Ten Years Down the Road: Predictors of Driving Cessation

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Purpose: Recent prospective studies have found that cognition is a more salient predictor of driving cessation than physical performance or demographic factors among community-dwelling older adults. However, these studies have been limited to 5 years of follow-up. The current study used data from the Maryland Older Drivers Project to examine predictors of driving cessation in older adults over a 10-year period. Design and Methods: Participants (N = 1,248) completed baseline and 5-year assessments of physical and cognitive abilities. Driving status was ascertained at baseline and annually thereafter. Results: Cox proportional hazard models were used to examine the risk of driving cessation as a function of demographic, physical, and cognitive predictors. The final model indicated three significant predictors of driving cessation, older age at baseline (hazard ratio [HR] = 1.12, p < .001), days driven per week (HR = 0.83, p = .05), and slower speed of processing as measured by the Useful Field of View Test (HR = 1.76, p < .01). Implications: These results underscore the importance of cognitive speed of processing to the maintenance of driving. Brief cognitive assessment can be conducted in the field to potentially identify older adults at increased risk for driving cessation. Further research is needed to determine the costs and potential benefits of such screening.

Key Words: Driving outcomes, Older drivers, Longitudinal

In 2004, more than 28 million licensed U.S. drivers were aged 65 years and older (Center for Disease Control and Prevention, 2006), and this number is projected to reach 40 million by the year 2020 (Dellinger, Langlois, & Li, 2002). Mobility is fundamental to successful aging with most older adults relying on driving for sustained mobility (Jette & Branch, 1992; O’Neill, 2000). Accordingly, many older adults view driving as a mark of independence and freedom (Gillins, 1990), and maintained driving mobility is increasingly recognized as being vital to health and quality of life for older adults (Oxley & Whelan, 2008).

Prospective studies have indicated that driving cessation results in many negative consequences for older adults (Edwards, Perkins, Ross, & Reynolds, 2009; Freeman, Gange, Munoz, & West, 2006; Marottoli et al., 1997, 2000; Mezuk & Rebok, 2008; Windsor, Anstey, Butterworth, Luszcz, & Andrews, 2007). Seniors who do not drive diminish their contact with outside stimuli that is necessary for a healthy and robust existence (Marottoli et al., 2000). As an example, social isolation occurs following driving cessation (Mezuk & Rebok) and leads to subsequent increases in depression (Azad, Byszewski, Amos, & Molnar, 2002; Marottoli et al., 1997; Windsor et al.). Of further concern, even after considering health status, driving cessation is prospectively associated with increased risk for nursing home placement as well as mortality (Edwards et al.; Freeman et al.).

Most studies of driving cessation have been retrospective comparing older drivers with older adults who have ceased driving. Such studies have found that older drivers tend to have fewer physical limitations, and better health, vision, and cognitive function than do older nondrivers (Brayne et al., 2000; Campbell, Bush, & Hale, 1993; Ragland, Satariano, & MacLeod, 2004). Older adults who
have ceased driving also tend to have less education, less income, and more medical conditions compared with drivers (Campbell et al.; Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001). Typically, retrospective studies have revealed that women have been more likely to cease driving than men (Brayne et al., 2000; Campbell et al.; Freund & Szinovacz, 2002). Whether or not one lives with other drivers may also be related to the decision to stop driving (Freund & Szinovacz). However, when such demographic factors were prospectively considered in concert with cognitive and physical performance variables among participants from the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study, cognitive and everyday functional abilities emerged as stronger predictors (Ackerman, Edwards, Ross, Ball, & Lunsman, 2008; Edwards et al., 2008).

More than 15 years ago, a longitudinal study across 10 years was conducted to identify patterns of driving among older adults (Jette & Branch, 1992), but until fairly recently, driving habits among modern cohorts of older adults have not been longitudinally examined. Recent analyses have prospectively examined predictors of driving cessation across 3 and 5 years among U.S. and Australian older drivers (Ackerman et al., 2008; Anstey, Windsor, Luszcz, & Andrews, 2006; Edwards et al., 2008; Freeman, Munoz, Turano, & West, 2005). These longitudinal studies have indicated that increasing age, poor vision, poor health, less than ideal physical functioning, diminished cognitive speed of processing, and problems with instrumental functional abilities contribute to the decision to cease driving (Ackerman et al.; Edwards et al., 2008; Freeman et al.). Similarly, among Australian older adults, poor grip strength, subjective feelings of health and well-being, and poor cognition as indicated by memory and reasoning were associated with increased rates of driving cessation (Anstey et al.). The purpose of these analyses was to examine the relationship of performance-based measures of cognitive and physical abilities, administered in a state motor vehicle administration setting, to subsequent rates of driving cessation among a modern cohort of older drivers from a population-based sample across a 10-year period.

