Can High-Risk Older Drivers Be Identified Through Performance-Based Measures in a Department of Motor Vehicles Setting?

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OBJECTIVES: To evaluate the relationship between performance-based risk factors and subsequent at-fault motor vehicle collision (MVC) involvement in a cohort of older drivers.

DESIGN: Prospective cohort study.

SETTING: Motor Vehicle Administration (MVA) field sites in Maryland.

PARTICIPANTS: Of the 4,173 older drivers invited to participate in the study, 2,114 individuals aged 55 to 96 agreed to do so. These analyses focus on 1,910 individuals recruited through MVA field sites.

MEASUREMENTS: Gross Impairment Screening Battery, which included Rapid Pace Walk, Head/Neck Rotation, Foot Tap, Arm Reach, Cued Recall, Symbol Scan, Visual Closure subtest of the Motor Free Visual Perception Test (MVPT), Delayed Recall, and Trail Making Test with an Abbreviated Part A and standard Part B; Useful Field of View (UFOV®) subtest 2; a Mobility Questionnaire; and MVC occurrence.

RESULTS: In drivers aged 55 and older with intact vision (20/70 far visual acuity and 140° visual field), age, sex, history of falls, and poorer cognitive performance, as measured using Trails B, MVPT, and UFOV subtest 2, were predictive of future at-fault MVC involvement. After adjusting for annual mileage, participants aged 78 and older were 2.11 as more likely to be involved in an at-fault MVC, those who made four or more errors on the MVPT were 2.10 times as likely to crash, those who took 147 seconds or longer to complete Trails B were 2.01 times as likely to crash, and those who took 353 ms or longer on subtest 2 of the UFOV were 2.02 times as likely to incur an at-fault MVC. Older adults, men, and individuals with a history of falls were more likely to be involved in subsequent at-fault MVCs.

CONCLUSION: Performance-based cognitive measures are predictive of future at-fault MVCs in older adults. Cognitive performance, in particular, is a salient predictor of subsequent crash involvement in older adults. High-risk older drivers can be identified through brief, performance-based measures administered in a MVA setting. **J Am Geriatr Soc 54:77–84, 2006.**

Key words: older drivers; motor vehicle collisions

Older drivers are overly represented in crashes and fatalities per mile driven[1,2] and are more likely to be injured or killed as a result of collision[3,4] than most other age groups. For injured victims who are hospitalized and recover, the length of hospital stay increases with advanced age.[5] Thus, the elderly traffic injury victim represents a costly problem in terms of acute healthcare costs and the need for continued care. At the same time, older people represent the most rapidly growing segment of the driving population in our society in total number of drivers on the road and number of miles driven annually per driver.[6,7] Thus, dramatic increases in traffic fatalities due to age-related driving impairments have been projected over the next quarter century.[8] As the proportion of older people in the U.S. population increases, the burden of motor vehicle collisions (MVCs) in older people is also likely to expand. It is imperative that the factors that place some older drivers at risk be identified, not only to minimize their involvement in MVCs and thereby improve public health, but also to foster the development of procedures to identify and place high-risk drivers in appropriate intervention programs.

Many risk factors for MVC involvement in older people have been investigated, including poor visual function,[9–11] attention and processing speed as measured

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using the Useful Field of View Test (UFOV®),[11,12] dementia-related cognitive impairments,[13–15] physical abilities,[16–18] and the functional effect of diseases such as diabetes mellitus or cardiovascular disease, as well as the medications used to treat various disorders.[17,19–21]

Although research has identified several risk factors for MVC involvement in older adults, studies have often been retrospective in nature or relied on self-report of accident involvement. Furthermore, population-based studies are lacking. There have been no large-scale, prospective studies wherein a wide range of performance-based risk factors for crash involvement have been objectively evaluated. Recent research has confirmed that existing screening measures used at motor vehicle administrations (MVAs), such as vision tests, are not always associated with lower driver fatality rates but that, for adults aged 85 and older, requiring in-person license renewal is associated with lower driver fatality rates.[22] Thus, although current screening practices in drivers aged 65 to 84 are inadequate, merely requiring in-person renewals for drivers 85 and older is a life-saving practice.[22]

