

The Longitudinal Impact of Cognitive Speed of Processing Training on Driving Mobility

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Purpose: To examine how cognitive speed of processing training affects driving mobility across a 3-year period among older drivers.

Design and Methods: Older drivers with poor Useful Field of View (UFOV) test performance (indicating greater risk for subsequent at-fault crashes and mobility declines) were randomly assigned to either a speed of processing training or a social and computer contact control group. Driving mobility of these 2 groups was compared with a group of older adults who did not score poorly on the UFOV test (reference group) across a 3-year period. **Results:** Older drivers with poor UFOV test scores who did not receive training experienced greater mobility declines as evidenced by decreased driving exposure and space and increased driving difficulty at 3 years. Those at risk for mobility decline who received training did not differ across the 3-year period from older adults in the reference group with regard to driving exposure, space, and most aspects of driving difficulty. **Implications:** Cognitive speed of processing training can not only improve cognitive performance but also protect against mobility declines among older drivers. Scientifically proven cognitive training regimens have the potential to enhance the everyday lives of older adults.

Key Words: *Cognitive training, Cognitive interventions, Transfer of training, Prolonging driving, Older drivers*

An important index of mobility in Western societies is driving. According to the Centers for Disease Control and Prevention (2006), the number of licensed U.S. drivers older than 65 years increased by 17% during the 1990s, such that in 2004 there were more than 28 million drivers aged 65 years and older. Maintaining safe mobility is an important health concern for older adults. Several studies have documented that driving cessation leads to many adverse consequences for older adults such as increased dependency, social isolation, and depression (Fonda, Wallace, & Herzog, 2001; Marottoli et al., 1997, 2000; Ragland, Satariano, & MacLeod, 2005). A recent longitudinal study found that older adults who ceased driving were at higher risk for subsequent nursing home placement (Freeman, Gange, Munoz, & West, 2006). Thus, the loss of driving capacity has a negative impact on multiple areas of life for seniors.

Prior to ceasing driving, older drivers tend to increasingly limit their driving to particular times and places in which they feel safe (Ball et al., 1998; Chu, 1994; Janke, 1994). The reasons that older individuals may limit or stop driving are multifaceted including declining vision, poor health, physical difficulties, and cognitive decline.

Vision, Health, and Physical Performance

With regard to vision and driving restrictions, Ragland, Satariano, and MacLeod (2004) found that 29% of the adults older than 65 years reported problems with their eyesight as a primary reason they limit their driving. Other research has indicated that older adults with visual difficulties in contrast sensitivity, visual fields, or both were subsequently more likely to restrict or cease driving (Freeman, Munoz, Turano, & West, 2005).

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Brayne and colleagues (2000) found that the most frequent reason reported for driving cessation among individuals 84 years of age and older (a much older sample) was general health problems. Older individuals who have ceased driving not only have more medical conditions but also rate their own health more poorly (Campbell, Bush, & Hale, 1993; Forrest, Bunker, Songer, Coben, & Cauley, 1997; Marottoli et al., 1993). In addition to vision, health, and medical conditions, physical abilities are also associated with driving restriction and cessation among older adults (Campbell et al.; Marottoli et al., 1998). These results have been found with both self-report and performance-based measures such as balance (Ackerman, Edwards, Ball, Ross, & Lunsman, 2008; Edwards et al., 2008). Although it is generally assumed that functional and health limitations precede driving restriction or cessation, there may be a bidirectional relationship such that driving cessation results in further decline and reduced quality of life.

Cognition and Driving

Although vision, physical performance, and health are associated with driving mobility, cognitive performance may be the strongest predictor of subsequent driving limitations (Vance et al., 2006). Ball and colleagues (1998) found that older adults with slower cognitive speed of processing, as measured by the Useful Field of View (UFOV; a registered trademark of Visual Awareness, Inc.) test, experienced the greatest mobility losses. Similarly, in a longitudinal study, Anstey, Windsor, Luszcz, and Andrews (2006) found that cognitive performance as indicated by speed of processing and reasoning were strong indicators of older adults' subsequent likelihood to cease driving over a 5-year period. Edwards and colleagues (2008) found that even while adjusting for vision, health, and physical performance, cognitive speed of processing as measured by UFOV and the Digit Symbol Substitution Test predicted subsequent driving cessation among older adults.

