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A cost-effectiveness analysis of cognitive training programs for older drivers misestimating their cognitive abilities

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Abstract

Depending on the self-assessment of their cognitive abilities, some older people might stop driving prematurely (under-estimators, UE) and others could expose themselves at risky situations (over-estimators, OE). Our hypothesis is that a cognitive training can help drivers to better estimate their cognitive abilities and consequently to better self-regulate their driving behavior. The aim of the study is to compare the effectiveness of two training programs intended for older drivers presenting a cognitive self-assessment bias. One hundred and twenty drivers (70 years and more) are included and assigned among six groups: two cognitive training groups associated or not with a driving simulator experience and a control group, each one containing as many OE as UE. Both training programs last 36 hours spread out over 3 months. Training is expected to improve cognitive self-assessment, and driving simulator experience could improve the driving self-regulation (transfer effect). Global benefits are estimated on driving performance and well-being. The cost-effectiveness analysis is conducted comparing the training costs and a quality of life measure.

Keywords: Cognitive training activity; driver training; driving simulator; older driver; self-assessment; self-regulation

Résumé

En raison d'un biais d'auto-estimation, certains conducteurs âgés peuvent arrêter de conduire prématurément (sous-estimateurs, SsE) et d'autres s'exposer à des situations à risque (sur-estimateurs, SE). Notre étude repose sur l'hypothèse qu'un entraînement cognitif peut aider les conducteurs à mieux estimer leurs capacités cognitives et ainsi mieux autoréguler leurs comportements de conduite. Notre objectif est de comparer l'efficacité de deux programmes d'entraînement adressés aux conducteurs seniors présentant un biais d'auto-estimation cognitive. Cent vingt conducteurs âgés de plus de 70 ans sont répartis en six groupes : deux suivant un entraînement cognitif associé ou non à une immersion sur simulateur de conduite et un groupe contrôle, comprenant chacun autant de SE que de SsE. La durée des programmes est de 36h, réparties sur trois mois. Suite à l'entraînement, les conducteurs devraient estimer correctement leurs capacités cognitives et grâce à l'immersion sur simulateur, ils devraient mieux autoréguler leur activité de conduite. De plus, une analyse coût-efficacité comparera les coûts des deux entraînements, rapportés aux bénéfices sur la qualité de vie.

Mot-clés : Entraînement cognitive, Simulateur de conduite, conducteurs seniors, auto-estimation, autorégulation

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Introduction

Many demographic events have conducted to a continued augmentation of elderly in developed countries since about half-century. According to the OECD, one quarter of the population of its members will be aged 65 and more by 2050 (OCDE, 2012). Normal ageing is related to a decrease in visual, psychomotor and cognitive abilities, which could interfere with activities of daily living. Driving is a complex task requiring visual, psychomotor and cognitive functions. The age-related declines can make this activity more difficult, and consequently affect drivers' safety (Anstey, et al., 2005). Indeed, driving requires being attentive to relevant information and ignoring other one in a visually complex scene. Hence, changes in visual attention components (such as selective attention, divided attention or alertness) can harm hazard perception in the driver' field of view. Moreover, processing speed and executive functions are crucial to integrate information, correctly anticipate risks, and finally plan an appropriate answer to the driving situation (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 & Laumon, 2003). Thus, understand the aftereffect of cognitive declines on driving skills is an important issue to limit accident risk for this population.

Driving self-regulation consists in the driver's behavioral adaptation to maintain a safe driving despite the age-related functional decline (Donorfio, et al., 2008). By ageing, some drivers use compensatory strategies consisting in the avoidance of difficult situations (e.g. driving at night, in bad weather, or during rush hours), or consisting in 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 & Rabbitt, 1992, Molnar & Eby, 2008). The main component between age-related functional decline and self-regulation is self-awareness of this decline. Indeed, behavior depends on abilities perception and driving adaptation to a specific situation depends on the self-awareness of abilities (Anstey, et al., 2005). Thus, promoting this awareness is important to help older drivers to avoid driving situations judged too difficult and maintain their safe driving. Self-assessment and self-screening questionnaires have been used to improve self-awareness among older drivers (Eby, et al., 2003, Holland & Rabbitt, 1992, Levasseur, et al., 2013, Molnar, et al., 2010). These questionnaires are useful to reveal driving-related difficulties encountered by older drivers. Moreover, these tools can initiate discussion with family and relatives about keep driving or stop it. However, these methods seem effective to improve self-awareness, but older drivers had to use the self-regulation strategies, because there is a difference between a declared self-regulation and an effective self-regulation. These formations focused on the improvement of driving self-regulation did not prove any reduction in crash risk (Ker, et al., 2005, Nasvadi & Vavrik, 2007). Nevertheless, an intervention aiming to improve the self-regulation abilities could lead to the opposite effect: the impairment of self-regulation patterns and prevent driver in correctly self-regulate their driving (Moták, 2011).