Because driving is a highly visual task, it has traditionally been assumed that the higher prevalence of visual problems and eye disease in older people is a primary cause of their driving difficulty.[23] This assumption is reflected in the practice of assessing visual acuity at state driver licensing sites. There have been several large-sample studies attempting to link visual deficits and driving performance in older drivers, and several indices of visual function have been examined as potential predictors of crash involvement,[9,24,25] but overall, visual function alone is a poor predictor of driving outcomes.[25–27]

Operating a motor vehicle requires the coordination of physical movements. Accordingly, some researchers have been interested in determining the extent to which restrictions in such abilities increase the risk of crash involvement. One study demonstrated that older women who had difficulty extending their arms above their shoulders had a greater probability of being involved in a crash.[16] Another study aimed at linking physical mobility measures with driving performance found that a timed physical performance test, Rapid Paced Walk, was most strongly associated with adverse events, including MVC involvement, in the year after testing.[17] Similarly, some researchers have indicated that limited neck rotation is a risk factor for future crash involvement.[18]

Prior research examined how crash frequency in 300 older drivers was related to visual and cognitive capacities such as ocular disease, visual sensory function, visual attention, and cognitive status.[12] The best predictor of crash frequency was a model incorporating a composite measure of visual attention and processing speed, the UFOV test, which alone was highly correlated to crash involvement (correlation coefficient = 0.54). More recently, the predictive power of the UFOV test was evaluated prospectively[28] and was found to be the best predictor of crash frequency over a 3-year period. Difficulty in dividing attention under brief target durations primarily mediated increased risk for crash (subtest two of the UFOV assessment; see Methods section).

The present study aimed to evaluate a range of performance-based screening measures related to driver competence in a MVA setting. The goals were to establish the feasibility of administering such tests in such settings as well as to evaluate the measures as predictors of future at-fault, MVC involvement. Along with UFOV subtest 2, the Gross Impairment Screening Battery[29] (GRIMPS) was included in the screening battery. The GRIMPS assessed performance-based physical and cognitive abilities that are likely to affect driving performance and have been associated with driving performance in prior research.[16–18,30–34] This study extends prior work by simultaneously evaluating a series of performance-based tests in a population-based study of older drivers renewing their licenses at several Maryland MVA field sites.

METHODS

Participants

Participants in these analyses consisted of older adults presenting to renew their driver's license at three MVA field site offices in Maryland (Glen Burnie, Annapolis, Bel Air) between November 1998 and October 1999. The study also tested participants from a community site, Leisure World, and through individuals referred for assessment to the Maryland Advisory Board. Preliminary analyses revealed that the Leisure World and Advisory Board samples differed significantly from the MVA site samples in demographics, driving habits, and performance. Therefore, the present analyses focused upon only those older adults who were recruited at the MVA. An MVA staff member approached adults aged 55 and older who had just renewed their licenses at the MVA and asked them to assist in the evaluation of a series of assessment measures. Approximately 48% (n = 1,910) of those approached (N = 3,970) agreed to do so; those who declined participation primarily cited a lack of time as the reason for their refusal. Recruitment occurred after license renewal was completed, and participants were explicitly assured that their performance on the assessment would have no bearing on their driving privileges. Because, in Maryland, visual acuity and visual fields are assessed as part of the license renewal process, all participants in this study had passed vision screening and therefore had at least 20/40 monocular, far-visual acuity (corrected or uncorrected) and a minimum binocular, far-visual acuity of 20/70 as well as continuous field of vision of at least 140°. (Individuals in Maryland may also bring certification from a licensed practitioner indicating that they meet these visual requirements. Thus, specific assessments used to ensure that drivers meet the minimum visual criteria may vary. Vision assessments were not a part of this study.) The sample was therefore demographically representative of the population of licensed drivers aged 55 and older, all of whom met vision criteria, in the state of Maryland.

Protocol

Individuals who agreed to participate were escorted to a room where informed consent was obtained. The battery (described in further detail below) was divided into two parts of approximately equal duration. Part 1 consisted of the GRIMPS, and Part 2 consisted of subtest 2 of the UFOV test and a Mobility Questionnaire. The order in which Parts 1 and 2 were administered was counterbalanced across participants. The ethical guidelines for human experimentation stated in the Declaration of Helsinki were followed, and approval from an institutional review board was obtained.

Data Collection and Measurements

For a screening battery of any kind to be feasible in a MVA setting, it must be brief. Thus, an overriding consideration for inclusion of measures in the present study was brevity. The GRIMPS battery, designed as an 11-minute assessment, was composed of the following measures.