The UFOV test is of particular interest in that it predicts a number of driving mobility outcomes and can also be improved through training. The UFOV test can distinguish older drivers at risk for crashes (Clay et al., 2005; Owsley et al., 1998). Older adults who perform poorly on the UFOV are also at higher risk for decreased mobility (Ball et al., 1998) including driving cessation (Ackerman et al., 2008; Edwards et al., 2008). At the same time, UFOV performance can be improved with cogni-

tive speed of processing training (Ball et al., 2002). Thus, of interest is whether such training also transfers to driving mobility outcomes.

Cognitive Training and Mobility

Considering the significant role of cognition in subsequent driving behaviors, cognitive training may be a means of prolonging mobility among older adults. It is clear that cognitive abilities among older adults can be enhanced through training (e.g., Ball et al., 2002; Kramer & Willis, 2002; Willis et al., 2006). Prior research with a particular training technique, speed of processing training, has been successful in demonstrating transfer of training to not only UFOV performance but also everyday performance including measures of driving safety (for a review, see Ball, Edwards, & Ross, 2007). In a controlled clinical trial, older adults randomized to speed of processing training experienced immediate improvements in UFOV performance, which were maintained over a 5-year period relative to controls (Willis et al., 2006). This training has also translated to improved performance of timed instrumental activities of daily living (Edwards, Wadley, Vance, Roenker, & Ball, 2005; Edwards et al., 2002) and is protective against declines in health-related quality of life across 5 years (Wolinsky, Unverzagt, Smith, Jones, Stoddard, et al., 2006; Wolinsky, Unverzagt, Smith, Jones, Wright, et al., 2006).

The present study attempted to replicate and extend the findings of Roenker, Cissell, Ball, Wadley, and Edwards (2003) who examined the impact of speed of processing training among older drivers. Older adults who were at risk for crashes based upon their poor UFOV performance were randomized to a speed of processing training group or a social contact control group of simulator and on-road training and were compared with older adults who were not at risk based on their UFOV performance (the reference group). Results indicated that after an 18-month period, older drivers who completed speed of processing training made fewer dangerous maneuvers than did the simulator-trained controls or reference group during an on-road driving test. In addition, relative to the reference group, the controls reported reduced driving mobility across the 18-month period. In contrast, those who completed speed of processing training maintained driving mobility throughout the study. Thus, speed of processing training may be protective against declines in driving mobility.

Analyses reported here examine the impact of cognitive speed of processing training upon subsequent driving mobility over a 3-year period in the Staying Keen in Later Life (SKILL) study. It has not been clear whether cognitive training reverses, delays, or protects against age-related functional decline. Based on the results of Roenker and colleagues (2003), we hypothesized that cognitive speed of processing training may delay or slow the rate of decline in driving mobility among older adults who are already at risk for mobility loss. Because older adults who complete the training become less risky on the road, this may in turn prolong their safe mobility. Thus, we expected that training would protect against subsequent mobility decline. Specifically, we hypothesized that even after controlling for baseline age, vision, physical function, and health, speed of processing training would protect against declines in driving mobility across a 3-year period.

Methods

Participants

Participants of this study included 500 individuals who completed the baseline phase of the SKILL study, defined themselves as current drivers at baseline, and were successfully contacted for interviews 3 years later (Edwards, Wadley, et al., 2005).

The original SKILL baseline study involved 895 community-dwelling adults aged 60 years and older, who were recruited from mass mailings to residents of Birmingham, AL; Bowling Green, KY; and surrounding areas. The inclusion criteria for the SKILL training study included age of 60 years or older, literacy level of fifth grade or better, adequate vision to view study materials (far visual acuity $\geq 20/80$ and Pelli-Robson contrast sensitivity ≥ 1.35), and a Mini-Mental State Examination score (MMSE) of 23 and above to exclude those with potential dementia.

