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Evaluating Older Drivers' Skills

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16. Abstract

Research has demonstrated that older drivers pose a higher risk of involvement in fatal crashes at intersections than younger drivers. Age-triggered restrictions are problematic as research shows that the majority of older people have unimpaired driving performance. Thus, it has become important to be able to identify which drivers are at risk of crashes and apply driving limitations based on this risk (instead of age alone). The objective of this project was to review the report from the 2003 University of Florida Consensus Conference as well as other important documents on similar topics, and to interview experts to obtain information about the strengths and weaknesses of these specialist-administered screening and assessment tools, self-screening instruments and training methods. This report will help to guide future research by highlighting tools and methods commonly used by clinicians that have not yet been adequately evaluated and those which may already be recommended for use. The goal was not to reach consensus but to provide a rich background from the literature combined with expert opinions in an attempt to guide decisions and research goals related to these evaluation tools.

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Executive Summary

Research has demonstrated that older drivers pose a higher risk of involvement in fatal crashes than younger drivers. The problem is expected to worsen as older drivers become an increasing portion of the driving population. Efforts to identify which drivers are at high risk can help Departments of Motor Vehicles (DMVs) limit driving by people most likely to be involved in crashes.

In 2003, the University of Florida convened a meeting to discuss the current state of older adult transportation issues, including an appraisal of the strengths and weaknesses of specialist-administered screening and assessment tools, self-screening instruments, and training methods. The objective of this project was to review the report from the 2003 University of Florida Consensus Conference as well as other important documents on similar topics, and to interview experts to obtain information about the strengths and weaknesses of these specialist-administered screening and assessment tools, self-screening instruments, and training methods.

The study initially included several assessment instruments identified as potentially predicting driving performance. Instruments were selected and categorized into one of five general categories: cognitive, education and training, motor skills, self-screening, and vision. The literature reviews described research showing any relationship between these instruments and driving-related outcome measures including road performance (e.g., as measured by road tests) crash risk (at fault and in general), violations (self-reported and State recorded) and performance in a driving simulator.

The research team distributed the literature review to a panel of experts in older driver safety, and asked panelists to note any tools that should be omitted from discussion; if any experts objected to the removal of an item it was kept in for further discussion. When the expert panel convened, members discussed the remaining items. The panel either provided information regarding the tool's usefulness or recommend that it be omitted from the body of the report. They recommended whether instruments be used for screening (determining whether further evaluation was needed) or assessment (determining what action, if any, a licensing agency should take). The panel discussed the circumstances under which the instrument could be administered (e.g., DMVs, or occupational settings) and overall strengths and weakness of each instrument.

A second group of experts reviewed the measures and gave information about them in an online survey. These experts rated the items in terms of strengths and weaknesses, perceived relationship to driving outcome and need for additional research.

The experts noted that almost all the instruments retained in this report need additional research to document their efficacy in identifying risky drivers. This report can be used to prioritize those research needs and to aid in decisions regarding the use of various instruments to identify potentially unsafe older drivers.

I. Introduction

Research has demonstrated that older drivers pose a higher risk of involvement in fatal crashes at intersections than middle-aged drivers. Older drivers account for a relatively small proportion of crash related fatalities and injuries (Lyman et al., 2002). However, the portion of the population made up of older people has been projected to increase over the next decades. Data show that while the overall risk (per capita) of older driver involvement in fatal crashes is low, that risk starts to increase starting around age 75. Some of the increased risk results from the fragility of the older adults that leaves them more vulnerable to fatality than younger people experiencing similar crash forces. The increased relative risk in fatal crashes is somewhat offset by older drivers typically driving fewer miles than younger drivers. However, in recent years older drivers have been increasing their mileage (Braver et al., 2004). Thus, the problem of older driver crash involvement is likely to increase over time.

Despite age-related increases in crash rates, age-triggered restrictions are problematic. Research shows that most older people have unimpaired driving performance (Braver et al., 2004). As such, license restrictions based solely on age are unwarranted, particularly given potential consequences of restricting older adults' driving. Older people with sudden mobility reduction may have a difficult time meeting daily survival and social needs that may affect their health and overall quality of life. Therefore it has become imperative to be able to identify which drivers are at risk of crashes and apply driving limitations based on this risk (rather than based on age per se).

In 2003, the University of Florida convened a meeting to discuss the state of older adult transportation issues, including an appraisal of the strengths and weaknesses of specialist-administered screening and assessment tools, self-screening instruments, and training methods. In the years since, other groups have published research on the same issues (e.g., Wang, Kosinski, Schwartzberg, & Shanklin, 2003; Dickerson et al., 2007). The 2003 University of Florida meeting only met its goal of establishing consensus to a limited extent (see Stephens, McCarthy, Marsiske, Schectman, Classen et al., 2005).

The objective of the current project was to review the report from the 2003 University of Florida Consensus Conference as well as other documents on older adults' driving performance, and to obtain expert opinion regarding strengths and weaknesses of specialist-administered screening and assessment tools, self-screening instruments, and training methods. The project entailed three main research activities: reviewing the literature, convening a panel of experts, and providing a report that provides information about a variety of tools for screening and assessing at-risk older drivers. The report will guide future research by highlighting tools and methods commonly used by clinicians that have not yet been adequately evaluated and those whose validity has been demonstrated. The goal was not to reach consensus but to provide a rich background from the literature and expert opinion to guide decisions and research goals related to assessing and remediating older drivers' safety.

II. Method

TOOL SELECTION

The research team selected tools based on the Driving and Functions Forum Consensus Conference (2006) and on findings from the literature review. Some tools were added based on results of the literature search.

LITERATURE REVIEW

The University of Michigan Transportation Research Institute (UMTRI) conducted a literature review and provided a summary of each measure. The summaries are presented in the following sections. The search engines and databases included in the search were: TRISonline; Transport, PSYCHINFO; LexisNexis; ProQuest; ScienceDirect; MEDLINE; Google Scholar and UMTRI Library. Articles were limited to those available in English. Outcomes measures in the studies were limited to: crashes (self-reported and driver history records); on-road drive tests (test tracks, open-road course and naturalistic driving); simulators; and citations (self-reported and driver history records). UMTRI staff reviewed, synthesized and summarized the articles. The summaries are included in this report.

EXPERT PANEL

An Older Driver Mobility expert panel met on April 7-8, 2008, at the Hilton Garden Inn in Greenbelt, Maryland, in the Washington, DC, suburbs. Panel members were selected based upon their knowledge and expertise in fields related to older driver safety. Panel members and their affiliations at the time of the meeting are listed in Appendix A.

Prior to the meeting, the research team gave panelists the literature review and asked them to indicate any items that could be removed from discussion. Items removed from the main body of this report are listed with their literature review alphabetically in Appendix B.

Panel members discussed how to best categorize the different measures. They recommended that various factors be considered when deciding how to categorize a given measure including:

1. Is the measure a screening or assessment tool? Screening tools are used to identify people who may require further testing to determine their ability to drive safely. Assessment tests provide more complete information about a person's driving related skills.
2. Can the measure be used in the real world (e.g., a clinic or licensing agency (DMV)) or solely in a research setting?
3. In what setting can the instrument appropriately be used (e.g., DMV, clinical setting)?
4. What population would be tested with the tool (e.g., drivers with age related cognitive deficits, older driver with no known health problems)?

ONLINE SURVEY

The research team created an online survey and sent a link to the online survey panel members, along with detailed follow-up questions for each measure. Experts were asked to read the literature review and then respond to questions about each measure. The goal of these virtual surveys was to collect additional information that was not collected during the expert panel meeting in April.

Invitees were asked to read the accompanying literature review for each tool and answer several questions as illustrated in Table 1.

