MULTIPLE-SESSION SIMULATOR TRAINING FOR OLDER DRIVERS AND ON-ROAD TRANSFER OF LEARNING

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Summary: Driving retraining classes may offer an opportunity to attenuate some of the aging manifestation that may alter driving skills. Unfortunately, there are suggestions that classroom programs do not allow to improve the driving performance of elderly drivers. The aim of this study was to evaluate if specific simulator training sessions with video-based feedback can modify on-road behaviors of elderly drivers. In order to evaluate the effectiveness of the training, 10 elderly drivers who received feedback were tested before and after the training program with an on-road standardized evaluation. A control group (12 older drivers) also participated. Participants in this group received a classroom training program and similar exposure to driving in a simulator but without driving-specific feedback. After attending the training program, the control group showed no modification of their driving performance (on-road score, frequency of successful turning maneuvers and frequency blind spot verification before lane change maneuvers). On the other hand, participants in the feedback group improved their driving skills for all maneuvers that were evaluated. These results suggest that simulator training transferred effectively to on-road performance. In order to be effective, driving programs should include active practice sessions with driving specific feedback.

INTRODUCTION

More than ever, road safety is a public health concern. One cause for this concern arises from the continuous growth of older drivers. In response to this fact, several retraining programs specific for older drivers have been developed and are now offered. Most often, these programs are classroom oriented (such as AARP's 55ALIVE Driver Safety Program)(AARP). They promote safe driving and increase older drivers' confidence behind the wheel through a curriculum emphasizing awareness of traffic hazards, anticipating the actions of other drivers and a general overview of traffic rules and signalization. There are suggestions that these classroom programs do not allow to reduce crash occurrences (Owsley, McGwin, Phillips, McNeal, & Stalvey, 2004). In a recent study, Bédard et al. (2008) measured knowledge of safe driving practices before and after a training program combining in-class and on-road training. Compared to a control group (no training), the intervention group showed improvements of driving knowledge (measured through the 55ALIVE Driver Safety Program questionnaire) and some aspects of on-road driving (starting/stopping/backing and moving in roadway). As reported by the authors, it is difficult to isolate the specific and unique contribution of the classroom and on-road training on the global on-road improvements but their data suggests that classroom-only training does not yield to on-road improvements. There are motor learning principles suggesting that several aspects of driving may not be optimized in conventional classroom oriented programs. According to such principles, general driving information or 'watch how to do it' procedures should not be sufficient to change driving behaviors. If inadequate eye-head coordination precedes a driving error (as an example, before a left turn), corrective feedback for this specific action and practice are needed if a decrease of such errors is to be achieved. Presumably, this is so because sensory and motor information is at the basis of all coordinated actions. This key concept is often defined as transfer-appropriate practice (Lee, 1988). For driving, it simply states that one has to experiment specific driving contexts highlighting driving deficits or reduction in capacities of processing information in order to engage the necessary processes yielding to adaptive and more secure driving.

Simulator training may offer a secure mode of training where drivers can physically practice driving strategies that mimick those used on-road. In the present study, we evaluated if specific simulator training coupled with video-based feedback can modify on-road behaviors of elderly drivers. A control group receiving a classroom training program and simulator exposition without feedback was also tested. The effectiveness of the training was evaluated by comparing on-road driving performance before and after the training program with a standardized evaluation.

METHODS

Participants

23 elderly drivers were assigned randomly to the training (6 men and 4 women) or the control group (10 men and 3 women). One subject in the control group did not complete the study because of sickness symptoms. Data presented are for the remaining 22 subjects. All participants were given a general verbal questionnaire that included items on driving (years of driving experience, frequency of driving and average km/year, presence of accident within the last years) and general health condition (neurological and musculoskeletal problems, use of medication). Simple clinical tests (Mini Mental State Examination (MMSE) Snellen visual acuity, Melbourne Edge Test, Motor-Free Visual Perception Test (MVPT)) were used to screen for impairments that might affect driving and cognition.