The SKILL participants who were baseline drivers ($N = 640$) and had completed the SKILL study within the past 3 years (± 3 months) were invited to participate in the present study. Five hundred of these potential participants (78%) were successfully contacted and agreed to participate. Of the 140 potential participants not interviewed, 32 were unable to be reached, 30 were deceased, and 78 refused to participate in the telephone interview. The participants were mostly women ($n = 275$) and of Caucasian descent ($n = 443$) but also included individuals of African American descent ($n = 53$).

Education levels ranged between sixth grade and PhD. These characteristics match those of the overall baseline sample (Edwards, Wadley, et al., 2005). Within this sample, 366 served as the reference group. These participants had not experienced significant cognitive slowing as measured by UFOV and did not participate in training. Of the remaining participants who performed poorly on the UFOV test at baseline (indicating increased risk for mobility decline), 66 were randomized to speed of processing training and 68 were randomized to a social and computer contact control group.

Procedure

The SKILL study was conducted in several phases, including screening, baseline, training, and immediate post-training assessments (Edwards, Wadley, et al., 2005; Wood et al., 2005). At the screening visit, vision, hearing, and mental status were assessed, and a mobility questionnaire (MQ) was administered (Ball et al., 1998; Owsley, Stalvey, Wells, & Sloane, 1999; Stalvey, Owsley, Sloane, & Ball, 1999). The baseline phase entailed a more extensive battery of both cognitive and physical performance in addition to questions about health.

A subset of the baseline participants with poor UFOV performance (Subtest 3 + Subtest 4 ≥ 800 ms or Subtest 2 ≥ 150 ms) was invited to participate in the training phase of the study. These criteria were chosen for two reasons. First, prior training studies have found the largest training gains and greater likelihood of transfer among older adults with initial UFOV scores within this range (Ball et al., 2007). Second, older adults who score in this range on the UFOV test are known to be at higher risk for negative driving outcomes such as at-fault crashes and driving cessation (Ball et al., 2006; Edwards et al., 2008). Thus, older drivers at risk for adverse mobility outcomes based upon their UFOV test performance were randomized to receive either a cognitive speed of processing training or a social and computer contact Internet training control group. These two groups were compared with a reference group of older adults who did not exhibit poor UFOV performance at baseline.

Across the two training conditions, 10 one-hour sessions were held over the course of 5 weeks. These sessions involved individual practice exercises on the computer that were guided by a trainer. The intervention and control conditions were identical, with the exception of the types of exercises that were practiced on the computer.

The speed of processing trainees practiced computerized tasks involving identifying and localizing visual (cars and trucks) and auditory (series of tones) targets. Each of the 10 sessions was led by a trainer, included 1–3 participants, and lasted 1 hr in duration. During the session, participants individually practiced computerized exercises designed to enhance the amount of information they could process over brief periods of time. The training included more than 18 different tasks that require visual target awareness (i.e., Was there a target? yes/no), identification (i.e., What was the target? car/truck), discrimination (i.e., Were the two targets same or different?), and localization (i.e., Where was the outside car?). At the most advanced level, simultaneous visual and auditory (series of three tones) identifications were required (i.e., What tones did you hear? up/down?). Trainees practiced blocks of 16 trials of computerized tasks at a display speed and difficulty level tailored to their ability by the trainer. Feedback (number of correct trials) was provided at the end of each block of trials. This practice followed the specific protocol described in detail elsewhere (Ball et al., 2007; Edwards, Wadley, et al., 2005). Throughout the training, the primary modification was the speed at which these tasks are displayed, which ranged between 20 and 400 ms and was customized for each individual's level of ability. Based on each trainee's abilities and progress, the difficulty of the tasks was modified according to the protocol to increase the speed at which participants can process information as well as the amount and complexity of that information.

Internet training was chosen instead of a no-contact control condition to control for both computer and social contact. Just as in the experimental condition, participants attended 10 sessions, 1 hr in duration, guided by a trainer, involving 1 to 3 participants. Participants in the Internet training condition received instructions on computer hardware, how to use the mouse, how to acquire and use an e-mail account, and how to access and use Web pages. Participants individually practiced these skills on the computer through exercises guided by the trainer in each session.

