Predicting Road Test Performance in Adults with Cognitive or Visual Impairment Referred to a Veterans Affairs Medical Center Driving Clinic

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OBJECTIVES: To develop a screening battery for office-based clinicians that would assist with the prediction of impaired driving performance and deciding who should proceed to road testing in a sample of adults with cognitive or visual deficits.

DESIGN: Prospective observational study.

SETTING: Driving evaluation clinic at a Veterans Affairs Medical Center (VAMC) in St. Louis, Missouri.

PARTICIPANTS: Seventy-seven individuals aged 23 to 91 with diagnoses of cognitive or visual impairment or both referred to an occupational therapy based driving clinic by VAMC providers because of concerns regarding driving safety.

MEASUREMENTS: Predictor variables included tests of visual and cognitive functioning and activities of daily living. The major outcome was pass or fail on a standardized performance-based on-road driving test.

RESULTS: Thirty percent of the referrals failed the road test. The best predictors of driving performance were the Trail-Making Test Part A and the Mazes Test from the Neuropsychological Assessment Battery.

CONCLUSION: Measures of visual search, psychomotor speed, and executive functioning accurately predicted road test performance in a significant number of participants. These brief tests may assist clinicians in deciding who should proceed with a road test in a driver rehabilitation clinic or perhaps to whom it should be recommended to cease driving. **J Am Geriatr Soc 60:2070–2074, 2012.**

Key words: automobile driving; driving safety; psychometric testing; road testing

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In 2006, there were estimated to be more than 30 million licensed drivers aged 65 and older in the United States.[1] There is a greater prevalence of chronic diseases with each ensuing decade. A number of these medical conditions may result in functional impairments that negatively affect driving performance.[2] Medical conditions that are known to affect driving ability include neurological conditions (e.g., multiple sclerosis, Alzheimer's disease, traumatic brain injury, stroke), conditions or diseases affecting vision (e.g., macular degeneration, diabetic retinopathy, glaucoma, hemianopsia), psychiatric disorders (e.g., bipolar disorder, anxiety), cardiovascular disease, metabolic disease, and musculoskeletal disease, along with medication side effects.[3]

The performance-based road test is often viewed as the criterion standard for assessing driving fitness. However, road tests are expensive, not usually covered by Medicare or insurance, and time consuming and may not be readily available or acceptable to patients. Moreover, there are concerns of taking severely impaired drivers into actual traffic situations. In addition, many of the conditions affecting driving safety are progressive, so a driver who performs well on the road test at one point may be unsafe months later and require reevaluation. Therefore, office-based tests that predict driving performance that are valid, reliable, brief and easily administered are needed. Impaired cognitive domains that have been associated with decrements in driving performance include episodic memory,[4] visuospatial skills,[5] executive function,[6] and tests of selected and divided attention.[7] The majority of studies that have attempted to create cognitive test models for road test prediction have typically approached an 80% correct classification rate when using multiple tests.[8] There

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is no test battery that has been universally adopted according to consensus for use in the clinician's (e.g., occupational therapist, physician, neuropsychologist) office or in departments of motor vehicles.

The current study was designed to determine whether previous predictive models of driving performance could be improved upon by adopting brief visual and cognitive tests that could serve as part of a tiered evaluation approach, be easily administered by clinicians or trained staff, and used at low cost in any setting. This type of effort could be useful in validating an approach by clinicians to assess older drivers, as the American Medical Association suggests.[3] Thus, the goal of this study was to determine whether a brief office-based instrument or set of instruments could accurately predict on-road driving performance in a sample of adults referred to a Veterans Affairs Medical Center (VAMC) driving clinic.

METHODS

The human studies committee at the St. Louis VAMC and the Washington University School of Medicine approved this study. Various VAMC health professionals and providers referred participants for a driving evaluation. The Jefferson Barracks Division of the St. Louis VAMC provides geriatric health care, spinal cord injury treatment, rehabilitation services, psychiatric treatment, a nursing home care unit, and a rehabilitation domiciliary program for homeless veterans. The driver rehabilitation clinic has served the region for 30 years and receives referrals from providers within the VAMC system. Fitness-to-drive referrals are frequently made because of cognitive, motor, or visual impairment due to a number of conditions, including dementia, stroke, multiple sclerosis, amputation, and spinal cord injury.

All clients referred for a driving evaluation between October 2007 and December 2010 were mailed information on the research study, including a copy of the informed consent form and the Authorization for Release of Protected Health Information (form from the VAMC). Upon arrival for their scheduled appointment, clients were asked whether they had received the documents and whether there was interest in participating in the study. All participants were required to re-review and sign all appropriate forms.

