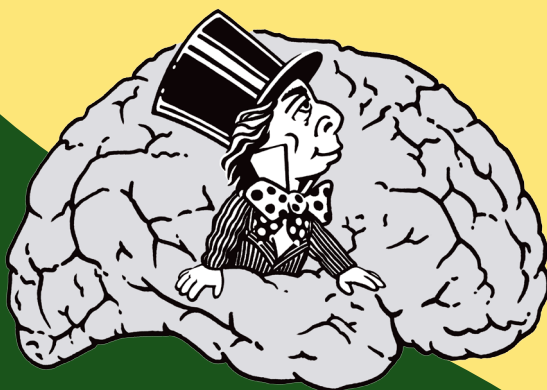


# КОГНИТИВНАЯ НАУКА

В МОСКВЕ



НОВЫЕ ИССЛЕДОВАНИЯ

МАТЕРИАЛЫ  
КОНФЕРЕНЦИИ  
2023

Под ред. Е.В. Печенковой, М.В. Фаликман, А.Я. Койфман

УДК 159.9  
ББК 88.25  
К57

Когнитивная наука в Москве: новые исследования. Материалы конференции 21 – 22 июня 2023 г. Под ред. Е.В. Печенковой, М.В. Фаликман, А.Я. Койфман. – М.: ООО «Буки Веди», Московский институт психоанализа. 2023 г. – 604 стр.

© Авторы статей, 2023

ISBN 978-5-4465-3880-5

УДК 159.9  
ББК 88.25

ISBN 978-5-4465-3880-5

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## THE COLOR TRAIL TEST

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**Abstract.** The Color Trail Test (CTT) is a commonly used neuropsychological assessment tool that measures a person's cognitive flexibility, visual-motor tracking, and visual scanning abilities. The CTT can be used for assessing cognitive impairments, diagnosing neurological disorders, evaluating treatment outcomes, and for research purposes. Nowadays, such a test is needed at clinics in different countries around the world. To fill this gap, the Center for Language and Brain has developed an electronic version of the test, which is available in 23 languages. In the current study, we determined the cut-off scores in a cohort of healthy participants. Moreover, we investigated the differences in test performance among people with different types of brain damage and the factors affecting task success. The data collection is still ongoing, so in this study we share preliminary results.

**Keywords:** assessment tool, cognitive impairment, brain damage, neurological disorders, Color Trail Test

### Introduction

A huge number of people suffer from numerous cognitive impairments all over the world. These deficiencies seriously affect a person's quality of life. For example, people suffering from the impairment of executive functions cannot control their behavior (Diamond, 2013). So it's important to investigate and measure such deficits for further rehabilitation. Scientists have made lots of attempts to create a convenient and valid tool for the assessment of cognitive functions. One of such tests is the Trail Making Test (TMT, first introduced back in the late 1940's; Partington, Leiter, 1949) which received great popularity. This tool had several corrections, and finally began to look like the TMT researchers use nowadays (Reitan, 1958).

This version of TMT became popular among scientists and clinicians willing to assess the driving competence that involves the integration of a complex set of behaviors, such as selective attention, motor speed, visuospatial abilities, and mental flexibility (Anstey et al., 2005; Brown, Ott, 2004; Reger et al., 2004). However, studies have shown that classical TMT is not culture-free (Reitan, 1971) because it requires knowledge of the Latin alphabet, and it may not be appropriate for people who are illiterate or for those who have other primary language than English. Due to this fact, TMT was modified to Color Trail Test (D'Elia et al., 1996) which is not influenced by knowledge of the alphabet.

The test consists of two parts: TMT/CTT (Part A) and TMT/CTT (Part B). TMT-A and CTT-A require an individual to connect numbers in ascending order from 1 to

25 as quickly as possible. TMT-B and CTT-B require alternation between two different sets of stimuli. TMT-B involves alternation between numbers and letters (1-A, 2-B, etc.) whereas CTT-B involves alternation between numbers and two colors (1-pink, 2-yellow, 3-pink, etc.; Elkin-Frankston et al., 2007).

The results of the study by Elkin-Frankston et al. (2007) show that the CTT and the TMT provide similar information regarding outcome. Thus, the CTT may be a culture-free alternative to the TMT in the assessment of driving competence. So, CTT is non-language-driven in nature (Partington, Leiter, 1949) and it may help scientists to identify the features of cognitive functions in individuals with conditions such as stroke, epilepsy, traumatic brain injury, dementia, and attention-deficit/hyperactivity disorder etc.

