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Effectiveness of two cognitive training programs on the performance of older drivers with a cognitive self-assessment bias

INTRODUCTION

Since about a half-century, several demographic developments result in a continuous rise in the number of older adults in industrialized countries. An OECD report predicted that one quarter of the population of its members countries will be aged 65 or older by 2050 (OCDE, 2012). Consequently, the number of older adults on the roads is increasing. Driving is a complex activity which required visual, psychomotor and cognitive functions. Normal ageing entails a decrease in visual, psychomotor and cognitive abilities which could affect drivers' safety (Anstey et al., 2005). Older drivers are physically more fragile and vulnerable than younger ones, and present a major risk of injury during a road accident (Lafont and Laumon, 2003). In order to deal with the deterioration of their health, some older drivers are stressed in certain traffic situations and choose (or are obliged) to stop driving (Hakamies-Blomqvist and Wahlstrom, 1998). This solution has noticeable negative consequences such as the social isolation or the increased risk of depression (Boots et al., 2013; Edwards et al., 2009b). However, by ageing, older drivers also use compensatory strategies consisting of the avoidance of difficult situations (e.g. driving at night, in bad weather, or during rush hours), or an individual adaptation (e.g. by increasing safety distances or reducing speed; Ball et al., 1998; Donorfio et al., 2009; Gabaude et al., 2010; Holland and Rabbitt, 1992; Molnar and Eby, 2008). These strategies define the driving self-regulation, which consists in the behavioral adaptation of the driver to maintain a safe driving despite the age-related functional decline (Donorfio et al., 2008). A correct self-regulation of driving is based on a correct calibration, which consists in a fair balance between the assessment of skills and the task demands (Kuiken & Twisk, 2001). Self-regulation strategies used by the drivers, aiming at reducing task demands, depend on: i) the correct self-assessment of driving skills, ii) the correct evaluation of the task complexity, and iii) the correct choice of the adapted behavior (De Craen, 2010). Ageing is associated with the impairment of lower level skills, based on cognitive, sensory and motor functioning (Siren & Meng, 2013). This functional decline causes a discomfort while driving and leads the driver to self-regulate his driving (Meng & Siren, 2012). However, this pattern of actions is not always fulfilled and drivers with low cognitive performance are more inclined to incorrectly self-regulate their driving (Baldock et al., 2008; Wong et al., 2012). Finally, the awareness of cognitive difficulties is essential to correctly adapt the behavior (Anstey et al., 2005) and appears to be a key factor in the self-regulation of driving (Meng & Siren, 2012). To conclude, the improvement of both the awareness of cognitive difficulties and the cognitive performance by itself is important to help older drivers correctly self-regulate their driving behavior.

Various interventions have been designed to help older drivers to use adaptive self-regulation strategies and maintain their driving safe. First, self-assessment and self-screening questionnaires have been useful to reveal driving-related difficulties and to initiate discussion with family and relatives about keep driving or stop it (Eby et al., 2003; Holland and Rabbitt, 1992; Levasseur, et al., 2013; Molnar et al., 2010). Thus, although these questionnaires were effective to improve self-awareness, there is still a difference between declared self-regulation and real, applied self-regulation. Second, educational interventions in which an occupational therapist reminds older drivers about driving rules; gives recommendations for a safer driving and information about age-related difficulties did not improve the on-road driving performance (Bédard et al., 2004), nor prove any crash rate reduction (Ker et al., 2005; Nasvadi and Vavrik, 2007). Furthermore, this type of intervention could even have the opposite effect and activate the stereotype threat of the elderly. This concept reflects the psychological effect of the stereotype on older adults: the behavior of a person who perceives the stereotype threat tends to confirm the negative stereotype of the group to which he belongs (Steele and Aronson, 1995). This stereotype has a negative effect on older adults' driving-related cognitive performances (Chapman et al., 2014) and driving performance (Joanisse et al., 2013), and prevent older drivers in correctly self-regulate their driving (Moták 2011). Third, educational interventions coupled with practical driving training (on-road or with a driving simulator) showed an improvement of driving knowledge regarding traffic rules and road safety (Bédard et al., 2008; Marottoli 2007), and on-road transfer of the driving skills trained on simulator (Lavallière et al., 2012; Romoser and Fisher 2009; Roenker et al., 2003). Finally, in parallel with the improvement of self-awareness, several studies have assessed training programs benefits on driving abilities of older adults. Training physical abilities through aerobics, fitness or stretching improved neck, shoulders, and back flexibility leading to better vehicle handling, visual scanning, and more mirrors controls, inducing an improvement of driving skills and on-road driving performance (Caragata et al., 2009; Marottoli et al., 2007). In addition, even though cognitive training improved cognitive abilities relevant for the driving safety (Marmeleira et al., 2009), contradictory results have been found regarding the benefits of cognitive training on simulated driving performance (Cassavaugh and Kramer, 2009; Gaspar et al., 2012; Seidler et al., 2010). A training aimed at processing speed and visuospatial abilities reduced the number of dangerous maneuvers on a driving simulator and allowed seniors to keep driving longer (Edwards et al., 2009a, c).