**Methods**

**Participants**

Adults aged 55 years and older who had just renewed their drivers’ licenses were invited to participate at various Maryland State Motor Vehicle Administration (MVA) sites (N = 3,970). Thus, all participants are presumed to have met the Maryland drivers’ licensing requirements of 20/40 monocular far visual acuity (corrected or uncorrected), 20/70 binocular far visual acuity, and a continuous visual field of at least 140°, and are representative of licensed drivers 55 years of age and older in the state of Maryland. Approximately half of those approached to participate at the MVA agreed to do so (n = 1,910); those who declined participation primarily cited a lack of time as the reason for their refusal. The characteristics of the participants and decliners are reported elsewhere (Ball et al., 2006). The individuals who chose to participate in the original MVA study did not significantly differ from those who declined participation in terms of age at baseline, race, education, or prior crash involvement, but participants were significantly more likely to be men (Ball et al., 2006).

A subsample of these participants (n = 1,248) were successfully contacted for annual follow-up telephone interviews and are included in these analyses. This sample had a mean age at baseline of 69.56 years (SD = 7.85) and included 47% women. The majority of the sample included Caucasian participants but also included individuals of African American (5%) and other (1%) racial backgrounds. Across the study period, 182 participants dropped out of the study, indicating that they were no longer interested in participating.

**Measures**

The primary outcome of interest for this study was driving cessation measured across a 10-year span. Like other studies involving driving habits and cessation (i.e., Ackerman et al., 2008; Ball et al., 1998; Edwards et al., 2008; Fisk et al., 2002), the Mobility Questionnaire (Owsley, Stalvey, Wells, & Sloane, 1999; Stalvey, Owsley, Sloane, & Ball, 1999) was used to ascertain driving status, with current driver defined as “someone who has driven a car in the last 12 months and would drive a car today if they needed to.” Participants were asked to report the date they stopped driving if they no longer defined themselves as a current driver. Drivers reported the average number of days per week that they drove. Independent variables include demographics as well as several performance-based measures of cognitive and physical abilities.

The Gross Impairments Screening battery was designed for the study and included performance-based
measures of physical and cognitive abilities related to driving performance (Staplin, Lococo, Gish, & Decina, 2002). Measures from the battery are detailed below.

**Physical Measures.**—*Rapid Walk Test.* This assessment was used to determine leg strength and endurance of each participant. Test-takers were instructed to walk as quickly as possible along a clearly marked 10-foot corridor and return to their starting point. Total time from departure to return was recorded in seconds. Use of assistive devices (i.e., canes) was allowed. Individuals who perform poorly are at higher risk for adverse driving events (Marottoli, Cooney, Wagner, Doucet, & Tinetti, 1994).

**Arm reach.** This test is a measure of the upper body strength needed to quickly and firmly turn the steering wheel of a car in an emergency situation. The participant raised their arms, one at a time, as high over their head as possible. The elbow must be raised above the shoulder to pass. The results are dichotomously coded as pass or fail for each arm. The number of failed attempts was used in analyses (0, indicating both elbows were raised above the shoulder; 1, either left or right elbow raised above the shoulder; 2, indicating neither elbow was raised above the shoulder).

**Head–neck rotation.** This examination assessed the participant’s ability to rotate their head to look directly back and over their shoulder, with minimal torso movement. The test-taker is seated and restricted with a seat belt while instructed to read a cardboard clock that has been placed 10 feet behind (approximately 180 degrees) the participant. The participant can turn to the right or left. The results were dichotomously coded as pass (turned and read the clock correctly) or fail (could not turn far enough to read the clock).

**Self-rating.** Additionally, a self-rating of physical performance was obtained by asking participants whether or not they experienced difficulty walking a few blocks or climbing several flights of stairs (Walk/Climb). Answers were coded dichotomously (yes/no).