In the current study, we introduce an electronic version of the CTT with 23 language versions. This will allow us to unify the test procedure and avoid subjectivity in the interpretation of the results. Moreover, we demonstrate the cut-off scores in the cohort of healthy participants, the difference in the test performance in Russian-speaking people with and without aphasia. Moreover, collecting and analyzing data from people with tumors and epilepsy is still ongoing.

## Methods

**Procedure.** The CTT consists of two main parts. During Part A (Fig. 1) a participant should connect circles with numbers in the ascending order, and during the Part B (Fig. 2) the task is to connect circles with numbers in ascending order while alternating colors (for example, 1 pink – 2 yellow – 3 pink – 4 yellow and so on). There was also a simplified training task (Fig. 3, Fig. 4) before each main part.

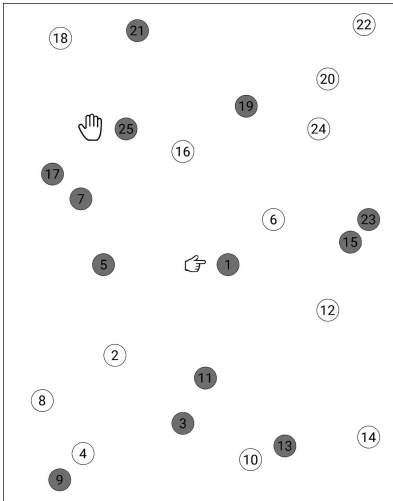


Figure 1. Part A

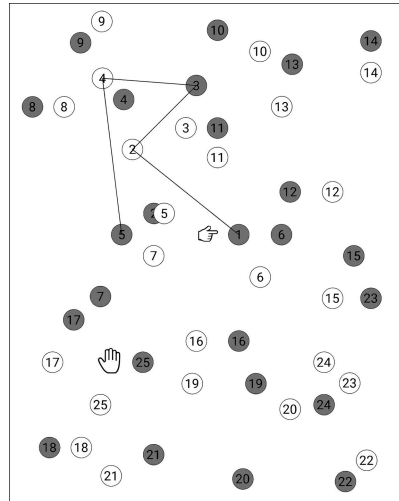


Figure 2. Part B

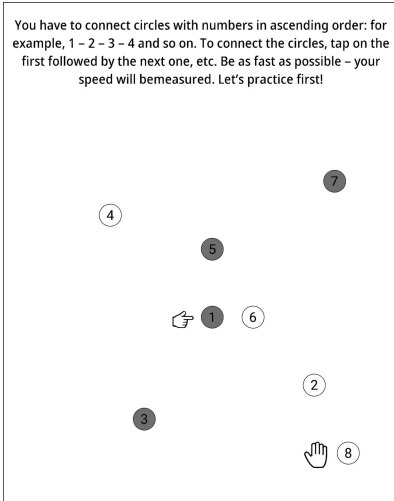


Figure 3. Training task for Part A

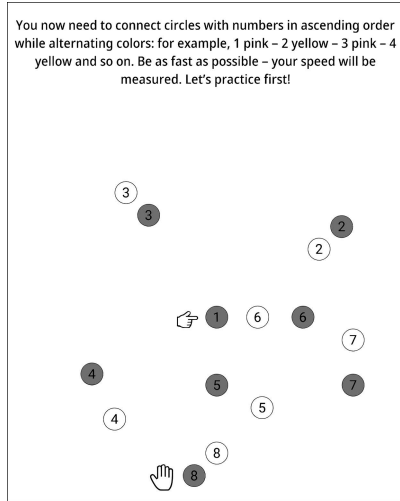


Figure 4. Training task for Part B

**Color trail test**  
assesses visual attention and task switching ability.

The test consists of two parts in which you will need to connect numbers following certain rules. The test takes 5 minutes to complete.

