Older Driver Training Using Video and Global Positioning System Technology—a Randomized Controlled Trial

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Background. There is emerging evidence that older driver training programs with on-road instruction are more effective than driver education programs that are conducted only in the classroom. Although most programs have provided this additional in-vehicle training with a driving instructor and a dual-braked vehicle, technology could assist in providing this feedback. It was hypothesized that participants who received video and global positioning system (GPS) feedback (Video group) in addition to classroom education would improve to a greater extent than those who received a classroom-based course alone (Education) or Control participants.

Methods. Fifty-four participants (32 men and 22 women), 70–89 years old, randomized to one of the three groups, completed the study. All participants underwent pre- and postintervention driving tests, in their own vehicle, on a standardized route, that were recorded with video and GPS equipment. The Video group met with a driving instructor to receive feedback on their driving errors in their preintervention driving test. A blinded assessor scored all driving tests in random order.

Results. The Video group significantly reduced their driving errors by 25% (p < .05) following the intervention, whereas the other two groups did not change significantly. Fifty-two percent of participants from the Video group improved their global safety rating, whereas only 5.3% in the Control and 22.2% in the Education groups did.

Conclusions. This study suggests that direct driving feedback using video and GPS technology could be an effective and novel means to provide older driver education.

Key Words: Automobile driving—Training—Older adults—Video—GPS

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TRAINING has been advocated for older drivers as one means to improve their road safety (1). There is emerging evidence that various forms of training for older drivers can improve self-regulation and promote avoidance of challenging driving situations (2), increase knowledge (3,4), and improve on-road driving performance (3,4). Both of the latter two studies examined the combination of classroom-based education along with on-road training with a driver instructor compared with a control intervention (3) or wait-list control (4). From studies conducted to date, there is mixed evidence that education alone is beneficial. Owsley and coworkers (2,5) found that their educational interventions were effective in improving self-reported driving behaviors in older drivers with impairments in vision or visual processing speed, but these interventions were not effective at reducing crashes. Bédard and coworkers (6) did not find a reduction in driving errors with on-road testing in those who were randomized to a classroom-based education program versus controls.

Although older driver in-vehicle education has typically been done with a driving instructor and a dual-braked vehicle, this might not be the best form of older driver education. Because driving an unfamiliar vehicle “represents a motor-sensory secondary task,” (7) older drivers might not benefit fully from driving instruction because they cognitively cannot deal with the combination of the driving task, the secondary task of an unfamiliar vehicle, along with the instruction information. Commercially available technology may provide an alternate means of educating drivers without the need to use dual-braked vehicles, and receiving the education while driving. The purpose of this study was to examine an alternate form of driver training by utilizing video and global positioning system (GPS) technology, in combination with a classroom-based education program. The primary hypothesis was that driver errors would be reduced to a greater extent in those receiving the added feedback on their driving by video and GPS than those who received the classroom-based education alone or a Control group. A secondary hypothesis was that the global ratings of driving safety would be improved more in the added feedback group.
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Overview of the Study and Design

Older drivers (aged 70 and older) were randomly assigned to three different groups: Education (received the classroom education alone), Video (received video and GPS feedback in addition to classroom education), and Control. All participants underwent initial laboratory testing, underwent a driving test on a standardized route, and provided demographic and background information on their health and driving, prior to group randomization. Postdriving tests were conducted approximately 4–6 weeks after the pre-test on the same route. Driving tests were recorded and scored by a blinded observer in random order after all the testing was completed. The primary outcome variable was total score (eg, number of driving errors) on the on-road test.