To conclude, educational programs are not sufficient to improve the driving performance of older drivers, educational and practical training programs are more effective, but are costly, and finally, cognitive training programs, which are cheaper, present advantages for driving safety but, they need to be confirm on the road. Discrepancies of these findings can assumed to be due to the different levels of self-awareness present in older drivers. Indeed, people whom are aware of their own abilities could use adapted strategies learnt during these programs. However, people whom are not aware of their own abilities could not take full advantage of the content of these programs (Meng & Siren, 2012).

Our study is based on the hypothesis that older drivers training needs are not the same depending on the self-assessment of their cognitive abilities, and how they regulate their driving activity. Indeed, a correct self-assessment of their cognitive abilities would lead them to correctly adapt their behavior, and consequently correctly self-regulate their driving activity. Among these cognitive incorrect estimators, we could distinguish two categories of people: over-estimators (OE), who are people thinking they have cognitive abilities higher than same-aged people, whereas they are not; and under-estimators (UE), who are people thinking they have lower cognitive abilities than same-aged people, whereas they are not. Thus, an intervention aiming to improve the self-awareness of cognitive abilities of older drivers could allow OE to reduce their risk of injury exposure, and UE to regain self-confidence and keeping them driving longer. Therefore, this intervention attempts seniors to keep driving in safe conditions.

The purpose of this study was to compare the effectiveness of two training programs: a pure cognitive training and a cognitive training coupled with the experience of driving in a simulator specifically aimed at older drivers with a cognitive self-assessment bias. Effectiveness of the training was evaluated on the self-assessment of older drivers' cognitive abilities and on their cognitive and driving performances. The first hypothesis was that the cognitive training would allow drivers to become aware of their cognitive abilities, thanks to feedback on performance received all along the training program. As this training was focused on cognitive functions required while driving, the second hypothesis was that the driving simulator immersion would allow the transfer of the training benefits on the road, by improving the driving performance. As the experiment is still in progress, this paper presents preliminary results.

METHOD

Participants

Participants included in our study came from the Safe Move cohort, comprising 1200 older drivers aged at least 70 years. The self-assessment of their cognitive abilities was determined comparing the objective and subjective cognitive performances. The comparison between results from two cognitive tests (the Wechsler Digit Symbol Substitution Test and the Trail Making Test parts A and B) and normative data (from performance of people having the same age and the same educational level) resulted in the objective cognitive performances. By crossing these data with the subjective ones collected thanks to a self-assessment questionnaire, three profiles of drivers emerged: under-estimators (UE, 15% of the cohort, or 180 drivers), correct estimators (CE, 42% of the cohort, or 502 drivers), and over-estimators (OE, 43% of the cohort, or 508 drivers) (Lafont et al., 2014). One hundred and twenty drivers

(OE and UE), recruited from the cohort, are expected to be included in our study. The inclusion criteria were: drive at least three thousand kilometers per year, have a computer connected to Internet (essential to complete the cognitive training), not susceptible to motion sickness or have vertigo or Meniere's disease (in order to restrict the number of participants sick on the driving simulator), and have a visual acuity higher than 5/10th at the Monoyer's test.

Experimental design

The experimental design of the study consisted of the "training" factor comprising two conditions: "cognitive training" (CT), "cognitive training coupled with driving simulator immersion" (CT + DS), and "control activity". Performances were compared between baseline and after three months of activity (training or control). Three groups were constituted: 40 participants (20 OE and 20 UE) performing a computerized cognitive training (36h); 40 participants (20 OE and 20 UE) performing the same cognitive training (35h) associated with a driving simulator immersion (1h), and 40 participants (20 OE and 20 UE) performing a control activity (36h of reading).

