Examination of Cognitive and Instrumental Functional Performance as Indicators for Driving Cessation Risk Across 3 Years

Michelle L. Ackerman, PhD, Jerri D. Edwards, PhD, Lesley A. Ross, PhD, Karlene K. Ball, PhD, and Melissa Lunsman, MS

Purpose: The purpose of this study was to prospectively examine the role of cognitive and instrumental functional performance in driving cessation while simultaneously accounting for any contributions of demographics, vision, physical performance, and health among a sample of older adults without dementia. Design and Methods: Included in the analyses were 1,838 participants from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study who were drivers at baseline and completed the third-year assessment. Participants completed baseline assessments of sociodemographic characteristics, health, sensory function, physical function, cognitive abilities, instrumental functional performance, and depressive symptoms. Driving status was again ascertained 3 years later. Results: We used Cox proportional hazard analyses to examine prospective predictors of driving cessation over a 3-year period. The final model indicated four significant risk factors for driving cessation: older age (hazard ratio [HR] = 1.06, \( p = .009 \)), poorer balance as measured by the Turn 360° test (HR = 1.17, \( p = .002 \)), slower cognitive speed of processing as measured by the Useful Field of View test (HR = 1.37, \( p = .004 \)), and poorer instrumental functional performance as assessed by the Everyday Problems Test (HR = 1.59, \( p < .001 \)). Implications: Although vision, health, and physical abilities are commonly considered when determining driving capacity, cognitive speed of processing and instrumental functional performance may be better indicators of subsequent likelihood of driving cessation across 3 years among older adults. Poor health and vision may only impact driving cessation to the extent that cognitive speed of processing and instrumental functioning are affected.

Key Words: Speed of processing, Instrumental activities of daily living, Longitudinal studies

Motor vehicle driving is an important aspect of maintaining mobility and independence for older adults in the United States. Almost 90% of this population uses a personal automobile as their primary method of transportation (Jette & Branch, 1992). Access to social activities, entertainment, shopping, and health care services is often dependent on individuals’ abilities to drive themselves (Barr, 2002; Marottoli et al., 2000), and a loss in access via reduction in driving or driving cessation can have serious consequences. Research has suggested that such consequences may include worsening of depressive symptoms (Fonda, Wallace, & Herzog, 2001; Marottoli et al., 1997; Windsor, Anstey, Butterworth, Luszcz, & Andrews, 2007), which may be due to decreased sense of control (Windsor et al., 2007); decreased out-of-home activities (Marottoli et al.,...
Most studies investigating factors associated with driving cessation have been cross-sectional, simply examining group differences between former drivers and those who continue to drive. This provides little information about whether these differences occurred prior to cessation of driving or as a result of the cessation itself. Many of these studies have focused on demographic variables, self-report of health status and medications, physical functioning, and visual ability. Such cross-sectional studies have reported that older adults who cease driving tend to be older (Campbell, Bush, & Hale, 1993; Gilhotra, Mitchell, Ivers, & Cumming, 2001) and female (Campbell et al., 1993). However, this gender finding has not been consistent across studies (Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001). Alternatively, older adults who continue to drive tend to be married (Brayne et al., 2000; Kington, Reuben, Rogowski, & Lillard, 1994). Whether one resides with other drivers may also play a role (Freund & Szinovacz, 2002).

Former drivers have poorer self-rated health (Dellinger et al., 2001) and are more likely to have medical conditions such as stroke, cardiovascular disease, diabetes, neurological conditions such as Parkinson's disease, syncope, and paralysis (Gilhotra et al., 2001; Kington et al., 1994). Similarly, a variety of visual conditions and abilities have been associated with driving cessation, including poor visual acuity; poor night vision; greater glare sensitivity; and presence of glaucoma, macular degeneration, or retinal hemorrhage. Poor vision is the most common reason that older adults report ceasing driving (Ragland, Satariano, & MacLeod, 2004). Whether one resides with other drivers may also play a role (Freund & Szinovacz, 2002).

