Brief report

The use of the Color Trails Test in the assessment of driver competence: Preliminary report of a culture-fair instrument

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Abstract

Studies have shown that the Trail Making Test (TMT) predicts real-world driving performance in individuals who have cognitive deficits. However, because this test requires knowledge of the Latin alphabet, the TMT may not be appropriate for individuals who are illiterate or for those whom English is not their primary language. Because the Color Trails Test (CTT) is not influenced by knowledge of the alphabet, the CTT may be a culture-fair alternative to the TMT. To date, the utility of the CTT in the evaluation of driver competence has not been established. In the current study, individuals referred for a comprehensive driving assessment underwent testing with the TMT and CTT. The results suggest that the CTT and the TMT provide similar information regarding road-test outcome. Thus, the CTT may be a culture-fair alternative to the TMT in the assessment of driver competence.

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1. Background

By the year 2030 the nation’s population of senior citizens is expected to double, reaching an estimated 72 million. As America’s elderly population increases, so too will the number of elderly drivers. As people age, their driving ability may decline in the context of increased cognitive and medical problems. Because of the increasing number of elders at risk for driving problems, the development of objective tests for driving assessment is critical.

Driving involves the integration of a complex set of behaviors that include, but that are not limited to, selective attention, motor speed, visuospatial abilities, and mental flexibility (Anstey, Wood, Lord, & Walker, 2004; Brown & Ott, 2004; Dobbs, Heller, & Schopflocher, 1998; Hunt et al., 1997; Reger, Welsh, Watson, Cholerton, & Craft, 2004). Neuropsychological instruments allow for the assessment of a broad range of cognitive abilities in an office setting. A growing body of literature supports the utility of neuropsychological assessment in the prediction of driving competence (Anstey et al., 2004; Hu, Sengupta, Velkoff, & Debarros, 2005; Rizzo, Reinach, McGehee, & Dawson, 1997). One commonly used instrument, the Trail Making Test (TMT; Reitan, 1958), has been shown to be particularly useful as a predictive tool when assessing on-road driving performance.

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Performance on the TMT has been significantly associated with driving performance on both road tests and driving simulators in elders with and without dementia (Brown & Ott, 2004; Dobbs et al., 1998; Grace et al., 2005; Hunt et al., 1997; Odenheimer et al., 1994; Ott et al., 2003; Reger et al., 2004; Rizzo et al., 1997; Uc, Rizz, Anderson, Shi, & Dawson, 2005; Wang, Kosinski, Schwartzberg, & Shanklin, 2003). In fact, the American Medical Association (AMA) has recommended the use of the TMT when evaluating driving competence (Wang et al., 2003). Despite its utility, the TMT has inherent problems that limit its validity when it is used with individuals who are not familiar with the Latin alphabet.

In light of U.S. Census data indicating that 26% of senior citizens will be identified as belonging to an ethnic group other than non-Hispanic white by the year 2030 (Hu et al., 2005), there is a clear need for investigation of culturally unbiased test instruments. The Color Trails Test (CTT) was designed as a culture-fair analogue to the TMT (D’Elia, Satz, Uchiyama, & White, 1994). Both tests focus on selective attention, mental flexibility, visual spatial skills and motor speed. The CTT, however, is free of the language demands of the TMT. To date, no studies have evaluated the relationship between the CTT and real-world driving performance. The goal of the current study is to examine the relative efficacy of the TMT and the CTT as screening instruments in the identification of the “at risk” driver who can then be referred for a road test. We predict that participants who fail the road test will perform the TMT and the CTT significantly slower than those who pass the road test.

2. Method

2.1. Participants

A total of 29 participants (19 males, 10 females) were recruited through DriveWise, a multi-disciplinary driving assessment program at Beth Israel Deaconess Medical Center (BIDMC) in Boston. The DriveWise team consists of a clinical social worker, an occupational therapist, and a certified driving remediation instructor. The 60 min road test is a modified version of the Washington University Road Test (Hunt et al., 1997). DriveWise participants were referred by friends, family members, and physicians because of concerns about their ability to safely operate a motor vehicle. Informed consent, as per BIDMC Internal Review Board guidelines, was obtained from all participants prior to participation in the current research project.

Participants varied with respect to their primary medical conditions. The sample consisted of patients with mild dementia (n = 13), cerebrovascular disease (n = 8), Parkinson’s disease (n = 3), encephalopathy (n = 2), hip replacement surgery (n = 1), syncope (n = 1), and head injury (n = 1). The average age of participants was 76.6 years (S.D. = 9.5), with a mean education of 17.4 years (S.D. = 2.7).