Follow-Up Procedure

Follow-up interviews occurred within 3 years plus or minus 3 months of the participants' last assessment. At the appropriate time, potential participants were contacted via informational letters,

which were followed by telephone calls. Participants provided their verbal consent to participate during the telephone interviews (as approved by the Institutional Review Boards of the University of Alabama in Birmingham and the University of Alabama in Huntsville) and were readministered the MQ and asked questions about their health.

Measures

Mobility Questionnaire.—All participants completed the MQ to assess driving behaviors over a time period of 7 days to 2 years. This measure has been shown to have good test-retest reliability and construct validity (Owsley et al., 1999). The first question ascertained whether the participant was a current driver, which was defined as "someone who has driven a car within the last 12 months and someone who would drive a car today if they needed to." The remaining questions inquired about driving exposure, driving difficulty, and driving space. Participants were asked to indicate whether they had encountered any of eight different situations during the prior 2 months while driving. For each encountered situation, participants were asked to rate the level of difficulty experienced (1 = *no difficulty* to 4 = *extreme difficulty*). For example, participants were asked if they had driven in the rain during the prior 2 months, and if so, how difficult they found the experience. Participants also were asked how far they had driven from their home in the past week and 2 months, with places ranging beyond their property to out of the region.

Composites were formed based upon prior research and confirmatory factor analyses and included driving exposure, two driving difficulty composites (three and five items), and driving space. Prior research has indicated that the test-retest reliability is .86 for the driving space composite, .83 for the driving exposure composite, and .60 for the driving difficulty composite (Owsley et al., 1999). The number of driving situations encountered was totaled as a measure of driving exposure, ranging between 0 and 8 (driving exposure). The three-item difficulty composite included driving alone, making lane changes, and making left-hand turns across oncoming traffic and ranged from 3 to 12, with higher values indicating greater levels of difficulty. The five-item difficulty composite included driving in high traffic, driving at night, driving in the rain, merging with traffic, and driving during rush hour. This composite ranged from 5 to 20, with higher values indicating greater levels of difficulty. The

Table 1. Description of Driving Outcomes From the Mobility Driving Habits Questionnaire

Outcome	Range	Description	Questionnaire items
Driving exposure	0–8	Total number of challenging conditions encountered while driving	High traffic Night Rain Merge into traffic Rush hour Alone Lane changes Left-hand turns
Driving space	1–6	Extent into environment driven	Beyond property (1) Beyond neighborhood (2) Beyond town/community (3) Beyond city (4) Beyond state (5) Beyond region (6)
Driving difficulty 3	3–12	Rating of difficulty while driving in each situation; 1 = no difficulty to 4 = extreme difficulty	Alone Lane changes Left-hand turns
Driving difficulty 5	5–20	Rating of difficulty while driving in each situation; 1 = no difficulty to 4 = extreme difficulty	Rush hour High traffic Night Rain Merging into traffic

driving space composite indicated the extent to which the participant has driven beyond their home in the prior week (beyond property, beyond neighborhood, or beyond town/community), and beyond their city, or state, or region in the prior 2 months. Items were summed so that larger numbers (range 0–6) indicate larger driving space. These driving outcomes are summarized in Table 1.

Health.—The health questions included self-report of whether a doctor or nurse had ever informed participants of having any of the following: cataracts, diabetic retinopathy, glaucoma, macular degeneration, optic neuritis, retinal detachment, dry eye syndrome, arthritis, asthma, cancer, chronic skin problems, diabetes, heart disease or other heart problems, high cholesterol, hypertension, mood problems or anxiety disorders, multiple sclerosis, osteoporosis, Parkinson's disease, or stroke (including ministroke or transient ischemic attack). In addition, participants were asked whether they had any other significant eye or health conditions not provided in the list. The total number of health conditions reported was used in analyses.

Physical Performance.—Balance was assessed using the Turn 360 test (Steinhagen-Thiessen & Borchelt, 1999). Participants were asked to stand and turn in one complete circle. The number of

steps required to make one complete turn was calculated, with fewer steps indicating better balance. Participants were then asked to complete a second 360° turn. The average number of steps taken for both attempts was computed and used for the analyses.