Table 1. Summary of results for the general health evaluation and driving experience
Mean values and Standard deviation

	Control group	Feedback group	P values
Age	69.3 (4.5)	72.1 (5.3)	p > 0.05
Years of experience	47.3 (7.5)	49.7 (5.2)	p > 0.05
Kilometers per year	9490 (4399)	8024 (5571)	p > 0.05
MMSE	28.2 (1.1)	28.1 (0.9)	p > 0.05
Snellen visual acuity High contrast	0.9217 (0.2161)	1.1033 (0.3053)	p > 0.05
Melbourne edge test	21.0 (1.3)	20.9 (1.7)	p > 0.05
MVPT	103.6 (22.5)	118.9 (20.9)	p > 0.05
Lower limb touch thresholds	0.3 (0.2)	0.4 (0.2)	p > 0.05

Procedures

All subjects were first tested on-road and then, in-simulator. No feedback was given during these initial sessions. Then, participants assigned to the Control group received a driver refresher course based on the AARP's 55ALIVE Driver Safety Program. The training was given individually to drivers during three sessions and each session lasted about 40 minutes. The program included specific sections with graphical support to inform participants about blind spot verification and vehicle control, particularly when turning at intersections and when changing lanes. They also drove through a 16-km scenario in the simulator after each of these training sessions. Participants in the Feedback group received the same classroom program. Their simulator sessions, however, included driving-specific feedback prior to the training sessions. This feedback emphasized the role of preventive rather than reactive driving. This was based on the Risk Awareness and Perception Training Program (Fisher, Pollatsek, & Pradhan, 2006; Pollatsek, Narayanaan, Pradhan, & Fisher, 2006; Pradhan et al. 2005; Romoser, Fisher, Mourant, Wachtel, & Sizov, 2005). Also, specific video-based feedback of the driver were used to highlight the importance of visual inspections (with or without head movement) to reduce the perceptual narrowing observed previously (Lavallière et al. 2007; Lavallière, Tremblay, Cantin, Simoneau, & Teasdale, 2006; McPhee, Scialfa, Dennis, Ho, & Caird, 2004). As an example, specific instructions were given on the importance to glance at the blind spot prior to engage in a lane change maneuver. When inappropriate behaviors were noted, drivers were shown their own response (head view, scenario and vehicle parameters) prior to their simulator sessions and invited to drive over the particular section of the scenario. In addition, feedback of the on-road driving evaluation was provided to the Feedback group only at the first training session. Finally, both groups were again evaluated on-road and in-simulator. No feedback was provided during these final evaluations. Hence, overall subjects participated to 7 different sessions (Pre-training on road and in-simulator evaluation, 3 training sessions and Post-training on road and in-simulator evaluation). Data for the training simulator sessions will not be presented herein.

On-road evaluation. The on-road evaluation took place in a car instrumented with a global positioning system (GPS, Novatel, Canada) and four digital cameras (1 for the driver's head and 3 for the driving environment, PointGrey Research, Canada). Also, the tester could mark driving events (for instance, a lane change maneuver or an intersection) for reviewing specific driving maneuvers. All data were collected synchronously (20 Hz for the GPS, 25 Hz for the video data, 100 Hz for the manual marking). The road test circuit (12 km) was similar for all drivers and included a complete range of driving maneuvers. The scoring was standardized and resembled the Passenger Vehicle examination from the Société de l'assurance automobile du Québec (SAAQ, Québec, Canada). In addition, we examined the vehicle control performance during left and right turn maneuvers at intersections (5 right-turns and 3 left-turns) and the frequency of blind spot verifications before lane change maneuvers. Turning maneuvers were executed properly when the subject engaged the car in the appropriate lane (i.e. for a right turn maneuver to a multiple lanes road, the driver needed to move into the rightmost lane).

Simulator and simulator training. A fixed-based open-cab simulator powered by STISIM Drive 2.0 (Allen et al. 1997) was used. Images are projected on a flat wall (1.45 m high x 2.0 m wide) located 2.2 m from the steering wheel using a projector (Hitachi CP-X275) that displays a 40° horizontal by 30° vertical field-of-view with the center of the screen located at eye-level through the midline of the subject. To simulate real-driving conditions, the left-side mirror and a panel positioned in the left blind spot are instrumented with light emitting diodes (LED). If the LEDs are turned off it informs the driver that a lane change is possible. When LEDs are on, the driver is instructed to delay their maneuver until LEDs are turned off. The information displayed by the LEDs is in correspondence with the information displayed in the rear-view mirror embedded into the simulator's scenario. Three video cameras (Prosilica CV-640, Canada) are mounted on the cab facing the subject and zoomed to fully capture head and eye movements. A fourth camera (Point Grey Research, Flea BW, Canada) captures the scenario displayed on the screen. For each session, subjects were first familiarized with a practice scenario (with less graphical information than the training scenario). A 5-min rest was then provided before a continuous 16-km run for the Control group and the training run for the Feedback group. No emergency braking response was necessary unless a driving error was made. Subjects were asked to follow speed limits and to comply with local traffic regulations throughout the duration of the scenario. A custom made software allowed to display synchronously video information and simulator or vehicle data (e.g., position and speed). This information was used for providing driving-specific feedback.