Although driving itself has been defined as an instrumental activity of daily living (IADL; Barr, 2002), instrumental functional performance of older adults in other domains has not been widely explored as a correlate or predictor of driving cessation. Traditional definitions of IADLs include actions that require higher cognitive abilities to perform tasks from the domains of telephone use, housekeeping, shopping, food preparation, medications, finances, and laundry (Lawton & Powell, 1969). Research over the past two decades has resulted in several objective, performance-based measures of functional performance that focus on domains of instrumental activities considered essential for maintaining an independent lifestyle (Diehl et al., 2005; Owsley, McGwin, Sloane, Stalvey, & Wells, 2001; Owsley, Sloane, McGwin, & Ball, 2002; Willis, 1996). A few studies have reported an association of functional performance as indicated by IADLs with driving (Brayne et al., 2000; Ragland et al., 2004; Rimmo & Hakamies-Blomqvist, 2002). However, the latter two studies used self-report of functional performance, and the Brayne and colleagues study did not detail how IADL was assessed. Despite these limitations, all of these studies found a significant association between functional performance and driving outcomes.

There have been only a few prospective studies of driving cessation (Anstey, Windsor, Luszcz, & Andrews, 2006; Freeman, Munoz, Turano, & West, 2005; Jette & Branch, 1992). Such studies have found that demographic factors such as older age (Freeman et al., 2006; Jette & Branch, 1992; Marottoli et al., 1993), unemployment (Marottoli et al., 1993), and lower income (Jette & Branch, 1992) are predictive of subsequent driving cessation.

Several health and physical functioning measures have been longitudinally associated with later cessation of driving, including poorer self-reported health (Anstey et al., 2006; Freeman et al., 2005; Jette & Branch, 1992), diabetes, stroke (Freeman et al., 2005), poor grip strength (Anstey et al., 2006), and greater number of physical difficulties (Marottoli et al., 1993).

Visual function measures prospectively associated with driving cessation include the presence of cataracts (Marottoli et al., 1993), baseline visual acuity, contrast sensitivity, and central and lower peripheral visual fields deficits (Freeman et al., 2005).

Most studies of driving cessation have not included indices of cognitive functioning beyond dementia screening measures, which are insensitive to subtle cognitive declines. Only one longitudinal study of driving cessation has examined the role of cognitive performance in the decision to stop driving (Anstey et al., 2006), and no longitudinal studies have examined instrumental functional performance as a predictor. Using data from the Australian Longitudinal Study, Anstey and colleagues reported that poorer cognitive performance was associated with subsequent cessation. Data for the Australian Longitudinal Study were collected at baseline (1992) and at four follow-ups between 1993 and 1998. Cognitive impairment, as measured by the Mini-Mental State Examination (MMSE), was a significant predictor of driving cessation at the first follow-up. Poorer verbal reasoning scores and poorer picture memory scores were significant at both the second and third follow-up assessments. Worse symbol memory scores were predictive of driving cessation at the first and second assessments. Poor cognitive speed of processing, as measured by Digit Symbol Substitution, was a significant predictor of cessation at approximately 2 years and was marginally predictive at approximately 3 years after baseline. Anstey and colleagues concluded that cognitive performance and self-rated health were stronger indicators of subsequent driving cessation than either medical conditions or sensory function.
The purpose of this study was to prospectively examine the role of cognitive and instrumental functional performance (e.g., IADLs) while simultaneously examining the contributions of demographic variables, vision, physical performance, and health to subsequent driving cessation among community-dwelling older adults without dementia. To accomplish this aim, we used data over a 3-year period from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) project, a prospective cohort study conducted to test several cognitive interventions.