Computerized cognitive training program

A collaboration with a company specialized in cognitive training (named Scientific Brain Training, or SBT) was conducted. SBT developed a training program called Happyneuron®. The effectiveness of this training method has been proven among seniors exempt of pathology (Croisile, 2006). Twenty exercises with 15 difficulty levels each from the Happyneuron® program were used in our study. These exercises were specifically focused on functions required in the driving activity as: attention (8 exercises, with, for example, exercises aiming at clicking on moving ladybugs as often as possible while ignoring the distractions; or evaluating the speed of moving object), memory (4 exercises, with, for example, exercises aiming at memorizing itineraries through different countries; or location of monuments in different cities across the world), executives functions such as updating, flexibility, or planning (4 exercises, with, for example, exercises aiming at rebuilding the tower of rings by making strategic moves), and visuo-spatial abilities (4 exercises, with, for example, exercises aiming at guessing from which point of view the pictures were taken). Another collaboration has been involved with an e-learning company, Symetrix, which contributed to provide the technologic support for the study's realization. From this mutual work came up a learning management system (LMS) allowing our participants to complete the different cognitive exercises. Hence, each participant had his/her own personal account in which he/she could log in and complete his/her daily activity and could get information about his/her last performances and progression on this program. The choice of the cognitive exercise was made by a virtual coach, whom also chose the difficulty level following a progression rule: if the exercise was successful (100%), the participant passed to next level, if the score was comprised between 70 and 99%, the participant remained at the same level, and if the score was below 70% three times in a raw, the participant went down to the lower level. After completing an exercise, the participant got a feedback about his/her performance: the score obtained (in percent), the average reaction time, and a sentence that encouraged the trainee to continue. Participants were told to train three hours per week during twelve weeks.

Driving simulator experience

The study was carried out in an instrumented full-cab fixed-base simulator (308 Peugeot). This simulator consisted in virtual reality-based visual and audio systems, a computer program for vehicle motion simulation, and a host computer system for simulating the driving environment. The road scene was projected in the front, on five screens (220 x 165 cm and 1024 x 1280 pixels) which provided an approximate 270° horizontal and 40° vertical view of the virtual environment. Force feedback was provided through the steering wheel, and auditory feedback was delivered in the form of engine and outside noises. Driving performance parameters were captured at 60 Hz from the sensors from the equipment (brake, accelerator and steering wheel). The simulator was also equipped with a CAN-bus system to send/receive information to/from the car. The simulator was also equipped with cameras (front view: traffic and infrastructure; driver view: visual activity and verbalizations; driver and environment view: overall behavior of the driver and pedals use). Microphones allowed interaction between the driver and the experimenter (e.g. give the instructions to the participant at the beginning of the simulation).

Before the first driving session, participants drove on an urban scenario during 10 minutes to familiarize with the car and the virtual reality device. Three 20-minute simulated driving sessions were completed by each participant of the experimental CT + DS group. Five training scenarios were performed during each driving simulator session: pedestrian crossing, intersection with traffic lights, vehicle following, left-turn, and overtaking on a highway. These situations were chosen after a literature review on the situations perceived as complex, avoided by older drivers, or with a high crash risk (Lallemand et al., 2013). Three difficulty levels were available for each trained situation. Each participant began the simulated drive at the easiest level. Thanks to an algorithm developed in our laboratory and assigning penalty points depending on the driver’s behavior, a performance score between 0 and 100 was calculated for each situation. When the score was equal or less than 50/100, the participant remained at the same level and retried an equivalent situation during the next driving session. When the score was higher than 50/100, a higher difficulty level situation was unlocked and presented to the participant during the next driving session. Feedback was given to the participant after each driving situation through a screen placed inside the vehicle. If the score was less than 50/100, the feedback consisted of the educational goals waited to reach the next level. Conversely, if the participant successfully completed the exercise, the feedback congratulated him/her and indicated the progression to a higher difficulty level. To avoid the test-retest effect, alternative learning situations had been developed. Hence, the participant could not face the same situation twice.