Inclusion criteria were having a referral for a driving evaluation because of cognitive or visual impairment, having an active driver's license, being aged 18 and older, having physician approval of the evaluation after referral from a provider, having the ability to understand the informed consent form and comprehend the purpose and objectives of the study and communicate in English, and having completed at least part of the road test (such that a pass–fail determination was made).

Exclusion criteria were primary joint or muscle impairments (e.g., spinal cord injury, lower extremity amputation, neuropathy, spinal stenosis, degenerative join disease, lower extremity fracture; n = 30), cognitive impairment or fatigue too severe to follow road test instructions from the occupational therapist (OT) (PMN) administering off-road tests (n = 12), and road test could not be performed because of weather conditions (n = 1).

Data Collection and Measurements

Based on the entry criteria noted above, 77 participants were included in the final sample. The sample included individuals with a variety of diagnoses, including macular degeneration, multiple sclerosis, dementia, bipolar disorder, schizophrenia, stroke, brain injury, medication side effects, brain tumor, cardiac disease, and unspecified cognitive disorder.

An OT interviewed each participant regarding driving history (e.g., getting lost in familiar areas, stressed while driving, difficulty using car equipment, tickets, crashes, near misses) and functional abilities (e.g., memory problems, family or doctor concerns, managing medications, finances and meal preparation, bathing and dressing ability, recent falls). A clinical psychologist with more than 20 years of experience provided training on the administration of the neuropsychological tests. The lead therapist (PMN) administered the neuropsychological tests and performed the role of the driving instructor on the road test.

Vision Evaluation

Participants were tested for visual acuity, color identification, road sign recognition, depth perception, lateral and vertical phoria, and field of vision using the Titmus 2 Screener and the Drivers Testing Education slides.[9]

Cognitive Evaluation

Tests administered included the Freund Clock Drawing test[10] (a measure of executive function and visuospatial abilities), Trail-Making Test (TMT) Parts A and B[11] (tests of psychomotor speed, visual scanning ability, and executive functioning), the Short Blessed Test[12] (a brief mental status screen), and three tests from the Neuropsychological Assessment Battery (NAB):[13,14] driving scenes (a measure of working memory and visual attention), map reading (a test of visuospatial functioning, visual scanning, and attention), and mazes (a measure of psychomotor speed and executive functioning, including, planning, and impulse control).

Motor

Participants' upper and lower extremity range of motion and strength and cervical range of motion were screened and rated as within functional limits or impaired. Motor speed was assessed according to the Rapid Pace Walk[4] (test of lower limb strength, balance, endurance, range of motion).

Traffic Safety Question

Thirteen traffic safety questions taken in part from practice questions that the Missouri State Department of Revenue for novice drivers provided were asked (unpublished data).

Road Test

The lead OT performing the driving evaluations was a Certified Driver Rehabilitation Specialist (CDRS) with 9 years of experience performing driving evaluations. The Jefferson Barracks VA Road Test (JBVART) was modeled after the modified Washington University Road Test (WURT)[15] and was used for the major outcome measure.

The JBVART adapted a qualitative scoring system (e.g., pass, marginal, fail) but did not have the quantitative or point score that would have required a second evaluator in the backseat. Driving initially takes place on the medical center grounds, allowing participants to become familiar with the car and the surroundings. If participants are able to demonstrate proficiency with the basic operations of the automobile and follow instructions, they proceed off the grounds in a suburban setting. The course was gradually increased in difficulty, with more-challenging tasks in the latter aspects of the route (e.g., complex intersections and highway driving). The JBVART is 14 miles long and takes approximately 45 minutes to complete.

The road test had three unprotected left turns, 10 protected left turns, nine unprotected right turns, five protected right turns, and four merges using signs. The unprotected left turns were included because difficulty with them is overrepresented in older adult crashes.[16] The initial investigator of the WURT assisted in the creation of the road test.[17]

All participants drove a facility vehicle with automatic transmission and an instructor's brake with the OT/CDRS sitting in the passenger's seat evaluating driving performance and safety. At the end of the drive, the OT/CDRS gave an overall score of pass, marginal, or fail, which was the outcome measure of this study. Marginal and pass categories were combined. Significant driving errors that resulted in a fail rating were documented a priori and included if the evaluator had to use the instructor's brake or take the wheel to avoid a collision or avoid a dangerous situation, if the driver failed to stop at a stop sign or traffic light or required multiple verbal cues to maintain safety, lane drifting, driving in the wrong lane, failure to yield to a pedestrian or vehicle requiring intervention, or if the driver consistently had errors in important driving maneuvers (e.g., scanning, gap acceptance).