Vision.—Two measures assessed visual capabilities. The first of these measured far visual acuity with a GoodLite Model 600A light box with the Early Treatment Diabetic Retinopathy Study chart using standard procedures. Participants stood 10 feet from the chart and were tested first with no corrective lenses and then with corrective lenses (when applicable). Scores were assigned using a method from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study (Ball et al., 2002), which provides credit for each letter correctly identified, with scores ranging from 0 to 90, with higher scores reflecting better performance.

Visual contrast sensitivity was also assessed using the Pelli-Robson contrast sensitivity chart (Pelli, Robson, & Wilkins, 1988). Using standard procedures, the scores were derived from the last set of triplets in which two letters were identified correctly. The possible range of scores was 0–2.25 log10 (poorest to best performance, respectively). Participants were required to score 1.35 log10 or more for inclusion in this study.

Table 2. Group Means and Standard Deviations for Covariates

	Low-risk reference (<i>n</i> = 366)		At-risk speed of processing trained (<i>n</i> = 66)		At-risk controls (<i>n</i> = 68)	
	M	SD	M	SD	M	SD
Age	72.08	4.98	74.13	4.91	74.52	5.69
Contrast sensitivity	1.71	0.12	1.65	0.14	1.63	0.14
Visual acuity	74.16	10.09	69.41	12.43	70.26	12.69
UFOV total ^a	319.23	165.15	592.89	216.24	633.98	220.75
MMSE total	28.55	1.42	27.98	1.43	27.91	1.69
Health	4.74	2.85	5.50	3.02	5.11	2.58
Turn 360 ^a	6.75	1.48	6.97	1.37	6.94	1.39

Notes: UFOV = Useful Field of View; MMSE = Mini-Mental State Examination.

^aSmaller scores reflect better performance.

Cognition.—The MMSE was used to assess mental status and decrease the possibility of including participants with dementia. The questions measured attention, memory, language, orientation, and construction skills, with scores ranging from 0 (poor cognitive function) to 30 (high cognitive function; Folstein, Folstein, & McHugh, 1975). Participants were required to have a score of 23 or more for inclusion in these analyses.

The UFOV test (Edwards et al., 2006) was used to measure the speed at which an individual can process multiple stimuli across the visual field and to identify those at risk for adverse mobility outcomes. The touch PC version of the test was administered with four subtests, with each subtest progressively more difficult than the previous (Edwards, Vance, et al., 2005; Edwards et al., 2006). In each subtest, the display duration threshold value for 75% correct performance was measured using the double staircase method (Cornsweet, 1962), with performance varying between 16 and 500 ms.

Results

Missing data for the Turn 360 test was substituted by mean substitution for one case. Means and standard deviations for age, vision, health, and physical performance are presented by group in Table 2. Means and standard deviations of the mobility outcomes at baseline and at 3 years are reported in Table 3.

Dependent measures were transformed into standardized *z* scores, with 3-year outcome data standardized by baseline mean and standard deviation. Outliers were recoded to $\pm 2.5 z$. Age, vision, health, and physical performance may obviously impact

subsequent driving mobility of older adults, so these variables were used as covariates in analyses.

Multivariate analyses of variance ensured that the control and experimental groups did not differ across the covariates of age, vision, balance, and cognition or in baseline driving space, exposure, or difficulty, Wilks' $\lambda = .965$, $F(9, 122) < 1$, $p = .879$.

If driving mobility loss is slowed for at-risk drivers who receive training, we would expect the mobility trajectories of the trained participants to be more similar to the reference group than the at-risk drivers who did not receive training. Compared with the reference group, the at-risk control group would be expected to experience steeper trajectories of decline in driving mobility across time.

Repeated-measures multivariate analyses of covariance were used to compare driving exposure, driving difficulty, and driving space composites across time for the reference group, the speed of processing trained group, and the Internet-trained control group after adjusting for baseline age, vision, health, and physical performance. Analyses revealed an overall significant Training Group \times Time interaction, Wilks' $\lambda = .945$, $F(8, 982) = 3.50$, $p = .001$. Age, vision, health, and physical performance were significant covariates ($ps < .01$).