### Methods

#### Participants

The design and procedures of the ACTIVE clinical trial, which was conducted between 1998 and 2004, are detailed in Jobe and colleagues (2001). Community-dwelling older adults were recruited from Jefferson County, Alabama; Boston, Massachusetts; Indianapolis, Indiana; Baltimore, Maryland; Cumberland, Maryland; Detroit, Michigan; and Centre County, Pennsylvania. Exclusion criteria included age younger than 65 years, substantial cognitive problems as evidenced by a score of 23 or less on the MMSE (Folstein, Folstein, & McHugh, 1975), self-report of Alzheimer’s disease or other disabling or life-threatening conditions, substantial functional declines including in vision or hearing, communication deficits, and recent participation in a cognitive training study. We examined data for 1,838 participants who were drivers at baseline and completed the third-year assessment. Table 1 reports the baseline characteristics of this sample overall and by driving status at 3 years.

### Measures

A primary outcome of interest in the ACTIVE study was driving, thus the study included many measures based upon their potential relationship with driving outcomes. We selected the following measures for analyses based on previous research that suggests impaired ability in these areas may be linked to driving avoidance, exposure, or cessation.

**The Mobility Questionnaire (Ball et al., 1998; Owsley, Stalvey, Wells, & Sloane, 1999; Stalvey, Owsley, Sloane, & Ball, 1999).**—The first item on the Driving Habits portion of the questionnaire assessed whether the participant was a current driver, defined as “someone who has driven a car within the last 12 months and who could drive a car today if they needed to.” Current drivers were asked about their driving habits and the average number of days driven per week.

**Eye Health Questionnaire.**—Participants reported whether a doctor or nurse had ever informed them that they had a number of eye health conditions. These conditions included cataracts, diabetic retinopathy, glaucoma, and/or macular degeneration.

**Health Questionnaire.**—Participants reported whether a doctor or nurse had ever informed them that they had a number of health conditions including asthma/chronic bronchitis/emphysema, angina due to heart disease, congestive heart failure, high cholesterol, hypertension, osteoporosis, and/or stroke (including transient ischemic attacks).

**Short Form-36 Health Survey.**—This 36-item questionnaire (Ware & Sherbourne, 1992) assessed

### Table 1. Baseline Sample Characteristics Overall and by 3-Year Driving Status

<table>
<thead>
<tr>
<th>Baseline Characteristic</th>
<th>Total</th>
<th>Drivers</th>
<th>Non-Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age</td>
<td>73.08</td>
<td>5.55</td>
<td>72.77</td>
</tr>
<tr>
<td>Driving frequency</td>
<td>5.63</td>
<td>1.76</td>
<td>5.75</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>25.1</td>
<td>25.5</td>
<td>41.4</td>
</tr>
<tr>
<td>Marital status (% married)</td>
<td>40.0</td>
<td>41.4</td>
<td>65.2</td>
</tr>
<tr>
<td>Living arrangements (% alone)</td>
<td>48.8</td>
<td>65.2</td>
<td></td>
</tr>
<tr>
<td>SF-36 Physical Functioning</td>
<td>72.09</td>
<td>22.62</td>
<td>73.05</td>
</tr>
<tr>
<td>Turn 360°</td>
<td>6.72</td>
<td>1.79</td>
<td>6.64</td>
</tr>
<tr>
<td>Self-rated health</td>
<td>2.53</td>
<td>0.85</td>
<td>2.50</td>
</tr>
<tr>
<td>Stroke (% with)</td>
<td>6.4</td>
<td>5.9</td>
<td></td>
</tr>
<tr>
<td>Congestive heart failure (% with)</td>
<td>3.4</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td>12.77</td>
<td>3.77</td>
<td>12.85</td>
</tr>
<tr>
<td>Useful Field of View</td>
<td>895.31</td>
<td>266.22</td>
<td>878.72</td>
</tr>
<tr>
<td>Visual acuity</td>
<td>74.29</td>
<td>11.11</td>
<td>74.71</td>
</tr>
<tr>
<td>Observed Tasks of Daily Living</td>
<td>18.30</td>
<td>4.16</td>
<td>18.48</td>
</tr>
<tr>
<td>Everyday Problems Test</td>
<td>19.82</td>
<td>5.29</td>
<td>20.10</td>
</tr>
<tr>
<td>Timed instrumental activities of daily living</td>
<td>125.71</td>
<td>62.44</td>
<td>123.07</td>
</tr>
</tbody>
</table>

**Notes:** SF-36 = Short Form-36.

*Smaller scores reflect better performance.
functional impairment and symptoms due to medical health problems and comprised eight subscales. The Role—Physical, General Health, and Physical Functioning subscales of this measure assessed health and physical functioning, with scores on each ranging from 0 to 100. Lower scores on each subscale represented poorer health and functioning.