**Cognitive Measures.**—*Motor-Free Visual Perception Test (Visual Closure subtest).* The Motor-Free Visual Perception Test (Visual Closure subtest) (MVPT/VC) was used to assess an individual’s ability to recognize incompletely drawn objects and respond by matching the object with the complete item. This ability allows an individual to recognize obstructed signs and objects as they are driving and has been shown to be correlated to driver performance (Tarawneh, McCoy, Bish, & Ballard, 1993). The score was recorded as number of errors out of 11.

**Delayed recall.** The examinee was asked to immediately recall three orally presented nouns. After a delay of 5 min, the participant was again asked to recall the words, and the number of words not correctly recalled (i.e., errors) was recorded.

**Trail Making Test.** This test evaluates an individual’s ability to visually search an area and to divide their attention (mental flexibility) effectively. The Trail Making Test includes two parts, A and B. An abbreviated Trails A (including numbers 1–8 instead of up to 25) required participants to connect numbers in order, while Trails B required connecting both numbers and letters in alternating sequence (e.g., 1 to A, then A to 2, then 2 to B, etc.). Examiners pointed out errors but continued timing. Part B, in particular, has been shown to predict driving performance (i.e., Goode et al., 1998). Performance on this test was timed, with censoring occurring at the 6-minute mark. The score is equal to time taken to complete the test in seconds.

**Useful Field of View Test.** Subtest 2 of the Useful Field of View Test (UFOV) was used to assess cognitive speed of processing for a divided attention task. The test is associated with driving performance and has sufficient validity and reliability (Edwards et al., 2005, 2006). Subtest 2 consists of two vehicles being simultaneously displayed on a monitor including an object (car or truck) to be identified in the center and a car to be located on the outside, which is alternately positioned at eight different points around the screen. The targets remain on the screen at durations varying between 16.67 and 500 ms using a staircase method, with the score representing the display speed in milliseconds at which the participant can perform the task correctly 75% of the time. If a participant is unable to perform the task at the longest display speed of 500 ms, then a score of 500 is assigned.

**Procedure**

The Maryland Older Drivers Project was a prospective cohort study designed to examine the relationship of cognitive and physical performance to
safe driving mobility. The study procedures and rationalization for measures are detailed elsewhere (Ball et al., 2006; Ross et al., 2009; Staplin et al., 2002). Recruitment and testing occurred in Maryland MVA sites after completion of license renewal, and participants were explicitly assured that their participation and performance would not affect their driving privileges. No feedback was provided to the participants about their performance, and no financial incentives for participation were offered. Baseline performance data were collected between 1998 and 2000 with subsequent follow-up telephone interviews conducted annually through the year 2008. The mean length of time for follow-up was 89.52 months ($SD = 22.16$). Participants were interviewed annually until they ceased driving, died, or refused further participation. Additionally, midway through the study a second in-person evaluation took place at the MVA approximately 5 years after the baseline assessment (range 53–71 months). All the measures were readministered at the second assessment with the exception of arm reach (which was eliminated from the battery based on interim statistical analyses indicating lack of predictive value).

**Statistical Analyses**

Time to cessation was coded for all cases as to when they stopped driving in months from their baseline interview date and was right censored from baseline to the last interview completed for those who remained drivers. There were 267 participants who died, were no longer reachable by phone, or refused further participation. These participants were right censored at the time of their last interview. Spearman correlations among predictor variables were then examined for multicollinearity. No correlations exceeded .70. Cox hazard regression models were constructed to examine the risk of driving cessation as a function of demographic, physical, and cognitive predictors. Both the baseline and 5-year assessments were included in the models as time-varying covariates. Significant predictors from each of these three models were then combined into a final multivariate model. For all data points that were missing from baseline assessment, the 5-year score was assigned and vice versa. Five cases were dropped due to missing data.

**Results**

Across the 10-year period, 149 of the participants ceased driving. Descriptive statistics are displayed in Tables 1 and 2. In the first Cox model, demographic indicators including age at baseline, gender, race, and days driven per week (at baseline and 5 years) were explored as indicators of risk for driving cessation. Age at baseline (hazard ratio [HR] = 1.13, 95% confidence interval [CI] 1.01–1.16) and days driven per week (HR = 0.86, 95% CI 0.79–0.94) were significant predictors ($p < .001$). Older adults and those who drove fewer days per week were more likely to subsequently cease driving.