Univariate results indicated a significant training group by time interaction for driving exposure, $F(2, 493) = 3.27$, $p = .039$; the driving difficulty three-item composite, $F(2, 493) = 11.99$, $p < .001$; and driving space, $F(2, 493) = 3.35$, $p = .036$, but not for the driving difficulty five-item composite, $F(2, 493) = 1.83$, $p = .161$. Simple contrasts were performed to compare the speed of processing trained group with the reference group and the reference group with the control group. The contrasts revealed that whereas

Table 3. Group Means and Standard Deviations for Driving Mobility Outcomes

	Low-risk reference (n = 366)		At-risk speed of processing trained (n = 66)		At-risk controls (n = 68)	
	M	SD	M	SD	M	SD
Driving space						
Baseline	3.69	1.23	3.53	1.24	3.50	2.79
3 years	3.65	1.40	3.19	1.61	2.87	1.72
Driving exposure						
Baseline	7.66	0.74	7.47	1.30	7.30	1.01
3 years	7.41	1.34	6.86	2.27	6.44	2.72
Driving difficulty, 3 items^a						
Baseline	3.22	0.61	3.53	1.24	3.34	0.84
3 years	3.54	1.30	4.24	2.28	4.87	2.79
Driving difficulty, 5 items^a						
Baseline	6.90	2.43	7.52	3.24	7.81	2.55
3 years	7.75	3.14	8.97	4.17	9.62	4.73

Note: ^aSmaller scores reflect better performance.

the control group experienced decline across time relative to the reference group in driving difficulty, driving space, and driving exposure ($p < .015$), those participants who completed speed of processing training were not significantly different from the low-risk reference group across time ($p > .05$), with the exception of the three-item driving difficulty composite ($p = .004$). Results are depicted in Figures 1–4.

Those with slowed cognitive speed of processing who did not receive speed of processing training (control group) experienced steeper decline in driving mobility across the 3-year period relative

to the reference group as indicated by increased driving difficulty and decreased driving exposure and space. Those who completed speed of processing training experienced increased driving difficulty across time when driving alone, making lane changes, and making left-hand turns across oncoming traffic than did the reference group (driving difficulty three-item composite). However, those who were trained did not differ across time from the reference group in driving exposure, driving space, or the degree of driving difficulty as indicated by the five-item composite

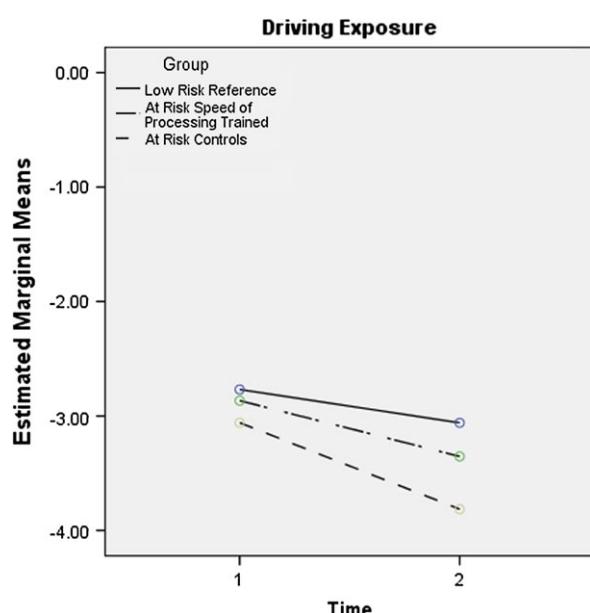


Figure 1. Driving exposure by group at baseline and at 3 years adjusted for age, vision, health, and physical performance.

