Brief Report

Cognitive Speed of Processing Training Delays Driving Cessation

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Background. As our population ages, interventions that can prolong safe driving for older adults will be increasingly important.

Methods. Data from two studies were combined in order to investigate the effectiveness of cognitive training in delaying driving cessation. Stratified Cox hazard regressions were used to examine risk of driving cessation as a function of training participation, baseline driving, and visual acuity.

Results. Older drivers with cognitive speed of processing difficulties who completed speed of processing training were 40% less likely to cease driving over the subsequent 3 years (hazard ratio = 0.596, 95% confidence interval 0.356–0.995, p = 0.048). Whereas 14% of older drivers who did not receive speed of processing training ceased driving, only 9% of those who completed eight or more sessions of speed of processing training ceased driving.

Conclusion. Speed of processing training may delay driving cessation among older drivers with speed of processing difficulty.

Key Words: Cognitive training—Driving—Intervention.

Older adults who cease driving experience fewer out-of-home activities (1), increased depression (2), and decreased sense of control (3). Furthermore, those who cease driving are at increased risk for long-term care institutionalization and mortality (4,5). As the percentage of older adults comprising our population increases, health care workers will increasingly be faced with advising older patients about driving. Finding ways of maintaining safe driving mobility will be of ever more concern.

Research on risk factors for driving cessation has indicated that older adults who have ceased driving report poorer health and physical abilities (6,7). Ragland and colleagues (8) found that older adults report concerns about being in an accident and vision problems as reasons for self-regulating their driving. Poor vision is a prospective risk factor for driving cessation (8,9).

Recent evidence also highlights the importance of cognitive abilities to maintained driving (10). Anstey and colleagues (11) found that older drivers with poor cognitive abilities, including speed of processing, had a higher probability of driving cessation. Recent analyses found that slower speed of processing was a significant risk factor for driving cessation, even while considering baseline driving, age, health, vision, memory, reasoning, and physical performance (10).

Ongoing research has indicated that speed of processing can be enhanced through a computerized training regimen (12) and that such training may improve on-road driving safety (13) and protect against declines in driving mobility across 3 years (14). Given that the training has resulted in maintained driving mobility, it was of interest to examine whether training delays the outcome of driving cessation. The current analyses were conducted to examine whether completing this speed of processing training regimen delays driving cessation.

Methods

Participants

Driving cessation over a 3-year period among community-dwelling older drivers is a relatively low-frequency event. To gain statistical power and ensure an adequate sample size of those who ceased driving, data from comparable populations from two studies were combined. The first study, Staying Keen in Later Life (SKILL), recruited relatively healthy community-dwelling older adults with intact vision and hearing who did not have evidence of dementia or other severe cognitive impairment (Mini-Mental State Examination [MMSE] score of 23 or better). SKILL participants were primarily recruited via mass-mailed letters to older adults residing in the area as well as through local senior agencies and health clinics. Inclusion criteria for the SKILL training study also required Useful Field of View Test (UFOV) performance indicating risk for mobility decline (Task 2 ≥150 ms or...
Task 3 + Task 4 $\geq 800$ ms) (15). Eligible SKILL participants who performed poorly on the UFOV ($n = 124$) were randomly assigned to either speed of processing training ($n = 61$) or a control condition that involved the same amount of social contact and computer contact (internet use, $n = 63$). One participant did not complete at least eight sessions of speed training.

The second study was Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE), which recruited participants with the same inclusion criteria as described previously for SKILL with the exception that participants were not required to show UFOV difficulties, and ACTIVE specifically excluded individuals with functional disabilities and life-threatening disease. In ACTIVE, older adults who resided in the community were recruited through senior centers, churches, senior housing, senior community organizations, and health clinics. Complete inclusion and exclusion criteria are detailed elsewhere (16). Similarities and differences between the two studies are summarized in Table 1. ACTIVE participants were randomly assigned to speed of processing, memory, or reasoning training or to a no-contact control group. To aggregate the data sets, a post hoc subsample of ACTIVE participants from the speed of processing training and control groups with baseline UFOV scores that met the SKILL inclusion criteria were selected ($n = 444$). Of these 444 participants, 211 were randomly assigned to the control condition and 233 to speed of processing training. Seventeen of those randomized to training did not complete at least eight sessions.

The sample consisted of 568 adults ranging in age between 63 and 91 years and comprised 70% females and 76% Caucasians. These participants had a wide range of education from sixth grade to PhD, with an average of some college or vocational training.

To examine the impact of completing speed of processing training upon subsequent driving cessation, we compared those who attended eight or more training sessions ($n = 276$) with those who completed no training sessions. This criterion was chosen a priori in that attending at least 8 of 10 sessions was considered completing the training in both the ACTIVE and the SKILL studies as well as prior training studies (15–18). The number of participants by study and condition as well as the number of training sessions completed are presented in Table 2.