**Self-Rated Health.**—Participants rated their general health status on a Likert-type scale, with scores ranging from excellent (1) to poor (5).

**Depression.**—The Center for Epidemiological Studies—Depression scale (CES-D) 12-item form (Radloff, 1977) assessed the frequency of depressive symptoms during the preceding week. Response options on this self-administered scale ranged from 0 (rarely or none of the time/less than 1 day per week) to 3 (most or almost all of the time/5–7 days per week). Higher total scores on the CES-D indicated greater depressive symptoms experienced during the previous week.

**Mental Status.**—General cognitive status was assessed using the MMSE (Folstein et al., 1975), a brief instrument that is often used to screen for dementia. Skills assessed included orientation, memory, basic attention, language, and visuospatial/visuoconstructive abilities. Possible scores on the MMSE range from 23 to 30, with lower scores indicating greater cognitive impairment.

**Physical Performance.**—The Turn 360° test measured balance (Steinhagen-Thiessen & Borchelt, 1999). Participants stood and turned in a complete circle, performing two trials in any direction. An observer recorded the number of steps required to complete each turn, and we used the average of both trials for analysis. Fewer steps indicated better balance.

**Vision.**—Vision was assessed binocularly using a GoodLite Model 600A light box with ETDRS letter chart via standard procedures. Distance visual acuity was measured with optical correction (if applicable). Scores were based on a scale of 0 to 90, depending on the number of letters correctly identified (0 is equivalent to a Snellen score of 20/125, and 90 to a Snellen score of 20/16), with higher scores reflecting better far visual acuity.

**Useful Field of View (UFOV®).**—Cognitive processing speed for several visual attention tasks was measured using the PC, touch, four-subtest version of the UFOV (Edwards et al., 2005). We used the four subtest total score in analyses, with higher scores reflecting slower cognitive speed of processing (e.g., longer display durations).

**Digit Symbol Substitution.**—This task was also included as a measure of cognitive speed of processing. Participants had 90 s to complete the Wechsler Adult Intelligence Scale–Revised Digit Symbol Substitution Test, which relies on cognitive speed of processing, memory, and reasoning (Wechsler, 1987). The test required participants to complete a grid of empty squares by substituting the number (appearing above each square) with its paired symbol (from a key provided at the top of the page). Participants completed as many substitutions as possible in the time allotted. We used the number of correct substitutions made in analyses.

**Hopkins Verbal Learning Test.**—This test (Brandt, 1991) was one of three memory measures and included a list of 12 words from four semantically related categories. The presenter read the list aloud, after which participants completed a recognition task that included target words plus 12 distractor words (six semantically related, six semantically unrelated). Three such free recall trials were administered. We used the discrimination index, created by subtracting the number of false positives from the number of true positives, in the analyses.

**Rivermead Behavioral Memory Test.**—The Story subtest of the Rivermead (Wilson, Cockburn, & Baddeley, 1985) assessed prose memory. Participants listened to a short passage (54–65 words) read aloud and then recalled (in writing) as much of the passage as they could within 2 min. Words and phrases were “blocked together” and scored as individual units, with possible scores ranging from 0 to 21. Higher scores indicated better recall.

**Auditory Verbal Learning Test.**—This test (Jobe et al., 2001) was also used to assess memory. This task involved the auditory presentation of 15 words and a recall task, in which participants had 3 min to write down as many of the presented words as possible. This task was repeated five times, with the total number correct used in analyses. Higher scores reflected better performance.

