

TRAIL MAKING TEST (TMT)

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October 19, 2025

RECOMMENDED CITATION

mohammad looti (2025). *TRAIL MAKING TEST (TMT)*. PSYCHOLOGICAL SCALES.
Retrieved from <https://scales.arabpsychology.com/?p=53362>

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Primary Disciplinary Field(s): Neuropsychology, Cognitive Assessment

1. Core Definition and Function

The **Trail Making Test (TMT)** is a widely employed, standardized neuropsychological assessment tool designed to evaluate several critical cognitive functions, including visual attention, processing speed, and executive function. Often utilized within comprehensive assessment frameworks, such as the Halstead-Reitan Neuropsychological Battery, the TMT requires participants to sequentially connect a set of numbered and/or lettered targets distributed randomly on a sheet of paper. The fundamental objective is to assess the speed and accuracy with which an individual can execute a complex task requiring sustained attention and rapid cognitive shifting. It is fundamentally a psychomotor test that provides invaluable insight into the integrity of frontal lobe functions and the efficiency of cognitive pathways, distinguishing between simple motor speed and the more complex process of mental flexibility.

The structure of the TMT, specifically its division into two distinct parts (Trail A and Trail B), allows clinicians to differentiate between impairments in basic visual scanning and processing speed (measured predominantly by Trail A) and higher-order executive functions, such as set-shifting and working memory capacity (measured by Trail B). Successful performance hinges not only on visual-motor coordination but also on the ability to maintain the task goal while inhibiting distracting stimuli and efficiently switching between different cognitive sets. Consequently, the test serves as a crucial diagnostic instrument for identifying cognitive deficits associated with various neurological and psychiatric disorders, helping to characterize the nature and severity of mental disability.

The resultant score, typically the time required to complete each trail, provides a quantitative measure that can be compared against normative data, allowing neuropsychologists to pinpoint areas of cognitive decline. While seemingly a simple "connect-the-dot" activity, the TMT places significant demands on the attentional system, making it sensitive to subtle cognitive impairments that might not be evident in less taxing cognitive screens. The test's utility lies in its dual nature: offering a measure of fundamental processing speed while simultaneously taxing the central executive system necessary for complex sequencing and alternation.

2. Historical Context and Development

The genesis of the Trail Making Test can be traced back to the United States Army during World War II, where it was initially developed to screen for neurological impairment and assess fitness for duty. In its earliest iterations, the test was known by different names, reflecting its evolving clinical focus. The source material indicates that it was initially recognized as the **Divided Attention Test**, emphasizing its reliance on simultaneously managing visual input and sequential motor output.

Following further refinement, it was also referred to as **Parrington's Pathways Test**, a nod to one of its key developers.

The formal cultivation and standardization of the TMT are credited to American psychologists **Russell G. Eiter** and **John E. Parrington**. Their efforts transformed the preliminary screening tool into a robust, standardized instrument suitable for broader clinical application. The integration of the TMT into the comprehensive Halstead-Reitan Neuropsychological Battery solidified its status as an indispensable component of cognitive assessment in the mid-20th century. Its inclusion in such a well-established battery provided the empirical validation necessary for its widespread adoption across clinical, research, and forensic settings globally.

The enduring success and utility of the TMT stem from its clear, objective scoring method and its sensitivity to diffuse brain dysfunction, particularly in areas related to executive control. Despite its age, the TMT remains one of the most frequently administered neuropsychological instruments because its design effectively captures impairment in fundamental cognitive operations that underpin daily functioning. Its historical evolution reflects a shift from a general screening tool to a precise measure of specific cognitive constructs, particularly **mental flexibility** and attentional sequencing, which are critical markers for diagnosing neurocognitive disorders.

3. Detailed Components: Trail A

Trail A of the TMT serves as the baseline measure, primarily assessing visual scanning, graphomotor speed, and simple sustained attention. The task is relatively straightforward: the examinee is presented with a sheet containing twenty-five circles, each identified by a numeral (1 through 25), distributed randomly across the page. The participant must use a pencil to connect these dots in ascending numerical order as quickly as possible without lifting the pencil from the paper or making errors.