In parallel with the improvement of self-awareness, several studies have attempted to assess training programs benefits on driving abilities among older drivers. Training physical abilities through aerobics, fitness or stretching improves driving skills and on-road driving performance (Caragata, et al., 2009, Marottoli, et al., 2007). Indeed, these exercises improve neck, shoulders, and back flexibility leading to better vehicle handling, visual scanning, and more mirrors controls (Caragata, et al., 2009, Marottoli, et al., 2007). In addition, cognitive training of attention, memory or executive function improves driving performance evaluated on a simulator (Cassavaugh & Kramer, 2009, Marmeleira, et al., 2009). The processing speed and visuospatial abilities training reduced the number of dangerous maneuvers on a driving simulator and allows seniors to keep driving longer (Edwards, Delahunt, et al., 2009, Edwards, Myers, et al., 2009). During theoretical or educational training dedicated to older drivers, an occupational therapist reminds about the driving rules; gives recommendations for a safer driving and information age-related difficulties. These educational sessions were also coupled with on-road driving abilities training, where a driving instructor gave feedbacks to participants on their driving performance (Bedard, et al., 2004, Bedard, et al., 2008, Lavalliere, et al., 2012, Marchal-Crespo, et al., 2010, Marottoli, 2007, Marottoli, et al., 2007, Romoser & Fisher, 2009, Rosenbloom, et al., 2008). Training benefits were evaluated either on driving simulator or directly on-road. Moreover, surveys assessing these programs' benefits report that participants have better driving knowledge (regarding traffic rules and road safety) and better knowledge on the self-regulation strategies to use in order to counterbalance aging effects. However these surveys do not all show on-road driving performance improvement nor a crash rate reduction (Korner-Bitensky, et al., 2009, Korner-Bitensky, et al., 2010, Korner-Bitensky, et al., 2010, Kua, et al., 2007).

Discrepancies observed between studies on training benefits are probably related to the fact that all older drivers do not have the same awareness of their capabilities. Hence, these programs seem appropriate and effective for people whom correctly assess their cognitive and/or driving abilities. However, these programs would not be appropriate for people whom do not properly assess their abilities. Our study is based on the hypothesis that senior drivers training needs are not the same depending on their cognitive status and how they self-regulate their driving activity. Indeed, a correct cognitive abilities self-assessment would lead to a correct driving self-regulation. Thus, an intervention aiming to improve drivers' awareness of their cognitive abilities could allow over-estimators to reduce their exposure to risk of injury, and under-estimators to regain self-confidence and

keeping them to drive whereas they thought they were unable. Therefore, this intervention attempts seniors to keep driving in safe conditions. The purpose of this study is to compare the effectiveness of a cognitive training program alone and a cognitive training program coupled with a driving simulator immersion, on the driving self-regulation improvement. These programs are dedicated to older drivers overestimating or under-estimating their cognitive abilities.

Methods

1.1. Participants

One hundred and twenty drivers aged 70 and over have been 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), do not be 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 5/10ème at the Monoyer's test.

Participants included in our study came from the Safe Move cohort of 1200 older drivers aged at least 70 years. These participants completed questionnaires related to their health status, driving habits, and cognitive abilities self-assessment. Additionally, participants completed two cognitive tests (the Wechsler Digit Symbol Substitution Test and the Trail Making Test parts A and B) chosen because they are predictable of driving risk (Lafont, et al., 2010, Stutts, et al., 1998). The comparison between cognitive tests results and normative data (from performance of people having the same age and the same educational level) gives objective data about the cognitive performances of participants. By crossing these objective data with the subjective ones collected, with the self-assessment questionnaire, three profiles of drivers emerged: under-estimators (UE, 15% of the cohort, or 180 conductors), correct estimators (42% of the cohort, or 502 drivers), and over-estimators (OE, 43% of the cohort, or 508 drivers).

