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The Maze Test: A significant predictor of older driver crash risk

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ABSTRACT

A study sponsored by the National Highway Traffic Safety Administration performed functional assessments on approximately 700 drivers age 70 and older who presented for license renewal in urban, suburban, and rural offices of the Maryland Motor Vehicle Administration. This volunteer sample received a small compensation for study participation, with an assurance that their license status would not be affected by the results. A comparison with all older drivers who visited the same sites on the same days indicated that the study sample was representative of Maryland older drivers with respect to age and prior driving safety indices. Relationships between drivers' scores on a computer touchscreen version of the Maze Test and prospective crash and serious moving violation experience were analyzed. Results identified specific mazes as highly significant predictors of future safety risk for older drivers, with a particular focus on non-intersection crashes. Study findings indicate that performance on Maze Tests was predictive of prospective crashes and may be useful, as a complement to other, established cognitive screening tools, in identifying at-risk older drivers.

1. Introduction

Motor vehicle crash statistics show that, relative to their miles driven, older persons are at greater risk of fatal crash involvement than any group except newly licensed, teenage drivers; in part, this reflects their increasing frailty, such that crashes of comparable severity result in more bodily harm for an older than a younger person (IIHS, 2008). These data also appear to reflect age-related declines in the visual, cognitive, and physical abilities needed to safely operate a motor vehicle in everyday traffic conditions (Staplin et al., 2003), spurring research into which domains of functional ability significantly predict crash involvement by older drivers, and how best to measure them.

Perhaps the most urgent research need in this regard is to identify reliable measures for detecting drivers at elevated crash risk due to mild cognitive impairment (MCI) or to early stages of dementia. Our population is rapidly aging, and it has been estimated that 13% of persons over 65 and 45% of persons over 85 will be affected by Alzheimer's Disease (Alzheimer's Association, 2011). As reviewed by Carr and Ott (2010), crash studies indicate that drivers with a dementia have at least a 2-fold greater risk of crashes than cognitively intact older adults; but it should be noted that evidence (cf. Fitten et al., 1995) suggests that it is the *degree of cognitive impairment* rather than *type of dementia* (diagnosis) that is the more important determinant of risk. Accordingly, a standardized measurement technique with strong sensitivity to tap those most pertinent cognitive abilities and establish a performance threshold or cutpoint that significantly predicts older driver crash involvement would clearly be of value in diverse clinical and, potentially, regulatory settings.

It is not just the degree but the type of cognitive impairment that predicts driving difficulties. Reger et al. (2004) performed a meta-analysis of neurological tests and driving that highlighted the importance of measuring visuospatial skills, compared to other cognitive domains (e.g., memory), to discriminate differences in on-road tests of driving ability in persons with dementia. A prominent example of such tests that also draws upon the 'executive functions' of planning and foresight (Snellgrove, 2005) as well as judgment and visual attention (Ott et al., 2008) is the Maze Test.

Within this (visuospatial) domain, the Maze Test also stands out with respect to consistency of test administration methods and scoring protocols, in contrast to such alternatives as the Clock Drawing Test for which at least half a dozen different scoring criteria are documented in the literature (Lam et al., 1998; Mendez et al., 1992; Shua-Haim et al., 1996; Shulman, 2000; Sunderland et al., 1989; Wolf-Klein et al., 1989). In addition, the Clock Drawing Test has been shown to be relatively poor at detecting milder cognitive impairment in older community-dwelling adults (Nishiwaki et al., 2004) while the Maze Test appears to effectively discriminate between persons with mild dementia[1] and healthy controls

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[1] Clinical Dementia Rating (CDR) scale score of 0.5 or 1.0.

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(Ott et al., 2008). It could be asserted that the Clock Drawing Test and the Maze Test likely overlap to some degree in the constructs they are tapping; and, researchers have demonstrated significant correlations between impaired clock drawing performance and performance on a low-fidelity driving simulator (Freund et al., 2005) and on an on-road driving test (Oswanski et al., 2007). The Maze Test remains the tool of choice for the application examined in this research, however.

The research carried out by Snellgrove (2005) was based on the Porteus Maze Test, a timed paper-and-pencil procedure. Performance, measured in terms of time (seconds) to successfully draw a line from the beginning to the end point of the maze, and total number of errors (entering a dead-end alley or failing to stay within the lines) discriminated with high accuracy (77.8% sensitivity and 82.4% specificity) between participants who failed an on-road driving test and those who passed it. Participants included 115 community-dwelling older drivers age 65 and older (mean age 76.9 years) with either mild cognitive impairment (MCI) or probable (early) dementia. The author cited anticipatory and defensive driving skills in explaining the predictive validity of the Maze Test as demonstrated in this research.

