INTRODUCTION

Preserved motor, perceptual, and cognitive functions are necessary for driving competence. Impairment in such areas affects the ability to drive and may cause accidents and fatal crashes. The risk of motor vehicle crashes for individuals with cognitive decline was first reported in 1967. Dementia is a well recognized risk factor for unsafe driving, although some early-demented individuals retain driving capacity during the initial stages of disease. In general, subjects with dementia are poorer drivers than cognitively normal people, and increasing attention has been given to driving capacity and cognitive impairment. Crash risk is proportional to the severity of dementia. The problem, however, consists in estimating fitness to drive in persons with mild dementia. Physicians are constantly faced by situations in which they are asked to decide on whether the elderly should give up driving. This is a key issue in clinical practice with the elderly, since it affects the freedom to circulate and also some aspects of self-esteem of people who have always been independent.

A growing body of literature supports the utility of neuropsychological assessment to predict driving competence of elderly with early-stage cognitive decline. Neuropsychological testing provides a useful instrument for diagnosis and prognosis in geriatric assessment. Because of the increasing number of elderly at risk for driving impairment, the consensus on objective tests for driving assessment is critical. Relevance of neuropsychological measures in the evaluation of fitness to drive has not yet been established, nor is a ‘Test Stand Battery’ predictive of safe driving capacity available. Also, there is no consensus by investigators and professionals on whether old people with mild dementia should be prohibited to drive. The aim of this study is to review the evidence of specific neuropsychological measures that may be useful to predict driving competence of demented individuals.

METHOD

To address neuropsychological tests used for dementia and the ability to drive, the authors searched for the keywords dementia, Alzheimer’s, drive, driver, drivers, driving, tests, neuropsychological, and assessment, in Medline, PubMed, ISI and SciELO databases seeking articles from 2000 to 2008. From 131 articles, 27 met the inclusion criteria. Porteus Maze, Clock drawing, Trail B, UFOV and NAB Tests were found to be the most relevant neuropsychological measures for the evaluation of fitness to drive.

CONCLUSION

Porteus Maze, Clock Drawing, Trail B, UFOV and NAB tests highlight visuospatial attention demands and/or executive function. Those and other visuospatial and executive measures may be useful to predict driving competence of demented individuals.

Medline, SciELO, PubMed and ISI databases for articles from 2000 to 2008. Keywords used in combination were (neuropsychological and drive), (tests and driving), (driving and dementia), (driver and dementia), (Alzheimer and driver), (neuropsychological and driving), (assessment and driver), (driving and Alzheimer), (drive and dementia) and (dementia and drivers). Studies published in peer-reviewed journals that correlated driving performance with neuropsychological tests in demented drivers were included in this review. Studies with subjects aged 60 years or more presenting questionable dementia and/ or well defined cognitive loss were also included. Reports were excluded if they did not emphasize dementia with neuropsychological measures and ability to drive, if criteria of dementia were not described. Case studies, letters, comments, case reports and unpublished studies were not included.

**Results**

Search of literature yielded 27 studies that met criteria for inclusion out of 131 articles (26 studies were not about dementia; 49 studies did not emphasize neuropsychological measures; 22 articles were neither on dementia nor on neuropsychological measures; 3 studies were letters and 4 articles were not on driving competence). Studies disclosed conflicting results on cognitive factors and tests related to driving impairment among aged drivers with early dementia. Papers from 2000 to 2008, excluding review articles, are shown in table 1. A number of prospective and review studies have examined scores on the MMSE in relation to driving competence. Literature has yielded variable results. Some papers showed correlation between MMSE and driving competence, while other results showed MMSE scores that did not reflect ability to drive.

Specific tests with visuospatial and executive/attention tests demands demonstrate correlation with driving competence. Porteus Maze appears as a predictor of driving ability. Ott et al. evaluated the ability to drive in subjects with possible dementia and mild dementia with standard neuropsychological tests: Porteus Maze, Controlled Oral Word Association, Clock Drawing, and Trail Making Test (TMT) - Part B. Results showed that Porteus Maze performance and Trail B time were correlated with driving scores, but Porteus Maze was the only significant test to evaluate driving capacity. However, performance on the TMT has been significantly associated with ability to drive, especially Trail B, which evaluates executive function. In particular, Frankston et al. studied 29 individuals (13 with mild dementia) comparing TMT and a variant of it, the Color Trails Test (CTT). Results showed that both tools are useful and provide similar information regarding road test outcome. A study by Brown et al. showed the correlation between road test performance and scores on Driving Scenes Test of the new Neuropsychological Assessment Battery (NAB). Participants included 31 individuals with diagnosis of very mild dementia and 24 healthy elderly. NAB tests appeared to have ecological validity for on-road driving ability in very mildly demented individuals. Whellihan et al. found a strong relationship between visual attention and executive tests and on-road test performance, but not with other neuropsychological measures. They examined 46 older persons with mild cognitive decline using several measures, including general (e.g. MMSE), visuospatial (e.g. Visual Form Discrimination Test), executive/attention (e.g. Useful Field of View, TMT and Porteus Maze), language (e.g. Generative Naming), and learning/memory measures (Brief Visual Memory Test). Results showed consistent correlation between road test performance and executive and visual attention demands. Other studies found a strong correlation between UFOV and ability to drive. Correlation between Clock Drawing Test and fitness to drive was demonstrated in some studies and they all mentioned the Clock Drawing as an efficient instrument. Grace et al. compared driving performance in Alzheimer’s and Parkinson’s patients using Rey-Osterrieth Complex Figure (ROCF), Trail B, Hopkins Verbal List Learning Test (HVLT) and specific motor symptoms. According to the authors, a major finding of this study was that driving impairment for both patient groups was related to performance on ROCF and Trail B measures, which are involved with executive and visuospatial functions. However, ROCF may not predict ability to drive.