**Letter Series.**—In this task of inductive reasoning (Thurstone & Thurstone, 1949), participants were shown a string of 10 to 15 letters. Each row of letters formed a series based on one or more rules that the participant had to discover. Based on the rule(s) in each row, the participant determined which letter would come next in the series from a list of five possible answers. There were 30 items in this task, with up to 6 min allotted for completion. Higher total scores indicated more items answered correctly.
Word Series.—Similar to the letter series task, the participants were asked to determine patterns among a series in order to assess reasoning. In this task (Gonda & Schaie, 1985), each participant was shown a string of words and asked to identify the next word in the series out of five given options. As in the letter series task, there were 30 test items, with a time limit of 6 min. Higher total scores indicated more items answered correctly.

Letter Sets.—In this third reasoning task (Ekstrom, French, Harman, & Derman, 1976), a participant was presented with 15 rows, each comprising five sets of letters with four letters per set. Participants determined the rule that made four of the five letter sets alike and eliminated the letter set that did not fit the same pattern as the other four. Participants had 7 min to complete the task, with higher scores indicating better ability to identify the rules within the sets.

Vocabulary (Ekstrom et al., 1976).—This five-choice synonym test assessed participants’ knowledge of word meanings. The participant was presented with a reference word, then was required to choose a synonym among a set of five alternatives. The score used in analyses was total number correct.

Instrumental Functional Performance.—Three measures of instrumental functional performance were included as outcomes in the ACTIVE study: the Everyday Problems Test (EPT), the Timed IADL test, and the Observed Tasks of Daily Living (OTDL) test. Each of these tests are measures of cognitively demanding IADLs that are critical for remaining an independent older adult in the United States (Jobe et al., 2001). The EPT and OTDL were included in ACTIVE because it was hypothesized that memory and/or reasoning training would impact performance. The Timed IADL test was included in ACTIVE because it was hypothesized that cognitive speed-of-processing training would impact performance.

The EPT was designed to assess practical problem-solving and reasoning ability; a shortened version was used in this study (Willis, 1996). This test taps the IADL dimensions of medication use, shopping, finances, household activities, meal preparation, transportation, and telephone use. Participants were presented with 14 examples of everyday stimuli, such as medication labels, recipes, Medicare benefit tables, and transportation schedules. Two multiple-choice questions were asked about each stimulus, with no time limit imposed for responses. This instrumental functional performance measure is a pencil-and-paper measure and is strongly associated with cognitive reasoning abilities (Willis, 1996). We used the total score, which could range from 0 to 28, in analyses.

The Timed IADL test assessed participants’ speed interacting with real-world stimuli to quantify their ability to quickly perform IADLs (Owsley et al., 2001, 2002). In this measure, all of the tasks were timed such that efficiency in cognitive speed of processing was required for optimal performance. The test consisted of tasks sampling five domains of IADL: (a) telephone use, (b) finances, (c) food preparation, (d) shopping, and (e) medications. For the first task, participants located a phone number in a directory. The second task required them to count out correct change. The third task required them to read the ingredients on food can labels. The fourth task required that they find two grocery items on a crowded shelf. The last task required correct discernment of medication directions. The time taken to perform each task was recorded. Each task had a preset maximum time; if the participant did not complete the task within this time period, testing on that item was discontinued. The tester also recorded whether the participant committed any errors in performing the tasks (which resulted in a time penalty). We used a standardized global time composite in analyses.

The OTDL (Diehl et al., 2005) assessed instrumental functional ability using behavioral simulations that were designed to simulate as closely as possible actual IADL tasks. This multidimensional measure consisted of nine tasks, with a total of 13 questions addressing three domains of IADLs (medications, telephone use, and finances). Like the Timed IADL test, each task required participants to demonstrate their ability using real-word props (e.g., making change based on a bill and actual money, determining the possible side effects of a medication based on pharmacy labels). Like the EPT, this measure was not timed. In contrast to paper-and-pencil measures of everyday functioning, the OTDL tasks require participants to comprehend information from multiple sources, and then combine this information to complete the tasks. Test administrators recorded the accuracy of each response and indicated whether it was necessary to prompt the participant. We used total scores, which ranged from 1 to 28, in analyses.