The simplicity of Trail A ensures that performance primarily reflects non-executive functions. It is designed to isolate the impact of basic psychomotor speed and visual search capabilities from the more complex demands of cognitive switching. Therefore, poor performance on Trail A--manifested by an excessively long completion time--suggests impairment in fundamental processes such as visual acuity, motor coordination, or the speed of information processing. If a patient performs poorly on Trail A, any poor performance on Trail B must be interpreted cautiously, as the difficulty may stem from underlying motor or visual deficits rather than purely executive dysfunction.

The time required to complete Trail A is recorded in seconds. This score establishes an individual's foundational speed and capacity for simple sequential processing. It is essential for interpreting the results of Trail B, as it provides the necessary context to determine whether slowness on the latter task is due to the added cognitive load of set-shifting or simply a generalized slowing of motor or

visual processing. A significant difference between the time taken for Trail B versus Trail A (the B-A difference score) is the most critical metric derived from the TMT, but the robust measurement of the baseline required by Trail A is indispensable for this calculation.

4. Detailed Components: Trail B

Trail B significantly increases the cognitive load and complexity compared to Trail A, making it a powerful measure of executive function, specifically **mental flexibility** or cognitive set shifting. In this section, the examinee is presented with twenty-five circles distributed on the page, but these targets are identified by alternating numerals (1 through 13) and letters (A through L). The participant must connect these targets sequentially, alternating between the two sets (i.e., 1-A-2-B-3-C, and so forth, until reaching the final target).

The requirement to alternate between two distinct cognitive sets--the numerical sequence and the alphabetical sequence--imposes substantial demands on the central executive system. The participant must hold two rules in working memory simultaneously and efficiently switch between them after each connection. This process requires continuous inhibition of the previous set (e.g., inhibiting the tendency to move to "4" after connecting to "3" and instead switching to "C") while selecting the correct target from the alternate set. This necessity for rapid switching makes Trail B highly sensitive to frontal lobe dysfunction.

Completion time for Trail B is typically substantially longer than Trail A, even in cognitively healthy individuals, due to the inherent difficulty of set shifting. A disproportionately long time taken for Trail B, relative to Trail A, is highly suggestive of deficits in executive control, particularly difficulties with planning, working memory, and overcoming cognitive inertia. Errors in Trail B often include sequence errors (failing to switch sets, e.g., 1-A-2-3), which require immediate correction and further slow the process, providing additional qualitative data regarding the severity of the switching deficit.

5. Cognitive Functions Measured

The TMT is highly valued because it is not a pure test of a single function but rather a composite measure that taps into several core cognitive operations simultaneously. The functions most prominently measured include **visual search sequencing**, which is the ability to systematically scan a visual field to locate specific targets in a predetermined order. This visual-spatial component is critical for both trails and is often impaired following posterior brain injury or generalized attentional deficits. The speed at which this search occurs contributes directly to the overall score.

Furthermore, the TMT provides a robust measure of both sustained and selective attention. The examinee must maintain sustained focus throughout the entire test duration to avoid skipping

targets or making sequence errors. In Trail B, the demand for **selective attention** is increased, as the participant must selectively attend to one set (numbers) while ignoring the immediately preceding set (letters) and vice versa. This constant attentional modulation is crucial for successful completion and is often compromised in conditions affecting vigilance and concentration, such as Traumatic Brain Injury (TBI) or Attention Deficit Hyperactivity Disorder (ADHD).

Crucially, the TMT also measures **motor speed** and dexterity, which serves as a necessary baseline for understanding the cognitive components. Perhaps the most significant function assessed, however, is **mental flexibility** (cognitive flexibility). This executive function, uniquely isolated by the comparison between Trail A and Trail B, refers to the ability to shift quickly and efficiently between different mental sets or response patterns in response to changing task demands. Deficits in mental flexibility are classically associated with damage to the prefrontal cortex and are hallmark signs of neurodegenerative diseases like Alzheimer's or vascular dementia.

6. Clinical Applications and Utility

The clinical utility of the TMT is profound and widespread, making it one of the most widely utilized instruments for assessing general mental disability and specific neurocognitive decline. In clinical neuropsychology, the test is routinely used in the evaluation of patients suspected of having various forms of neurological impairment, including stroke, multiple sclerosis (MS), and Parkinson's disease. Performance on the TMT, particularly Trail B, often shows a high correlation with real-world functional outcomes, demonstrating its ecological validity in predicting an individual's capacity for complex daily activities requiring planning and rapid decision-making.

