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Errors versus speed on the trail making test: Relevance to driving performance

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ABSTRACT

Background/Objectives: Many studies have demonstrated that speed to complete items on the Trail Making Tests (TMT A and TMT B) is useful in the prediction of driving safety. However, there is no consensus regarding optimal "cut scores" to discriminate between safe and unsafe drivers. In this study, we examine TMT speed and errors in drivers referred for a road test.
Design: Retrospective analysis.
Setting: Patients referred for a DriveWise® evaluation at Beth Israel Deaconess Medical Center in Boston, Massachusetts.
Participants: Drivers age 65 or older were included (total $n = 373$). Forty-five percent of the sample had been diagnosed with Cognitive Impairment (CI) whereas the remaining participants were in the No Cognitive Impairment (NCI) group.
Measurements: TMT Parts A & B, Folstein Mini Mental Status Examination, Washington University Road Test.
Results: CI drivers with TMT A speed exceeding 46 s were more likely to fail the road test whereas TMT B speed was not a sensitive metric in this group. In the No Cognitive Impairment (NCI) group, TMT B speed exceeding 131 s predicted driving impairment whereas TMT A speed was not sensitive. Error scores were not useful in the determination of driving fitness for either group.
Conclusions: This study provides useful criteria for health providers working with older people in the determination of driving fitness. Results suggest that TMT speed, but not error rate, is associated with road test performance. Based on our work, we advocate that pre-existing dementia should be taken into consideration when using TMT performance as a screen for driving.

1. Introduction

As the "baby boom" generation ages there is a clear need for more efficient health management strategies to address their medical needs. A critically important issue pertains to driving competence. Physicians and other health providers are often asked to comment on the driving fitness of their older patients. In the setting of busy medical practices, it is often not practical or possible to assess this very important issue. Many providers use screening measures to identify the at-risk driver who may require further examination with a road test. The Trail Making Test (TMT), a simple pencil and paper task, has been identified as a robust screen for driving safety and has been recommended by the (American Medical Association, 2003). There are two TMT subtests. TMT A involves drawing lines between numbers 1 and 25 whereas TMT B entails alternating between numbers and letters. Both tests depend on visual scanning, processing speed, and capacity to maintain focus. TMT B is also dependent on divided attention/mental flexibility.

The TMT appeals to health providers because it is brief, easy to administer, and accessible as it is in the public domain. There are good normative data regarding task performance but data regarding the predictive value of TMT for driving safety have been mixed (Roy and Molnar, 2013). The TMT provides two outcome metrics: speed of completion and error rate. There is a lack of consensus regarding optimal cut scores for either of these measures in the prediction of driving fitness. A variety of cut scores have been proposed for TMT completion speed. Driving cut scores of 53 s (Vaucher et al., 2014), 39 s (Bedard et al., 2008), and 32 s (Choi et al., 2016) have been cited for TMT A whereas cut scores of 90 s (Hargarve et al., 2012), 133 s (Marottoli et al., 1998), 147 s (Ball et al., 2006) and 180 s (Staplin et al., 2003) have been proposed for TMT B. Inconsistencies across these studies are likely due to differences in participants and the different ways that driving outcome was measured. For example, some studies included

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community samples of older adults, stroke patients, and/or patients with a traumatic brain injury. Driving safety has been examined via performance on a formal road test (Hunt et al., 1997), self-report of prior crashes (Singletary et al., 2017), and number of future at-fault accidents (Das et al., 2015). These factors may influence the sensitivity and specificity of potential cut scores; however, sensitivity and specificity values were often not reported. Proposed cut scores may yield false positive errors (i.e., identification of a competent driver as impaired) or false negative errors (i.e., failure to identify at risk drivers). Further work is needed in order to derive reliable and valid TMT speed criteria to identify potentially unsafe drivers.

TMT error rate provides unique information regarding capacity to maintain and shift set – aspects of cognition critical for safe driving. However, few studies provide information regarding error rate. This may have to do with the statistical problem of restriction of the range; there is limited variability in error rate. Most people make very few errors and the test is often discontinued after an individual makes only two or three. Research has shown that error rate is associated with driving competence whereas its utility is less impressive in the determination of unsafe driving (Dobbs and Shergill, 2013). Of note, participants in that study were a heterogeneous group of healthy and cognitively impaired people and there was no analysis as to whether outcome varied based on the cognitive status of the individual.