Neutral control activity

The control group followed an activity inspired by the work of Smith and colleagues to observe an involvement in the program during thirty-six hours of computer activity (Smith, et al., 2009). The principle was to replicate as much as possible the experimental conditions of the experimental groups, through the type of activity, its support, and duration. Participants from the control group were instructed to read articles posted on the SAFE MOVE platform and answer to simple quiz. Each article was accessible only once and various themes of reading were offered to satisfy tastes and interests of each driver. Moreover, as for the cognitive training, participants received feedbacks on their quiz performance. This activity was not supposed to contribute to the improvement of cognitive functions solicited while driving because only focused attention and short-term memory were involved in this reading exercise.

Evaluation

Cognitive evaluation

The cognitive performance was objectively evaluated via the Trail Making Test and the Digit Symbol Substitution Test. The cognitive performance was also evaluated subjectively, with a self-assessment questionnaire composed of five questions. The participants had to rate his/her own cognitive abilities on Likert scales, compared to same-aged people. For example, a question about focused attention was “Compared to people of the same age, is it more or less difficult for you to concentrate?” The participant had to answer on a five-point scale ranging from “Much less difficult” to “Much more difficult”. A self-assessment score was calculated by adding the responses obtained at the different questions. In addition, the Useful Field Of View test (UFOV®) was performed to assess the speed of processing and visual attention of our participants. This computerized test of visual attention took place on a computer provided with a 17” screen. It included three subtests, assessing the processing speed, the divided attention, and the selective attention.

Driving evaluation

The on-road driving evaluation was conducted by a driving instructor seated at the right of the driver, in an instrumented vehicle. This car was a 5 speed manual transmission 307 Peugeot, fitted with dual controls and dual rear-view mirrors. Sensors were placed on pedals to record driver’s actions. Other sensors recorded steering wheel angle, car speed, distance travelled, indicators use, and GPS position. These data were recorded on an onboard computer. These records were used to retrospectively analyze driver behavior (e.g. sudden braking, inappropriate speed, etc.) throughout the trip. The experimental vehicle was also equipped with video cameras to collect information about the driver’s behavior in real driving condition (front view: traffic and infrastructure, rear view: traffic, driver view: visual activity and verbalizations, driver and driving instructor view: overall driver behavior and actions of the instructor). The road trip lasted about 40 minutes for 28 km traveled. During the first ten minutes, the participant drove to familiarize with the vehicle. The route combined: urban circuit, suburb and rural circuits and a section of ring road / highway. During this course, the participant experienced different infrastructure types (intersections, roundabouts, insertions or ring-road exits, or lane changes). The driving instructor gave the direction to the driver throughout the trip. Two different but equivalent road trips were performed at baseline and post-training to avoid the test-retest effect.

Two grids were used to assess the driving performance; one completed by the driving instructor and the other by the experimenter. The driving instructor and the experimenter were blind regarding to the cognitive profile of the participant (OE or UE). The first grid is an adapted French version of Test Ride for Investigating Practical fitness to drive (TRIP) (Withaar et al., 2000). This grid assessed eleven dimensions of driving: vehicle position on the road, vehicle tracking, speed, visual behavior, road signs, overtaking, anticipatory reactions, communication with other road users, confrontation to specific situations (such as left-turn or dual carriageway), vehicle handling, general impressions of the instructor. Each of these dimensions was evaluated as: insufficient, doubtful, sufficient, good or not applicable. The driving instructor completed this grid at the end of the course which led to a global score on 100 points. The second grid was completed in real time during the trip by the experimenter seated behind the driver. This pre-established observational grid consisted in a description of the encountered situations and a list of the potential driving behaviors, gathered into broader dimensions to ease coding: visual attention, interaction with other road users, planning, lane positioning, speed adaptation, car control handling, and driving instructor interventions. This detailed list of situations and potential behaviors limited the subjectivity of coding (Dobbs et al., 1998; Lafont et al., 2010). In addition, the experimenter could mention any unplanned event affecting the driver's behavior, or any action make by the instructor. The video recording allowed to complete the grid if the experimenter missed an event in real time. From this grid a penalty total score and seven penalty sub-scores (one for each dimension) were calculated, based on the driver's behavior.