RESULTS

On-road data pre- and post-training are presented (Figure 1). Participants completed the program in less than two weeks (on average, 9.5 and 11.4 days for the Control and Feedback groups, respectively). No difference was found between the two groups concerning the general questionnaire that included items on driving and general health condition. On-road data (overall score, frequency of successful turning maneuvers and frequency of blind spot verifications before lane change maneuvers) were submitted to a Group (Control, Feedback) x Visit (Pre, Post) ANOVA with repeated measures on the last factor. For the overall score, the ANOVA

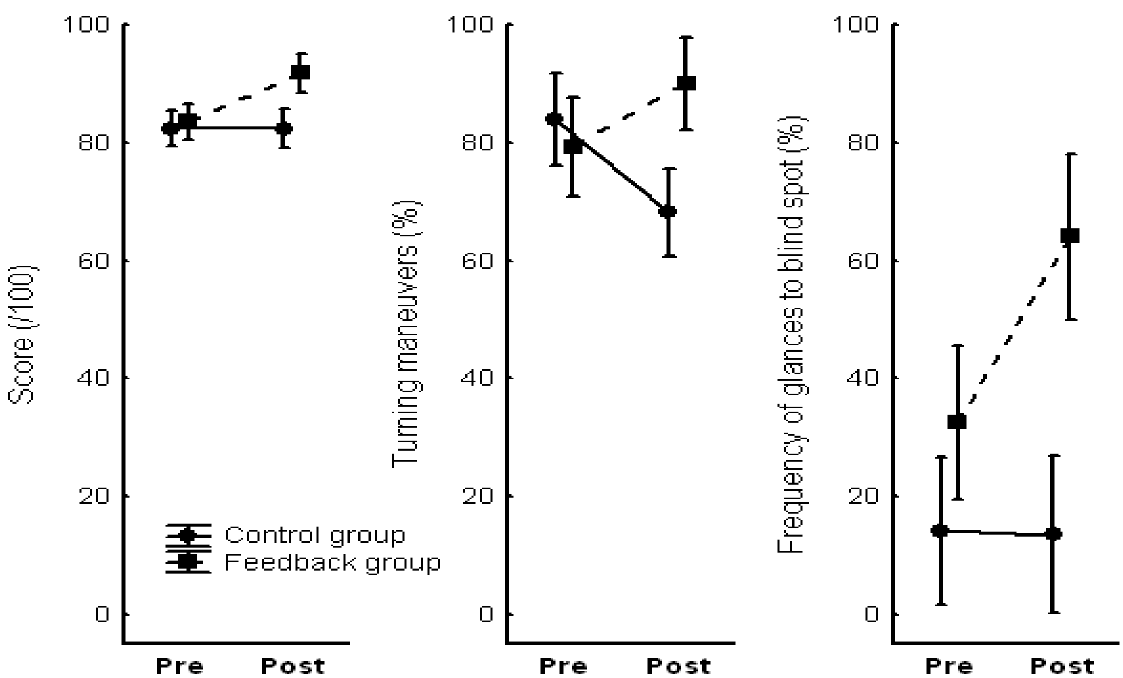

Figure 1. On-road standardized score (left panel), frequency of successful turning maneuvers (middle panel) and frequency of blind spot verification before lane change maneuvers (right panel).