The second model included physical performance indicators of Rapid Walk, head–neck rotation, arm reach, and self-reported difficulty walking a block or climbing several flights of stairs. Only Rapid Walk was a significant indicator of driving cessation risk (HR = 1.91, 95% CI 1.37–2.65, $p < .001$). Individuals with physical performance difficulties as indicated by slower walk times were more likely to cease driving.
Cognitive performance as indicated by the MVPT, delayed recall, Trails A and B, and UFOV were examined in the third model. MVPT (HR = 0.65, 95% CI 0.44–0.95, \( p = .027 \)), Trails B (HR = 1.52, 95% CI 1.02–2.24, \( p = .038 \)), and UFOV (HR = 2.45, 95% CI 1.68–3.57, \( p < .001 \)) emerged as significant predictors of driving cessation. Poor cognitive performance was associated with greater risk of driving cessation.

The final model included all the significant predictors from the first three models: age at baseline, days driven per week, Rapid Walk, Walk/Climb, MVPT, Trails B, and UFOV. Age at baseline (HR = 1.12, 95% CI 1.10–1.15, \( p < .001 \)), days driven per week (HR = 0.83, 95% CI 0.693–1.000, \( p = .50 \)), and UFOV performance (HR = 1.76, 95% CI 1.15–2.69, \( p = .01 \)) remained significant indicators of risk for driving cessation. Results are displayed in Table 3. Participants who were older, drove fewer days per week, and who had slower cognitive speed of processing as measured by UFOV were more likely to cease driving.

**Discussion**

In this study, demographic, physical, and cognitive risk factors for driving cessation were examined in a population-based sample of older drivers over a 10-year period. In keeping with the findings of recent longitudinal research (i.e., Anstey et al., 2006; Edwards et al., 2008), it was discovered that age, days driven per week, and cognitive speed of processing for a divided attention task, as measured by the UFOV test, predicted driving cessation above and beyond demographic variables and physical functioning.

Recent longitudinal analyses of older adults have highlighted the importance of cognition, visual speed of processing, in particular, to maintained driving mobility (Edwards et al., 2008). The present results extend these findings by confirming that these relationships hold over a 10-year period and among a population-based sample of older drivers from the state of Maryland. Furthermore, the results of this study show that indicators of potential risk for driving cessation can possibly be assessed by staff in a state motor vehicles administration setting. Whereas prior studies have examined the full UFOV test (including three to four subtests), the present findings indicate that subtest 2 alone, which can be administered in 5–10 min, is also an indicator of subsequent risk for driving cessation. Further research is needed to determine the potential costs of and benefits from such assessments.

Although female gender has been associated with higher risk of driving cessation in the past (i.e., Campbell et al., 1993), it was not a significant predictor of cessation in the current study. Prior data from the Maryland project indicate that female drivers self-regulate and limit their driving more so than do male drivers (Vance et al., 2006). On the other hand, in these analyses, as well as data from the ACTIVE study, female gender has not emerged as a risk factor for cessation in modern cohorts of older drivers when controlling for baseline driving (i.e., Ackerman et al., 2008; Edwards et al., 2008). The results from these studies combined may indicate that the gender differences in rates of driving cessation are diminishing among modern cohorts of older adults and are deserving of further investigation.

The battery administered in the MVA was necessarily brief and so a limitation of the present study is the lack of variability among some of the measures. For example, the delayed recall measure included only three words, so the range of the outcome (number of errors) was restricted. Another limitation to the present study is the lack of health indicators. At the same time, performance-based

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**Table 2. Baseline Sample Characteristics for Categorical Variables Overall and by 10-Year Driving Status**

<table>
<thead>
<tr>
<th>Baseline characteristic</th>
<th>Total ((N = 1,248))</th>
<th>Drivers ((n = 1,099))</th>
<th>Ceased driving ((n = 149))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (% male)</td>
<td>52.56</td>
<td>52.87</td>
<td>50.34</td>
</tr>
<tr>
<td>Race (% White)</td>
<td>96</td>
<td>96</td>
<td>97</td>
</tr>
<tr>
<td>Walk/Climb (% no difficulty)*</td>
<td>93</td>
<td>94</td>
<td>86</td>
</tr>
<tr>
<td>Head–neck rotation (% pass)*</td>
<td>82</td>
<td>83</td>
<td>73</td>
</tr>
<tr>
<td>Arm reach (% pass)</td>
<td>99</td>
<td>99</td>
<td>98</td>
</tr>
</tbody>
</table>

* \( p < .05 \).