Procedure

During their first visit in the laboratory, the study was presented to participants and they signed a consent form. Two evaluations took place at baseline and after 12 weeks of training, consisted of 2-hour sessions comprising the cognitive evaluation (1 hour) and the on-road driving evaluation (45 min). Between both, a 15min-break was given to the participant in order to limit fatigue effect due to the cognitive activities performed. After baseline, participants came back to the lab for their first supervised session, in 6-to10-persons groups (week 1), during which the experimenter presented the training program on the web platform. Then, participants began their computerized cognitive training or control activity at home. Two other supervised sessions (in week 4 and week 7) consisted of the presentation of normal ageing and cognitive functioning. During these sessions, participants discussed about what they liked or disliked in the program, and exposed difficulties they had encountered. Finally, five weeks after the last supervised session (week 12), the post-training evaluation took place. Participants from the CT + DS group completed their 20-minute simulator driving sessions each time they came for these supervised-sessions. The experimental design is summarized in the Table 1.

Table 1. Overview of the experimental design with detailed content of the evaluations and interventions provided to older drivers. CT: cognitive training. CT + DS: cognitive training + driving simulator experience. OE: over-estimators. UE: under-estimators.

Nature of the intervention	Duration and number of participants concerned	Content
Evaluation	- Before and after training - 2h each time - All participants (N = 120)	- Self-assessment of cognitive abilities - Objective evaluation - Trail Making Test (A and B) - Digit Symbol Substitution Test - Subjective evaluation

		(questionnaire) - Cognitive evaluation - UFOV® test - On-road driving evaluation - Test Ride for Investigating Practical fitness to drive - Behavioral observation grid
CT	- 36h of computerized cognitive training during 3 months - N = 40 (20 OE + 20 UE)	- 20 cognitive exercises with 15 difficulty levels each - Exercises focused ont: attention, memory, visuo-spatial abilities, executive functions

CT + DS	- 35h of computerized cognitive training during 3 months
	- 1h of simulated driving (3*20 min)
	- N = 40 (20 OE + 20 UE)
		- Cognitive training
		  - 20 cognitive exercises with 15 difficulty levels each
		  - Exercises focused on: attention, memory, visuo-spatial abilities, and executive functions
		- Driving simulator experience
		  - 5 scenarios with 3 difficulty levels each
		  - Situations: pedestrian crossing, intersection with traffic lights, vehicle following, left-turn, and overtaking on a highway

Neutral activity	- 36h of reading during 3 months - N = 40 (20 OE + 20 UE)	- Articles available on a web platform - Various themes of reading provided
Supervised sessions	- 3 sessions on week 1 (beginning of the training), week 4, and week 7 - 3h each time - All participants (N =	- Informative talks about normal ageing and cognitive functioning

	120)	

Statistical analyses

Statistical analyses were performed on Statistica® software. Cognitive and driving data were statistically analyzed with repeated-measures of analysis of variance (ANOVA) using a design with 2 groups (between subject factor: CT and CT + DS groups) X 2 time conditions (within-subject factors: baseline and post-training). Driving data (TRIP's scores and penalty scores from the behavioral grid) were transformed into standardized z-scores.

RESULTS

Of the 120 expected participants included in our study, 67 have finished the experiment. Among them, 40 followed the CT (18 UE and 22 OE) and 27 the CT + DS program (14 UE and 13 OE). Participants of both training groups did not differ in age neither in the time they spent on the training. Characteristics of the sample are detailed in Table 2. In addition, one participant could not complete the UFOV® during the post-training evaluation because of a problem with the computer.

Table 2. Characteristics of the 67 participants. CT = cognitive training group. CT + DS = cognitive training coupled with driving simulator experience. UE = under-estimator. OE = over-estimator. SD = standard deviation.

	CT		CT + DS		Total
	UE	OE	UE	OE	
Number of participants	18	22	14	13	67
Age (mean ± SD years)	74.6 ± 2.7	74.7 ± 4.1	75.6 ± 4.1	75.4 ± 4.5	75 ± 3.8
Gender	6 ♀, 12 ♂	9 ♀, 13 ♂	4 ♀, 10 ♂	4 ♀, 9 ♂	23 ♀, 44 ♂
Playtime (mean ± SD hours)	30.3 ± 10.8		27.3 ± 11.2		29.1 ± 11

Cognitive performance

Repeated measure of ANOVA of the UFOV® data showed a time effect on the processing speed ($F(1, 64) = 5.68$, $p = 0.02$, partial eta-squared: 0.08), the selective visual attention ($F(1, 64) = 16.5$, $p = 0.0001$, partial eta-squared: 0.20), and the divided visual attention ($F(1, 64) = 5.82$, $p = 0.019$, partial eta-squared: 0.08), without a training effect. Participants of both training groups significantly improved their visual attention performance, resulting in shorter reaction times after training at: i) the speed of processing sub-test (-28%), the divided attention subtest (-33%), and iii) the selective attention sub-test (-14%).