**Country of residence**  
Select the country

**Age**

**Gender**

**Years of education (starting with primary school)**

**I do not have neurological and psychiatric disorders**

**Participant ID (if there is one)**

Figure 5. Form

Date	ID	Part A (Total time spent / Number of errors / Number of prompts)	Part B (Total time spent / Number of errors / Number of prompts)	Interference index
18.05.2023 (15:01:26)	1	28:29 sec. / 2 / 0	1 min. 50:92 sec. / 2 / 1	2.92

Figure 6. Test's outcome

**Table 1.** The Average Values of Time, Hints and Errors in Both Parts of CTT and Interference Index for the Two Groups

Average indicators	Part A			Part B			Index
	Time/sec	Hints	Errors	Time/sec	Hints	Errors	
Control group	46.5	0	0	86.6	1	2	0.9
Clinical group	120.7	1	4	219.2	3	10	0.8

Testing was performed on a touch screen tablet. First, the experimenter chose the language for the presentation of instructions. Then s/he entered demographic data (country of residence, age, number of years of formal education, and gender) along with a short informed consent form (Fig. 5) that the experimenter also filled out. Next, a person took the tablet with the CTT: first, s/he passed the trial version of the test, then proceeded to the main part.

The test performance outcome included several measures (Fig. 6): the time to finish the task, the number of mistakes and hints for both parts; and an interference index calculated as:  $(\text{timepart B} - \text{timepart A}) / \text{timepart A}$ . This index shows the relation of time spent on part A to the time spent on part B. It reflects the difference between the subject's performance in the first and the second parts of the test.

**Participants.** In the present study two groups were recruited: the control group included 213 participants without any cognitive impairments (110 women,  $M_{\text{age}} = 19$ ,  $SD = 11$ , range 6–55 years).

The clinical group included 71 participants with stroke which led to aphasia (34 women,  $M_{\text{age}} = 57$ ,  $SD = 12.98$ , range 26–80 years) recruited from the Centre for Speech Pathology and Neurorehabilitation (Moscow). All participants were native speakers of Russian, they had (corrected to) normal vision and hearing. All participants did not have a history of psychiatric or neurodegenerative disorders. Participants who reported alcohol abuse before stroke were excluded from the study. The patients performed the test with the hand which functions were preserved.

**Data analysis.** Statistical analysis was performed in (R Core Team, 2020) and Microsoft Excel. In this study, we calculated cut-off scores based on the performance of the control group (95th percentile). We also demonstrated the average number of seconds needed to pass both parts of the test, the number of hints and errors, as well as the interference index for each part in the control and post-stroke groups. Moreover, we have assessed the impact of demographic factors on the test performance using Pearson correlation.

## Results

Based on the results of the control group, 83.3 s was determined as the cut-off value for the first part of the test, and 143.6 s was the cut-off value for the second part of the test. The performance above the cut-off score was suggested to be an abnormal performance.

The average values for the two groups are presented in Table 1.

Age, education, gender, and the number of months after stroke onset did not influence the results of the test significantly ( $p > .05$ ).

## Discussion

The preliminary results demonstrated the abnormal pattern of test performance. Generally, longer completion times and more errors in Part B are indicative of greater cognitive impairment or dysfunction (Kortte et al., 2002). In the future research, we are going to do a more comprehensive statistical analysis of the patterns of CTT performance in different pathological populations such as people with strokes, brain tumors, and epilepsy.

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## ЦВЕТНОЙ ТЕСТ СЛЕДОВАНИЯ ПО МАРШРУТУ

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**Аннотация.** Цветной тест следования по маршруту — это нейропсихологический инструмент для оценки управляющих функций, внимания и других когнитивных навыков человека. С помощью этого теста также можно провести диагностику неврологических заболеваний или оценить результаты лечения/проведенной терапии. В настоящее время такой инструмент необходим в клиниках по всему миру, в связи с чем сотрудники Центра языка и мозга НИУ ВШЭ создали электронную версию теста для расширения возможностей его использования, а также перевели инструкцию к тесту на 23 языка. В текущем исследовании мы рассчитали пороговые значения, чтобы в дальнейшем с помощью этого теста можно было дифференцировать людей с когнитивными нарушениями и без них. Кроме того, мы проанализировали различия в результатах теста у людей с разными типами поражения головного мозга и факторы, влияющие на прохождение теста. В данный момент продолжается активный сбор данных, поэтому полный статистический анализ будет проведен в ближайшее время.

**Ключевые слова:** управляющие функции, когнитивные нарушения, диагностика, поражение мозга, Цветной тест следования по маршруту