Table 1. Questions for "Virtual Panel" Members

Question	Choices
Do you feel that this instrument is likely to predict driving performance and/or crash risk?	Very likely
	Somewhat likely
	No opinion
	Unlikely
Should further research on the relationship between this item and driving ability be conducted? (Note that you will be given an opportunity to rate the priority of the need for research if you think research is needed).	Yes
	No, the item is unlikely to be shown to be useful
	No, the item has already been shown to be useful
If yes to above please rate the priority with which research on this item is needed.	1 to 10 with end points and middle labeled as below:
	1-Very low priority
	5-Moderate priority
	10-Urgent priority
Assuming that there is some utility to this measure, please place a check next to the situations where this measure could be administered (check all that apply).	DMV at renewal
	DMV during road test
	Trained professional (OT, physician, psychologist)
	Self assessment
	Other (please specify)
Based on either experience or what you have read in this survey, please list any strengths of this measure.	Open ended
Based on either experience or what you have read in this survey, please list any weaknesses of this measure.	Open ended

The Self-Screening Tools section was not included in the virtual panel because the nature of these tools made them incompatible with the question structure described above. In some instances the in-person panel and the virtual panel viewed a tool or measure differently. This may be in part due to the lack of available discussion with other experts for the virtual panel.

Panelists indicated that nearly all of the measures included in the study would benefit from more research documenting their relationships to measures of driving performance or safety.

III. Cognitive Measures

A. VISUOSPATIAL ABILITY

Visuospatial measures document how well one understands spatial relationships among stationary and moving objects. This supports a driver's ability to navigate safely through traffic and to navigate toward a destination.

Embedded Figures Test

Literature Review:

The Embedded Figures Test (EFT) measures perceptual style and analytical ability. The test requires finding simple forms which are embedded in larger figures. The score is the average time in seconds to detect the forms or the number of forms correctly identified. Longer completion times reflect poorer performance in analyzing a part separately from a wider pattern.

The EFT has been compared to various measures of driving. Demick and Harkins (1999) found EFT score to be a better predictor of driving performance than age. In a similar study, Mercier, Mercier, O'Boyle, and Strahan, (1997) reported EFT scores, which were significantly correlated with age, predicted driving errors. However, other studies did not find EFT scores to be significantly correlated to measures of driving performance (Guerrier, Manivannan, & Nair, 1999; Marottoli, Richardson, Stowe, Miller, Brass, Cooney, & Tinetti, 1998).

Expert Panels:

Experts from both the in-person and virtual panels indicated that the EFT was easy to administer and considered it useful as a screening tool. They would have preferred more research support for the tool's relationship to driving outcomes and indicated that the available research does not support a conclusion regarding the relationship between the EFT and driving performance.

Rey-Osterreith Complex Figures Test

Literature Review:

The Rey–Osterrieth Complex Figure Test (RO-CFT), an alternate to the Taylor-Complex Figure Test (the stimulus figures are different for each test), is used to evaluate visuospatial constructional ability and visual memory. It consists of three test conditions: copy, immediate recall, and delayed recall. During the first step examinees receive the RO-CFT stimulus card, and are asked to draw the same figure. Subsequently, they are instructed to draw the figure from memory. Then, after a delay of 30 minutes, they are told to draw the same figure (from memory) once again. Each condition of the RO-CFT takes 10 minutes.

The RO-CFT has been found to be significantly correlated with crash avoidance, evasive action, and threat recognition actions during simulated driving (Uc, Rizzo, Anderson, Shi, & Dawson, 2006). In another simulator study, RO-CFT scores were significantly predictive of crashes and unsafe actions (Rizzo, McGehee, Dawson, & Anderson, 2001). Scores on the test have also been found to be related to on-road driving performance (Uc, Rizzo, Anderson, Shi, & Dawson, 2005). Some studies have also examined the specific subscores of the RO-CFT in terms of driving outcomes. A study of State-reported at-fault crashes found that the RO-CFT copy score and immediate recall score were significantly correlated with crash status (Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998). RO-CFT immediate recall scores have been found to differ significantly among groups of people with a suspended license due to crash involvement, suspended license without crash involvement, and those with a clean driving record (Lundberg, Hakamies-Blomqvist, Almkvist, & Johansson, 1998).

Expert Panels:

The panels noted that the test is difficult to administer and score, so may not be appropriate for a DMV setting. Panelists considered the RO-CFT to be an evaluation, rather than a screening measure, and indicated it could be useful for those with language limitations. Overall, this test was considered to be useful in occupational therapy driver rehabilitation. This test incorporates immediate as well as delayed recall, which panelists indicated is useful to know before a behind the wheel test. Panel members noted that this measure is often used in simulator studies and with people with Alzheimer's disease.

Block Design Test

Literature Review:

The Block Design Test (BDT), a subtest of many intelligence tests, assesses visuospatial and motor skills. The examinee arranges blocks that have all white sides, all red sides, and red and white sides to match examples provided by the examiner. Time to complete this task is compared to a normative sample.

Research has shown significant correlations between BDT scores and on-road driving measures (Schanke & Sundet, 2000), including ability to properly identify landmarks (Uc, Rizzo, Anderson, Shi, & Dawson, 2005). Simulator study results have shown significant correlations between BDT scores and a variety of driving performance measures (Rinalducci, Mouloua, & Smither, 2001; Rizzo, McGehee, Dawson, & Anderson, 2001; Szlyk, Myers, Zhang, Wetzel, & Shapiro, 2002; Uc, Rizzo, Anderson, Shi, & Dawson, 2006). BDT scores have also shown a relationship to license status (suspended license for crash involvement, suspended without crash involvement, and clean driving records) (Lundberg, Hakamies-Blomqvist, Almkvist, & Johansson, 1998).

Expert Panels:

This test must be administered by a professional and it is not readily available (although some panel members felt that it should be). Some panelists indicated that the BDT should only be used in the context of an entire battery, while others saw value in using it alone. They considered the BDT useful in driver rehabilitation evaluation, when given prior to an on-road evaluation. The test does not take long to administer but is rather difficult to score. Panelists considered the BDT as an assessment tool rather than a screening tool and indicated that it is appropriate to a clinical, rather than a DMV setting.

Letter Cancellation Test

Literature Review:

The Letter Cancellation Test (LCT) consists of six 52-character rows in which the two target characters are randomly interspersed approximately 18 times per row. The examinee crosses out the target characters as quickly as possible until finishing all the rows.

One study reported LCT scores related to both braking and steering behavior (Whelihan, DiCarlo, & Paul, 2005).

Expert Panels:

The panel indicated that the LCT was useful for assessment as opposed to screening. The panel considered that this measure needs more research with specific populations, such those with cognitive impairment.

Experts were hesitant to make a statement regarding the usefulness of this tool, given the limited research regarding its relationship to driving performance. Panelists indicated that the LCT is useful in some contexts, but that the limited research support make it inappropriate to a DMV setting.

Maze Navigation Test

Literature Review:

The Maze Navigation Test (MNT) consists of a set of paper forms. The examinee traces a path through mazes of varying complexity. The examinee must avoid dead ends and is not allowed to back-track. There is no time limit for this test.

One study reported significant relationships between scores on the MNT and on-road evaluations (Whelihan, DiCarlo, & Paul, 2005).

Expert Panels:

The panel indicated that this kind of test is typically used for evaluation following traumatic brain injury or stroke. Some panel members reported that the MNT has good face validity, although they questioned whether the test was a valid measure of spatial ability.

Motor-free Visual Perception Test

Literature Review:

During the Motor-Free Visual Perception Test (MVPT), an examiner provides stimuli depicting four incomplete figures and one whole figure. Examinees select the incomplete figure that, when completed, matches the target figure; the score is the number of errors.

Ball and colleagues (2006) reported that MVPT scores for at-fault crash-involved participants differed significantly from those of a control group. However, a study of MVPT scores and self-reported driving history found no significant group difference (Lesikar, Gallo, Rebok, & Keyl, 2002).

Expert Panels:

This measure is one of a number of similar tests and has been used mostly in clinical settings. Panelists familiar with the tool report that it takes approximately 4 to 5 minutes to administer, so could be used in a DMV setting. Panelists considered the MVPT better suited for screening than assessment.

