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EC NEUROLOGY
Research Article

The Relationship between Psychomotor Speed and Shift Attention with Response Inhibition in Adults

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Received: December 16, 2020; **Published:** June 30, 2021

Abstract

Psychomotor speed and the ability of shift attention along with response inhibition are among neurological abilities influencing cognitive processes. The population included 138 adults (male = 63, female = 75) selected by convenience random sampling. The participants were asked to complete the TMT and Stroop color-word test assignments to measure psychomotor speed and shift attention at the highest possible speed. Then, the time was recorded and the results were analyzed using ANOVA. Based on the results, a positive correlation was observed between parts A and B of TMT test and between first and second parts in Stroop test ($p < 0.01$). In addition, good performance in one part predicts good performance in the next part of the same test, and vice versa. Further, a positive correlation was reported between part A of TMT test and the first and second Stroop color-word test ($p < 0.05$). Further, in the second part of the Stroop test, a significant difference was observed in performance between men and women ($p < 0.05$) indicating that men perform better in keeping their attention on a task and disturbing stimuli have less effect on their work process. However, a significant difference was reported between men and women in other parts of the tests ($p < 0.05$). Thus, it seems that doing different tasks well influences psychomotor speed and attentional shift in performance of the person. Finally, men have better performance in constant attention to stimuli.

***Keywords**: Selective Attention; Trail Making Test; Response Inhibition*

Abbreviation

TMT: Trail Making Test

Introduction

In neuroscience, there exists a parallel concept next to information processing called action, which is considered as transmitting a message sequentially from one neuron to another from a neurological point of view. In psychology, the external and objective behavior of individuals which has been highly emphasized by neuropsychologists is more visible. Psychomotor speed is regarded as one of the most scales affecting people's performance referring to direct relationship with speed of action in analyzing sensory information or short-term memory [1] and then acting on those perceptions. Psychomotor speed means the ability to receive sensory stimuli from the environment mental processing [2] and finally perform objective actions by large muscles such as the arm or leg or small muscles such as eyebrows in a certain period of time, which is typically based on the average time of people in the community. Research in this area has focused more on cognitive aging since 1965. The present descriptive study seeks to identify the aspects related to functioning of intelligence, which affects

older people compared to younger ones. Since the mid-1960s, there has been a growing interest in how and why of specific components related to the cognitive domain, which are affected with age, and an increasing focus on cognitive aging neuroscience [3]. Based on the results, various factors affect cognitive functions such as attention and psychomotor speed with a lot consequences. In particular, psychomotor slowing has been observed in patients with various pathologies such as chronic fatigue syndrome, overtraining syndrome [4], heart failure [5], AIDS [6], type 1 diabetes [7], type 2 diabetes [8], Sickle cell disease [9], major depression [10], schizophrenia [11], epilepsy [12], obesity [13], multiple system atrophy [14] and low blood pressure [15]. In addition, psychomotor slowing is associated with an increased risk of dementia, Alzheimer's, Parkinson's, disability, depressive symptoms, and stroke [16]. Further, using alcohol [17] and drugs such as codeine [18] leads to psychomotor slowing. Some studies indicate that taking citicoline supplementation improves attention and psychomotor speed in men [19]. Even chronic exposure to metals affects a person's cognitive functions [20]. Neurologically, psychomotor slowing is related to white matter hyper-intensity, which is considered as a common symptom in the elderly population. Furthermore, the reason for the slowing is high frequency of white matter lesions in the occipito-parietal cortex [21]. A wide range of psychomotor functions including biochemical, physiological and pathological is attributed to D2 [22]. However, age, gender, and education cannot be considered as important factors for evaluating cognitive functions on psychomotor speed and attention. A large number of studies have focused on differences in psychomotor slowing in men and women.

Aim of the Study

The present study aims to investigate the relationship between age and function in healthy adults over 18 years and gender differences in performing neurological tests such as TMT and Stroop color-word test because some studies examined psychomotor speed and attention in groups with different diseases.

