the use of such strategies. Many such courses are currently organized [11]. The absence of a correlation between the use of compensation strategies and self-insight suggests that, since car driving is a highly automated task, less effort should be put into the enhancement of self-insight and more into the acquisition of new automatic compensatory actions. Although research reveals that elderly people have more difficulties with the acquisition of new automatic actions [12], older subjects are able to learn perceptual motor skills [13] and procedural planning strategies [14] as well as younger subjects (although they may need more time to reach the same level of performance).

At present, the retraining of older drivers in road programmes focuses mainly on theoretical aspects. Implementing scientifically-based practical retraining driving courses adapted to elderly drivers could, therefore, be potentially useful in enhancing safety among older drivers, bearing in mind the mobility needs of older drivers.

Since this is the first study using a direct methodology to assess the effect of compensation on a rather small sample, the results need replication. Nonetheless, they reveal that neuropsychological screening procedures need a broader perspective to prevent over-emphasis on unidimensional screening procedures focusing mainly on deficits and less on capacities for safe driving behaviour.

Key points

- Older people with driving problems who use compensation strategies can avoid accidents.
- Screening procedures must focus on capacities as well as deficits.

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References

1. Christ R. Ageing and driving—decreasing mental and physical abilities and increasing compensatory abilities. IATSS Res 1996; 20: 43–52.

2. Salthouse TA. Cognitive competence and expertise in aging. In Birren JE, Shaie KW eds. Handbook of the Psychology of Aging. San Diego: Academic Press, 1990.

3. Baltes PB, Graf P. Psychological aspects of aging: facts and frontiers. In Magnusson D ed. The Lifespan Development of Individuals: behavioral, neurobiological, and psychosocial perspectives. Cambridge: Cambridge University Press, 1996; 427–60.

4. Michon JA. Modellen van bestuurdersgedrag. In Van Knippenberg CWF, Rothengatter JA, Michon JA eds. Handboek Sociale Verkeerskunde. Assen/Maastricht: Van Gorcum, 1989; 207–31.

5. Rosenberg S, Weber N, Crocq MA *et al.* Random number generation by normal, alcoholic and schizophrenic subjects. Psychol Med 1990; 20: 953–60.

6. Folstein ML, Folstein SE, McHugh PR. Mini Mental State: A practical method for grading the cognitive status of patients for the clinician. J Psychiatr Res 1975; 12: 189–98.

7. Brouwer WH. Ageing and information processing. Proceedings of the Symposium on Aging and Driving, Stockholm, 24 September 1994. Stockholm: Karolinska Institutet, 1994.

8. Marottoli RA, Richardson ED. Confidence in, and self-rating of, driving ability among older drivers. Accid Anal Prev 1998; 30: 331–6.

9. Hakamies-Blomqvist L. Compensation in older drivers as reflected in their fatal accidents. Accid Anal Prev 1993; 26: 107–12.

10. Welford AT. The gerontological balance sheet. In Cerella J, Rybash J, Hoyer W, Commons ML eds. Adult Information Processing: limits on loss. San Diego: Academic Press, 1993; 3–10.

11. Staplin L, Lococo KH, Stewart J *et al.* Safe Mobility for Older People Notebook. Research report no. DTNH22-96-C-05140. Washington, DC, USA: National Highway Safety Administration, 1999.

12. Korteling JE. Effects of aging, skill modification and demand alternation on multiple-task performance. Hum Factors 1994; 36: 27–43.

13. Thomas-Anterion C, Marion A, Laurent B *et al.* Aging and procedural memory. Study of a series of tests on micro-computers. Rev Med Interne 1994; 15: 581–8.

14. Vakil E, Agmon-Ashkenazi D. Baseline performance and learning rate of procedural and declarative memory tasks: younger versus older adults. J Gerontol B Psychol Sci Soc Sci 1997; 52: 229–34.

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