2.2. Procedure

Participants arrived at the DriveWise clinic accompanied by friends or family. Driving and medical histories were obtained by the clinical social worker (L.K.). Participants were then seen by the occupational therapist (A.H.) for the clinical assessment of vision, coordination, brake reaction time, and road sign identification. Subsequently they underwent a 60 min road exam based on the Washington University Road Test (WURT; Hunt et al., 1997) which was adapted for use on comparable Boston streets. The road test was conducted in a vehicle that had hand controls and instructor brakes. A Massachusetts certified driving instructor sat in the front passenger seat in order to direct the driver and, when needed, to use safety brakes. The occupational therapist sat in the back seat of the vehicle in order to observe the driver and to assess overall driving safety. Prior to the road test, a 5–10 min practice session was completed. The road test included a variety of challenges experienced by any driver navigating the urban streets of Boston. A final decision regarding driving safety is made by the DriveWise team solely on the basis of the participant’s road test performance.

In addition to the above, DriveWise participants underwent a brief (20 min) cognitive screening battery. A subset of these screening tests is included in the present study: the Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975), the TMT, and the CTT. The MMSE was chosen to yield information regarding overall cognitive functions. The TMT was selected due to the many prior studies indicating that it is a useful predictor of driving competence. The CTT was chosen in order to investigate this instrument as a possible culture fair alternative to the TMT in the assessment of driver competence. Both the TMT and CTT have two subtests. TMT-A and CTT-1 require...
Table 1
Demographics and Performance on the Cognitive Measures

<table>
<thead>
<tr>
<th></th>
<th>Pass (N = 15)</th>
<th>Fail (N = 14)</th>
<th>p value</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>74.2 (10.3)</td>
<td>79.2 (7.9)</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Sex (% male)</td>
<td>73</td>
<td>57</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>17.33 (2.96)</td>
<td>17.46 (2.53)</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>MMSE(^a)</td>
<td>28.67 (1.98)</td>
<td>25.50 (4.38)</td>
<td>0.007</td>
<td>0.89</td>
</tr>
<tr>
<td>TMT-A(^a)</td>
<td>48.40 (22.06)</td>
<td>78.07 (50.45)</td>
<td>0.023</td>
<td>0.75</td>
</tr>
<tr>
<td>TMT-B</td>
<td>132.33 (60.57)</td>
<td>184.64 (72.78)</td>
<td>0.073</td>
<td>0.75</td>
</tr>
<tr>
<td>CTT-1(^a)</td>
<td>77.87 (47.90)</td>
<td>136.86 (118.04)</td>
<td>0.045</td>
<td>0.66</td>
</tr>
<tr>
<td>CTT-2</td>
<td>149.40 (62.15)</td>
<td>219.62 (96.22)</td>
<td>0.056</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Note: Data are presented as mean (standard deviation). MMSE: Mini Mental Status Exam; TMT: Trail Making Test (raw completion time in seconds); CTT: Color Trails Test (raw completion time in seconds).

\(^a\) Individuals who failed the driver evaluation scored significantly lower on the MMSE, and were significantly slower on the TMT-A and CTT-1 in comparison to those who passed (p < 0.05).

the individual to connect numbers in ascending order from 1–25 as quickly as possible. TMT-B and CTT-2 requires alternation between two different sets of stimuli. TMT-B involves alternation between numbers and letters (1-A, 2-B, etc.) whereas CTT-2 involves alternation between numbers and two colors (1-pink, 2-yellow, 3-pink, etc.).

2.3. Statistical analysis

Contingency table analysis and t-tests were conducted to compare the two participant groups on demographic characteristics. Nonparametric statistical techniques were used in the analysis of neuropsychological test data in light of the fact that test scores were not normally distributed. Dependent variables were analyzed using a Mann–Whitney U-test. Spearman correlation coefficients were used to determine relationships between selected dependent variables. Significance was determined at a level of (p < 0.05). To better understand any group differences on the cognitive measures, effect sizes were calculated and interpreted based on the guidelines of Cohen (1992).

3. Results

The results for all analyses in this section are presented in Table 1. Individuals who passed the road test did not differ significantly from those who failed with regard to age (t = 1.45, p = 0.16), sex (\(\chi^2 = 0.84, p = 0.36\)), or education (t = 1.2, p = 0.90). A significant difference in total score for the MMSE was revealed, with those who passed scoring higher than those who failed (U = 44.00, p < 0.05).