Paper Folding Test

Literature Review:

In the Paper Folding Test, the examinee views a fold for a sheet of paper presented on a computer screen. In the next step, a hole is made somewhere in the sheet. The examinee chooses between two alternatives to report how the unfolded sheet would look.

In a study of participants referred for a general fitness-to-drive evaluation, the Paper Folding Test was used as part of a battery of other tests. Analyses compared scores to self-reported crashes and an on-road test performance. Paper Folding Test score were significantly correlated with self-reported crashes and on-road driving performance (De Raedt & Ponjaert-Kristoffersen, 2000).

Expert Panels:

Panel members were not familiar with the Paper foldFolding Test, pointed out that it lacked face validity, and were hesitant to embrace this measure based on a single study.

Visuospatial Construction Task of the Mattis Dementia Rating Scale (MDRS)

Literature Review:

The Mattis Dementia Rating Scale (MDRS) is a 36-task and 32-stimulus card instrument designed to assess level of cognitive functioning for individuals with brain dysfunction. The five subscales include a six-item construction subscale.

The construction task of the MDRS was used in a study comparing participants of different ages and their performance in a simulated driving task; however the results of the construction task were not discussed (Rinalducci, Mouloua, & Smither, 2001).

Expert Panels:

Panelists noted that the MDRS is a lengthy tool used to diagnose dementia. This test covers multiple domains. Neuropsychologists use this as a starting point when diagnosing a patient. This measure should be categorized as assessment, not screening.

B. EXECUTIVE FUNCTION

Executive function is a process that regulates other cognitive processes. Executive functioning allows a driver to use information from the driving environment and from previous experience to manage multiple driving tasks. These include maintaining speed and lane position, monitoring the changing traffic situation, assessing progress toward a destination, ignoring task-irrelevant stimuli, and responding to unexpected events.

Trail Making Test – Part A

Literature Review:

To complete the Trail Making Test – Part A (TMT-A), the examinee connects circles numbered 1 to 25, scattered across a page of paper, in sequence. If the examinee makes a mistake, the examiner quickly indicates the error, and examinee continues from the last correct circle.

The TMT-A has been widely studied in conjunction with various driving outcomes. Studies have shown significant relationships between TMT-A scores and crash records (Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998; Lundberg, Hakamies-Blomqvist, Almkvist, & Johansson, 1998; Stutts, Stewart, & Martell, 1998). Other studies reported significant relationships between TMT-A and on-road driving performance (Ball, Roenker, Wadley, Edwards, Roth, McGwin, Raleigh, Joyce, Cissell, & Dube, 2006; Janke & Eberhard, 1998; Whelihan, DiCarlo, & Paul, 2005). In a driving simulator study, TMT-A scores were significantly correlated with braking and steering behavior, number of lane boundary crossings, speed, and brake pedal pressure (Szlyk, Myers, Zhang, Wetzel, & Shapiro, 2002). This test is usually administered along with the TMT-B (discussed below). Scores on the TMT-B have generally been found to have stronger associations with driving ability than the TMT-A (Kantor, Mauger, Richardson, & Unroe, 2004; Rizzo, McGehee, Dawson, & Anderson, 2001; Schanke & Sundet, 2000).

Expert Panels:

Panelists considered TMT-A easy to administer and indicated that it could be automated for use in a DMV. Some panelists recommended using only TMT- B as a screening tool, while others favored using the tests together as TMT-A can serve as an introduction to TMT-B.

Trail Making Test – Part B

Literature Review:

To complete the Trail Making Test – Part B (TMT-B), the examinee connects circles containing the letters A through L, and 13 numbered circles intermixed and randomly arranged. Examinees connect the circles by drawing lines alternating between numbers and letters in sequential order until they reach the circle labeled "End.” If the examinee makes an error, the examiner quickly brings the error to the examinee’s attention, and the examinee continues from the last correct circle.

TMT-B scores have been compared with various driving measures. Scores have been found to predict at-fault crashes (Ball, Roenker, Wadley, Edwards, Roth, McGwin, Raleigh, Joyce, Cissell, & Dube, 2006; Goode, Ball, Sloane, Roenker, Roth, Myers, & Owsley, 1998). One study found TMT-B scores to be associated with crash risk even after controlling for age, race, and measures of driving exposure (Stutts, Stewart, & Martell, 1998). However, a study including only female participants did not show TMT-B scores to be significantly associated with crashes (Margolis, Kerani, McGovern, Songer, Cauley, & Ensrud, 2002). Studies have shown TMT-B scores to predict on-road driving performance (Kantor, Mauger, Richardson, & Unroe, 2004; Ott, Heindel, Whelihan, Caron, Piatt, & DiCarlo, 2003, Schanke & Sundet, 2000; Whelihan, DiCarlo, & Paul, 2005). However, another study did not show a significant relationship between TMT-B scores and on-road performance (McCarthy & Mann, 2006). Uc, Rizzo, Anderson, Shi, & Dawson (2005) reported that scores on this measure were significantly related to participants' ability to identify landmarks during on-road driving. In driving simulator studies TMT-B scores were significantly related to general driving performance, crashes, lane boundary crossings, speed, brake pedal pressure, and general unsafe driving actions (Rinalducci, Mouloua, & Smither, 2001; Rizzo, McGehee, Dawson, & Anderson, 2001; Szlyk, Myers, Zhang, Wetzel, & Shapiro, 2002; Uc, Rizzo, Anderson, Shi, & Dawson, 2006).

Expert Panels:

Panelists described this test as a measure of visual search, sequencing, and divided attention. While panelists generally considered TMT-B an assessment tool, they noted that it could be used for screening purposes. The panel indicated that a driver who has difficulty completing TMT-B likely needs more on-the-road training than those who score well. A number of panelists used only TMT-B (as opposed to using TMT-A followed by TMT-B) in clinical practice.

Benton Visual Retention Test

Literature Review:

The Benton Visual Retention Test (BVRT) assesses visual perception, visual memory, and visuoconstructive abilities. It has three alternate forms, consisting of 10 designs. Generally, the examinee views 10 designs, one at a time, and reproduces each on paper, as accurately as possible, from memory.

The BVRT has been used in studies of both on-road and simulated driving. BVRT scores predicted crashes or risky avoidance behavior in a simulated driving study (Rizzo, McGehee, Dawson, & Anderson, 2001), but not in another (Uc, Rizzo, Anderson, Shi, & Dawson, 2006). During a study of on-road driving, BVRT scores were significantly correlated with participants' scores on a landmark identification task and with safety errors (Uc, Rizzo, Anderson, Shi, & Dawson, 2005).

Expert Panels:

The studies conducted by Rizzo's group involved Alzheimer's or Parkinson's patients, so findings may not generalize to other drivers. Panelists favored using this test in clinical settings. This test is most commonly used in dementia evaluation.

C. SELECTIVE ATTENTION

Selective attention is the ability to focus on task-relevant information in the presence of distracting, irrelevant items. Driving in heavy traffic may require close attention to movements of other vehicles, street signs, and changing traffic signals, while ignoring billboards or passengers. A driver who is distracted by a bumper sticker on another vehicle or by the car radio may fail to notice brake lights on the car ahead.

Cognitive Flexibility Test

Literature Review:

Cognitive flexibility is the ability to switch from one behavioral strategy to another. During this test, the examiner presented four-choice visual stimuli, which required a hand response, and aural stimuli, which required a foot response. The stimuli are first presented separately and then combined. Examiners instructed examinees to prioritize the visual task over the aural task, and to switch to another modality when an aural stimulus was presented. Scores were based on the median reaction time to the aural stimuli. The reaction time under the single task condition was subtracted from that in the dual-task condition to correct for reaction speed. Participants' scores were significantly correlated with road test performance, but not with crash involvement (De Raedt & Ponjaert-Kristoffersen, 2000).

Expert Panels:

Panelists pointed out that this instrument tests complex reactions; some referred to it as a crossover to motor assessment. Several panelists noted that cognitive flexibility may prove a useful measure, but were not convinced that this was the best way to test it.