Procedure

The procedures of the study are detailed elsewhere (Jobe et al., 2001). A telephone interview followed by in-person assessment was used to determine eligibility. All baseline questionnaires and performance tests were administered during in-person visits. Following baseline visits, participants were randomly assigned to receive either memory, reasoning, or cognitive speed-of-processing training, or to participate in a no-contact control group. Follow-up assessments were conducted approximately 2 months (posttest), 1 year (first annual), 2 years (second annual), and
3 years (third annual) after baseline. A primary outcome for the study was driving behavior. Therefore, the data were useful for examining predictors of driving cessation across 3 years by controlling for any intervention participation.

**Statistical Analyses**

We examined baseline demographic, cognitive, visual, physical, health, and instrumental functional characteristics as predictors of driving cessation over a 3-year period, statistically controlling for baseline driving (days per week) and participation in cognitive training (dummy coded as 1 = any training and 0 = control group). We conducted Cox regression analyses to ascertain the likelihood that an individual would cease driving across the 3-year period based upon the predictors (after controlling for baseline driving and training participation). The resulting hazard ratios (HRs) represent the risk for cessation associated with an increase of 1 SD in the predictor, all other explanatory variables remaining constant. HRs less than 1 indicate a decreased risk of cessation associated with a 1-SD increase in the predictor, whereas those greater than 1 indicate a greater risk for cessation associated with a 1-SD increase in the predictor (or as compared to the reference group for categorical predictors). We right-censored participants who were current drivers at the third annual assessment in that we used the number of months between baseline and the 3-year follow-up interview to time the event. For individuals who stopped driving, we used the number of months between baseline and the point of driving cessation to time the event.

**Results**

In order to select variables for inclusion in the Cox regression models, we first conducted Spearman correlations to examine the relationships between all variables from the domains of demographics, physical abilities, health, vision, cognition, and instrumental functional performance with time to cessation as well as driving status at 3 years. We included in further analyses variables significantly correlated with either driving status at 3 years or time to cessation (eliminating gender, high cholesterol, heart disease, hypertension, osteoporosis, asthma, and macular degeneration). We then examined these predictor variables for multicollinearity by calculating squared multiple correlations as recommended by Tabachnick and Fidell (2001). Factor analyses revealed squared multiple correlations greater than .90 for the three reasoning measures (letter series, letter sets, and word series). To avoid multicollinearity, we included in further analyses only letter series, because it was the reasoning measure most strongly correlated with 3-year driving status.

We converted continuous data (other than age in years and baseline driving days per week) to z scores and conducted six Cox regression models using the enter method to identify predictors of time to driving cessation within each domain while controlling for baseline driving and intervention participation. For all models, driving fewer days per week at baseline was a significant risk factor for driving cessation ($p$s < .001). Based upon correlational results, we further examined age, living arrangement (alone vs with others), and marital status as demographic risk factors for driving cessation. Only older age in years was a significant demographic risk factor ($HR = 1.13, p < .001$).

Physical functioning variables examined as predictors of driving cessation included Short Form-36 physical functioning rating and Turn 360° test performance. Poorer balance, as measured by the Turn 360° test ($HR = 1.39, p < .001$), was indicative of greater risk, whereas better physical function ratings were indicative of decreased risk of cessation ($HR = 0.72, p < .001$). We also examined physical functioning as a risk factor by examining self-ratings as well as the Short Form-36 General Health scale, and whether participants reported incidence of stroke, congestive heart failure, or heart disease. We also examined depressive symptoms as indicated by the CES-D. Results indicated that self-rated health ($HR = 1.54, p = .006$) as well as incidence of stroke ($HR = 1.90, p = .020$) or congestive heart failure ($HR = 2.41, p = .017$) were all significant risk factors for driving cessation.