Physical Measures

Rapid Walk. The participant is asked to walk 10 feet, turn, and return to the starting position. Elapsed time (seconds) for completion of the task is recorded. This task assesses lower limb mobility.[17]

Foot Tap. While remaining seated, the participant is required to touch the floor on alternating sides of a 2-inch-tall barrier five times with their right foot. Time (seconds) to complete is measured. This task assesses lower limb mobility.[17]

Arm Reach. While seated, participants are asked to raise each of their arms, one at a time, above their head. To pass, each arm must be raised so that the elbow is above shoulder height. This task assesses upper limb mobility.[16,32]

Head/Neck Rotation. While seated and wearing a seat belt, participants are instructed to turn their head and identify a high-contrast stimulus (clock face) located on the wall directly behind them at a distance of 10 feet. To pass, the individual must complete the task without rotating the body below the waist. This task measures the head/neck flexibility.[18]

Cognitive Measures

Cued and Delayed Recall. Participants are read three nouns and asked to repeat them. The number recalled correctly on the first attempt and the number of presentations required to achieve correct recall of all three nouns is recorded. After a 5-minute interval, participants are instructed to recall the three words. Number correct is again recorded. This task assesses memory.[16,31]

Symbol Scan. The participant, who stands at arm's length from and at eye level with a test chart 55 inches in length containing 10 common symbols arranged in two rows of five columns each scans the chart. The participant must identify the symbols without turning his or her head. Verbal report indicates normal scanning pattern versus hemi-neglect.[33]

Motor Free Visual Perception Test, Visual Closure Subtest.[34,35] Participants are given stimuli depicting four incomplete figures and one whole figure. Participants select the incomplete figure which, when completed, would match the target figure. Accuracy is recorded as number of errors (maximum = 11). Motor Free Visual Perception Test (MVPT) is a measure of the understanding of spatial relationships, which is important for identifying partially obscured objects.

Trails A & B.[36] Participants use a pencil to sequentially connect integers in ascending order (Trails A) or a mix of integers and letters in alternating and ascending order (Trails B) as quickly as possible. Time (seconds) to completion is recorded. Trails is a measure of visual search and sequencing, information processing speed, divided attention, and set flexibility. In addition to the GRIMPS, speed of information processing and self-reported mobility were evaluated as follows.

Speed of Processing

Only subtest 2 of the UFOV was included in the battery for a 4-minute evaluation.[23] This divided-attention task was chosen, because it correlates highly with the UFOV total score, as has been used in previous analyses, and is the single subtest that best predicted crash involvement in earlier work; it therefore represents the least sacrifice in predictive power for the benefit of brevity.[11] Participants are required to identify a central target and locate a simultaneously presented peripheral target. Display duration is manipulated using a double staircase method until a 75% correct detection threshold is identified. The threshold is reported in milliseconds (ms). The UFOV test is a measure of the cognitive processing speed required for rapid recognition and response to simultaneous demands in central and peripheral visual fields under varying conditions.

Self-Reported Mobility

Participants complete a one-page questionnaire assessing employment status, driving exposure (days per week, miles per week, and miles per year), driving avoidance (night, bad weather, left turns across traffic, high-traffic roads, unfamiliar areas, and concerns about ability), and general mobility (e.g., falls within the previous 3 years and difficulty walking or climbing stairs).

Tester Training

Volunteer MVA staff were selected from three different license renewal sites to serve as test battery administrators. Each staff member received 1 day of training on the administration of the test battery. For all elements of the battery except the UFOV subtest, training consisted of a video demonstration of correct administration followed by an in-person demonstration and corrected practice. For UFOV training, participants observed the test being administered correctly by one of the authors and then practiced with correction. For each tester, practice on all elements of the battery was continued until the individual could administer each test smoothly and without error. To maintain consistency of test administration, each tester was observed at least twice during the data collection period, with the second observation period separated from the first by at least 2 months. For all elements of the battery, except UFOV, a second training session was held 4 months after the start of data collection to correct problems in test administration.