D. SHORT TERM MEMORY

The information a person is currently aware of or is thinking about comprises short term memory. This enables a driver to hold information from the traffic environment and from knowledge of traffic rules to support executive functioning.

Short Blessed Test

Literature Review:

The Short Blessed Test measures memory, orientation, and concentration and is used to screen for possible cognitive impairment. Scores range from 0 to 28, with lower scores indicating better performance. This six-item test has been widely used in community epidemiological studies to indicate probable dementia. It has been shown sensitive to both dementia presence and severity. The test requires the examinee to report the current year and month, identify the time within 1 hour, count backwards from 20 to 1, say the months in reverse order, and repeat a name and address that the examiner has told the subject earlier in the test.

Studies have reported no significant correlation between test scores and driving performance measures. Although the Short Blessed Test may be a good predictor of cognitive impairment and dementia, it does not seem to be a reliable predictor of measures of driving performance (Stutts, Stewart, & Martell, 1998).

Expert Panels:

Panelists considered the Short Blessed Test useful as a dementia screening tool.

Rey Auditory Verbal Learning Test

Literature Review:

The Rey Auditory Verbal Learning Test consists of a list of 15 words that examinees learn during five presentations. The score is the number of words recalled after a 30-minute retention interval. Suspended drivers with a history of crashes had significantly lower scores on this test than did suspended drivers without crashes (Lundberg, Hakamies-Blonqvist, Almkvist & Johansson, 1998).

Expert Panels:

Panel members did not recommend this measure as a predictor of driving performance.

E. MENTAL STATUS

Mental status examinations generally screen for some sort of impairment, such as dementia. People who score poorly on these tests may have difficulty managing the multiple tasks that driving demands.

Mini-Mental Status Examination

Literature Review:

The Mini Mental Status Exam (MMSE), an 11-question measure, tests six areas of cognitive function: orientation, registration, attention and calculation, recall, language, and visuospatial perception/praxis. The maximum score is 30. While interpretations of performance vary, generally scores of 28 to 30 are considered normal; 21 to 27 indicate mild dementia, 11 to 20 moderate, and 0 to 10 severe dementia. The MMSE takes only 5 to 10 minutes to administer.

The MMSE has been in numerous studies of the relationship between cognitive function and driving performance. On-road and simulator studies have reported significant correlations between MMSE score and driving measures (Cox, Quillian, Thorndike, Kovatchev, & Hanna, 1998; Kantor, Mauger, Richardson & Unroe, 2004; Odenheimer, Beaudet, Jette, Albert, Grande, & Minaker, 1994). However, the studies suggest that the specificity and sensitivity of the MMSE were not sufficient for effective prediction of driving outcome measures (Lesikar, Gallo, Rebok, Keyl, 2002; MacGregor, Freeman, & Zhang, 2001; Margolis, Kerani, McGovern, Songer, Cauley, & Ensrud, 2002; Ott, Heindel, Whelihan, Caron, Piatt, & DiCarlo, 2003; Rinalducci, Mouloua, Smither, 2001; Szlyk, Myers, Zhang, Wetzel, Shapiro, 2002). One study found that those with scores indicating borderline cognitive impairment were more likely to have self-reported crashes than those with higher or lower MMSE scores (Marottoli, Cooney, Wagner, Doucette, & Tinetti, 1994). A clear limitation on the usefulness of this test is that the MMSE does not discriminate well in the higher part of the scale due to ceiling effects.

Expert Panels:

The MMSE tends to be used in retirement communities or doctors' offices, and is mostly used as a screening tool. Most panel members found this measure valuable in these contexts despite its limitations, but noted that the way the MMSE is administered can affect the results. Panelists indicated that scores of 24 and above are considered compatible with driving.

Clinical Dementia Rating

Literature Review:

The Clinical Dementia Rating (CDR) is a numeric scale used to quantify the severity of symptoms of dementia. The CDR score is based on a 90 minute interview with the examinee and a collateral source (e.g., a family member). This interview assesses the examinee's cognitive abilities in the areas of memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. CDR scores of 0, 0.5, 1, 2, and 3 represent no dementia, very mild, mild, moderate, and severe dementia, respectively.

The CDR has been widely used to assess the relationship between dementia severity and driving performance. On-road studies have shown significant correlations between CRD and driving performance (Duchek, Carr, Hunt, Roe, Xiong, Shah, et al., 2003; Hunt, Murphy, Carr, Duchek, Buckles, & Morris, 1997). There have also been significant correlations reported between CDR score and self-reported crashes and driver history records of citations (Ott, Heindel, Whelihan, Caron, Piatt, & DiCarlo, 2003; Johansson, Bronge, Lundberg, Persson, Seideman, & Viitanen, 1996).

Expert Panels:

This is not a screening test – it is specifically designed for people who have been diagnosed with dementia. The CDR requires expertise to score and interpret, so is appropriate only in a clinical setting. One panel member noted that it is often included in reports to DMVs for evaluation.

Clock Drawing

Literature Review:

The Clock Drawing Test (CDT) evaluates cognitive function including comprehension, memory, visuospatial abilities, abstract thinking, and executive function. It generally takes less than five minutes to administer. Administration and scoring criteria vary considerably. Most versions require examinees to draw a clock, write in the numbers, and set the time at 10 minutes after 11.

Studies examining the relationship between CDT scores and driving measures have produced mixed results. An on-road study found the CDT to significantly predict driving performance (McCarthy & Mann, 2006). A simulator study showed the CDT significantly predicted driving performance. Participants scoring fewer than 5 out of 7 points on the CDT made significantly more hazardous and general errors (Freund, Gravenstein, Ferris, Burke, & Shaheen, 2005). However, CDT score was not found to predict driving ability a study of driving ability as rated by a family member or caregiver (Ott, Heindel, Whelihan, Caron, Piatt, & DiCarlo, 2003).

Expert Panels:

The panel noted that the CDT can be administered quickly and has the potential to be useful in a variety of settings, although it needs to be standardized and validated as there are currently multiple administration and scoring methods.

Traffic Sign Recognition Test

Literature Review:

There are many variations of the Traffic Sign Recognition Test (TSRT). Some States have developed forms of the TSRT that include only signs used in the area in which the test is conducted. Generally, an examinee views a variety of traffic signs and identifies and explains the meaning of each. Scoring criteria vary across tests.

TSRT scores have been shown to predict driving scores (Kantor, Mauger, Richardson, & Unroe, 2004) and were found to be significantly related to recent crash involvement (MacGregor, Freeman, & Zhang, 2001; Stutts, Stewart, & Martell, 1998).

Expert Panels:

Panelists had mixed opinions on this measure; some members supported its use for both screening and assessment.

Stroke Driver Screening Assessment

Literature Review:

The Nordic Stroke Driver Screening Assessment (SDSA), an adaptation of the British Stroke Driver Screening Assessment, is a set of four simple cognitive tests to evaluate driving fitness in stroke patients.

To determine whether the SDSA was a suitable instrument for Scandinavian stroke patients, the tests were adapted and administered to a group of 97 stroke patients from Sweden and Norway. The four tests were: dot cancellation test, directions test, compass test, and the road sign recognition t`est. An on-road driving test served as criterion to evaluate the test's validity (Lundberg, Caneman, Samuelsson, Hakamies-Blomqvist, & Almkvist, 2003). A discriminate analysis using the scores of a subsample of 49 participants who had experienced strokes correctly classified 78% of the group as pass, borderline pass, or fail. There were significant differences in most screening battery scores between those who passed their first driving test and those who failed.

Expert Panels:

Panelists questioned whether this test should be restricted to stroke patients, or if it could be applied to the general population. They noted that strokes have three types of effects: motor, cognitive and visual; however, this test only measures cognitive performance.

Functional Rating Scale

Literature Reviews:

The Functional Rating Scale (FRS), a derivative of the Clinical Dementia Rating Scale, includes two additional domains: language and affect. The test measures functional impairment. Domains are rated from 1 (healthy) to 5 (severely impaired).