Driving performance

TRIP grid

Statistical analyses did not show any modification of the TRIP's total score ($F(1, 65) = 2.41$, $p = 0.12$) neither of the tactical compensatory sub-score ($F(1, 65) = 0.36$, $p = 0.55$), nor of the operational sub-score ($F(1, 65) = 0.86$, $p = 0.36$) for both experimental groups. However, participants improved their tactical sub-score ($F(1, 65) = 5.69$, $p = 0.02$) regardless the training they completed.

Behavioral observation grid

The Spearman correlation test revealed a negative correlation between the TRIP's total score and the penalty total score both at baseline ($r = -0.53$, $p < 0.001$), and after training ($r = -0.30$, $p = 0.013$), indicating that the fitness to drive, determined by the driving instructor, is associated with few driving errors, mentioned by the experimenter.

Statistical analyses of the standardized scores from the behavioral observation grid did not show any modification of the total penalty score ($F(1, 65) = 1.67$, $p = 0.20$) for both experimental groups. By analyzing in detail each dimension rated in the grid, repeated measures of ANOVA showed no post training changes for the visual attention penalty sub-score ($F(1, 65) = 0.41$, $p = 0.53$), neither for the interaction with other roads users penalty sub-score ($F(1, 65) = 0.40$, $p = 0.53$), nor for the planning penalty sub-score ($F(1, 65) = 0.98$, $p = 0.32$), nor for the lane positioning sub-score ($F(1, 65) = 0.23$, $p = 0.63$), and nor for the driving instructor interventions ($F(1, 65) = 1.28$, $p = 0.26$). By contrast, repeated measures of

ANOVA indicated a time X training group interaction for the speed adaptation penalty sub-score ($F(1, 65) = 6.39$, $p = 0.014$), and for the car control handling penalty sub-score ($F(1, 65) = 5.19$, $p = 0.026$). For both dimensions, these penalty sub-scores decreased after training for the CT group, whereas they increased for the CT+DS group.

Self-assessment of cognitive abilities

After training, the comparison between objective and subjective cognitive data of our participants was performed, as described above (Lafont et al., 2014). Results of this cognitive self-assessment are presented in Table 3. This table shows that, compared to baseline, half of the participants from the CT group and a little more than a third of those from the CT + DS group correctly self-assess their cognitive abilities after training.

Table 3. Self-assessment of cognitive abilities of 67 drivers at baseline and after training. CT = cognitive training group. CT+DS = cognitive training coupled with driving simulator immersion. UE = under-estimator. OE = over-estimator. CE = correct estimator.

	CT		CT+DS	
	Baseline	Post-training	Baseline	Post-training
UE	18	5	14	8
OE	22	15	13	8
CE	-	20	-	11

DISCUSSION

After three months of cognitive training, both groups significantly improved their speed of processing and visual attention. This result is in accordance with a previous research in which a cognitive training combined to physical exercises allowed a beneficial contribution on the speed of processing and visual attention (Marmeleira et al., 2009). Our cognitive training contained several exercises focused on visual attention, effective to enhance the width of the useful field of view of our participants. Hence, participants have less difficulty to detect peripheral visual information. Moreover, the three sessions of simulated driving did not change the visual attention performances at the UFOV® test, as previously demonstrated by Roenker and colleagues (2003). Performances at the UFOV ® test are associated with crash risk and also on road driving performance (Ball et al., 1993; Owsley et al., 1991, Sims et al., 2000, Whelihana et al., 2005). Thus, the improvement of visual attention should be associated with a reduced crash risk and better driving performances.

The hypothesis was that the driving simulator contribution would allow a transfer of the cognitive training benefits on the road. Results on driving performance showed that both training programs improved the tactical sub-score of the TRIP. This finding indicated that participants improved their adaptation in terms of lane changing, safety distances, speed regulation and anticipation regarding changes in traffic or related to unexpected events. This finding suggests that both training programs improved the executive functioning and more precise planning and anticipation during a complex activity: driving.