### Measures

Measures common to the two studies are listed subsequently and were administered with identical protocols in both the SKILL and the ACTIVE studies.

The Mobility Driving Habits Questionnaire (19) was used to ascertain driving status and the number of days per week driven.

A standard letter chart was used to measure far visual acuity. Scores were assigned from 0 to 90 based upon how many letters were correctly discriminated (90 is equivalent to a Snellen score of 20/16). The scores can be easily converted to Log minimum angle resolvable but for convenience are scaled so that higher numbers reflect better vision.

Mental status was assessed with the MMSE (20), which is commonly used to screen for dementia. Scores can range from 0 to 30, with higher scores representing better cognition.

### Table 1. General Characteristics of the ACTIVE and SKILL Studies

<table>
<thead>
<tr>
<th></th>
<th>ACTIVE</th>
<th>SKILL</th>
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<tbody>
<tr>
<td>Inclusion criteria</td>
<td>Intact vision and hearing. MMSE $\geq 23$ and no diagnoses of dementia. No communicative difficulties. No functional disabilities. No cancer, chemotherapy, or other life-threatening illness.</td>
<td>Intact vision and hearing. MMSE $\geq 23$ and no diagnoses of dementia. English speaker and literacy of fifth grade or higher</td>
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<tr>
<td>Study sites</td>
<td>University of Alabama at Birmingham, Hebrew Senior Life; Indiana University; Johns Hopkins University; Pennsylvania State University; Wayne State University.</td>
<td>University of Alabama at Birmingham; Western Kentucky University.</td>
</tr>
<tr>
<td>Study visits</td>
<td>Screening, baseline, immediately posttraining, 1, 2, 3, and 5 years.</td>
<td>Screening, baseline, immediately posttraining, and 3 years.</td>
</tr>
<tr>
<td>Training arms</td>
<td>4: Speed of processing training, reasoning training, memory training, and no-contact control group.</td>
<td>2: Speed of processing training and social contact and computer contact control group.</td>
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<tr>
<td>Speed of processing training protocol</td>
<td>5 sessions of specified followed by 5 sessions of adaptive training. 2 times per week for 5 weeks.</td>
<td>10 sessions of adaptive training. 2 times per week for 5 weeks.</td>
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</table>

**Note:** ACTIVE = Advanced Cognitive Training for Independent and Vital Elderly; MMSE = Mini-Mental State Examination; SKILL = Staying Keen in Later Life; UFOV = Useful Field of View Test.
The UFOV measured speed of information processing for tasks of visual attention across four increasingly difficult subtests (21). Each subtest is scored as the display duration (16–500 ms) at which the participant could perform the task correctly 75% of the time.

**Procedure**

Speed of processing training was led by a trainer and involved 10 sessions in which trainees practiced computerized exercises of visual attention aimed at enhancing the speed and accuracy of visual performance. In both studies, the training sessions were 1 hour in duration and were completed twice a week for a period of 5 weeks (15). The cognitive assessments, conducted by testers who were blind to treatment condition, were repeated immediately posttraining, and the driving questionnaire was repeated 3 years after training.

**Analyses**

The two study populations did not significantly differ at baseline in age, cognition, or days driven per week (ps > .05). However, the SKILL participants tended to have poorer vision overall (p < .05). Thus, vision was included as a covariate. Although older adults are likely to cease driving due to poor vision (8,9), visual acuity would not be expected to be significantly affected by training participation. Given that driving cessation rates did not differ by sex or race (ps > .05), these variables were not further explored in analyses.

Stratified Cox regression analyses were used to assess the probability that an individual would cease driving across the subsequent 3 years as a function of training participation (completing eight or more sessions) while controlling for baseline driving and vision, stratified by study. A different baseline hazard is calculated for each study, and the overall hazard function is obtained for each covariate in the model. Time was right censored, calculated as the number of months between baseline and the 3-year interview, for persons who reported driving at the 3-year follow-up assessment. For persons who did not remain drivers, the point at which driving ceased in terms of months after baseline was used to time the event.

**RESULTS**

Multivariate analyses of variance were first conducted to assure that the training and control groups did not differ at baseline in age, cognition, vision, or number of days driven per week. No significant group differences were found, Wilks’ Λ = .986, F(5,552) = 1.55, p = .173. Of the 294 participants randomized to speed of processing training, the 18 who did not complete eight or more sessions did not differ at baseline from the 276 who did in age, days driven per week, cognition, or visual acuity, Wilks’ Λ = .994, F(5,288) < 1, p = .901.

Repeated measures analysis of variance confirmed a significant group by time interaction for UFOV performance, p < .001.