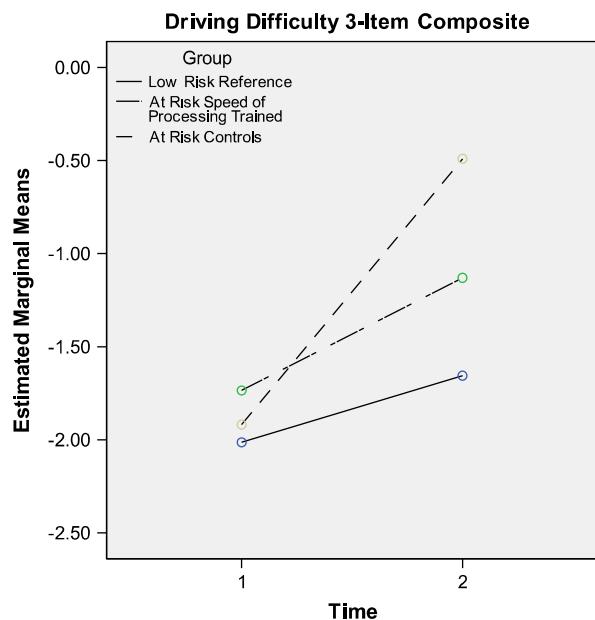


Figure 2. Difficulty when driving alone, making lane changes, and making left-hand turns by group at baseline and at 3 years adjusted for age, vision, health, and physical performance.

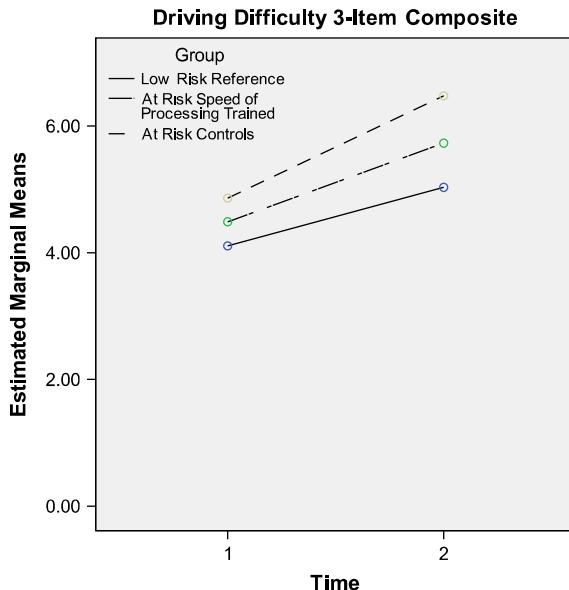


Figure 3. Difficulty while driving in high traffic, at night, in the rain, merging with traffic, and during rush hour by group at baseline and at 3 years adjusted for age, vision, health, and physical performance.

(driving in high traffic, driving at night, driving in the rain, merging with traffic, or driving during rush hour).

Discussion

The present results provide further evidence that cognitive training can positively impact everyday functional abilities among older adults. Willis and colleagues (2006) demonstrated that older adults who completed cognitive reasoning

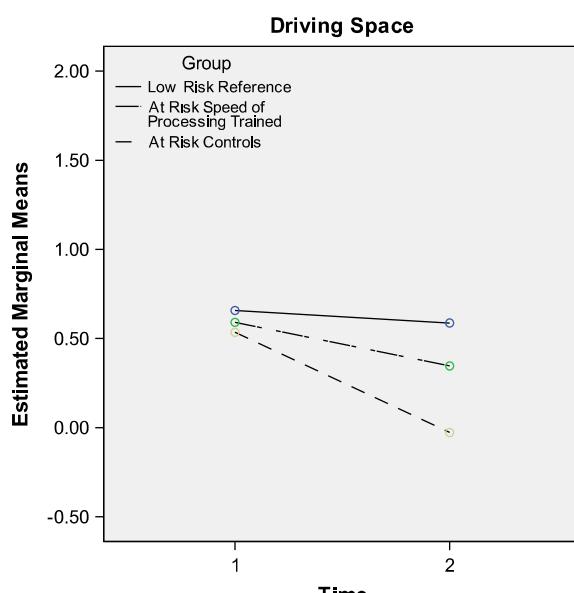


Figure 4. Driving space by group at baseline and at 3 years adjusted for age, vision, health, and physical performance.

training reported less difficulty with instrumental tasks of daily living after a 5-year period relative to controls. Similarly, our results indicate that older adults at risk for mobility declines who completed speed of processing training experienced similar driving mobility trajectories as older drivers who are not at risk for such declines. Those at risk who did not complete training but were randomized to a social and computer contact control group experienced greater mobility declines and difficulty across 3 years. These results replicate and extend those of Roenker and colleagues (2003) who found that at-risk older drivers who completed training drove more safely and maintained mobility over an 18-month period. Our results extend these findings by indicating that the transfer of training to driving outcomes endures for up to 3 years.