Individuals who passed the driver evaluation completed both the CTT-1 and TMT- A significantly faster than those who failed (TMT-A, \(U = 53.00, p < 0.05\); CTT-1, \(U = 59.00, p < 0.05\)). On both the CTT-2 and TMT-B, group differences approached significance, with individuals who passed the road test completing both measures in a shorter amount of time than those who failed (TMT-B, \(U = 77.00, p = 0.07\); CTT-2, \(U = 56.00, p = 0.06\)).

Completion times on the two measures of interest (CTT; TMT) were significantly correlated (CTT-1 versus TMT-A = 0.91, \(p < 0.01\); CTT-2 versus TMT-B = 0.72, \(p < 0.01\)). Overall, the analyses revealed an effect size range of 0.66–0.89 between the group of individuals who passed the driving evaluation in comparison to those who failed across the cognitive measures (MMSE, CTT, TMT). For the measures of interest to the current study (CTT, TMT), effect sizes were similar across each of the four components, ranging from 0.66–0.88. The effect sizes for each measure are presented in Table 1.

4. Discussion

In the current study, we examined the utility of the CTT, as a possible culture-fair alternative to the TMT in the identification of the “at risk” driver. The sample consisted of a heterogeneous group of individuals referred for a driving evaluation because of concerns about driving safety. Performance on both the TMT and the CTT were significantly related to road test outcome. Individuals who failed the road test were slower than individuals who passed the road test.
on each subtest (CTT-1, CTT-2; TMT-A, TMT-B). The difference between groups on the CTT-2 and TMT-B did not reach statistical significance at the 0.05 level (0.07, 0.06, respectively). Importantly, however, analysis of effect sizes revealed uniformly large effects for each of the test components (ranging from 0.66 to 0.88). Given both the small sample size in our study, as well as the use of non-parametric analyses, it is likely that our study lacked sufficient power to detect a significant difference between groups on the CTT-2 and TMT-B. In this preliminary study, selection biases (i.e., all participants were suspected of having driving problems) and the small sample size undermined the determination of clinically relevant cut off scores applicable to the general public. It will be important for future studies to establish clinical norms that will guide the clinician in determining whether an on road driving evaluation is needed.

Both the TMT and CTT provided useful information regarding road test outcome. Given this finding, the study supports the use of the CTT as an alternative to the TMT in the evaluation of driver competence. The CTT may be particularly useful for those individuals who are less familiar with the Latin alphabet.

Limitations of the current study include the small sample size and selection biases inherent in the group of individuals referred for driving evaluations. DriveWise participants came to the evaluation because of concerns about driving safety, and many had pre-existing cognitive vulnerabilities. It is not known whether the CTT would be a useful predictor of road-test outcome in non-referred samples. That is, the results of this study are limited to patients who have already been identified as possibly being unsafe drivers. Another possible bias of the current study concerns the high level of education of study participants. DriveWise participants had an average education of 17 years. It is not known at this time whether similar results would be found using a sample of individuals with a wider range of educational backgrounds. The CTT will need to be explored in a community-based sample of drivers before the more general use of the CTT as a driver screening measure can be supported.

An additional limitation of the study is the small number of neuropsychological measures that were available to analyze. It could be argued that any cognitive measure, including the CTT, would predict driver competence in a sample of cognitively compromised individuals. In fact, some support for this interpretation can be drawn from the current findings. In our study performance on the MMSE, a composite index of global cognitive functioning was significantly related to pass/fail status. This test has been shown to be a useful predictor of driver competence in individuals with pre-existing cognitive deficits but it may be less sensitive when employed with higher functioning individuals. It is our belief that the TMT and the CTT are more sensitive to driver safety issues than is the MMSE because these tests assess selective attention, motor speed, visuospatial abilities, and executive functions, tasks that particularly critical in the safe operation of a motor vehicle.

The current study provides preliminary evidence that the TMT and CTT have equivocal utility when used as part of a driver screening evaluation. The culture-fair nature of the CTT suggests that it may be particularly suitable with individuals for whom the TMT is not appropriate. However, before the use of the CTT can be fully endorsed as an alternative to the TMT, the relationship between the CTT and driving performance in community dwelling individuals will need to be established. In addition, information regarding the relationship between the CTT and road test performance should be studied in non-English speaking populations. We believe, however, that this study provides the initial step in establishing the utility of the CTT in the evaluation of driver competence.

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References