When we examined visual acuity and incidence of glaucoma or cataracts as risk factors for cessation, only visual acuity emerged as a significant predictor ($HR = 0.97, p < .001$), with better acuity indicating decreased risk of cessation. With regard to cognitive performance, we evaluated measures of memory, reasoning (letter series), cognitive speed of processing, vocabulary, and cognitive status as risk factors. Results revealed that poorer UFOV ($HR = 1.67, p < .001$) and vocabulary ($HR = 1.25, p = .039$) were significant risk factors for driving cessation.

We also examined instrumental functional performance in relation to time to cessation by including the EPT, Timed IADL test, and the OTDL as predictors. We reverse-scored the EPT to match the scaling of the Timed IADL test, such that higher scores indicated worse performance. Among these instrumental functional performance outcomes, worse performance on the EPT emerged as a significant risk factor for driving cessation ($HR = 1.65, p < .001$).

We calculated a final Cox regression model with the enter method to determine the best predictors from each of these domains including age, physical functioning (Turn 360° test and SF-36 physical functioning rating), health (self-rating, stroke, and congestive heart failure), visual acuity, cognition (UFOV), and instrumental functional performance.
Table 2. Final Model of Risk Factors for 3-Year Driving Cessation

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training participation (1 or more sessions vs none)</td>
<td>0.735</td>
<td>0.486–1.110</td>
<td>.143</td>
</tr>
<tr>
<td>Baseline driving (days per week)</td>
<td>0.667</td>
<td>0.604–0.737</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.056</td>
<td>1.014–1.101</td>
<td>.009</td>
</tr>
<tr>
<td>Turn 360°a</td>
<td>1.166</td>
<td>1.006–1.353</td>
<td>.042</td>
</tr>
<tr>
<td>Self-rated healtha</td>
<td>1.151</td>
<td>0.917–1.444</td>
<td>.106</td>
</tr>
<tr>
<td>SF-36 Physical Functioning</td>
<td>0.837</td>
<td>0.674–1.039</td>
<td>.226</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>1.889</td>
<td>0.912–3.913</td>
<td>.087</td>
</tr>
<tr>
<td>Stroke</td>
<td>1.366</td>
<td>0.749–2.491</td>
<td>.309</td>
</tr>
<tr>
<td>Visual acuity</td>
<td>0.898</td>
<td>0.745–1.082</td>
<td>.258</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>1.181</td>
<td>0.915–1.526</td>
<td>.202</td>
</tr>
<tr>
<td>Useful Field of Viewa</td>
<td>1.373</td>
<td>1.106–1.706</td>
<td>.004</td>
</tr>
<tr>
<td>Everyday Problems Testa,b</td>
<td>1.598</td>
<td>1.242–2.036</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Notes: All scores are z except for age, days per week, and categorical variables (stroke, congestive heart failure, and training participation). HR = hazard ratio; CI = confidence interval; SF-36 = Short Form-36.

*(Smaller numbers reflect better performance.)

Discussion

Age, physical functioning, health, vision, cognition, and instrumental functional performance capacity all play a role in driving cessation across 3 years among older adults. However, when considered in concert, physical functioning as indicated by balance, cognitive speed-of-processing performance as measured by the UFOV, and instrumental functional performance as indicated by the EPT are the strongest independent risk indicators of subsequent driving cessation over a 3-year period. These results highlight the importance of using performance-based measures in assessment of older adults. Furthermore, the results highlight the significance of cognitive and functional performance for the maintenance of driving mobility among older adults.

The strengths of the present analyses include the large sample size and use of longitudinal data, the extensive cognitive battery included, and the inclusion of several performance-based indicators of instrumental functioning. Within the past 15 years, there have been only two prospective studies of driving cessation (Anstey et al., 2006; Freeman et al., 2005), only one of which included drivers from the United States, and none of which evaluated instrumental functional performance as a predictor.