The TMT is also instrumental in the assessment and monitoring of cognitive decline associated with dementia. Patients with mild cognitive impairment (MCI) or early-stage dementia typically exhibit measurable deficits on Trail B due to the deterioration of executive functions and processing speed. Longitudinal monitoring using the TMT can help clinicians track the progression of the disease and evaluate the effectiveness of pharmacological or behavioral interventions. Similarly, in psychiatry, the TMT is utilized to characterize cognitive deficits observed in conditions like schizophrenia and major depressive disorder, where attentional control and processing speed are frequently compromised.

Beyond traditional neurological and psychiatric settings, the TMT is frequently employed in rehabilitation settings, particularly for patients recovering from traumatic brain injury (TBI). The test provides a sensitive measure of residual cognitive impairment, helping therapists gauge the severity of frontal lobe damage and plan tailored cognitive rehabilitation strategies. Its clear, objective, and easily quantifiable scoring system makes it highly valuable for research, allowing investigators to reliably measure cognitive changes across diverse populations and experimental

conditions.

7. Scoring and Interpretation

The primary quantitative score derived from both Trail A and Trail B is the total time (in seconds) required for completion. Longer completion times indicate poorer performance, suggesting slower processing speed, reduced attention, or impaired executive function. These raw scores are typically converted into scaled scores or percentile ranks based on normative data specific to the patient's age, education level, and sometimes cultural background, to determine whether the performance is within normal limits.

A crucial measure derived from the TMT is the difference score, often calculated as Trail B time minus Trail A time (B-A). This difference is intended to be a purer measure of **cognitive flexibility**, isolating the time cost associated with the necessary cognitive switching while factoring out the baseline motor and visual speed measured in Trail A. A significantly elevated B-A score suggests specific impairment in set-shifting abilities, even if the patient's absolute time on Trail A is within normal limits.

In addition to timing, qualitative scoring involves recording the number and type of errors made. Common errors include: **Sequence Errors** (connecting targets in the wrong order, especially failing to alternate correctly in Trail B), and **Near Misses** or Off-Trail Errors (drawing outside the lines or near the boundaries of the targets). While errors must be corrected immediately by the examiner, the number of corrections required provides valuable qualitative data regarding the patient's planning ability, self-monitoring skills, and impulsivity. High error rates, even if corrected, suggest significant attentional instability and poor executive control.

8. Limitations and Criticisms

Despite its extensive use, the TMT is subject to several methodological and interpretational criticisms. One primary limitation is the heavy influence of non-cognitive factors on performance, particularly **motor speed** and visual processing. While Trail A attempts to account for baseline motor speed, generalized physical slowness or tremor can artificially inflate both Trail A and Trail B times, potentially leading to an overestimation of cognitive impairment. This necessitates the use of auxiliary tests of motor function to properly contextualize TMT results.

Furthermore, the TMT is highly susceptible to the influence of demographic variables, most notably education level and age. Individuals with lower educational attainment often score poorly, not necessarily due to neurocognitive impairment, but due to lack of familiarity with the alphabetical sequence or general testing strategies. Similarly, performance naturally declines with age, requiring the use of stringent, age-adjusted norms. Without careful consideration of these variables, there is a risk of misinterpreting normal variation as pathological impairment.

A significant theoretical criticism is that the TMT, particularly Trail B, is not a measure of a single, isolated cognitive function but rather a complex measure of several interwoven processes (visual search, attention, working memory, set shifting, motor output). While this complexity contributes to its sensitivity, it reduces its specificity. If a patient scores poorly on Trail B, it is difficult to definitively state which specific component of the executive system is failing without additional, targeted neuropsychological testing. This lack of specificity requires clinicians to integrate TMT data with results from other tests to draw precise diagnostic conclusions.

Further Reading

[Trail Making Test - Wikipedia](#)

[Halstead-Reitan Neuropsychological Battery - Wikipedia](#)

[The Trail Making Test: A Comprehensive Review of Normative Data and Clinical Utility](#)

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