Tuokko, Tallman, Beattie, Cooper, and Weir (1995) studied two groups: one group met criteria for dementia and the other did not. Each group had a matched control group. The dementia sample had significantly more drivers with one or more crashes than did its matched control group The sample of participants with dementia sample had approximately 2.5 times the traffic crash rate of their matched control sample. However, the group comprised of participants without dementia had 2.2 times the traffic crash rate of their matched controls.

Expert Panels:

Panelists did not recommend using this measure to predict driving performance.

Driving Scenes Test of The Neuropsychological Assessment Battery

Literature Review:

The Driving Scenes Test (DST) of the Neuropsychological Assessment Battery (NAB) measures several aspects of visual attention. Examinees are shown color drawings of a road scene from the perspective of a driver. After 30 seconds, they are shown a similar picture and given up to 2 minutes to indicate everything that was new or missing; they score one point for each new or missing detail identified. The test takes 5 to 10 minutes and includes 6 scenes; scores range from 0 to 70.

A study examined the relationship between DST scores and on-road driving performance. Participants (one group with and one without very mild dementia) who had been rated as safe by a driving evaluator performed significantly better on the DST than did those who received poorer ratings (Brown, Stern, Cahn-Weiner, Rogers, Messer, Lannon, et al., 2005).

Expert Panels:

Panelists noted that, while the research indicated a relationship between scores and driving performance, the test is expensive and requires a psychologist to interpret the results, so is appropriate only in a clinical setting.

Center for Epidemiological Studies – Depression Scale

Literature Review:

The Center for Epidemiological Studies-Depression Scale is commonly used to screen for depression. It consists of 20 items measuring how an individual has felt and behaved over the past week. The score is the sum of the 20 item weights with a range of 0 to 60. A person with a score of 16 or more is considered depressed.

Sims and colleagues (2000) assessed mood, cognition, and alcoholism using this scale. , Subjects scoring in the depressed range were 2.5 times more likely to experience a vehicle crash in the following 5 years than were people with normal Geriatric Depression Scale scores.

Expert Panels:

Panelists indicated that this is not a clinical tool; it was originally developed for epidemiological studies (a score of 16 does not necessarily indicate depression, but rather a need to be referred for evaluation). The panel noted that this is not a cognitive measure and that depression may be amenable to treatment. Panelists considered that the measure could predict driving safety to the extent that depression affects driving.

CogStat

Literature Review:

CogStat is a composite measure of cognitive impairment obtained by assigning standard T-scores to each of eight tests from a neuropsychological assessment battery. The tests included auditory verbal learning test–recall, Benton visual retention test, complex figure test–copy, complex figure test–recall, judgment of line orientation, block design subtest, trail making test subtest B, and controlled oral word association.

Participants in a study of the relationship between CogStat scores and a driving task included 33 people with mild Alzheimer’s disease and 137 neurologically normal controls. Driving performance was measured using the Landmark and Traffic Sign Identification Task (LTIT). Participants were asked report traffic signs and restaurants (ubiquitous roadside landmarks) along a one mile commercial segment of a four lane divided highway. Dependent measures were the percentage of landmarks and traffic signs identified and the number of at-fault safety errors such as erratic steering, lane deviation, shoulder incursion, stopping or slowing in unsafe circumstances, and unsafe intersection behavior. CogStat measures correlated significantly with the outcome measures of the LTIT (Uc, Rizzo, Anderson, Shi, & Dawson, 2005).

Expert Panels:

This battery of eight tests is time-consuming, especially for people with mild dementia. Experts felt that the preliminary results were promising but that the test's length may make it impractical.

IV. Education and Training Programs

Traffic laws may have changed dramatically over the past several decades. Training programs update drivers' knowledge of rules of the road and provide strategies to deal with situations that have proven particularly risky for older drivers. Other programs aim to improve an older driver's ability to manage multiple driving tasks.

Classroom Only

Literature Review:

A number of classroom and in-home older driver education programs exist including AAA's Driver Improvement Courses for Seniors and AARP's *Driver Safety Course*. These programs generally consist of several hours of instruction on topics related to older driver safety, such as the effects of perceptual declines on driving, rules of the road, alcohol and medication use, driving in hazardous environments, and self-assessment.

Research has not indicated that participants of these programs exhibit significant improvement in driving performance or reduced crash rates, although there is evidence that those who took the course had fewer traffic citations (Bédard, Isherwood, Moore, Gibbons, & Lindstrom, 2004; Berube, 1995). A study of more than 800 older drivers who completed a classroom educational course showed an increase in crash risk among men 75 and older (Nasvadi & Vavrik, 2007).

Expert Panels:

Although this is the least costly older driver education method, panel members pointed out that some studies have shown no impact of these programs on safety outcomes, or an impact in the wrong direction.

Classroom Plus On-Road

Literature Review:

Some classroom programs have been augmented with behind-the-wheel instruction on strategic driving skills (e.g., vehicle controls/adjustments, use of seat belts), tactical driving skills (e.g., lane changes, intersection negotiation, merging), and operational driving skills (e.g., speed control, lane changes).

A study of this combination of classroom and on-road instruction found significant improvements in driving performance relative to controls as measured by an on-road assessment, as well as significant increases in knowledge relative to controls as measured by a written test (Marottoli, Van Ness, Araujo, Iannone, Acampora, Charpentier, et al., 2007).

Expert Panels:

Panel members felt that creative applications such as this example are needed and that this program has potential for success in the future.

One-On-One Education

Literature Review:

One-on-one educational programs include screening or assessment followed by feedback tailored to the driver's deficits. The "Knowledge Enhances Your Safety" (KEYS) curriculum developed at the University of Alabama is an example of one-on-one education. KEYS focuses on the impact of age related changes in vision on driving performance.

A randomized controlled study that included 365 older adult drivers found that KEYS participants were more likely to acknowledge declining eyesight and to report avoiding dangerous driving situations and regulating or restricting their driving (Owsley, Stalvey, & Phillips, 2003; Stalvey & Owsley, 2003). However, KEYS has not been shown to reduce crash risk of participants as compared to controls (Owsley, McGwin, Phillips, McNeal, & Stalvey, 2004).

Expert Panels:

This program was not intended for the general population, but was designed specifically for people with visual impairment and a history of crash involvement. Panelists noted that one-on-one educational programs are expensive, but can be appropriate for some drivers.

Simulator Training

Literature Review:

These programs use a driving simulator to train drivers on specific driving tasks or improve perceptual or cognitive functioning using simulated driving scenarios.

Roenker, Cissell, Ball, Wadley, and Edwards (2003) used a driving simulator to train older drivers on simple and choice reaction time measures. Simple reaction time was trained by having the subject brake as quickly as possible in response to simulated brake lights. Choice reaction time was measured by having the subjects react to simulated traffic signs. Based sign features, the subject braked, turned the steering wheel, or did nothing. As compared to a group of subjects who did not receive training, simulator-trained drivers improved driving performance as measured by an on-road evaluation on two driving measures: turning and signal use. These improvements had dissipated at an 18-month follow-up.

Expert Panels:

Panelists noted that simulator training may increase drivers' confidence, although can cause motion sickness, particularly in older drivers.

Physical Fitness

Literature Review:

Fitness training involves a multi-month program designed to improve flexibility, stamina, strength, coordination, and/or speed of movement. These programs can be led by professionals and tailored to the individual or conducted at home following a proscribed regimen.

The literature on fitness training is mixed. Drivers who participated in physical fitness programs targeting conditioning and flexibility failed to show significantly improved driving performance as measured by an on-road assessment, relative to control subjects who did not receive the training (Marottoli, Allore, Araujo, Iannone, Acampora, Gottschalk, et al., 2007). In another study, subjects who completed training performed better than control subjects on two of nine measures of driving performance (Ostrow, Shaffron, & McPherson, 1992).

Expert Panels:

Panel members considered these programs promising, but noted that there was little research to support them.

Cognitive Retraining

Literature Reviews:

Cognitive retraining involves improving examinees' cognitive functioning following injury or diagnosis of a medical condition.