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**Table 3. Final Model of Predictors of 10-Year Driving Cessation**

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR</th>
<th>95% CI</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days driven per week</td>
<td>0.83</td>
<td>0.693–1.000</td>
<td>.050</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.12</td>
<td>1.095–1.147</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rapid Walk (s)*</td>
<td>1.33</td>
<td>0.952–1.869</td>
<td>.094</td>
</tr>
<tr>
<td>Motor-Free Visual Perception Test Visual Closure</td>
<td>0.68</td>
<td>0.453–1.027</td>
<td>.067</td>
</tr>
<tr>
<td>Trails B (s)*</td>
<td>1.21</td>
<td>0.836–1.746</td>
<td>.314</td>
</tr>
<tr>
<td>Useful Field of View Subtest 2 (ms)*</td>
<td>1.76</td>
<td>1.15–2.692</td>
<td>.009</td>
</tr>
</tbody>
</table>

* Lower numbers reflect better performance.
measures of physical abilities like those included in the present study are usually better predictors of driving outcomes (i.e., Anstey et al., 2006) than health per se.

In both prior studies and the present results, increasing age is consistently associated with increased rates of driving cessation. In light of the literature that equates quality of life to driving, the risk of premature driving cessation in the older population should be considered. Given the many negative consequences that older adults experience when they cease driving, ways of intervening to prolong safe driving mobility could potentially extend older adults’ independence and quality of life (Oxley & Whelan, 2008).

The results of this study indicate that we can potentially identify older adults at increased risk for driving cessation in a state motor vehicles setting using UFOV subtest 2. This is particularly relevant given that prior research has consistently demonstrated that such cognitive difficulties can be remediated among older adults without dementia through speed of processing training (i.e., Ball et al., 2002; Sekuler & Ball, 1986). Such cognitive speed of processing training also positively enhances driving mobility in a number of ways including improved on road driving safety (Roenker, Cissell, Ball, Wadley, & Edwards, 2003), prolonged mobility as indicated by measures of driving exposure, driving space, and driving difficulty (Edwards, Myers, et al., 2009), and decreased rates of driving cessation (Edwards, Delahunt, & Mahncke, in press). Older adults with speed of processing difficulties, such as those observed among the participants in this study who ceased driving, are most likely to immediately benefit from cognitive speed of processing training and experience enhanced performance of everyday abilities, including driving (Ball, Edwards, & Ross, 2007).

In addition to cognitive training, there are other potential avenues for remediation on an individual level to prolong mobility including physical interventions, educational driver training, and alternative transportation programs. A physical exercise intervention was recently found to improve older adults’ on road driving safety (Marottoli, Allore, et al., 2007), and physical exercise holds promise as a way of prolonging driver fitness and thereby mobility (Marmeleira, Godinho, & Vogelae, 2009). Driver education programs are another potential way of enhancing and possibly prolonging safe driving mobility, although research on the effectiveness of such programs has yielded mixed results (Bédard et al., 2008; Marottoli, Van Ness, et al., 2007; Owsley, Stalvey, & Phillips, 2003). Another option is to begin counseling individuals who are at risk for driving cessation about alternative transportation options to maintain mobility in the future. A recent advance in providing effective and acceptable alternative transportation options to seniors is demonstrated by the Independent Transportation Network model (Freund, 2003).

The present study indicates that older drivers at increased risk for driving cessation can potentially be identified in a motor vehicles setting using a measure of cognitive speed of processing. Paired with recent research on interventions that can prolong older adults’ safe driving mobility, these results indicate that we may be able to identify older adults at risk for mobility loss and intervene to promote maintained and safe driving mobility. Given the negative ramifications of driving cessation, such interventions have potential to improve the health and quality of life of older adults.

References