As the aim of our study is to allow participants to estimate correctly their cognitive abilities, we included sixty under-estimators and sixty over-estimators. The experimental design of the study is based on two factors: the "training" factor comprising three conditions (i.e. "cognitive training", "cognitive training coupled with driving simulator immersion", "control activity: press clipping reading) and the "cognitive profile of self-assessment" factor, including two conditions (i.e. "OE" and "UE"). Six groups are constituted: 20 OE (i) and 20 UE (ii) performing a computerized cognitive training (36h); 20 OE (iii) and 20 UE (iv) performing a computerized cognitive training (33h) associated with a driving simulator immersion (3h); 20 OE (v) and 20UE (vi) performing a control activity (33h of reading) associated with a driving simulator immersion (3h).

1.2. Procedures

The protocol involved a battery of cognitive and perceptive tests, intending to evaluate the abilities suitable to safe driving. Two evaluation sessions were planned at baseline and after 12 weeks of training. These sessions lasted approximately a half day, in which each participant completed cognitive tests, on-road driving evaluation, driving simulator based evaluation and questionnaires. During the first visit in the laboratory, the study was presented to participants and they signed consent form. The day began with questionnaires' completion (10 min), followed by the cognitive evaluation (1 hour), the on-road driving evaluation (45 min), and ended with the simulator driving evaluation (15 min). In order to limit fatigue effect due to the cognitive mobilization, each of these steps were followed by 15min-breaks and other ones could be added if participants needed it. Few days after this evaluation, participants came back to the lab for their first supervised session, in 6-to10- persons groups (week 1). During this first supervised session, the experimenter presented the cognitive training program or the control activity and the web platform. Then, participants began their computerized cognitive training or control activity at home, during 3 hours per week for twelve weeks. Two other supervised sessions (in week 4 and week 7) were proposed to participants and consisted in the presentation of normal ageing and cognitive functioning (presentation of attention, executive functions, visuo-spatial abilities and memory). Moreover, participants exchanged with each other on what they liked or disliked in the program, and exposed the difficulties they have encountered. Finally, five weeks after the last supervised session (week 12), the post-training evaluation took place. This half-day session was the same at the first evaluation. Participants completed the cognitive evaluation, the on-road driving evaluation and the simulator driving evaluation and answered to questionnaires.

1.3. Cognitive evaluation

1.3.1. Objective assessment

Cognitive processes are objectively evaluated via a neuropsychological tests battery comprising paper and pencil and computerized tests. The latter took place on a computer provided with a 17" screen. Participant used even

keyboard or mouse or both of them to complete exercises. We focused on the cognitive functions required while driving, such as divided attention, selective attention, visuo-spatial abilities, memory, and executive functions.

Trail Making Test (TMT): This paper and pencil test consists of two parts. In the TMT part A (TMT-A), the participant has to link as fast as possible the numbers in the croissant order from 1 to 25. In the TMT part B (TMT-B), the participant has to link as fast as possible the numbers in the croissant order (from 1 to 13) and the letters in the alphabetic order (from A to L) with respect to the alternation number/letter. This test assesses the speed-of-processing and visual search strategies. The part B gives more information about mental flexibility, attentional switching, and working memory (Hagen, et al., 2014). As a significant correlation exists between performances at this test and driving abilities, the TMT is commonly used to appraise driving skills (Stutts, et al., 1998).

Digit Symbol Substitution Test (DSST): This paper and pencil test is a component of the Wechsler Adult Intelligent Scale (Wechsler, 1958). In this test, the participant has to associate a maximum of digits (from 1 to 9) to symbols, during 90 seconds, in respect with a model. This task involves the short term memory. Authors found a correlation between low performances at the DSST and high risk during driving (Lafont, et al., 2010).

Stroop test: This paper and pencil test has three parts, the first part consists to name colors, the second parts consists to read words of colors written in black ink; the last part is the interference condition, in which the participant has to name the color of the ink of colors names, without reading the words. This test involves the function of inhibition and the selective attention (Anstey, et al., 2005).

Useful Field of View (UFOV[®]): This is a computerized test of visual attention including three subtests, assessing the processing speed, the divided attention, and the selective attention. The useful field of view is defined as the visual field that can be treated during a short glance (Sanders, 1970). This test appears to be a good indicator of vehicle crashes among older drivers (Ball, et al., 1993).