Because the lack of blinding to psychometric testing could potentially affect final road test ratings, a second OT and driver rehabilitation specialist with 5 years of experience was recruited to review documentation from the original road test and rate performance. This second rater was blind to the neuropsychological and vision testing and the categorical rating (pass, marginal, fail) of the driving evaluation. The kappa value comparing instructor ratings was good (0.62), indicating adequate overall agreement and the lack of effect of the primary rater conducting the neuropsychological testing and the road test. Therefore, the original instructor's road test evaluation (pass/fail) was used as the major driving outcome measure in this study.

Statistical Analysis

Statistical analysis was performed using SPSS version 19.2 (IBM, Armonk, NY) and SAS 9.2 (SAS Institute, Inc., Cary, NC). Demographic variables and participant characteristics were evaluated for association with driver JBVART failure using the *t*-test for continuous variables and the Pearson chi-square test for categorical variables (Table 1). Associations between psychometric tests were examined using Pearson correlation coefficients (data not shown). Individual receiver operating characteristic (ROC) curves were created with the brief clinician predictor measures, and area under the ROC curve (AUC) was calculated. Based on these results, stepwise logistic regression was performed to determine which test or combination of tests were most predictive of a fail rating on the road test.

RESULTS

Table 1 shows the demographic information and tests of functional abilities based on road test outcome. Table 2 presents individual test characteristics for the psychometric tests that had good to excellent prediction of road test performance (e.g., AUC > 0.85). Using a simple logistic regression approach, the two tests that were most accurate in predicting failure on the road test were the TMT Part A and the Maze Test from the NAB. Figure 1 depicts the ROC curve for TMT Part A. Trying to combine these tests or

Table 1. Demographic Characteristics and Measures Based on Road Test Outcome

Characteristic or Measure	Total, N = 77	Pass Road Test, n = 49 (64%)	Fail Road Test, n = 28 (36%)	*P*-Value
Age, mean ± SD (range)	67.8 ± 18.4 (23–91)	63.5 ± 20.8 (23–89)	75.4 ± 9.6 (25–91)	.006
Male, %	96	94	100	.25
Education, years, mean ± SD (range)	13.0 ± 2.7 (8–20)	13.4 ± 2.8 (8–20)	12.4 ± 2.4 (8–17)	.13
African American, %	10	8	14	.41
Far visual acuity both eyes ($\leq$20/40), %	86 (N = 66)	94 (n = 46)	71 (n = 20)	.02
Right field of vision ($\geq$85°), %	80 (N = 61)	90 (n = 44)	60 (n = 17)	.10
Left field of vision ($\geq$85°), %	74 (N = 57)	93 (N = 40)	60 (N = 17)	.25
Short Blessed Test, mean ± SD (range 0–28)	4.0 ± 5.2 (0–25)	2.6 ± 2.9 (0–12)	6.5 ± 7.2 (0–25)	.002
Clock Drawing Test–Freund, mean ± SD (range) (range 0–7)	4.8 ± 1.9 (0–7)	5.1 ± 1.8 (1–7)	4.3 ± 1.9 (0–7)	.04
Trail-Making Test Part A, seconds, mean ± SD (range)	62.6 ± 30.8 (18–168)	47.9 ± 18.0 (18–99)	88.4 ± 31.6 (46–168)	<.001
Trail-Making Test Part B, seconds, mean ± SD (range)	183.3 ± 88.3 (50–304)	144.8 ± 72.8 (50–301)	250.6 ± 71.5 (102–301)	<.001
Maze Test, mean ± SD (range) N = 72	6.3 ± 5.6 (0–22)	8.0 ± 5.6 (1–22)	2.6 ± 3.2 (0–12)	<.001
Driving scenes, mean ± SD (range)	37.0 ± 9.9 (4–61)	40.6 ± 8.3 (23–61)	30.7 ± 9.3 (4–51)	<.001
Map reading, mean ± SD (range) N = 72	6.4 ± 2.2 (0–11)	7.0 ± 2.0 (3–11)	5.2 ± 2.0 (0–9)	<.001

SD = standard deviation.

Table 2. Specific Test Characteristics of Selected Psychometric Tests in Predicting Failure on the Road Test (N = 77)

Test Cut-Point	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	LR+	LR−
Trail-Making Test Part A, seconds (AUC = 0.89)[a]						
40	1.000	.367	.475	1.000	4.5	.22
60	.821	.816	.719	.889	4.5	.22
80	.500	.939	.832	.767	8.2	.53
Mazes (N = 72, AUC = 0.85) range 0–22[b]						
17	.786	.102	.333	.455	.87	2.10
5.5	.679	.571	.475	.757	1.58	.56
.5	.107	1.000	1.00	.662	.00	.89

[a] Higher scores indicate poorer performance.
[b] Lower scores indicate poorer performance.
AUC = area under the receiver operating characteristic curve; LR = likelihood ratio.