Participants

Participants were recruited to participate in the study through advertisements in local newspapers, posters at community locations (eg, libraries, seniors’ centers, apartment buildings), and university e-mail postings. Inclusion criteria included the following: drivers aged 70 and older, valid driver’s license, ownership or access to an insured vehicle, and regular driver (at least 1 d/wk). Participants were excluded if they did not meet the earlier criteria or they had taken the Alive Mature Driving Program within the past 5 years. They could also be excluded after they performed the lab testing if they did not meet the provincial standards for vision or they scored less than 24 on the Mini-Mental State Examination. Additionally, participants who were not able to navigate the driving route within a reasonable time frame (ie, they exceeded the maximum recording time [60 min]) of the mini digital video tapes in the video camera or the battery life of the camera (about 55 min) were not asked to perform the postdriving test. An added feature of participant recruitment was to prevent participants who knew each other from participating so that contamination between treatments could be avoided. For example, friends or spouses could not both participate because they could potentially be randomized to different groups (experimental vs control). All participants provided written informed consent to participate in the study. The study protocol was approved by the Education and Nursing Research Ethics Board at the University of Manitoba. All participants received $30 to cover their fuel costs for driving their vehicle, parking passes for visits to the university, and all manuals for the classroom course.

Lab Testing

All laboratory testing was conducted prior to randomization by a registered occupational therapist who had several years experience in testing older drivers. She was not involved in the driving tests or any instructional components of the study. Tests were selected because they could be used for screening purposes to ensure that drivers met provincial standards (visual acuity, Mini-Mental State Examination) or because they could help to describe the underlying abilities of the drivers. The following is a list of the tests performed in all phases: vision testing, motor free visual perception test, Mini-Mental State Examination, useful field of view, grip strength, foot tapping, and reaction and movement time.

Vision testing was conducted with an Optec Vision Tester 2000 (Stereo Optical Co., Chicago, IL) and the participants used their corrective lenses, if appropriate. The following tests were done: distance binocular acuity, peripheral vision, and color vision. Participants were required to have a visual field of 120° across the horizontal meridian in order to drive (8), in addition to a visual acuity of at least 20/50 (9). If a participant did not meet the vision requirements, they could still participate if their optometrist or ophthalmologist provided a written statement that the person did in fact meet the provincial standards for driving.

The motor free visual perception test is a standardized test often used for the evaluation of older drivers’ visual perceptual skills, which includes spatial relations, visual discrimination, figure ground, visual closure, and visual memory (10). The test consists of 36 items (maximum score of 36) and usually takes about 20 minutes to administer.

As indicated previously, the Mini-Mental State Examination (11) was used for screening purposes. At the time of the study, a score less than 24 was seen as a cutoff for older drivers by the Canadian Medical Association (8). No driver was excluded from the study for having a score lower than 24, as the lowest score was 26.

The useful field of view (version 6.06, Visual Awareness, Birmingham, AL) was performed on a desktop computer with a 17-in. multiscan monitor (Sony CPDG400) and a mouse.

Two measures of general physical function were used: grip strength and foot tapping. Grip strength (in kg) was measured with a Jamar Hand Dynamometer (Sammons Preston, Birmingham, AL) was performed on a desktop computer with a 17-in. multiscan monitor (Sony CPDG400) and a mouse.

Two measures of general physical function were used: grip strength and foot tapping. Grip strength (in kg) was measured with a Jamar Hand Dynamometer (Sammons Preston, Birmingham, AL) on both the right and left hand, with the best attempt on each hand being used for scoring purposes. For the foot tapping test, participants were asked to dorsiflex and plantar flex their foot as fast as possible in 10 seconds while in a seated position, with their heels on the floor (12).

A Lafayette timer (Lafayette, Inc., Chicago) was used to measure the participants’ foot reaction and movement time when presented with visual stimuli. Two foot switches were mounted 0.14 m apart from one another (from center to center), 0.18 m (right pedal), and 0.20 m (left pedal) above the surface on a wooden board. Each participant completed 10 practice trials and 10 test trials moving their foot as quickly as possible (13). Reaction time was the time taken for the right foot to release the “accelerator” switch upon presentation of visual stimuli, and the movement time was the time taken for the right foot to move from
the “accelerator” switch to the “brake” switch. An average score was used for the 10 test trials for both reaction and movement time.