A limitation of this study is the use of self-report to assess driving mobility outcomes. It is very difficult to obtain objective measures of driving mobility. However, the similarity between the present findings and those reported by Roenker and coworkers (2003) mitigates this concern. Nevertheless, with the increasing availability of global positioning satellite technology, future research should attempt to more objectively evaluate the impact of cognitive training upon subsequent driving habits. Other studies have found that cognitive speed of processing training results in immediate improvements in performance-based measures of instrumental activities of daily living (Edwards, Wadley, et al., 2005; Edwards et al., 2002). Thus, future research may also verify that training positively impacts driving mobility using performance-based measures.

Although the effect sizes obtained in this study were small, the results are quite meaningful. Few studies of cognitive training have demonstrated far transfer of cognitive training to instrumental activities of daily living. Even small delays in driving mobility decline should have a significant impact upon older adults' quality of life and ability to remain independent. Results from the ACTIVE study have also demonstrated that this intervention is protective against both declines in health-related quality of life and depressive symptoms (Wolinsky, Unverzagt, Smith, Jones, Stoddard, et al., 2006; Wolinsky et al., in press). Considering the negative ramifications of driving cessation, the effect of maintained mobility is likely related to these prior findings. Overall, cognitive speed of

processing training has many potential benefits for older adults.

Future research should more closely examine longitudinal trajectories of mobility across time by using multilevel modeling techniques. Having only two time points, this was not possible with our data. Such analyses over longer periods of time would clarify whether cognitive training delays or prevents declines in mobility and other everyday functional abilities among older adults. By examining the data and these analyses, it appears that cognitive training may delay or slow down the rate of age-related functional decline. The slope of decline among the speed of processing training group was less steep than among those who did not receive training. All the groups' slopes, however, demonstrated decreased mobility across time. Thus, although training can reverse cognitive decline, it may not reverse functional decline. It would also be of interest to further examine how cognitive training precludes other declines associated with mobility loss such as depression, isolation, and the need for long-term care.

Cognitive training durability and optimal timing of additional training to maintain training gains also need to be determined. The present study only involved 10 hr of training and yet found significant differences in mobility trajectories across 3 years. Other studies have demonstrated that training is enhanced by booster sessions (i.e., Willis et al., 2006). Thus, it is likely that stronger effects may be obtained with more intensive and longer training protocols. The ACTIVE study indicated that when older adults received booster sessions, training gains were more likely to be maintained (Ball et al., 2007). Current research is investigating whether the benefits of training endure across a 10-year period. Presently, it is not known how often booster training is needed or how long training may endure.

An important point to make is that the training programs used in this and other studies that have resulted in improved cognitive and everyday functions among older adults involved rigorous protocols and targeted training techniques that are customized at an individual level. Although correlational studies indicate that older adults who remain active and socially engaged may be less likely to experience dementia (Scarmeas, Levy, Tang, Manly, & Stern, 2001; Verghese et al., 2003), this does not mean that engaging in any kind of stimulating activity will significantly enhance or maintain the everyday functioning of older adults. The strongest results with cognitive training protocols

have been found when older adults who have experienced a specific type of decline undergo a rigorous training program targeting that specific ability (Ball et al., 2007). To be most effective, training must be novel and continually challenge the trainee at his/her level of ability. Cognitive engagement and stimulation and even specific cognitive training protocols are not a panacea for age-related decline. The present results also highlight that maintained vision, health, and physical performance are vital for maintaining functional abilities with increasing age. Nevertheless, the potential benefits of scientifically proven cognitive training programs in combination with health and wellness programs show great potential to enhance quality of life and maintain independence into old age.

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Conflict of Interest

Karlene K. Ball and Daniel L. Roenker own stock in Visual Awareness, Inc. and Posit Science, Inc., the companies that market the UFOV test and speed of processing training software. Jerri D. Edwards has worked as a consultant to Visual Awareness, Inc.

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