Ott et al. (2003) found that Porteus Mazes were the only significant predictor among a battery of standard neuropsychological tests of caregivers' ratings of driving ability for an older sample with questionable to mild dementia. Next, Ott et al. (2008) examined the ability of Maze Tests (five separate mazes) to predict road test performance for 121 drivers ages 40–90, including a 'possible' Alzheimer's Disease (AD) group, a 'probable' AD group, and healthy controls. Subjects completed an on-road drive test based on the Washington University Road Test (WURT), with a driving instructor blind to the subject's diagnosis. In both studies, Ott and his colleagues used an innovation: computerized mazes. Subjects drew lines on a touchscreen instead of using the paper-and-pencil method. For all groups, based on a logistic regression model that classified road test performance as safe versus marginal versus unsafe, total maze completion time accounted for 15% of the variance with a correct classification rate of 68.6%. Considering only the mildly cognitively impaired sample (CDR = 0.5) and the controls, total maze completion time accounted for 23% of the variance, with a correct classification rate of 76.5%.

Finally, Carr et al. (2011), in collaboration with Snellgrove, Ott and others, found that the Snellgrove Maze Test was a significant predictor of passing or failing the modified WURT, in a sample of 99 older people with dementia (63% male, mean age 74.2) referred by community physicians to an occupational therapy driving clinic. Measures of visual and motor functioning were not associated with road test failure.

This article describes an investigation that advances our understanding of the validity of the Maze Test for predicting older driver crash risk. Researchers used the same stimuli employed by Ott et al. (2008) in a standardized, computer-based test protocol to assess a much larger sample of drivers, age 70 and over, who were representative of the general older driver population in their State in terms of recent driving history. Most importantly, prospective crash experience—rather than a driving performance measure serving as a safety surrogate—was the dependent variable in this study. The central research hypothesis was that drivers who required longer times to complete mazes (by tracing a continuous path from the start to the end), or who committed more errors during maze drawing (evidenced as 'dead ends' where a subject was required to discontinue the path s/he was following through the maze and shift to another path), would demonstrate a significantly higher risk of crash involvement and/or of citation for the most hazardous types of moving violations in an 18-month observation period keyed to each participant's assessment date.

2. Research method

Our research team recruited 692 drivers for this study from persons who visited one of four Maryland Motor Vehicle Administration (MVA) field offices to conduct business (license renewal, title transfer, etc.) between September 2008 and June 2009. All persons age 70 or older with a valid Maryland driver's license were eligible to participate. The study sites included one large city (Baltimore), one small city (Annapolis), one suburban location (Loch Raven/Parkville), and one rural location (Easton). Recruitment and assessment activities were discontinued at the Annapolis MVA office in November 2008, due to volumes that were much lower than anticipated; the other three sites remained active for the duration of data collection.

Initial contact to recruit study participants took place in one of two ways: a counter staff member at the MVA told potential participants about the study and provided a research flyer; or, the MVA mailed a letter to older drivers in the geographical catchment area of each field office whose license renewal date was approaching in the next month, advising them of this research opportunity. Both methods directed interested persons to project research assistants (RAs) on-site at each MVA office for more information. These RAs were trained by the lead author to administer the data collection protocol, then practiced in pairs under his supervision, prior to their interactions with older drivers.

The RAs enrolled potential subjects who received information about the research opportunity and indicated an interest in participating. Recruitment procedures, including informed consent procedures, were carried out according to protocols approved by the Institutional Review Board at Chesapeake Research Review. Those seeking more information were informed that this was a federally sponsored research study in which (a) all data are reported at the "group" level and no individuals would be identified, and (b) study participation would "not affect your driver's license in any way." They received a description of the research project, including the IRB-approved consent form, and learned that compensation (in the form of a $25 gift card for use at local convenience stores) was offered for their participation. Those who assented to participate in the research were guided to a nearby, private office, where the RA completed computer-based functional assessments, including the Maze Test, using a Windows® 2000 PC with a capacitance-based touchscreen display (Synaps Model S15TSM 15-in. LCD TFT, 1024×768).

The maze navigation test, described as a "route planning task" to subjects, replicated the stimuli used by Ott et al. (2008). Subjects traced a path, using their fingers or a stylus, through each of 5 mazes presented one after another on the touchscreen (see Fig. 1).

Subjects received the following instructions:

> *You will see five pages. Each contains a maze. Trace a path through each maze from the left side to the right side as quickly as possible.*
>
> *If you make a mistake, you can backtrack along the path you have traced, until you reach the point where you wish to head in a new direction.*
>
> *When you complete each maze, a new one will appear. Your score on this test will be the time to complete all five mazes.*

If a subject lifted his/her hand/finger from the screen while drawing a path through a maze, the line remained in place, and the subject then continued forward on the same path (or backtracked if s/he determined the path to be incorrect) when re-engaging the maze at the point s/he left off. At an RA's discretion, s/he could prompt a subject to "*Please continue drawing from where you stopped*."