**Driving Tests and Their Scoring**

Participants drove a 26 km standardized route in and around the city of Winnipeg in their own vehicle. Driving tests were performed with a digital video camera (Canon Optura, Canon, Inc., Tokyo, Japan) temporarily fixed to the passenger seat window with a specialized vehicle tripod (Gruppo Manfrotto, Bassano del Grappa, Italy), and a GPS receiver (GeoExplorer II, Trimble, Sunnyvale, California) in the back seat with a Trimble Range Pole antenna on top of the vehicle (see Porter and Whitton [14] for more detailed information on the set up, equipment settings, and data analyses). The equipment could be installed in about 10 minutes and removed in about 5 minutes. Participants were given a route to follow (map + street directions) and specific instructions on how to complete the route prior to leaving. However, they performed the drive alone, with no one in the vehicle. Great care was taken to try to ensure that consistent road conditions were used for all testing. When possible, testing was done at the same time of the day. All testing was done outside of peak traffic times, during daylight hours, and no testing was done when roads were snow covered.

Scoring of the driving tests was done by one observer who was blinded to the identity of the participants, their results on any of the lab tests, as well as group allocation. Each subject’s driving test was given a random number between 1 and 200. The evaluator did the scoring from the lowest number to the highest for several months, so that the order was random and therefore post-tests could be scored before pre-tests, and the time frame between tests for a particular individual could be several weeks. Before beginning the official scoring of the videos, the evaluator practiced with tests from a previous study to finalize the scoring system and provided herself with very detailed notes on how to categorize errors and ensure her own reliability. After all testing was completed, this person scored all tests in random order by watching DVDs on a 24-in. television. This allowed the assessor to rewind and watch situations over again if needed. Errors were determined based on the Manitoba Driver Examiner Form and the guide that goes along with it and were assessed 5 or 10 points according to the severity of the error. Because the scoring of errors was being done based on watching a video recording of the drive, this allowed the evaluator to be very systematic and precise. GPS data were used to score for speed-related infractions (eg, speeding or driving too slowly). The total number of demerit points was used as the main outcome variable of this study.

In addition to total errors, the evaluator determined whether the driver was “safe,” “marginal,” or “unsafe” based on the number and severity of errors. Very specific criteria were determined for these categories prior to the driving tests being scored. This was based on the type and frequency of errors. Some types of errors were deemed to be ones that are commonly made by all drivers and are unlikely to result in vehicle and pedestrian conflicts or crashes, so drivers could make these and be deemed “safe.” For example, rolling to a stop before a sidewalk would be assessed 10 demerit points according to Manitoba Driver Examination procedures but someone could do this many times in the test and still be categorized as “safe.” However, entirely failing to stop at a stop sign would result in a driver being categorized as “unsafe” because they were deemed to have a substantial risk of crashing or conflict. Someone who was deemed to have a moderate risk of crashing or having a traffic conflict was deemed to be “marginal.” These scoring criteria were determined by the evaluator in collaboration with an occupational therapist who had more than a decade of experience in conducting assessments of older drivers and making recommendations on whether to revoke someone’s license to a provincial licensing authority.

A check was performed to determine the reliability of our research assistant and to ensure no systematic shift in the scoring over time. This was done by scoring 20 randomly selected tests from the drivers from this study and scoring those tests over the course of the scoring all the tests (ie, more than several months). Results from this reliability check indicated that the evaluator was very consistent (intraclass correlation coefficient = 0.98 for total score). For global score reproducibility, there was only 1 person out of 20 that was scored differently from one time to the next (marginal vs unsafe).

**Randomization**

The study was conducted in four phases, in both the spring and fall of two different years, to ensure that road conditions were as similar as possible for all testing (ie, to avoid snow covered and slippery roads that could vary from one day to another). There were two phases for the Education group and two phases for the Video group. This was done to ensure that each class only had a maximum of 12 participants. The sessions were blocked such that each experimental group would have a spring and fall phase. Participants were randomized to the control group for each of the four phases. Random allocation to groups was conducted by an independent party, providing a sealed opaque envelope to study staff. Participants and study staff were informed of the group allocation after questionnaires, lab testing, and baseline road tests were completed. Control participants were able to participate in the 55 Alive course after the study was done. And both the Control participants and Education participants were able to meet with the driving instructor to receive individualized feedback once the study was done.