Materials and Methods

Population

The population included 138 eighteen year old adults who were selected based on a convenience sampling. They were neurologically and psychologically healthy and did not take psychiatric medications. TMT and Stroop color-word tests were performed individually in a clinical setting to observe and record their performance accurately and evaluate the performance of the neurological system in a coherent and accurate manner. First, the participants were asked to complete both parts of the TMT test. Then, each participant was requested to complete the sample for part A before performing part A and the sample for part B before performing part B. No time was taken in performing the sample and only the participants were taught to correct the method. Time was measured by a timer in performing the main parts of the test. In the Stroop color-word test, the participants were asked to perform the tasks of the test using the computerized version of Stroop color-word test. Finally, they were trained to perform Stroop color-word computerized tests after obtaining consent.

Measurement instruments

TMT test: This test was developed in 1944 as a part of the army individual test battery to assess the visual-motor and visual-perceptual abilities of US Army soldiers and later became widely used. The test became one of the most common neuropsychological tests [23], which examined information on processing speed, visual scanning ability, integrating visual and motor functions, recognizing letter and number, sequence, and the ability to hold two strands of different thoughts [24]. A large number of studies have shown that TMT performance is affected by various demographic factors [25]. Performing TMT test depends on age and education although the relationship with gender is still controversial. Some studies report that men are faster than women, while others show opposite or fail to demonstrate a significant difference between the sexes [26]. TMT includes part A and B. In part A, the participant should connect 25 numbers to each other with one line, respectively. These numbers are scattered on a piece of paper and the participant should connect them in order without removing the pen from the paper. Part B has similar requirements, except that the participant connects the numbers and letters alternately (1-A, 2-B, 3-C, etc.), which is considered more difficult [27]. Scoring is actually the time to complete each part and errors naturally increase over time [28]. TMT-A is regarded as a measure of visual attention/scanning skills and psychomotor speed, and its performance is correlated with the scores of other tasks, which require visual scanning. On the other hand, TMT-B is considered as a scale for executive control, cognitive

flexibility, and change of direction, which correlates with intelligent cognitive change and task change tests, as well as increased prefrontal cortex activity in FMRI studies and the results related to prefrontal cortex lesions. Both parts of the test indicated a high retest reliability (Part A = 0.76, Part B = 0.82) [29].

Stroop color-word test: This test was developed in 1935 to assess specific attention and cognitive flexibility, and different types of this test have been expanded since then [30]. Computerized Stroop color-word test is considered as a version in which participants should look at the computer screen. The Stroop color-word stimulus is displayed on the screen for a certain amount of time and the user's response is recorded [31]. This test records movement perception when reading words-color (e.g. red and green) and naming the colors in which a word is written. The test measures two experimental conditions including word-color reading speed and color-naming speed along with two parts of the intervention. The first part deals with reading interference tendency and the second part refers to naming interference tendency. First, participants are asked to find the correct color option as soon as possible without considering the meaning of the word. Then, they should focus on the meaning of the words instead of the color. No time limit exists for completing the test. The main variables of scoring include reading interference (difference in reaction time between reading interference conditions and reading baseline) and naming interference (difference in reaction time between naming interference conditions and naming baseline). A large number of studies have reported the validity and reliability of the Stroop color-word test [32]. In the computerized version of Stroop color-word test, the reaction time of the participants is determined more precisely by pressing the buttons on the keyboard. In addition, the characteristics in words include color and their content and meaning. It means that the individual should be able to select the dominant response in favor of the unusual response requested through cognitive inhibition of what has already been learned based on selective attention and cognitive flexibility and rejecting incorrect information. While performing the Stroop test, a picture of the words, a stopwatch and an individual are needed to record the duration of the test and the answers. In this test, the participant should recognize the color of words written in different colors regardless of their meaning. In the first version, the name of the color is evaluated with the coordinated word (automatic attention), while non-coordinated word (the effect of interference on the measurement of executive attention) is as sessed in the second version. In each case, the participant should read the name of the color in which the words are printed in 12 seconds. An individual score is the number of words which are read correctly. Scores range from zero to 24, and more errors indicate more difficulty in concentrating.