Outcome Measures

The primary outcome of interest for this study was the occurrence of at-fault MVCs after assessment at the MVA field sites. At-fault crashes were chosen, because this information was available from the MVA and this outcome is typically much stronger in studies relating risk factors to crash involvement due to the elimination of events (participant's unoccupied parked vehicle was hit) that have nothing to do with the participant per se. For participants in the study, the outcome period ranged from 4.18 to 5.13 years after assessment, depending on initial assessment date. Crash records across this follow-up interval were obtained from the Maryland MVA Administration of Driver Safety Research Office. For each crash incurred by individuals eligible for the study (participants and nonparticipants), the on-the-scene police officer determined the licensee's involvement in the crash to be at fault, not at fault, or fault unknown. At-fault and fault-unknown events were included in the dependent measure. Information was also obtained on each licensee's history of crash involvement for the 5 years before the date of assessment. To take into consideration differences in driving habits and therefore differences in opportunity to be involved in a vehicle crash, the crash data were adjusted for self-reported driving exposure. As part of the mobility questionnaire, participants were asked to estimate their annual driving mileage. Participants were presented a scale containing mileage in 2,500-mile blocks (0–2,500 miles, 2,501–5,000 miles, etc.) and asked to select the category that best represented their annual driving mileage. The midpoint of the selected interval was used as an estimate of annual mileage.

RESULTS

Feasibility of administering a performance-based screening battery in a MVA by MVA staff was tested through the implementation of this study. Some difficulties were encountered with the administration of measures, particularly those that required scoring judgments by the tester. Accordingly, tester retraining was required for all elements of the battery, with the exception of UFOV, the only computer-administered and -scored assessment measure included. The physical performance subtests tended to have the most missing data (Foot Tap, Rapid Walk, Head/Neck Rotation), with tester administration errors being the most common reason for missing data, but for the vast majority of the screening measures, the subtests were correctly administered, with complete data obtained 98% of the time. For the Rapid Walk subtest, 145 cases (25%) had missing data, but these individuals had completed the Foot Tap subtest. The bulk of the missing data on this measure (and on Foot Tap) occurred during the first 4 months of testing. When the assessment protocol was first administered, attempts were made to limit the time needed to complete the screening battery. Because the Foot Tap and Rapid Pace Walk served as markers of lower limb mobility, test administrators were given the option to administer either test as a measure of lower limb mobility. When it became apparent that retraining of the staff was necessary, the decision was also made to require both measures of lower limb mobility. Missing data on either of these measures after that point constituted less than 2% of the cases. Because these subtests assess lower limb mobility, and performance on these measures was highly correlated, an estimated score was imputed for Rapid Walk time based on Foot Tap time using a linear regression equation derived from the 1,287 cases with complete data on both variables. Because of excessive missing data (35%), Head-Neck Rotation was excluded from subsequent analyses. Test administrators found it difficult to have participants remain seated while performing this task. All participants performed the Cued Recall task perfectly, fewer than 1% evidenced visual hemi-neglect on the Symbol Scan Test, and fewer than 1% failed the Arm Reach task. Because this lack of variability eliminates any possible predictive ability of such screening measures, they were not included in further analyses.

Table 1. Characteristics of Participants and Nonparticipants

Characteristic	Participants (n = 1,910)	Nonparticipants (n = 2,060)
Age, mean ± SD	68.55 ± 7.95	69.37 ± 7.81
Male, %*	54	47
White, %	93	91
Annual mileage, mean ± SD	7,971 ± 7,420	—
Reporting falls in prior 3 years, %	14	—
Retrospective at-fault crashes, %	5.5	5.5
Prospective at-fault crashes, %*	4.9	2.0

* $P<.05$.
SD = standard deviation.

Descriptive statistics for demographic and crash characteristics are presented in Table 1. Demographic and crash characteristics of the participants were compared with those of the individuals who were approached but declined to participate using *t* tests and chi-square (χ^2) tests for continuous and categorical variables, respectively. The individuals who chose to participate in the testing protocol did not differ from those who declined participation in age (t (3,968) <1, $P=.94$), race (χ^2 (4) $=4.93$, $P=.30$), or prior crash involvement (χ^2 (1) <1, $P=.96$), but women were less likely to participate in the study than were men (χ^2 (1) $=20.37$, $P<.001$). Although retrospective crash involvement did not differ between those who did and did not chose to participate, participants were more likely to experience future at-fault MVCs (χ^2 (1) $=6.65$, $P=.01$).