**Driver Training**

The classroom training was the 55 Alive Mature Driving program based on Edition V (Canada Safety Council, 2002). There were two sessions of 4 hours each, a week
apart. In each phase, the whole group that was randomized to the experimental group attended the session together. Because they were all from the same experimental group (i.e., Education or Video), there was no possibility of contamination between treatments. In addition to the 55 Alive manual, all participants also received the Manitoba Driving Handbook (15), which is the manual that describes the rules of the road for the province of Manitoba.

The Video group met individually with a driving instructor (not involved in any other aspect of the study) on one occasion for about an hour and a half between their pre- and post-test. The instructor had several years of experience as a driving instructor for beginning drivers as well as older drivers who were referred for medical conditions. The participant watched the video of their own pre-test drive with the driving instructor and were given very specific instructions on how to improve their own driving. The driving instructor could also give them feedback based on a graph of their GPS-derived vehicle speed. For example, they could be told where they were speeding or driving too slowly.

There was approximately a 2–3 month time frame for all aspects of the study to be completed within each phase. This included pre-testing, the 55 Alive course (when appropriate), individual instructional sessions (when appropriate), and post-testing. Because of the relatively short time frame, and the availability of the participants, the time between the different components could not be standardized. The time between the predriving test and the instructional session was 13.9 ± 7.8 (5–29) days. The time between the instructional session and the postdriving test was 21.0 ± 9.2 (5–35) days. There was no correlation between the amount of time between testing and instruction and the percent change in their total demerits.

Statistical Analyses

For the assessment of the main outcome, a two-way repeated-measures analysis of variance was done with group being a between-subject factor and time being a within-subject factor. Post hoc testing was done using the Holm Sidak method. In addition, a best-subsets regression analysis was done to determine if the results were being affected by baseline scores on the driving test or any other baseline characteristics of the participants that might have been different between the groups despite randomization.

RESULTS

Participants

In Figure 1, a flow diagram shows the progression of individuals through all phases of the research project from initial contact through to data analyses. For those participants who were assigned to the intervention groups, everyone attended all required sessions, except for one participant who did not attend the second session of the classroom education. He did read all materials associated with both sessions and completed the postdriving test. His results are included. The one person who was allocated to the Video group but did not complete the intervention was also unable to attend a post-test, and so no results were analyzed for this person. Table 1 shows the characteristics by group for the participants who completed all aspects of the study.

Driving Test Results

Individual scores on the driving test are shown in Figure 2 for each participant. The results of the repeated-measures analysis of variance indicated that there was no significant group effect but there was a significant time effect (p = .005) as well as a significant interaction between group and time (<0.001). Post hoc testing showed that the Control and Education groups did not significantly change from pre- to post-testing, whereas the Video group significantly reduced their driving errors (p < .05; Table 2).

The regression analysis indicated that the baseline road test score had a significant effect (p = .005) on the amount of improvement in the total score, with those who had more errors at pre-test changing the most. However, group was still significant and the more important factor (p = .003), whereas age was not significant.

In addition to being scored on their total errors, all participants were also categorized as safe, marginal, and unsafe, at both pre- and post-tests. The percent of participants improving their scores, from marginal to safe or unsafe to marginal or safe, are shown for each group in Figure 3. Nine of 17 participants in the Video group improved, whereas only 4 of 18 improved in the Education group, and just 1 of 19 improved in the Control group. There were also individuals who had poorer global rating scores from pre- to post-test (4 of 17 in the Video group, 7 of 18 in the Education group, and 7 of 19 in the Video group). For all of these, there was only one category change (marginal to unsafe or safe to marginal). No one was initially scored as being safe and then was scored as unsafe at the post-test. All remaining participants (n = 20) did not change. Because more than one cell had less than five participants, statistical analyses could not be performed on this data.

DISCUSSION

In this study, it has been shown that an innovative form of driver education can be beneficial in improving performance of older drivers on a road test over a standardized route. It was also found that a publicly available driver education program for older drivers was not effective in reducing driving errors. These results concur with other randomized controlled trials that have examined classroom education in combination with individual driver instruction for older drivers (3,4). Both of these studies found improvements in on-road performance in participants who had been randomized to receive the combined
program. In contrast to this, Bédard and coworkers (6), using a randomized controlled trial design, did not find that driving errors were reduced in older drivers who received the same classroom-based program without individualized driver instruction in-vehicle, even though their knowledge appeared to increase.
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Figure 2. Individual scores are shown for participants pre- and postintervention(s), for the Video (V), Education (E), and Control (C) groups.

