Alternate Forms of the Original Trail Making Test:
Evidence of Equivalence from a US Sample

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Objective.
Clinical trials requiring repeated cognitive assessments arguably necessitate the use of alternate forms to diminish practice effects. The Trail Making Test (TMT) is perhaps the most widely used measure of executive functioning, yet the only study to describe alternate forms of the original TMT, which is preferable to other versions due to its brevity, was conducted on a European clinical sample of 55 individuals (Wagner et al., 2011). The objective of the current study was to provide evidence of equivalence of 4 forms of the TMT from a larger, racially diverse sample of research volunteers in the United States.

Method.
Students from a medium-sized public university in the mid-Atlantic region were recruited for this study and earned course credit for their participation. After removing participants with invalid data (e.g., due to obvious lack of effort, disruptions during test administration), the sample comprised 157 (59 white, 61 black, 37 mixed race) participants (120 self-identified as female, 29 male, 8 other/prefer not to say) with an average age of 19 years (SD = 1.9; range 18-31). We created 3 alternate forms of the TMT by rotating the original stimuli, using a mirror image of the original stimuli, and rotating the mirror image of the original stimuli. A board-certified neuropsychologist (CAM) trained 3 research assistants to administer the TMT. Each examiner administered all 4 forms of the test in random order; each form of the TMT was completed by only one participant. To compare scores obtained by the 3 examiners, we used ANOVA to compare 4 TMT scores: number of seconds and number of errors for parts A and B. To compare TMT performance on the 4 forms, used ANOVA and MANOVA with examiner entered as a covariate.

Results.
Our first analysis revealed that one examiner's administration yielded longer times to complete TMT part A (mean = 29.0 seconds) compared to the other two examiners (means = 25.1 and 23.8 seconds; $F_{2,154}$ 4.37, p = .01). Interestingly, number of seconds to complete part B was almost identical across examiners (mean number of seconds = 61.0, 62.0, 62.0). Examiner was entered as a covariate in subsequent analyses, which revealed no differences between forms on test performance (part A number of seconds: $F_{3,150}$ 2.37, p = .07; part A errors: $F_{3,150}$ 0.98, p = .41; part B time: $F_{3,150}$ 2.29, p = .08; part B errors: $F_{3,150}$ 1.51, p = .21). Repeating the analyses without entering examiner as a covariate did not change the results.

Conclusions.
The ability to administer the TMT up to 4 times to the same individuals while minimizing practice effects is useful for clinical trials whose cognitive outcomes include those measuring executive functioning. Our findings extend the work of Wagner and colleagues by comparing alternate forms of the original TMT in a larger, racially diverse, American sample. Our findings lend further support for the equivalence of the original and 3 alternate forms of the TMT.