The participants who were (n = 92) and were not (n = 1,808) involved in MVCs were compared using *t* tests. (Ninety-one participants involved in MVCs experienced one crash; one experienced two crashes.) When examining the participants in this manner, those who were involved in MVCs performed significantly worse on UFOV (t (1,838) $=-2.24$, $P=.03$) and MVPT (t (1,898) $=-2.51$, $P=.01$) than those who were not. The two groups did not significantly differ in performance on Cued or Delayed Recall, Foot Tap, Rapid Walk, Abbreviated Trails A, or Trails B ($P>.05$). Table 2 contains mean scores, standard deviations, and unadjusted *P*-values comparing those who were and were not involved in MVCs. Table 3 contains the number of participants who passed or failed the categorically scored elements of the screening battery.

For evaluating the predictors of at-fault MVC occurrence, a series of logistic regression analyses were run in SAS using the events/trials syntax of Proc Logistic (SAS Institute, Inc., Cary, NC). The interval between each participant's assessment and the end of the follow-up period (December 31, 2003) was calculated, and the resulting number of years for each participant served as the number of "trials" or opportunities for crash events. The number of at-fault crashes over this interval represented the number of events. Consequently, the number of at-fault crashes per year was estimated as the outcome variable of interest for these models.

Table 2. Summary Scores of Performance-Based Physical and Cognitive Measures

Performance-Based Test	Noncrashers	Crash Involved	*P*-value*
	Mean ± Standard Deviation (n)		
Delayed recall, correctly recalled words (range 0–3)	2.38 ± 0.84 (1,785)	2.30 ± 0.92 (91)	.34
Cued recall, number of trials to mastery (range 0–3)	1.03 ± 0.19 (1,785)	1.02 ± 0.15 (90)	.65
Foot tap, seconds	6.14 ± 2.36 (1,377)	6.48 ± 2.74 (61)	.27
Rapid walk, seconds	6.58 ± 2.20 (1,658)	6.83 ± 2.39 (84)	.32
Motor-Free Visual Perception Test (range 0–11 errors)	1.70 ± 1.77 (1,808)	2.17 ± 1.90 (92)	.01
Abbreviated Trails A, seconds	12.91 ± 29.03 (1,805)	13.40 ± 7.63 (93)	.64
Trails B, seconds	106.75 ± 47.50 (1,798)	114.75 ± 54.52 (91)	.17
Useful Field of View subtest 2 (range 16–500 ms)	176.35 ± 153.62 (1,749)	213.54 ± 174.43 (91)	.03

* *T* test.

The effect of annual mileage was highly significant in all models ($P < .01$), indicating that participants who drove more per year experienced more at-fault crashes per year. This was most likely due to increased exposure to risk. Therefore, annual mileage driven as reported during the assessment was used as a covariate in all logistic regression models.

Odds ratios (ORs) and 95% confidence intervals for each variable as a predictor of at-fault MVCs per year (adjusted for exposure based upon self-reported annual mileage) are presented in Table 4. The significant predictors of subsequent at-fault MVCs were age, sex, history of falls, Trails B, MVPT performance, and UFOV performance. Older age and male sex, as well as incidence of falls over the prior 3-year period, were predictive of subsequent at-fault MVCs. Poorer performance on Trails B, the MVPT, and the UFOV test, all cognitive measures, was also associated with future at-fault MVC involvement.

Those continuous variables that emerged as significant predictors were explored as dichotomous measures to identify cutpoints that maximized crash prediction. Percentiles of 70, 75, 80, 85, and 90% were examined as potential cutpoints for age, Trails B, MVPT, and UFOV. Analyses revealed that the 85th percentile was most sensitive for age, with participants aged 78 and older 2.11 times as likely to be involved in at-fault MVC as younger participants after adjusting for annual mileage. Those who took 147 or more seconds to complete Trails B (90th percentile), were 2.01 times as likely to be involved in an at-fault MVC as those who completed the task in less time. Those who made four or more errors on the MVPT (85th percentile) were 2.10 times as likely to crash as those with three or fewer errors, and those who took 353 ms or longer on subtest 2 of the UFOV (80th percentile) were 2.02 times as likely to incur an at-fault MVC as those whose threshold was less than 353 ms. All ORs based on these cutpoints differed significantly from the null value of 1.00 ($P < .01$).