Table 2. Total Score (points for driving errors; Mean ± SD) Pre- and Postintervention(s), Where a Higher Score Indicates More Errors. The Video Group Was the Only Group to Significantly Reduce Their Driving Errors (p < .05)

<table>
<thead>
<tr>
<th>Group</th>
<th>Prescore</th>
<th>Postscore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>428 ± 138</td>
<td>317 ± 142*</td>
</tr>
<tr>
<td>Education</td>
<td>380 ± 96</td>
<td>372 ± 87</td>
</tr>
<tr>
<td>Control</td>
<td>344 ± 107</td>
<td>367 ± 118</td>
</tr>
</tbody>
</table>

* p < 0.05.

The strengths of this study include its randomized controlled design, as well as the ability to truly blind the outcome assessor to the group allocation when analyzing the driving data. In a typical scenario (3,4), whereby the driver is being assessed by an examiner in the vehicle, it is more difficult to ensure that the examiner will not be given clues by the participants themselves of their group assignment. In this study, all the data were analyzed in a lab once everything had been collected, with DVDs that were assigned random numbers. Not only did the examiner not know whether the test was a pre- or post-test, but they also did not know anything about the identity of the participant.

Another strength of this study was the nature of the road test. Because GPS and video were used to record their road test, an examiner in the vehicle was not needed. This meant that the driving was more naturalistic than a typical on-road evaluation where there is interaction between the examiner and driver, with many instructions continually being given (4). In addition, the participants were able to drive their own vehicle and so there was no possible confound of the person being unfamiliar with the vehicle (7). Lundberg and Hakamies-Blomqvist (7) found that the driving performance on a road test appeared to be diminished when
older drivers, particularly those with decrements in cognition, were using an unfamiliar as opposed to familiar vehicle. They argued that driving an unfamiliar vehicle is akin to a secondary task, and this secondary task will demand extra cognitive workload and possibly exceed the cognitive reserve capacity to the extent that driving skill is impaired. Therefore, an on-road evaluation involving an unfamiliar vehicle may not be an accurate reflection of an older driver’s actual driving skills. In addition, from a research perspective, if driver training is done in that same unfamiliar vehicle with an intervention group and not a control group, then post-testing using that same unfamiliar vehicle could have a confounding effect on the post-test scores, because the intervention group has not only received driver skill training, but they have been able to familiarize themselves with the vehicle used for testing.

It could also be speculated that driver training using an unfamiliar vehicle could compromise the ability of an older driver to benefit from the lessons given. If the task of driving is close to their maximum cognitive workload capacity, then receiving instructions while driving might be counterproductive. Because feedback in this study could be provided outside of the vehicle with no cognitive workload required for actually driving the vehicle, the participants were able to focus on the lesson rather than driving. Given that their driving was recorded, the participants could be shown concrete examples of similar types of errors, along with the same error being played back multiple times. Both of these features might have increased the believability of the message and enhanced understanding. Porter and Melnyk (16) previously explored the utility of this type of intervention with a small pilot study whereby participants reported using the lessons in their day-to-day driving. A quote from one participant in that study exemplifies how useful they felt this type of training was: “[t]his was the most effective driver education. It takes the “fantasy” out of our perceptions about our driving practices and our capabilities and abilities!”.

Future studies could examine the benefits of the type of training outlined in this study as compared to, or in combination with, in-vehicle training. In-vehicle real-time training has the advantage of allowing for practice of driving maneuvers and direct feedback from an instructor and so might provide synergistic effects with preliminary video feedback. This training could also be examined without the addition of classroom education as it was not found to be beneficial on its own. Of course, it is also imperative that future studies examine more direct safety benefits of any type of older driver education program in terms of effects on older adults’ everyday patterns of driving and whether they have driving infractions or crash. It is not necessarily true that improvements based on on-road testing will necessarily transfer to reducing crash rates (2,17).

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