Prior work by our group indicated that a pre-existing diagnosis of dementia modified the effectiveness of mental status screening measures (MMSE and MoCA) in the prediction of driving (Hollis et al., 2015). Diagnosis affects the range of possible scores on tasks of cognitive functions. People with dementia show greater variability than non-cognitively impaired people. Because decreased variability reduces test sensitivity, screening measures may be less useful in people with No Cognitive Impairment (NCI). To date, there is limited information regarding whether the clinical utility of the TMT in relation to driving is different for individuals with CI as compared to those with NCI. This is important because health care providers working with older adults will frequently encounter patients with dementia; one of the leading health issues in this population (Heron et al., 2009). Furthermore, drivers with dementia have been found to commit more driving safety errors than cognitively intact drivers (Frittelli, et al., 2009; Man-Son-Hing et al., 2007). Thus, a reliable TMT cut score for patients with dementia is critical to aid the busy clinician in the assessment of driving safety.

In the current study, we address the above-mentioned limitations with a large cohort of people referred for a driving exam in a hospital based clinic. One goal of the study is to provide reliable cut scores for TMT A and TMT B speed and error rate that can be used by primary care physicians and other health providers in the detection of the at-risk driver who may need further assessment with a road test. Data are analyzed separately for healthy controls and people with prior diagnoses of cognitive impairment. Using Receiver Operating Characteristic (ROC) analyses, we provide sensitivity and specificity values to inform clinical decision making. Speed is calculated according to total seconds needed to complete the TMT. In this study, errors are calculated according to the number of items correctly completed. Hereafter, referred to as “total items completed.”

2. Methods

2.1. Participants

A retrospective data analysis was conducted with approval of the BIDMC Internal Review Board. A total of 373 participants were referred for a DriveWise® evaluation. The average age for the sample was 79.39 (SD = 7.37) with participants ranging in age from 65 to 97. Participants had an average of 15.85 (SD = 2.83) years of education ranging from 7 to 21 years. Diagnostic information was obtained from medical records provided by the referring physician. In this study, people with a Mini Mental Status Examination (MMSE) score of < 25 and/or a clinical diagnosis of mild cognitive impairment or dementia were included in the CI group. People with no clinical diagnosis of dementia and with an MMSE $\geq$ 25 were included in the NCI group. This cut off was based on normative criteria (Folstein et al., 1975). Forty-five percent of the sample had been diagnosed with Cognitive Impairment (CI) whereas the remaining participants were in the No Cognitive Impairment (NCI) group.

2.2. Measures

Trail Making Test Part A & B (Reitan, 1955)

The Trail Making Test (TMT) is a pen and paper test comprised of two parts. TMT A is a scattered array of the numbers 1–25. The examinee is asked to connect numbers in sequence as quickly as possible. A stopwatch was used to measure time completion. TMT A measures processing speed and visual scanning. TMT B is a random array of numbers and letters. The examinee is asked to alternate between sequential numbers and letters as quickly as possible (1-A, 2-B, 3-C, and so on). TMT B provides information about processing speed, visual scanning, and set-shifting.

2.3. DriveWise® evaluation

The DriveWise® evaluation included a social work assessment focused on driving, medical, and psychosocial histories. The occupational therapist (AMH) conducted an office based assessment of vision, physical function, and cognition. This was followed by a one-hour standardized road evaluation modeled after the Washington University Road Test (Hunt et al., 1997) adapted for comparable Boston Streets. The Washington University Road Test has been utilized in prior research studies (Hunt et al., 1997; Davis et al., 2012). Road tests were conducted in urban and suburban neighborhoods and included a variety of situations encountered in everyday driving. Drivers were directed to make left and right turns at different types of intersections, to make lane changes, to park at the curb and in a diagonal parking space and to drive on both single lane and multilane roads. All road tests were conducted in the afternoon between 2 and 4pm with the occupational therapist (AMH) and a certified driving instructor (in the front seat with access to a brake pedal). During the road test the occupational therapist (AMH) scored each maneuver in detail and on completion recorded a global performance rating. The driving instructor also recorded a global rating. Performance rating resulted in three outcomes: Safe (pass), Marginal or Unsafe (fail). Those participants whose performance was rated as marginal were recommended to undergo driving remediation or stop driving. For the current study those with marginal performance were included in the fail group.

2.4. Statistical analyses

Analyses were performed using IBM® SPSS® Statistics version 21 for Windows (IBM Corporation 2012). An independent samples t-test was conducted to compare pass/fail groups with respect to age, education, and TMT speed. Total items completed were analyzed with the Mann Whitney U-Test as these data were not normally distributed. Receiver Operating Characteristic (ROC) analyses were derived to evaluate sensitivity and specificity of speed and total items completed in relation to driving competence. Sensitivity rates of 70% and specificity of 70–80% are considered realistic for the human sciences (Goldstein et al., 2004).

3. Results

3.1. Group differences

Individuals with CI had significantly lower MMSE scores than did those with NCI (T (270.42) = −10.87, p = < 0.0001) (see Table 1).