Some reviews investigated the role of neuropsychological measures and driving ability in mildly demented drivers. They evaluated studies over the last 30 years, alerting about inconsistent results involving neuropsychological measures and driving competence. However, there is evidence that performance of executive and visual attention tasks was related to on-road tests of driving capacity.

The British Psychological Society has stated, “no one test, or sets of tests, can as yet be recommended for off-road assessment” and the American Academy of Neurology (AAN) recommends that elderly with possible Alzheimer’s disease, who have a total CDR score of 0.5 must be submitted to a driving evaluation.

**Discussion**

The purpose of this review was to examine the effectiveness of neuropsychological evaluations to test driving competence. The period studied comprised the eight years of this decade. We decided to review only the most recent studies and describe some that showed direct correlation between specific neuropsychological measures and ability to drive of demented elderly, since there were already a number of systematic reviews of previous studies on the issue.

Studies investigating the relationship between driving and neuropsychological tests among the elderly and mildly demented populations have yielded contradictory results. The Mini-Mental State Examination (MMSE) is one of the most frequently administered cognitive screening tools to investigate impairment of elderly and their ability to drive. In general, most articles agree that MMSE may fail to predict competence to drive in elderly with early cognitive decline, probably because MMSE focuses mainly on orientation, language, and memory omitting the other domains of cognitive functioning important for driving competence. As such the, MMSE did not predict future crashes or traffic violations.

Visual attention/ perception and executive demands are related to driving impairment. Porteus Maze is a brief, nonverbal test that yields information to assess the ability to plan and change problem solving approaches, and appears to be a predictor of driving ability. NAB tests incorporate several aspects of visual attention including working memory,
### Table 1 - Studies of Neuropsychological tests and drivers with Dementia (2000 - 2008)

<table>
<thead>
<tr>
<th>Study</th>
<th>Diagnoses</th>
<th>N</th>
<th>Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frankston et al., 2007</td>
<td>mild dementia/ CVD/ encephalopathy/ PD/ syncope/ head injury</td>
<td>29</td>
<td>Trail A and B, MMSE, CTT1 and 2</td>
<td>Trail A: U = 53.00, p &lt; 0.05; CTT-1: U = 59.00, p &lt; 0.05; Trail B: U = 77.00, p = 0.07; CTT-2: U = 56.00, p = 0.06; MMSE: U = 44.00, p &lt; 0.05</td>
</tr>
<tr>
<td>Ott et al., 2006</td>
<td>probable; possible DA/ Controls</td>
<td>133</td>
<td>NTB</td>
<td>Highest correlations: Trail A (r = .50 p &lt; .0005); Trail B (r = .48, p &lt; .0005); HVLT1 (r = -.47, p &lt; .0005) for the entire sample</td>
</tr>
<tr>
<td>Grace et al., 2005</td>
<td>mild AD/ PD/ controls</td>
<td>63</td>
<td>ROCF, Trail B, NAB, HVLT, Trail A, MNT, Finger tapping</td>
<td>Identifying AD at-risk drivers: Trail B, ROCF presence and HVLT - discrimination (p &lt; .01); Trail A, HVLT learning or delay; NAB, Mazes and Finger tapping (p &lt; .001)</td>
</tr>
<tr>
<td>Whelihan et al., 2004</td>
<td>questionable dementia/ Controls</td>
<td>46</td>
<td>MMSE, DRS, BSI, UFOV, AMNART, WCST, Action Fluency, Trail A and B, Ruff Figural Fluency, MNT, Generative Naming, BVMT-R, Letter Cancellation Test, BVMT - Copy, VFDT</td>
<td>Highest correlations: Maze Navigation Time (r = .52, p &lt; .01) and UFOV-I (r = .61, p &lt; .01) Maze Navigation time entered the analysis with a classification accuracy of 80% (Wilks lambda = 0.69, chi-square = 11.6, p &lt; .001)</td>
</tr>
<tr>
<td>Rizzo et al., 2004</td>
<td>probable AD/ controls</td>
<td>170</td>
<td>LTIT, NTB</td>
<td>Trail B (p &lt; 0.0001); AVLT r (p &lt; 0.0001); UFOV (p &lt; 0.0001); CS (p &lt; 0.0007); JLO (p = 0.0379) as predictors of LTIT</td>
</tr>
<tr>
<td>Brown et al., 2004</td>
<td>very mild dementia/ Controls</td>
<td>55</td>
<td>NAB, Road Test</td>
<td>Correlation between NAB and Road Test: (r(55) = -.55, p &lt; .01)</td>
</tr>
<tr>
<td>Ott et al., 2003</td>
<td>very mild dementia/ mild dementia/ controls questionable dementia</td>
<td>67</td>
<td>Porteus Maze errors, Porteus Maze time, Clock Drawing, Trail B, COWA</td>
<td>Porteus Maze drawing time emerged accounting 41% of the variance in ratings</td>
</tr>
<tr>
<td>Schanke et al., 2000</td>
<td>dementia/ brain damage</td>
<td>55</td>
<td>NTB</td>
<td>Trail B, SDMT and Block Design (p &lt; 0.001); Trail A (p = 0.002); Stroop Test (p = 0.382); Digit Span (p = 0.429)</td>
</tr>
</tbody>
</table>