Multivariate analyses were also conducted to examine whether the cognitive measures found to be significant predictors in univariate analyses (MVPT, UFOV, and Trails B) accounted for unique variance while considering an individual's age, sex, and mileage driven. Three multivariate models were thus examined. In all three multivariate models, mileage was a significant predictor, with those driving more miles experiencing more at-fault crashes per year. MVPT ($OR = 1.24$, $P = .03$) and UFOV ($OR = 1.23$, $P = .04$) were found to be significant unique predictors of at-fault crash rate per year, whereas Trails B was not. Thus, even with the knowledge of an individual's age, sex, and mileage driven, the MVPT and UFOV provide additional information in predicting prospective, at-fault MVC involvement.

Table 3. Number Who Passed or Failed Categorical Physical Screening Measures

Performance-Based Test	Noncrashers	Crash Involved
	Pass/Fail	
Head/neck rotation (35% of cases missing)	954/224	39/14
Arm reach		
Right	1,802/8	91/2
Left	1,800/7	91/2
Symbol scan	1,699/78	86/5

Table 4. Association Between At-Fault Motor Vehicle Collisions and Demographics and Selected Screening Tests

Characteristic	Chi-Square	*P*-value	Odds Ratio*	95% Confidence Interval
Age	4.17	.04	1.26	1.01–1.57
Female	4.81	.03	0.59	0.37–0.95
History of at-fault crash involvement	1.14	.29	1.49	0.72–3.11
History of falling	3.87	.049	1.67	1.00–2.78
Delayed recall	1.52	.22	0.88	0.73–1.08
Rapid walk time	2.47	.12	1.16	0.96–1.39
Tap time	1.98	.16	1.13	0.95–1.35
Motor-Free Visual Perception Test	7.79	.005	1.29	1.08–1.55
Trails A	.144	.71	1.03	0.89–1.19
Trails B	4.42	.04	1.21	1.01–1.44
Useful Field of View Test subtest 2	7.52	.006	1.31	1.08–1.59

* Covariate adjusted for annual miles driven.

DISCUSSION

The present research describes the results of the evaluation of a variety of performance-based measures in a field setting. Measures identified through prior research as useful in assessing driving competence were selected and evaluated prospectively in a large, population-based field study. When these measures are prospectively evaluated in a nonlaboratory setting with a large population-based sample, some remain related to crash involvement. In addition, these measures share common variance, indicating that impaired older drivers are likely to score poorly on multiple indices of a construct (e.g., cognitive function). The UFOV Subtest 2 and MVPT Visual Closure subtest appear to be the most sensitive of the performance-based measures within these analyses, although in univariate models Trails B also predicts at-fault MVCs at the 90th percentile. These results are face valid, in that cognitive processing speed and divided attention, as assessed using the UFOV Subtest 2 and Trails B, and an understanding of spatial relationships, as assessed using the MVPT Visual Closure subtest, are easily recognizable as cognitive functions that are integral to the driving task. These results confirm those reported earlier on a much smaller sample[11] and highlight another cognitive performance test, MVPT, as an important predictor of MVCs in older adults. Whereas prior research has indicated that other elements of the screening battery are predictive of MVCs, most of the measures did not emerge as significant predictors in this study. Possible factors that might account for this difference are the administration of the measures in the context of this specific battery and within this field setting and the examination of the measures as prospective predictors of MVC.

One reason that UFOV Subtest 2 and MVPT Visual Closure subtest in particular may endure as salient predictors when administered in a field site is the objectivity and ease of administration for these measures. For example, the UFOV is computer administered and scored, leaving little to no room for tester bias. Similarly, MVPT involves a forced choice format in which responses are easily scored as correct or incorrect. Alternatively, the physical performance measures relied more heavily upon the administrator and often involved subjective judgment of abilities. Such measures also tended to have more missing data. Recently, computer-administered and -scored modifications of the UFOV, MVPT, Trails A & B, Rapid Paced Walk, Delayed Recall, and Head/Neck flexibility have been developed into a single battery (the Driving Health Inventory), which is now being used in a longitudinal follow-up study of the Maryland sample during license renewal 5 years later. This battery is designed to reduce testing variability, thereby providing a better evaluation of the functional performance tests as predictors of MVCs in older adults. Preliminary results of the follow-up data reveal that these same measures remain predictive of at-fault crash involvement and that an additional 10% of older drivers fail the assessment 5 years later (unpublished data).