Phasic alertness task: The phasic alertness task is a computerized test consisting of the signal detection. The participant has to press the space bar as soon as he sees a target (cross) on the screen. Two conditions are presented, with and without distractor (a beep that preceded the cross apparition). Some authors showed the importance of the assessment of speed of processing for measuring driving performances among older drivers (Owsley & McGwin, 1999, Ferreira, et al., 2013).

Digit span test (forward and backward): The digit span test assessed the memory span by answering the participant to repeat digit items forward (from three to nine items) and backward (from two to eight items). This test implies both working memory and short term memory, which are functions involve in driving activity (Wagner, et al., 2011).

Dual-task walking test: This test estimates the costs of the simultaneous realization of a simple task coupled with an attentional task, and how a participant manages his/her attentional resources (Bessot, et al., 2012). Firstly, the participant has to walk through a distance of 10 m at a self-selected speed. Then, he/she has to count forward by three from a two-digit number at the speed of his/her choice in the standing position. Finally, the dual-task is performed twice: counting while walking. Results from these both trials used to give the average performance. Interference of this dual-task is observed in terms of performance (number of items correctly reported per second) and time (gait velocity higher in the dual-task condition than in the simple task).

1.3.2. Subjective assessment

Cognitive functions are also evaluated subjectively, with a self-assessment questionnaire composed by five questions. The participants has to rate his/her own cognitive abilities on Likert scales, compared to same-aged people. For example, a question about focused attention is “Compared to the same-aged people, is it more or less difficult to concentrate?”. The participant has to answer in a five-point scale from “Less difficult” to “More difficult”. A self-assessment score is calculated by adding the responses obtained to the different questions.

1.4. Driving evaluation

1.4.1. On-road driving objective assessment

Driving performance is objectively evaluated both on-road and on a driving simulator. The on-road driving evaluation is conducted by a driving instructor seated at the right of the driver, in an instrumented vehicle. This car is a 5 speed manual transmission 307 Peugeot, fitted with dual controls and dual rear-view mirrors. Sensors are placed on pedals to record driver’s actions. Other sensors record steering wheel angle, car speed, distance travelled, indicators use, and GPS position. These data are recorded on an onboard computer. These records are used to retrospectively analyze driver behavior (e.g. sudden braking, inappropriate speed, etc.) throughout the trip. The experimental vehicle is 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 lasts about 40 minutes for 28 km traveled. During the first ten minutes, the participant drives to familiarize with the vehicle. The route combines: urban circuit (13 km), suburb and rural circuits (5

km) and a section of ring road / highway (10 km). During this course, the participant experiences different infrastructure types: more than twenty-five intersections (eight-turn left), six roundabouts, four insertions or ring-road exits, eight lane changes, two automatic and educational radars. The driving instructor gives the direction to the driver throughout the trip. Sometimes, the driver has to find the route by him/herself depending on the indication given by the instructor (e.g. "Follow the direction of Bron").

Two grids are used to assess the driving performance; one is completed by the driving instructor and the other by the experimenter. The driving instructor and the experimenter are blind to the cognitive profile of the participant. The first grid is an adapted French version of Test Ride for Investigating Practical fitness to drive (TRIP) (Withaar, et al., 2000). This grid assesses 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 is evaluated as: insufficient, doubtful, sufficient, good or not applicable. The driving instructor completes this grid at the end of the course which leads to a global score on 100 points. The second grid is completed in real time during the trip by the experimenter seated behind the driver. This pre-established observational grid consists in a description of the encountered situations and a list of the potential driving behaviors, gathered into broader categories to ease coding: visual attention, traffic rules compliance, planning, vehicle position, speed adaptation, vehicle handling. This detailed list limit the subjectivity of coding (Dobbs, et al., 1998, Lafont, et al., 2010). In addition, the experimenter can mention any unplanned event affecting the driver's behavior, or any action made by the instructor. The completion of this grid can then be finalized with the video recording. This grid is used to calculate a penalty score based on the driver's behavior. Penalties are weighted according to the error type, its severity, and the situation inherent to performed behavior. Hence, forget the indicator will be penalized less severely than the non-compliance with a traffic light for example, depending on the effect of this behavior on the road users' safety.