While cognitive retraining has been shown to improve targeted cognitive function, little research has related improved cognitive functioning to driving performance or crash risk. Ball, Beard, Roenker, Miller, and Griggs (1988) reported that the size of useful field of view, a measure of visual attention that has been linked to elevated crash risk, can be improved through training. Roenker, Cissell, Ball, Wadley, and Edwards (2003) provided participants with approximately 4.5 hours of individualized, speed-of-processing training. When compared to subjects who did not receive this training, participants performed better on one of 13 composite driving measures on an on-road evaluation based on the raters' level of perceived danger at specific hazardous locations. A more recent study reported reduced crash involvement in drivers following UFOV training (Ball, Edwards, Ross, & McGwin, 2010). Another study (Mazer, Sofer, Korner-Bitensky, Gelinas, Hanley, & Wood-Dauphinee, 2003) provided useful field of view, divided attention, or selective attention training to stroke patients while a control group received traditional visuoperceptual retraining in the form of commercially available software (e.g., Tetris). When compared to the control group, on-road driving scores did not improve significantly for any of the types of training, except for useful field of view training in subjects with right-hemisphere lesions.

Expert Panel:

Panelists indicated that they needed more information about whether the retraining generalizes to other abilities, and specifically whether it generalizes to driving before they could determine its usefulness.

V. Motor Measures

As a driver ages, declines in strength, coordination and flexibility may make it difficult to fasten a seat belt, turn the head to do a blind spot check, or brake or turn sharply. These measures help to identify drivers potentially at risk due to limited motor skills.

A. RANGE OF MOTION

Foot Tap

Literature Review:

The Foot Tap Test, a part of the Gross Impairment Screening Battery (GRIMP), measures the number of seconds it takes a seated examinee to tap his or her foot left to right (either over an open notebook or between two circles on the ground) a set number of times.

In a prospective cohort study of nearly two thousand older adults, Ball, Roenker, Wadley, Edwards, Roth, McGwin, et al. (2006) found that Foot Tap Test scores predicted future crash involvement. Another study found no relationship between this measure and driving performance (Marottoli, Cooney, Wagner, Doucette, & Tinetti, 1994).

Expert Panels:

Panelists noted that both this test and rapid pace walk had similar odds ratios, both test for psychomotor slowness, and are easy to administer. Some panelists preferred the rapid pace walk because it requires less space and equipment. One panelist point out that the Foot Tap Test can be used for either foot. If a driver cannot complete the test with the right foot (“pedal foot”), a special left foot pedal can be installed into the person’s vehicle.

Neck Flexibility

Literature Review:

Neck flexibility is the extent to which a person can turn his or her head while keeping the torso facing forward. It can be measured by a graduated scale or by having a person read the time on a clock placed directly behind them.

Some studies found that drivers who wore restrictive neck braces performed more poorly on some on-road driving measures than did unrestricted controls (Barry, Smith, Lennarson, Jermeland, Darling, et. al., 2003). A driving simulator study found that older adults with limited neck movement exhibited delays in responding to stimuli at a T-intersection (Hunter-Zaworski, 1990). However, a retrospective analysis of more than 1000 older drivers reported no significant correlation between neck flexibility scores and crashes, citations, or police stops over the one-year study period (Ball, Roenker, Wadley, Edwards, Roth, McGwin, et al. (2006).

Expert Panels:

Panelists considered the test difficult to use as a screening tool, but some found it useful in an assessment setting. Some noted that people tend to turn their torsos to see the stimulus behind them. One remedy for the situation was to instruct subjects to use a mock seatbelt or grip the arms of their chair before turning (making it more difficult to rise up out of the seated position). The panelists noted that most drivers can accommodate for restricted flexibility.

Measure: Rapid Pace Walk

<u>Literature Review:</u>

The Rapid Pace Walk test measures the time in seconds an examinee takes to walk 10 feet, turn around, and walk back as quickly as (safely) possible.

In a prospective analysis of older drivers, time to complete the Rapid Pace Walk (>7 sec versus ≤ 7 sec) was strongly associated with crashes, citations, and police stops over the one-year study period. Those who took more than 7 seconds on this test had an increased relative crash risk of 2.0 (Marottoli, Cooney, Wagner, Doucette, & Tinetti, 1994). In another study, Rapid Pace Walk scores were significantly related to performance on a behind-the-wheel driving test (McCarthy & Mann, 2006). However, in a prospective cohort study of nearly 2,000 older drivers, Rapid Pace Walk scores did not predict future at-fault crash involvement (Ball, Roenker, Wadley, Edwards, Roth, McGwin, et al., 2006).

<u>Expert Panels:</u>

This test is similar to Foot Tap measure, but includes a balance component not present in the Foot Tap Test. Most panelists considered the Rapid Pace Walk to be a good screening tool.

B. REACTION TIME

Doron Cue Recognition

Literature Review:

The Doron Cue Recognition test is administered using a Doron Driving Analyzer, a low-fidelity driving simulator. A screen displays car icons. When one of the icons changes position on the screen, the examinee releases the simulator's throttle and presses the brake. The system records the time in milliseconds from the moment the icon starts moving to the release of the throttle and converts it to the distance in feet the simulated vehicle would have traveled if it were moving at 55 mph. Steering reaction time is measured by a similar method. The system can measure choice reaction time by instructing the subject select the more appropriate of two response options.

All three Doron Cue Recognition measures have been found to be significantly correlated with performance on a driving test in one study (Janke & Eberhard, 1998).

Expert Panels:

The panel members indicated that the relationship between choice reaction time and driving performance should be researched more extensively to document its usefulness in identifying risky drives.

C. UPPER/LOWER BODY MUSCLE STRENGTH

Manual Muscle Test

<u>Literature Review:</u>

The Manual Muscle Test assesses muscle strength and flexibility, particularly of the shoulders, hands, hips, and knees.

One study looking only at upper body strength found that upper body strength measures did not correlate with on-road driving performance (Kantor, Mauger, Richardson, & Unroe, 2004). Another study, testing both upper and lower body strength, did not find a significant relationship between muscle strength and performance on on-road driving performance (McCarthy & Mann, 2006). A prospective cohort study found that lower (but not upper) body strength was related to adverse outcomes including crashes, citations, and being stopped by police (Marottoli, Cooney, Wagner, Doucette, & Tinetti, 1994).

<u>Expert Panels:</u>

Therapists find this test useful in a rehabilitation setting to determine the appropriate type of medical adaptive equipment a driver needs. As pain is often related to poor muscle movement, this test may be an effective screening tool for non-therapists. They considered it appropriate in DMV use only as a second or third tier screen.

VI. Self-Screening Tools

Self-screening tools allow older adults to check their own driving skills and determine whether they need to address decrements or seek further evaluation. These tools, based on clinical measures, have been redesigned to allow people to test themselves.

Driving Decision Workbook

Literature Review:

The Driving Decisions Workbook is a 32-page self-screening tool. The workbook is a questionnaire that directs users to feedback based upon how they answer questions.

Among a convenience sample of 99 older adults, the workbook responses were correlated with on-road driving scores. Subjects reported the workbook was at least a little useful and most reported that the workbook made them more aware of changes that can affect driving. Some participants discovered a change in themselves of which they were previously unaware (Eby, Molnar, Shope, Vivoda, & Fordyce, 2003).

Expert Panels:

The panel suggested that self-screening tools could better be described as self-awareness or educational tools. These tools do what educational programs do – improve self-awareness and knowledge. Panelists were concerned that such instruments might make people feel overconfident and recommended research on the relationship between self-screening scores and crashes. One panelist uses this tool in a clinical setting and considers the results in developing clients' on-road evaluations. This test differs from other educational programs in promoting interaction among the driver and family members and/or physicians.

Safer Driving – The Enhanced Driving Decisions Workbook

Literature Review:

SAFER Driving: The Enhanced Driving Decisions Workbook (**S**elf-**A**wareness and **FE**edback for **R**esponsible **Driving**) is an interactive Web site that screens drivers based on their level of concern about their health. Users answer a series of questions and the site provides information about ways users' health concerns may affect their driving. Users receive individualized feedback from the site.