Results

The population included 138 participants including 63 men and 75 women (45.7% and 57.3%, respectively), aged between 19 and 69 years (SD = 9.01, Mean = 38.74). The level of education ranged from primary school to doctorate, in which the highest frequency of education was related to master's degree and above, and the lowest was for primary school (60.9% vs. 0.7%.). Table 1 represents the descriptive findings based on the gender.

Gender		TMT A	TMT B	Stroop 1	Stroop 2
Male	Mean	33.33	73.79	22.65	47.48
N = 63	Standard deviation	14.636	31.776	5.617	14.635
Female	Mean	32.03	75.53	21.00	42.91
N = 75	Standard deviation	10.773	34.182	4.745	12.260
Total	Mean	1.54	32.62	74.74	21.75
N = 138	Standard deviation	.500	12.652	32.997	5.208

Table 1: *Descriptive findings of TMT (part A and part B) and Stroop (1 and 2 stages).*

Pearson correlation was used to examine the relationship between Stroop color-word test and TMT tests. Then, the correlation of each of these tests with the age and education of the participants was assessed. Before performing Pearson test, Kolmogorov-Smirnov test was applied to check for normality, the result of which indicates non-significance and normal distribution. Thus, the Pearson test can be used for data analysis.

Table 2 indicates the results of Pearson correlation test for examining the relationship between TMT and Stroop color-word test.

	Time of part A	Time of part B	First Stroop	Second Stroop
Time of part A	1	0.302**	.181*	197.
Sign		000.	.034	.020
N	138	138	138	138
Time of part B	0.302**	1	.015	.039
Sign	.000		.857	.653
N	138	138	138	138
First Stroop	0.181*	.015	1	.613**
Sign	.034	.857		.000
N	138	138	138	138
Second Stroop	.197*	.039	.613**	1
Sign	.020	.653	.000	
N	138	138	138	138

Table 2: *Pearson correlation of TMT and Stroop color-word test.*

**: *Significance at the level of 0.01.*

*: *Significance at the level of 0.05.*

As shown in table 2, a significant correlation is observed between parts A and B of the TMT test and the first and second parts of the Stroop test at the significance level of 0.01, which means that a person who performs well in part A handles the test well in Part B as well, and vice versa. In addition, a significant correlation is observed between above-mentioned parts of the tests at the level of 0.05.

Regarding the Stroop color-word test, the person's performance in handling the first part of the test is positively correlated with his performance in the second part at the level of 0.01, which means that the person's performance in answering both parts of the test is directly related. Further, the relationship between age and education with different parts of the tests was calculated using Pearson correlation test (Table 3).

		Age	Education
Time of part A	Pearson correlation	.090	-.217*
	Sign	.296	.011
	N	138	138
Time of part B	Pearson correlation	.116	-.163
	Sign	.176	.056
	N	138	138
First Stroop	Pearson correlation	.124	-206*
	Sign	.148	.015
	N	138	138
Second Stroop	Pearson correlation	.177*	-.140
	Sign	.037	.102
	N	138	138
Education	Pearson correlation	.222**	1
	Sign	.009	
	N	138	138
Age	Pearson correlation	1	.222**
	Sign		.009
	N	138	138

Table 3: *Pearson correlation of demographic characteristics and tests among the participants.*

**: *Significance at the level of 0.01.=*

*: *Significance at the level of 0.05.*

As indicated in table 3, the time of part A in the TMT test and the first part of the Stroop color-word test is inversely related to the level of education, meaning that participants with higher education in aforementioned parts of the tests showed poorer performance at the 0.05 level. Further, a positive correlation was reported between age and performance in the second part of the Stroop color-word test.

ANOVA test was used to examine the difference between gender and TMT and Stroop color-word test, the results of which are shown in table 4.