1.4.2. Driving simulator objective assessment

In this study, a Peugeot 308 fixed-base simulator was used. This simulator is surrounded by screens and speakers in order to recreate a visual and sound driving environment. Five screens, which provide about 280° visual field horizontally and 40° vertically, completely immerse the driver in the simulation. In addition, screens placed along the vehicle allow realistic use of mirrors. Driving simulation is managed through five interconnected computers. The simulator is 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. This visual information is transmitted to the control room allowing the experimenter to encode in real time the driving episode. Microphones allow interaction between the driver and the experimenter and permit to the experimenter to give instructions during the simulation.

Two driving scenarios were developed: i) when they first come to the laboratory, participants drive in a 8-minute urban scenario in order to familiarize with the virtual environment and vehicle handling; ii) and after that, an evaluation scenario, lasting about 8 minutes, is performed by each participant. This episode of urban and suburban driving is used to assess the participant's behavior throughout the course. It consists in five specific driving situations (pedestrian crossing, intersection with traffic lights, vehicle following, left-turn, and overtaking on a highway).

As for the on-road driving evaluation, the experimenter completes a grid in real time, by watching driver's from the control room. This grid describes each situations encountered by the participant and a list of the driving behaviors. This grid is used to calculate a score based on the driver's behavior.

1.4.3. Subjective assessment

After each of these driving evaluations (on-road or on driving simulator), the participant completes a self-assessment questionnaire regarding his/her driving ability on-road and in driving simulator. As for the cognitive self-assessment questionnaire, the participant has to compare him/herself with same-aged people. Both questionnaires consisted in twelve questions whose nine are five-point Likert scale. To keep a link between the three self-assessment questionnaires, questions are all related to the same cognitive functions. For example, the question about focused attention is: "Compared to the same-aged people, is it more or less difficult to concentrate while driving?". This question is adjusted for the driving simulator immersion: "Compared to the same-aged people, was it more or less difficult to concentrate while driving during this episode?". The participant has to answer in a five-point scale from "Less difficult" to "More difficult". A self-assessment score is calculated by adding the responses obtained to the different questions.

1.5. Well-being and quality of life

A questionnaire is used to evaluate the quality of life of our participants. The WHOQOL-BREF (World Health Organization Quality Of Life) is a shorter version of the original WHOQOL. Its interest is to distinguish several

aspects of the well-being. Indeed, this questionnaire is composed by 26 items which measure the physical health, the psychological health, the social relationships, and environment. Hence, the programs' impact can be observed on the different aspects of participants' quality of life. This quick and easy-to-complete questionnaire has been translated in several languages and is adapted to older people.

1.6. Cognitive training

We conducted collaboration with a company specialized in cognitive training (named SBT: Scientific Brain Training) which designed a training program called Happyneuron®. The effectiveness of this training method has been proven among seniors exempt of pathology (Croisile, 2006). The training program proposed in our study contains twenty exercises from the Happyneuron® program. These exercises are specifically focused on functions required while driving as attention (8 exercises), memory (4 exercises), executive functions such as updating, flexibility, or planning (4 exercises), or visuo-spatial abilities (4 exercises) (Wagner, et al., 2011). Another collaboration has been involved with a 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) leading to propose cognitive training exercises to our participants. Hence, each participant has his own personal account in which he can log in and complete his daily activity (reading or training) and can get information about his last performances and his progression on this program. Regarding the cognitive training, the choice of the exercise is made by a virtual coach, whom also chooses the difficulty level following a progression rule: if the participant completes perfectly the exercise (100% success), he passes to next level, if the participant has a score between 70 and 99%, he stays at the same level, and if the participant failed below 70% three times in a row, he goes down to the last level. Each exercise has fifteen difficulty levels. After completing one exercise, the participant gets information about his performance: the percent of good answer and the speed of processing. Moreover, this feedback is accompanied by a sentence that encourages the trainee to continue. Each week, the experimenter can ensure the participant's compliance in the training via the access to personal data of each user. Thus, the experimenter can verify the participants' attendance thanks to their play time and performances. Participants have to train three hours per week during twelve weeks. This training duration of thirty-six hours allowed a benefic contribution to the speed of processing and visual attention, and a transfer in driving abilities in a previous study combining a cognitive tasks (e.g. dual tasks, attention, executive functioning, working memory or processing speed) with physical exercise (such as walking). For example, the authors showed the improvement of 10% in the response time during simple task, 13% in the response time during dual task, and 66% of the visual speed processing for participants assigned in the experimental group (Marmeleira, et al., 2009).