The tool was validated against the results of an assessment with a certified driving rehabilitation specialist that included an on-road driving assessment. Subjects' responses on the self-screening were positively correlated with scores for the on-road driving assessment. Subjects generally found the site useful in providing information about age-related changes that can affect driving; many indicated that the site reminded them of information they already knew. A number of participants discovered changes in themselves of which they were previously unaware (Eby, Molnar, Kartje, St. Louis, Parow, Vivoda, & Neumeyer, 2008).

Expert Panels:

While this tool is easy for drivers to access, panelists noted that generally the poorest drivers avoid educational/classroom situations, and that some drivers lack the insight into their functional limitations that is necessary to using the information appropriately. They considered the tool useful in that families can use it to start conversation about their older relatives' driving.

AAA Roadwise Review and Driving Health Inventory

Literature Review:

The AAA *Roadwise Review* is an interactive CD-ROM that includes a set of tests that the users complete with the help of a friend or family member. The results are summarized in terms of the level of apparent deficits (none, mild, or serious) on eight screening procedures. The software provides detailed feedback for each screening procedure.

Roadwise Review was developed based on the Driving Health Inventory (a clinical screening tool) which in turn was based upon the research findings from Model Driver Screening and Evaluation Program conducted in Maryland. This research tracked the at-fault crash history of more than 2,000 older adults who were screened at the Maryland MVA. All screening procedures used in *Roadwise Review* have been shown to be related to elevated at-fault crash risk for older adults (Staplin, Gish, & Wagner,2003). Significant correlations have been reported between an on-road evaluation and issues identified by the *Roadwise Review* (McCarthy & Mann, 2006; Staplin & Dinh-Zarr, 2006).

Expert Panels:

The panel members felt that this tool may be useful in alerting older drivers to potential problems. The tool was not intended to guide driving cessation decisions, but instead to inform drivers of functional health issues that could impact driving. Furthermore, the inventory could be repeated over time so that drivers could track any functional changes. The panel again noted that self-screening tools could be considered education tools.

The Older and Wiser Driver

Literature Review:

The *Older and Wiser Driver: A Self-Assessment Program* uses a self-screening tool based on the AAA Foundation for Traffic Safety's *Drivers 55 Plus: Check Your Own Performance* combined with an educational program. The program is not strictly self-screening, as the results are interpreted by a traffic safety professional.

McGee and Tuokko (2003) studied program effects in a convenience sample of 93 older adults. After completing the program, most participants reported being more aware of changes that can affect driving and the majority reported planning to change the way they drove.

Expert Panels:

Panelists noted that this tool was designed to make older drivers aware of the potential effects of age-related functional changes on driving safety.

VII. Vision

In order to drive safely, a person must respond appropriately to numerous objects including street signs, traffic lights, roadway markings and other vehicles, and to do so while moving and under a variety of light and weather conditions.

A. ACUITY-DYNAMIC

Structure From Motion

Literature Review:

Structure From Motion (SFM) is the ability to perceive a three-dimensional (3-D) shape from motion parallax information. SFM simulates animated 3-D objects from points on a computer screen. Thresholds for detecting SFM are usually determined by adding “noise” to the display (i.e., points of light that move independently of those that define the simulated object) and determining the signal-to-noise ratio where the viewer accurately identifies the object 75% of the time.

A study of on-road driving performance that included subjects with early-stage dementia as well as a control group found that SFM scores predicted at-fault safety errors during on-road driving (Uc, Rizzo, Anderson, Shi, & Dawson, 2005). Other work using a driving simulator and rear-end collision scenarios, found no relationship between SFM scores and rear-end crashes, abrupt slowing, or premature stopping (Uc, Rizzo, Anderson, Shi, & Dawson, 2006).

Expert Panels:

Panelists noted that SFM has been used primarily in specialty populations and that there was little evidence of its usefulness in the general population.

Moving “E”

Literature Review:

This test of dynamic visual acuity measures the ability to perceive details when there is relative motion between the person and stimuli. Computer generated moving stimuli are generally used to accurately measure motion thresholds.

McKnight and McKnight (1999) found a weak but significant correlation between scores on dynamic visual acuity and incidents of unsafe driving during an on-road driving assessment. In a different study that included measures of dynamic visual acuity, Janke and Hersch (1997) found that drivers who had been referred to a licensing agency for evaluation performed more poorly on dynamic visual acuity that did a control group.

Expert Panels:

Panel members pointed out that there is little variation in visual acuity among the driving population, so measures of acuity may not identify risky drivers. They indicated that there could be more variability in dynamic visual acuity, so it might prove a more useful measure.

B. ACUITY-STATIC

Multiple instruments

Literature Review:

Static visual acuity can be measured with a number of different charts that express visual acuity as the log minimum angle resolvable. Because most readers are familiar with acuity measured on a fractional scale (20/10-20/600), this scale is presented here. It is beyond the scope of this review to discuss the relative merits of each chart type, so all will be combined as they all measure the same sensory ability. Static acuity measures include the Snellen Chart, Bailey-Lovie, Early Treatment Diabetic Retinopathy Study Letter Chart, Sloan Letters, Lighthouse Distance Visual Acuity Charts, Rosenbaum Card, Ergovision Test System, AAA Vision Test, and Titmus Tester.

Some studies have found significant relationships between static visual acuity and crashes, landmark recognition, unsafe driving outcomes, and abrupt slowing (Sims, Owsley, Allman, Ball, & Smoot, 1998; Uc, Rizzo, Anderson, Shi, & Dawson, 2005; Uc, Rizzo, Anderson, Shi, & Dawson, 2006). However, overwhelmingly, studies find a poor relationship between acuity scores and driving outcomes measures when corrected vision is better than about 20/70 (Guerrier, Manivannan, & Nair, 1999; Marottoli, Cooney, Wagner, Doucette, & Tinetti, 1994; McCarthy & Mann, 2006; McCloskey, Koepsell, Wolf, & Buchner, 1994; Owsley, Stalvey, Wells, Sloane, & McGwin, 2001; Szlyk, Mahler, Seiple, Vajaranant, Blair, & Shahidi, 2004).

Expert Panels:

Panel members noted that, by the time people reached age 85, many have obtained a vision screening test from outside the DMV. Static acuity has been shown to be a poor predictor of driver performance, although it will likely remain as a DMV screening because it is easy to administer. Panel members emphasized that no matter how ambiguous the evidence, acuity should not be eliminated from DMV settings.

C. CONTRAST SENSITIVITY

Multiple instruments

Literature Review:

Contrast sensitivity can be measured with a number methods, all of which can ultimately be expressed as log minimum contrast sensitivity (0.5 – 2.0). It is beyond the scope of this review to discuss the relative merits of each chart type and method, so all will be combined under the assumption that they all measure the same sensory ability. Contrast sensitivity measures include the Pelli-Robson Contrast Sensitivity Chart, Berkeley Glare Tester, Smith-Settlewell Low-Luminance Card, Vector Vision CSV-1000 Chart, Vistech Vision Contrast Test System, Mentor Brightness Acuity Tester, and Difference in Letter Acuity Test (MCT-8000) Differentiating Stimuli in High/Low Contrast Images.

A number of studies have shown that contrast sensitivity scores are related to performance on driving measures. An analysis of more than 300 drivers found that drivers with a history of crash involvement were 8 times more likely to have a serious deficit in contrast sensitivity than those who were crash-free, even when the deficit was restricted to a single eye (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001). Other studies have shown that contrast sensitivity scores were significantly correlated with overall driving performance measured in an on-road driving evaluation, self-reported crashes and violations, and driving errors in a driving simulator (Bowers, Peli, Elgin, McGwin, & Owsley, 2005; Ivers, Mitchell, & Cumming, 1999; McKnight & McKnight, 1999; Uc, Rizzo, Anderson, Shi, & Dawson, 2005; Wood, 2002). Contrast sensitivity has been found useful in flagging potentially risky drivers (Janke & Eberhard, 1998), although a number of studies have failed to find a relationship between contrast sensitivity scores and crash history (Margolis, Kerani, McGovern, Songer, Cauley, & Ensrud, 2002) or other driving measures (Hennessy, 1995; Owsley, Ball, Sloane, Roenker, & Bruni, 1991; Szlyk, Mahler, Seiple, Vajaranant, Blair, & Shahidi, 2004).