Another reason that the physical performance measures in this study did not emerge as significant predictors of prospective crash may have been the lack of variability in this sample in their performance on at least some of the measures. In states such as Maryland, where in-person renewals are required, the ability to travel to the MVA, in and of itself, requires relatively intact physical capacities. Therefore, the present results may not indicate that such physical abilities are unrelated to MVC involvement but rather may reflect the fact that, when states require in-person renewals of any kind, they are eliminating the very frail elderly from license eligibility. Accordingly, current research has indicated that, in drivers aged 85 and older, requiring an in-person renewal reduces driver traffic fatalities.[22]

In summary, it would be shortsighted to conclude, based upon the results of this study, that the nonsignificant performance-based measures evaluated are of no value in identifying older drivers at-risk for MVC involvement. The relationship between each variable and crash risk becomes stronger when at-fault crashes, as opposed to all crashes, are examined. This indicates that, although some of the performance-based measures do not account for unique variance in models of crash prediction, all of the performance-based variables are associated with driver behaviors that engender crash.

Additionally, a practical concern when predicting crash risk is that licensing decisions with far-reaching ramifications for personal autonomy should be based upon a preponderance of evidence. Impaired performance on more than one measure affords the licensing agency, as well as the primary care physician, a greater degree of confidence that its recommendations are grounded in hard evidence. It further allows for a better determination of what interventions may be undertaken to improve individual driving capabilities, which in turn keeps individuals driving safely longer. This is critical in that the ultimate goals of assessment and remediation are to preserve the highest possible quality of life for each driver.

What is especially encouraging about the present results is that several studies have established that processing speed, as indicated by UFOV performance, can be improved with speed-of-processing training.[37–40] Furthermore, such training has been shown to result in improved driving safety for up to 18 months posttraining.[40] A large-scale clinical trial evaluating the effect of cognitive training (Advanced Cognitive Training for Independent and Vital Elderly) is currently analyzing the effect of this training on crash risk in a large sample of older drivers.[37] Thus, at least one of the most consistently identified cognitive predictors of crash risk can in many cases be modified, with potential for reducing crash risk.

It is important to reiterate that the sample used in this study is one that had already passed through a filter of vision screening. The fact that all of the participants had passed vision thresholds for driving safety before enrolling in this study allows the conclusion to be made that the study battery is predicting significant cognitive risks for crash in addition to that detected by vision screening alone, but if there had not been a vision screening in place, it is likely that prediction of crash with the performance-based battery would have only been strengthened. Because Trails B, the UFOV, and MVPT measures are sensitive to significant declines in functional visual abilities,[41] as well as declines in cognitive abilities, the sensitivity of these measures might be enhanced in a study without prescreening for vision.

The oldest adults, men, and individuals with a history of falling were more likely to be involved in at-fault MVCs after the assessment. Older age is associated with greater risk for functional decline (visual, cognitive, and physical), which in turn, results in increased risk of MVC. Indeed, once individual differences in functional abilities are accounted for, differences due to age become insignificant. In addition, male drivers in this older adult cohort drive more miles than female drivers, thus increasing their exposure to crash opportunities, given the same functional abilities as their female counterparts.

Driving cessation in this sample of older drivers also is likely to have weakened the associations between the battery measures and crash outcomes, given the assumption that participants continued to drive throughout the interval after the functional assessment. The inspection of a subsample of participants who were interviewed by telephone revealed that a growing number of participants stopped driving over time (7% by 3 years postscreening is a conservative estimate). Those who stopped driving would otherwise have been at high risk for crash, based upon their higher rates of impairment on UFOV Subtest 2, Trails B, and MVPT Visual Closure subtest. Because this interview sample was randomly selected, it is reasonable to infer that it is representative of the full sample presenting for license renewal and that driving cessation in the full sample therefore mitigated against finding stronger associations between the predictive measures and crash. Driving cessation will be accounted for in the ongoing longitudinal follow-up of this sample to examine this hypothesis.

Finally, these data demonstrate the feasibility of administering a performance-based battery of functional ability measures in a field setting. MVA staff with minimal training administered the current battery. The fact that the same basic relationships were found in the current study as have been observed in more-controlled clinical settings attests to the robustness of the effects and the low effect of variability in test administration, particularly for the cognitive measures such as UFOV, Trails B, and MVPT.

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