1.7. Driving simulator session

The same driving simulator as described above is used for the three-hour immersion on driving simulation. Five training scenarios are performed during each driving simulator session: pedestrian crossing, intersection with traffic lights, vehicle following, left-turn, and overtaking on a highway. Three difficulty levels are available for each trained situation. These are chosen after a literature review on the situations perceived as complex, or avoided by older drivers or those with a high crash risk. During the immersion on driving simulation sessions, the participant is confronted with these five situations. Each participant begins the training at the easiest level. Thanks to an algorithm we developed assigning penalty points depending on the driver's behavior, a performance score between 0 and 100 is calculated for each situation. When the score is equal or less than 50/100, the participant remains at the same level and retries an equivalent situation during the next driving session. When the score is higher than 50/100, a higher difficulty level situation is unlocked and presented to the participant during the next driving session. This technical feat is achieved through the connection made between the simulator and the SAFE MOVE platform. A feedback is given to the participant after each driving situation through a screen placed inside the vehicle. If the score is less than 50/100, the feedback consists in the educational goals waited to reach the next level. Conversely, if the participant successfully completes the exercise, the feedback congratulates him and indicates the progression to a higher difficulty level. To avoid the test-retest effect, alternative learning situations have been developed. Hence, the participant will not face twice to the same situation (i.e. there are three variants of the easy situation, two variants of the medium situation and one variant of the most difficult situation).

1.8. Active control activity

The control group follows 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 is to replicate as much as possible the experimental conditions of the experimental groups, through the type of activity, its support and duration. The control group has to read articles posted on the SAFE MOVE platform and associated with simple quiz. A varied themes choice is proposed to satisfy tastes and interests of each driver. Feedbacks in terms of play-time and correct answers to quiz allow us to ensure that the activity is correctly performed by participants. Moreover, as for the cognitive training, players receive feedbacks on their quiz performance.

Participant can read only once the article to avoid storing content between each reading. This activity should not contribute to the improvement of cognitive functions solicited while driving because only focused attention and short-term memory are involved in this exercise.

Perspectives

By comparing cognitive and driving evaluations from the different groups, we could determine the effectiveness of cognitive training program on the awareness of cognitive abilities and the development of self-regulatory strategies. Thanks to groups performing the simulator immersion, we could conclude on the role of this tool in the transfer of benefits on real-world driving, generated by the training. Indeed, we could see the potential benefits of a virtual confrontation with complex or difficult driving situations. Finally, we will look at whether there is a difference in awareness and self-regulation among drivers who overestimate and those who underestimate their cognitive abilities.

The interest of both groups achieving the driving simulator immersion (the cognitive training group coupled to simulator experience and the activity control group coupled to simulator experience) is to determine the usefulness of the cognitive training. Unlike participants who make the press review (control activity), those who follow the computerized cognitive training should improve their cognitive abilities on neuropsychological tests. As the trained cognitive functions are those requiring while driving, if we observe an improvement of the driving performance for the group following the cognitive training associated with the simulator immersion, we could conclude on the transfer effect of the cognitive benefits in the driving activity.

Regarding the awareness and secondary benefits, the cognitive training is expected to enable all drivers to become correct estimators of their cognitive abilities. Indeed, thanks to the feedbacks obtained for each exercise, the participant will be able to identify more precisely his/her own abilities. More specifically, the OE could become aware of the difficulties encountered when performing certain cognitive tasks, thanks to the progression in the program (difficulty levels), and the UE could regain self-confidence, thanks to through progression and feedback received after each exercise. The awareness' improvement of driving skills via the driving simulator immersion could lead the OE to reduce their driving risks by directly confronting them to critical situations, and the UE to regain self-confidence and develop better behavioral adjustments as their driving becomes consistent with their skills.

A cost-effectiveness analysis will be conducted. The cognitive training costs less to implement and remain functional than the driving simulator experience. Indeed, the driving simulator results in high operating and maintenance costs. In the end, this study will allow us to determine which intervention is the most effective to improve driving performance evaluate with the TRIP.

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