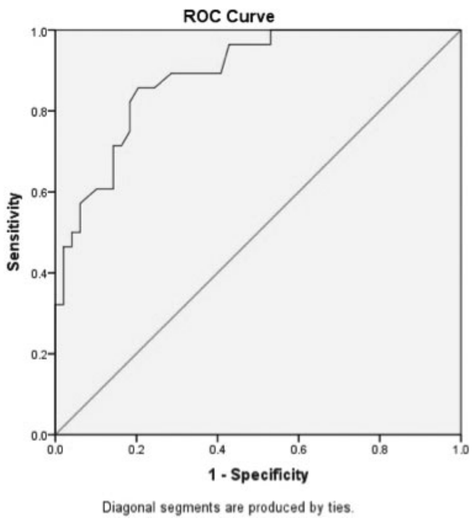

Figure 1. Receiver operating characteristic curve for Trail-Making Test Part A.

other tests did not enhance the predictive value of the individual tests. When TMT Part B was added to TMT Part A, the addition was marginally statistically significant ($P = .05$, 95% confidence interval = 1.01–1.02), but the TMT Part B was difficult to perform for this group of individuals, and 25% of the sample could not complete the test in less than 5 minutes, making it less useful for a screening test.

DISCUSSION

Almost one-third of the drivers referred to the VA driving clinic failed the road test. This is higher than previously reported studies,[18,19] but many published studies examining road test performance in medically impaired older adults have recruited samples in a research setting, where one might anticipate a higher level of driving skills because of volunteer bias. This study examined individuals that were deemed to be at risk because of the presence of medical illnesses and concerns raised by health professionals and families. Additional factors such as course difficulty, instructor bias, or other factors not related to disease severity but simply not assessed during the driving evaluation could also explain this higher rate (e.g., fatigue from off-road and on-road testing, test anxiety, lifelong poor driving habits, personality characteristics).

The office-based tests that best predicted failure on the road test were the TMT Part A and the Mazes Test from the NAB. Recent articles have found that similar tests of visuospatial skill (including visual search), psychomotor speed, executive functioning, and attention have predicted on-road driving performance.[7,8,14] Individual tests or combinations have been shown in the literature to have usefulness in some samples that have included medically impaired older drivers.[19–21] In the current study, the AUC for the two tests were so high that adding additional tests did not add to the predictive power of the individual tests. Although each individual test in the sample had acceptable sensitivity and specificity and overall accuracy rates consistent with those in previous studies, cutoffs should probably be set to minimize the number of false positives (e.g., those that are safe to drive who test positive and should not be penalized). This will continue to be a matter of public debate among clinicians and policy-makers.

The TMT Part A is available in the public domain, is brief (<1 minute to administer), and can be scored easily and quickly, although patients referred for driving evaluations found it to be less acceptable than other cognitive tests.[22] Presumably, people may have difficulty understanding the relevance of the test to driving. The Mazes test from the NAB must be bought and requires additional training and time for administration (~5–10 minutes) but may have more acceptability or face validity as a measure of or proxy for driving impairment for individuals in this setting.

There are several limitations to this study. The road test used has not been validated with retrospective or prospective crash data. The medically impaired sample was heterogeneous and mostly male and was recruited in a VA setting, making generalizability limited. There are other factors that could influence road test results that were not measures in this study, including personality characteristics, lifelong driving habits, and depression. All of these factors and others, such as lack of confidence[22] and test anxiety,[23] may need to be quantified during future studies of prediction of driving outcomes to determine whether there are differences in road test performance and whether testing these factors would improve prediction of the models.

This study lacks validation with model testing data. Validation will need to await larger data sets from a variety of sites to determine whether these tests should be adopted to assist in making driving decisions before road testing. Veterans referred to the driving clinic with motor deficits were excluded, so these findings should not be generalized to this subset of individuals, although the findings are consistent with other tests that were found to be predictive in the literature.[8,24] Historically there has been a poor match between traditional psychometric tests and road test performance.[25] Future research will need to focus on components of driving behavior to develop new tests that will improve predictive power.[26]

In summary, brief office tests of visual scanning and processing speed (e.g., TMT Part A, NAB Maze Test) were able to correctly classify a high percentage of drivers into a pass–fail category. Just as important, these tests are brief, administered in less than 10 minutes, and could be adopted in a clinical setting with appropriate training of personnel to administer psychometric tests. Further studies are needed to determine the ability of these tests to assist in determining who should be referred for on-road testing. Additional discussion among clinicians, patients, and caregivers are needed to determine the level of medical uncertainty that is acceptable to create and adopt these tools for clinical use.

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Dr. Stern is a coauthor of the NAB and received related royalties. This work was supported by grants from the National Institute on Aging (P30 AG13846; RAS) and the Alzheimer's Association (IIRG-08–89720; RAS). For information about the NAB, contact; Psychological Assessment Resources, Inc. www.parinc.com

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