As in prior studies, the present results confirm that older age continues to be a significant risk factor for driving cessation (Anstey et al., 2006; Freeman et al., 2005; Jette & Branch, 1992; Marottoli et al., 1993). Whereas earlier research found that women were more likely to reduce and cease driving (Campbell et al., 1993; Chipman, Payne, & McDonough, 1998; Hakamies-Blomqvist & Wahlström, 1998), these longitudinal results indicate that when we controlled for baseline driving, women were not more likely to cease driving across 3 years. These results extend support for recent cross-sectional analyses that also did not find gender to play a significant role in driving cessation (Dellinger et al., 2001; Hakamies-Blomqvist & Siren, 2003). Thus, in the United States, contemporary cohorts of older female drivers may be less likely to cease driving than has been reported previously.

Whereas prior studies have found that health conditions and self-ratings of health are longitudinally associated with driving cessation (Anstey et al., 2006; Freeman et al., 2005; Jette & Branch, 1992), the present results indicate that such relationships may be mediated by cognitive and functional performance. In other words, poor health leads to driving cessation when it significantly impacts cognitive and functional performance. We replicated the prior findings that physical performance is longitudinally associated with driving cessation (Anstey et al., 2006; Marottoli et al., 1993); this significant relationship remains even while one considers the role of cognitive and instrumental functional performance. It is interesting that, among the functional measures evaluated, only the EPT emerged as a significant indicator of driving cessation risk. This finding is not unlike that of Anstey and colleagues in that this particular functional measure is strongly associated with cognitive reasoning ability (Willis, 1996). These results together indicate that cognitive reasoning is related to subsequent driving cessation to the extent that instrumental functional performance is impaired.

We did not find mental status as indicated by MMSE score to be related to driving cessation in this sample. However, it is important to note that for inclusion in the ACTIVE study, participants were required to score 23 or greater on the MMSE. Thus, the nonsignificant contribution of MMSE score in this sample could be due to restricted range on this variable.

Other studies have found that visual function and incidence of cataracts are prospectively associated with driving cessation (Freeman et al., 2005; Marottoli et al., 1993). However, the present results did not find visual acuity or eye conditions to be associated with subsequent cessation when everyday and cognitive performance were considered. These results can be explained in a few different ways. The
The present study used the UFOV test to assess cognitive speed of processing. This test relies on both cognitive and visual function (Edwards et al., 2006) and thus is a stronger predictor of driving ability than visual function alone. Another explanation may be that the impact of vision on driving cessation is mediated by cognitive speed of processing. Recent studies in cognitive aging have indicated that visual sensory declines directly result in decreased speed of processing (Clay et al., 2008; Lovden & Wahlin, 2005). The lack of significant results for vision could also be due to the use of visual acuity as a measure rather than more sensitive measures such as contrast sensitivity, which are more ecologically valid (i.e., Lord, 2006).

The present results provide empirical support for Ragland and colleagues’ (2004) findings that older adults self-report ceasing driving due to functional status. Additionally, these findings indicate that although older adults do not report cognition as a factor in their decision to cease driving (Ragland et al., 2004), cognitive function plays an important role, even among community-dwelling older adults without dementia (Anstey et al., 2006). Results of the present study may suggest that the significant relationships between health, medical conditions, visual acuity, and driving cessation commonly found in prior research may be mediated by cognitive speed of processing and instrumental functional performance.

The present results indicate that older adults without dementia, but with more subtle cognitive speed-of-processing declines, are more likely to cease driving. It is interesting that although cognitive performance is associated with driving capacity among persons with dementia (Reger et al., 2004), there may not be a significant association between cognitive function and driving self-restriction among older adults with dementia (Carr, Shead, & Storandt, 2005). Thus, the relationship between cognitive impairment and driving self-regulation is not likely to be linear and deserves further investigation. As Freund and Szinovacz (2002) pointed out, the decision to cease driving can also be complicated by a number of factors not examined in the present study, such as alternative transportation opportunities, self-image, and interpersonal relationships.

References


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