AD = Alzheimers Disease; CVD = Cerebrovascular Disease; PD = Parkinsons Disease; CTT = Color Trails Test; MMSE = Mini Mental State Exam; ROCF = Rey-Osterrieth Complex Figure; DRS = Dementia Rating Scale; HVLT = Hopkins Verbal List Learning Test; NAB = Neuropsychological Assessment Battery; BSI = Brief Symptom Inventory; UFOV = Useful Field of View; AMNART = American version of the National Adult Reading Test; WCST = Wisconsin Card Sorting Test; BVMT-R = Brief Visual Memory Test - Revised; VFDT = Visual Form Discrimination Test; Maze Navigation Test = MNT; NTB = Neuropsychological Test Battery; LTIT = Landmark and traffic sign identification; DC = driving competence; COWA = Controlled Oral Word Association; CI = Confidence Interval; JLO = Judgment of Line Orientation; CS = Contrast Sensitivity; SDMT = Serial Digit Modalities Test.

visual scanning, selective attention and attention to detail. Correlation was found between road-test performance and scores on Driving Scenes Test of the new NAB. UFOV, an executive/attention test covers the ability to focus and the speed of visual attention. Some studies found a strong correlation between UFOV and ability to drive. In particular, UFOV is a now commercially available resource that seems to be promising as a predictor of driving ability. The American Medical Association’s (AMA) document, *Physician’s Guide to Assessing and Counseling Older Drivers* recommends the Clock Drawing Test and Trail Making Test-Part B as tools for the evaluation of drivers, rather than exclusively for the evaluation of dementia severity. The validity of the Clock Drawing Test was demonstrated in some studies. However, a recent systematic review disclosed that this is not sufficiently justified, although all Clock Drawing Test scoring methods appear as an efficient instrument to evaluate fitness to drive.

Our review found that no single test is sensitive enough to predict ability to drive. Performance of tests on visuospatial demands may identify fitness to drive in early dementia. Tasks that assess executive processing, particularly those that also have visuomotor demands may be useful to identify at-risk drivers with early dementia. Other cognitive measures, including...
memory scores, did not adequately predict driving performance in demented persons.

Porteus Maze, Clock Drawing, Trail B, UFOV and NAB tests correlate significantly with on-road driving performance. In contrast, MMSE is a rather limited instrument to estimate driving competence. MMSE scores do not include perception, and motor evaluations which are domains of cognitive functioning important for driving competence. Tasks that assess visuospatial attention and executive demands such as computer-administered tests should be the focus of future simulator studies. Such assessments may have good ecological validity to evaluate driving performance.

Our study includes a small number of articles, which may have limited our findings.

**Conclusion**

Driving competence is a key feature in daily clinical practice with elderly patients, regardless of the physician’s specialization. Usually, the physician has to decide whether the patient is still able to drive and is also asked by the family which measures should be taken in this regard. Among other results, this review shows that the MMSE score is not reliable for making this decision, and that specific visuospatial and executive tests should be performed.

**Conflict of interest:** none

**Resumo**

**Testes neuropsicológicos e direção na demência: uma revisão da literatura recente**

**Introdução.** Testes neuropsicológicos aferem diversos aspectos de cognição e são úteis para avaliar motoristas idosos que apresentam déficits cognitivos. Entretanto, ainda não existe consenso sobre uma bateria de testes capaz de apurar com eficiência os riscos de dirigir. Objetivo. O objetivo deste estudo foi revisar medidas neuropsicológicas específicas, capazes de prognosticar competência para dirigir em indivíduos com demência.

**Métodos.** Para identificar testes neuropsicológicos que predizem habilidade para dirigir, os autores intersecaram as palavras-chave: demência, Alzheimer, dirigir, condutor, conduções, direção, testes, neuropsicológicos e avaliação nas bases Medline, Pubmed, ISI e Scielo, buscando artigos entre os anos 2000 e 2008.


**Referências**