Stratified Cox regression analyses were used to examine training participation as a predictor of driving cessation together with both baseline driving and visual acuity stratified by study (ACTIVE vs SKILL). Results of the model are presented in Table 3 and Figures 1 and 2. Baseline driving (p < .001) and vision (p = .007) were significant predictors of subsequent driving cessation. Older drivers who initially drove more often and those with better vision were less likely to cease driving. Speed of processing training participation was protective against driving cessation (hazard ratio [HR] = 0.596, 95% confidence interval [CI] 0.356–0.995, p = .048). Participants who completed speed of processing training were 40% less likely to cease driving across the subsequent 3 years as compared with controls (see Table 4).

<table>
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<th>Table 2. Number of Participants by Study, Condition, and Number of Training Sessions Completed</th>
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<tr>
<td>Number of Training Sessions Completed</td>
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<td>---------------------------------------</td>
</tr>
<tr>
<td>SKILL</td>
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<tr>
<td>Controls</td>
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<tr>
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<tr>
<td>ACTIVE</td>
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<td>Controls</td>
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<td>Speed trained</td>
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*Note: ACTIVE = Advanced Cognitive Training for Independent and Vital Elderly; SKILL = Staying Keen in Later Life.*

<table>
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<tr>
<th>Table 3. Characteristics of the Speed of Processing Trained and Control Participants</th>
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<td>Variable</td>
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<tr>
<td>Age (y)</td>
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<tr>
<td>Sex (% female)</td>
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<tr>
<td>Race (% Caucasian)</td>
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<tr>
<td>MMSE (score out of 30)</td>
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<tr>
<td>Vision (score out of 90)</td>
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<tr>
<td>UFOV baseline (ms)*</td>
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<tr>
<td>UFOV posttraining (ms)*</td>
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<td>Ceased driving†</td>
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*Notes: MMSE = Mini-Mental State Examination; UFOV = Useful Field of View Test.

† Lower numbers reflect better performance.

‡ Cox regression indicated that trained participants were 40% less likely to cease driving. No other significant group differences were found.
There is increasing evidence that cognitive and physical interventions can prolong driving mobility and safety for older adults. In particular, cognitive speed of processing training may improve driver safety on the road (13), prolong driving mobility across 3 years (14), and reduce rates of driving cessation by 40% among older adults at risk for mobility decline. These results indicated that while 14% of the control participants ceased driving, only 9% of those who completed training (eight or more training sessions) ceased driving over 3 years.

Although cognitive performance is emerging as a salient predictor of cessation (i.e., 10, 23), it is important to note that social and demographic factors are also related to the decision to stop driving (24). Although female gender has been associated with higher risk of driving cessation in the past (25), it was not associated with driving cessation in this sample. In analyses that control for baseline driving, female gender has not emerged as a risk factor for cessation in modern cohorts of older drivers (i.e., 10, 23). Thus, the higher rates of cessation found among females in the past may reflect a cohort effect.

To have adequate power to examine driving cessation as an outcome with a sufficient sample size of speed of processing trained individuals, it was necessary to combine data across two different studies. We recognize that this method of estimating the impact of training is not without limitations. It is important to note that there were some methodological differences between the ACTIVE and SKILL studies. Most notably, SKILL used a control group that involved both social contact and computer contact, whereas the ACTIVE study involved a no-contact condition. However, the combination of these conditions is justified by prior research that found no differences between this type of social contact and computer contact condition and a no-contact control group when examining the impact of speed of processing training (26). Another difference is that the ACTIVE speed of processing training protocol involved specified practice for the first five sessions and adaptive training for the remaining sessions, whereas SKILL used only adaptive sessions (e.g., exercise difficulty is tailored to the individual). One would expect that these differences would not inflate the training effect size but rather would make it more difficult to detect training effects in that adaptive training is more effective than specified practice (15).

Another limitation is that the results presented are not intent-to-treat analyses. When examining all participants randomized to speed of processing training (n = 294) as compared with controls, the impact of training was marginally significant, HR = 0.64, 95% CI 0.39–1.06, p = .083. Given that the noncompleting participants appear similar to completing participants on baseline measures, this suggests that at least eight or more sessions of the
training is required for reduction in driving cessation rates. Ongoing analyses are examining the minimal dose of cognitive training needed to significantly affect older adults’ driving. Future research is required to confirm these results in a single prospective study of older drivers at risk for mobility problems.

Overall, research indicates that speed of processing training may prolong safe driving mobility among older adults at risk for mobility loss based on cognitive speed of processing performance. Paired with prior research, these results indicate that older drivers at risk for mobility problems can be identified with measures such as the UFOV and Digit Symbol Substitution Tests (10) and referred to a cognitive training program. Cognitive speed of processing training may enhance on-road driving safety (13); protect against declines in driving exposure (number of challenging conditions encountered while driving), driving space (extent into environment driven), and increased driving difficulty (14); and may delay driving cessation.

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REFERENCES