Error bars indicate the between-subjects 95% confidence interval.

yielded significant main effects of Group ($F(1,19) = 12.88$, $p<0.01$) and Visit ($F(1,19) = 7.4388$, $p<0.01$) as well as a significant interaction of Group x Visit ($F(1,19) = 7.4388$, $p< 0.01$). Figure 1 shows that both groups performed similarly at the initial on-road evaluation. The control group maintained its performance at the final evaluation whereas the Feedback group improved its score by 8 points. For the turning maneuvers, the ANOVA yielded no significant main effects of Group ($F(1,19) = 4.12$, $p>0.05$) and Visit ($F(1,19) = 0.61$, $p>0.05$). The interaction of Group x Visit, however, was significant ($F(1,19) = 16.7$, $p<0.001$). The Control group performed worse at the final than at the initial visit (83.9% vs. 68.2%) whereas the Feedback group increased their performance (79.3% vs 90%). For the blind spot verification, the ANOVA yielded significant main effects of Group ($F(1,19) = 23.16$, $p<0.001$) and Visit ($F(1,19) = 8.17$, $p<0.01$) as well as a significant interaction of Group x Visit ($F(1,19) = 8.96$, $p<0.01$). Interestingly, both groups showed a low frequency of verification for the first on-road evaluation (Control group, 14.2%; Feedback group, 32.6%). The Feedback group showed a large increase in the frequency of verification between the first and last visit (increase of 31.5%) whereas the Control group showed no change (14.2% vs 13.5%). It is noteworthy that the voluntary range of motion for the head was similar for both groups. On average, rotation to the right was greater than to the left for both groups (52.3 vs. 45.5 degrees, respectively).

CONCLUSION

The aim of this study was to examine the effect of a driving-specific training program based on simulator training to help elderly drivers to improve and maintain appropriate driving skills. The effectiveness of the program was compared to a classroom-only training and on-road transfer of training was examined. The variables examined (overall score, turning maneuvers and blind spot verification) showed that the driving-specific Feedback group improved its overall driving performance whereas the Control group showed no change in performance. The Feedback group showed better performance in lane change and while driving through intersections. The present study confirms observations of Bédard et al. (2008) that classroom training only are not effective to modify and improve driving skills. In their study, improvements were seen only when the classroom training was coupled with on-road training. Marottoli et al. (2007) reported similar results. In our study, we showed that in-simulator training could be an effective substitute to on-road training and that classroom training only is inefficient. This was the case even if the curriculum was given on a one trainer to one participant ratio.

A limitation of our study is that both groups obtained good score at the pre- and post-training on-road evaluation. Based on standards provided by the Passenger Vehicle examination from the SAAQ, all participants would have succeeded their on-road examination. Nevertheless, we were still able to observe an increase in performance for the Feedback group. It is a question of utmost interest to determine if similar improvements could be obtained with participants showing lower scores. At the pre-training evaluation, there was a significant difference between our two groups for the frequency of blind spots verification before initiating a lane change maneuver (Control, 14.2%, Feedback, 32.6%). The Feedback group, however, showed an increased frequency of verification of the blind spots after the training program whereas participants in the Control group showed a stable frequency of verification. It is important to note that this was an aspect that was specifically reviewed in the classroom program and that all drivers were explained the importance of blind spot verification prior to changing lanes with graphical materials. The low frequencies of verification towards blind spots obtained from the first on-road evaluation are similar to previous data on visual searches during lane change maneuvers (16% to 31%)(Kiefer & Hankey, 2008; Tijerina, Garrott, Stoltzfus & Parmer, 2005). This supports previous studies suggesting that elderly drivers are particularly inefficient at monitoring their own performance (Freund, Colgrove, Burke & McLeod, 2005; Holland & Rabbitt, 1994). Although they are aware of what hazardous situations consist of, they seem unable to realize that some of these situations may be dangerous for them. Such an attitude (i.e., high self-rating even in the presence of declining skills) is an obstacle to self-modification of driving habits since an essential aspect of learning consists in evaluating one's errors (Salmoni, Schmidt & Walter, 1984). By receiving specific video based feedback about their driving performance, the older drivers from the Feedback group were more able to identify problematic driving strategies. Moreover, by providing active practice sessions in the simulator, they were able to engage the necessary processes yielding to adaptive and more secure driving behaviors when tested on-road (i.e. turning maneuvers, blind spot verifications). For the moment, we are not able to determine how long the increased performance observed for the Feedback group would last. Future experiments should allow to provide important answers to this question.

In conclusion, our results suggest that when drivers are shown their own performance they engage the necessary cognitive processes for modifying their driving strategies. Providing classroom-only information does not appear to be sufficient to allow drivers to fully appreciate the nature of their driving errors. This suggests that simulator training combined with tools providing driving specific-feedback could be an important method to modify driving behaviors and reinforce proper driving responses. While on-road training is still considered as the reference, driving simulators combined with appropriate feedback could offer an efficient, cost-effective and safe means of retraining older drivers.

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