Furthermore, in this study we used another tool to assess the driving performance: the behavioral observation grid, assessed by the experimenter. Analyses showed a negative correlation between the total penalty score of the behavioral observation grid and TRIP total score, which indicates the validity of this tool. Indeed, as the TRIP's total score increases, suggesting an improvement of the driving performance, the total penalty score decreases. Analysis of the behavioral observation grid demonstrated that participants from the CT group improved their speed adaptation and car control handling after training (for example, after training, participants drove less slowly and better adapted their speed choice, depending on the driving situations), whereas participants from the CT + DS group made more mistakes in these dimensions (for example, after training, participants drove more above the speed limitations and had more difficulties with the gear shifting and the speed of the engine). This result goes against literature findings indicating gains on visual checking strategies, lane changing or indicator use after a driving simulator training (Roenker et al., 2003; Lavallière et al., 2012). Contrary to our hypothesis, our driving simulator experience did not allow the transfer of training benefits on the road, and even had the opposite effect regarding speed adaptation and car control handling. We notice that the "speed adaptation" dimension appeared both in the TRIP's tactical score and in the behavioral observation grid. Our analysis led to contradictory results: on one hand, the speed adaptation improved for all participants, and on the other hand, it reduced for participants from the CT + DS group. This finding could indicate that our behavioral observation grid contained more details on drivers' behavior, and allowed a more precise analysis of their driving activity. Another explanation could be that the driver instructor and the experimenter did not have the same assessment strategies. Further research should be conducted to investigate the inter-rater reliability of this driving assessment tool. Moreover, analysis of the behavioral observation grid did not show any improvement of the visual attention while driving after training, despite the improvement of the UFOV® performances. This could be explained by the fact that in the driving situation, the task was more complex than during the test, thus the size of the useful field of view of driver can be reduced because of the high attentional demands induced by the driving activity (Simoes 2003).

Results regarding the self-assessment of cognitive abilities indicated that the pure CT is more effective than the CT + DS program to improve the cognitive self-assessment of older drivers. Indeed, the CT program allowed half of the group to become CE after training (20 participants on 40), against a little more than a third for the other training program (11 participants on 27). This finding shows that the simulated driving immersion did not increase the self-awareness of cognitive abilities. We suppose that feedback received on their driving performances reduced participants' self-confidence. It would be interesting to analyze the simulated driving performance of the participants. In addition, both training programs are more effective for UE than for OE (21 CE post-training on the 32 initial UE, against 10 CE post-training on the initial 35 OE). Interestingly, when analyzing the training compliance, no difference in the total playtime between both groups was shown. However, when examining each training group, we notice that UE trained significantly more than OE in the CT + DS group (32h versus 22h, respectively), in contrast to what was found for the CT group (32h for the UE versus 29h for the OE, no significant difference between both). One possible explanation for this difference could be that as the CT + DS group had the simulated driving activity besides the cognitive training, the OE were, may be, more interested in driving the simulator than in the CT because they thought they did not need it. To summarize, the pure CT allows a better self-awareness of cognitive abilities and improves the self-confidence of older drivers who under-estimate their cognitive abilities, thanks to the feedback which provided information on progress made. Conversely, as all participants improved after training, we suppose that feedback comforted OE on the feeling that they were good performers, and it was more difficult for them to correctly self-assess their cognitive abilities. Finally, it would be interesting to analyze data from the driving simulator experience and see if performances could explain the difference observed between both groups.

CONCLUSION AND PERSPECTIVES

To conclude, first results of this study show that a 36 hours of cognitive training is more effective to improve the self-assessment of cognitive abilities of older drivers than the same training program coupled with a driving simulator experience. Furthermore, UE are more susceptible than OE to this sort of training and are better cognitive self-estimators after following the program. In addition, both cognitive training programs enhance the useful visual field of view of our participants during a computerized task. Nevertheless, the visual attention evaluated during the on road driving test does not change after training. However, all participants show better planning and anticipation during the on road driving test. Thus, some benefits of this computerized cognitive training can be transferred on road. Finally, it should be notice that the experiment is still in progress. Hence, other participants from the CT + DS group are achieving their training and other analyses will be performed later.

A limitation of this study is that some participants felt uncomfortable when they drove the simulator. Even if they could continue after short breaks, this moderate simulator sickness could have affected drivers' performances.

As it was mentioned above, the experiment is still ongoing and will end by the end of May 2015. Next analyses, including the control group, and thereby performed on bigger samples, will allow a better understanding of the effectiveness of each intervention.

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