		Sum of Squares	df	Mean Square	F	Sig.
Time of part A	Between group	58.459	1	58.459	.364	.548
	Within group	21869.947	136	160.808		
	Total	21928.406	137			
Time of part B	Between group	103.625	1	103.625	.095	.759
	Within group	149060.984	136	1096.037		
	Total	149164.609	137			
First Stroop	Between group	93.306	1	93.306	3.503	.063
	Within group	3622.317	136	26.635		
	Total	3715.623	137			
Second Stroop	Between group	714.932	1	714.932	3.985	. 048*
	Within group	179.427	136	24402.061		
	Total		137	25116.993		

Table 4: *Difference between gender and performance in the TMT and Stroop tests based on the ANOVA test.*

: Significance at the level of 0.01.

: Significance at the level of 0.05.

As shown in table 4, a significant difference is observed between the second part of the Stroop color-word test and gender, meaning that only in this part a significant difference is observed between gender and performance. Further, in part B of the TMT test, men showed a better average performance (M = 73.79) compared to women in part A in the TMT test (M = 32.03). However, in the first and second part of the Stroop color-word test, women had better mean scores (M = 21.00 and M = 42.91, respectively), indicating that they could complete the task in less time although the difference was not significant.

Discussion

Based on the results, the neurological function of the individual in TMT-A relating to attention/visual scanning and psychomotor speed skills is positively correlated with TMT-B, which is related to executive control and cognitive flexibility.

In fact, more accuracy and psychomotor speed in part A improve performance in part B. In addition, better performance in the test results in doing other scheduled tasks better requiring visual scanning. The correlation of the first part of the Stroop test with the TMT test indicates that a person with selective or floating attention has better attention, judgment, and decision-making power. This person distinguishes right and wrong quicker, chooses faster and better, and makes fewer mistakes. Therefore, increasing the level of attention and focus requires improving selective attention, which enhances other areas of attention.

Unlike the results of McGlad., *et al*. (2019) and Spesnoza., *et al*. (2009), the present study indicates that the only difference between men's and women's performance is related to Stroop B. However, differences in other parts were not significant. In fact, men are more

likely to focus on themselves in performing tasks where disturbing stimuli seek to distract them. This neurological process of men is better than women in keeping the focus on the principle of the task, i.e. recognizing the color. While writing a word like green, its color is associated simultaneously. However, when the color of the word is blue, men can refer to color better than women, indicating that they can ignore the extra content, which here is the word green and focus on the principle of practice which is recognizing the color of words. On the other hand, when a person can maintain his focus on a stable and focused stimulus, more blood reaches to the forehead, resulting in improving the quality of performance [35,36]. Based on the results, a strong correlation is observed between variable and selective attention. Among people with strong selective attention [37,38], other types of attention, namely selective, variable, and stable attention and the ability to distribute attention in their neurological dimension are strong as well. To better explain the significant difference in the second part of the Stroop color-word test, when a variable is presented, the participant should take his attention away from the words and somehow control it so that he can ignore the words and pay attention only to the color. In another words, he should be able to set aside the meaning of the words and perform only the main part of the exercise which expresses the colors. This process requires selective and transfer attention, which is more complex than using either of these types of attention alone. In the present study, although the tests were performed in a clinical setting to make the time and place of the study the same for all participants, unwanted variables such as hunger were not considered. In addition, other tests were not used to examine other neurological aspects of the individuals due to the fatigue caused by prolonging the tests, which may affect the performance of the participants.

Conclusion

In sum, it can be concluded that improving one type of attention affects its other types, and a person with the ability to shift attention according to the situation can show better performance. Further, psychomotor speed in performing different tasks enhances speed and quality of performance. Thus, both attention and the speed of its shift, and psychomotor speed play a significant role in the quality of a person's performance in doing different tasks. Further, it seems that improvement in one type of attention leads to an increase in other aspects of attention and ultimately in performance. Finally, men seem to be more able than women to turn their attention to a stimulus and perform better, despite annoying stimuli.

Conflict of Interest

There is no financial support and no conflicts of interest among the authors.

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