Expert Panels:

Panelists mentioned that California used contrast sensitivity with the first tier of their three-tier program, and considered it potentially useful in DMV settings.

D. VISUAL FIELD

Multiple instruments

Literature Review:

The visual field is the range across which a person can see without moving the eyes and is usually measured by having a person fixate gaze on a point and indicate when stimuli presented at various locations become visible. Performance is measured in terms of the number of degrees from a central point (0 degrees) where the viewer perceives stimuli. Loss of vision in the central visual field may result from macular degeneration or other ophthalmologic diseases. Visual field measures include the Friedman Visual Field Analyser MK2, Visual Field Test, Humphrey Field Analyzer, Goldmann Perimeter, Horizontal Visual Field Test using Mini-Lamps Set at Horizontal Peripherals of Different Degrees, Cognitive Behavioral Drivers' Inventory, Dynavision Performance Assessment Battery, Multiple Compentency Assessment for Driving, and Binocular Field Map Testing By Arditi Method

There is conflicting evidence regarding the relationship between central visual field loss and driving performance. A series of studies found that drivers with central field loss self-reported more crashes, had more crashes in simulated driving, and performed more poorly on some driving simulator tasks (Coeckelbergh, Brouwer, Cornelissen, van Woffelaar, & Kooilman, 2002; Szlyk, Mahler, Seiple, Vajaranant, Blair, & Shahidi, 2004; Szlyk, Seiple, & Viana, 1995). Whereas other studies found little or no significant relationship between visual field and self-reported crashes, State-reported accidents and citations, and performance during an on-road driving evaluation (Lamble, Summala, & Hyvärinen, 2002; Schanke & Sundet, 2000; Ivers, Mitchell, & Cumming, 1999; Owsley, Ball, Sloane, Roenker, & Bruni, 1991). Johnson and Keltner (1983) found elevated crash and conviction rates among participants with binocular visual field loss; those with monocular loss had rates similar to those of control participants. When combined in analysis with acuity and contrast sensitivity, visual field tests were found to be significantly related to crash involvement (Decina & Staplin, 1993).

Peripheral visual field loss, either through disease or artificially induced, has been shown to be related to poorer performance on simulated driving, particularly maintaining proper lane position. Drivers with greater visual field restrictions showed significantly poorer speed matching when changing lanes, maintaining proper lane position, and maintaining proper vehicle position on curves during an on-road driving evaluation (Bowers, Peli, Elgin, McGwin, & Owsley, 2005).

Expert Panels:

Vision researchers on the panel asserted that crash risk is elevated only among those with severe vision limitations; unfortunately, "severe" has not been defined. Some panelists indicated that drivers who can't compensate for visual field problems generally also exhibit some cognitive decline. They argued that drivers with substantial visual field restrictions should be referred for an in-depth driving evaluation to determine the extent to which they compensate for their field loss. They noted that Maryland used the OPTEC field test, which measures only the boundaries of the visual field, as a screening tool. The panel deemed this test appropriate as a screening tool, but noted the need for standardized testing, and cut points at which drivers are referred for further evaluation.

E. VISUAL ATTENTION

Useful Field of View Test

Literature Review:

The Useful Field of View test (UFOV) assesses the ability to respond to rapidly presented visual stimuli. This test relies on perceptual and cognitive abilities, including selective and divided attention.

Research has related UFOV scores and various measures of diving performance. Drivers with UFOV decrements generally performed more poorly on on-road driving tests, had a history of at-fault crashes, and were more likely to be in future at-fault crashes (Bowers, Peli, Elgin, McGwin, & Owsley, 2005; Goode, Ball, Sloane, Roenker, Roth, Myers, et al., 1998; Owsley, Ball, Sloane, Roenker, & Bruni, 1991; Sims, Owsley, Allman, Ball, & Smoot, 1998; Uc, Rizzo, Anderson, Shi, & Dawson, 2005; Whelihan, DiCarlo, & Paul, 2005). A prospective cohort study with a large sample of drivers found that drivers who performed poorly on the divided attention component were more than twice as likely as other drivers to be in an at-fault crash in the following four to five years (Ball, Roenker, Wadley, Edwards, Roth, McGwin, et al., 2006). Work by other researchers using driving simulators has shown that UFOV decrements were related to poor performance in a simulated driving task (Uc, Rizzo, Anderson, Shi, & Dawson, 2006).

Expert Panels:

One panel member had used UFOV for clinical screening, and another used UFOV for screening within DMVs. Panelists noted that it is not yet clear which specific characteristics of UFOV screening are appropriate for a DMV setting. Occupational therapists use UFOV as part of a larger assessment battery. Panelists stressed that, while poor scores on this test indicate drivers likely to be unsafe, a good score does not necessarily indicate a safe driver.

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APPENDIX A – Expert Panel Members

In Person Expert Panel Members

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(Moderator)

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Wendy Stav
Towson University

George Stelmach
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Jane Stutts
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APPENDIX B – Excluded Measures

Excluded Cognitive Measures

- Hooper Visual Organization Test
- Benton Judgment of Line Orientation
- Wisconsin Card Sorting Test
- Visual Form Discrimination Test
- Temporal Orientation
- Visual Search Test
- Test of Visual Imagery (East-West Test)
- Standardized Road Map Test of Directional Sense
- Rod and Frame Test
- Picture Completion
- Copy-A-Cross Test
- Controlled Oral Word Association Test
- Zoo Map Subtest of the Behavioral Assessment of the Dysexecutive Syndrome Test
- The Stroop Neuropsychological Screening Test
- Action Fluency
- Rey Auditory Verbal Learning Test
- Raven's Progressive Matrices
- Simultaneous Capacity Test
- Zimmermann/Fimm's Incompatibility Test
- Finger Tapping
- Brief Test of Attention (test of auditory selective attention)
- Eye Movement Recording
- Adaptation of Mackworth clock
- Wechsler Memory Scale – Visual Reproduction
- Wechsler Adult Intelligence Scales (arithmetic test)
- Wechsler Memory Scale - Memory Quotient
- Wechsler Adult Intelligence Scale - Digit Symbol
- Wechsler Adult Intelligence Scale - Digit Span
- Wechsler Adult Intelligence Scale - Similarities
- Logical Memory
- Sternberg Test
- Word Recall Memory Test
- Cued and Delayed Recall
- Recalling Information Immediately After Presentation (digit matching, figure matching), Recalling Information After Intervening Tasks
- Series of Additions Task

- Brief Visual Memory Test
- Mattis Organic Mental Syndrome Screening Examination
- Reading Test
- Impulsiveness, Venturesomeness, Empathy (IVE) Questionnaire
- Cognitive Processing battery (Color Word Test, Listening Span test, Paced Auditory Serial Addition test, K Test)
- Number connection task
- Number Comparison Test
- Category Fluency Test
- Brief Symptom Inventory
- Abstraction, Writing, Comprehension, Information Tests
- Short portable mental status questionnaire
- Selective Reminding Test
- Doron Driving Simulator system
- SAFE DRIVE, Ottawa Driving and Dementia Toolkit, CanDRIVE
- Aphasia Battery

Excluded Motor Measures

- Grooved Pegboard Test
- Functional Reach
- Symbol Digit Modalities Test
- Hand Signature
- Three Chair Stands
- Usual-Pace Walk
- Arm Reach
- Simple Reaction Time test
- Perception-Motor Reaction Time Test
- Performance-Oriented Mobility Assessment
- Battery of Physical Performance Items
- Timed 15-Foot Walk
- Dynamometer
- Grip-Strength

Excluded Motor Measures Vision/Hearing

- Color Vision/Discrimination
- Stereo-Acuity
- Hearing Sensitivity

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