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Research Article

Prediction of Cognitive Planning Based on Response Inhibition and Spatial-Visual Ability in Male Schizophrenic Patients

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Abstract

The purpose of the present study was to determine the relationship between response inhibition and spatial-visual ability with cognitive planning in male schizophrenia patients. The research method was descriptive-correlational. This study's statistical population was men and women with schizophrenia disorder in Sina psychiatric hospital, Iran. Thirty men with schizophrenia were selected by convenience sampling method. Research tools, including the Stroop test, clock drawing test, and Hanoi tower, were individually performed. The results showed that there was a significant positive relationship between interference time of Stroop test and time duration in Hanoi tower test ($r = 0.41$ and $p < 0.05$) and the second phase scores of clock drawing test and time duration in Hanoi tower test ($r = 0.42$ and $p < 0.05$). However, there was no significant relationship between the other variables. Also, the regression analysis showed that scores of the second phase of the clock drawing test and the Stroop test's interference time were positive predictors of cognitive planning (time dimension) in schizophrenia.

Keywords: *Cognitive Planning; Response Inhibition; Spatial-Visual Ability; Schizophrenia*

Introduction

One of the most common neuroscience disorders is schizophrenia, the fundamental nature of which is still unclear and is sometimes called the syndrome. Although schizophrenia is described as a single disease, it probably belongs to a group of disorders with a heterogeneous etiology. It includes patients whose clinical manifestations, therapeutic response, and process of the disease are not the same. Neuropsychological and cognitive deficiencies are among the main problems in many hospitalized and non-hospitalized patients with schizophrenia. These deficiencies are closely related to the patient's overall level of function [1]. One of these neuropsychological deficiencies that can have several negative consequences is impairment in the panning ability. The ability of planning to predict events as well as to monitor goal achievement is a main cognitive component of many problem-solving activities. Neurological studies on the planning ability of schizophrenic patients show that schizophrenic patients scored lower on tests related to measuring the ability of planning and are unable to explain and adjust the details of their daily plans [2]. The ability of planning by this definition can be linked to many other brain functions, including response inhibition and patient memory.

Response inhibition is another executive function that is an essential and critical concept in neurology. Response inhibition is a neurological element that refers to the ability to stop thoughts, actions, and emotions, and helps people respond without delay. The proper function of the components of planning, working memory, and mental flexibility is greatly affected by inhibition [3-6].

Visual-spatial memory is responsible for processing visual and spatial information that is impaired in schizophrenia. In a study of memory in schizophrenic patients, Guo, Ragland, and Carter [7] concluded that attention, working memory (of which spatial-visual memory is a part), and implicit memory are impaired in schizophrenia. Another study found that 70% of these patients had cognitive flexibility problems, and 65% with planning and working memory [8]. Memory impairment in schizophrenia is part of the widespread cognitive impairment in these patients [7]. Given that accurate evaluation of neuropsychological problems in cognitive disorders such as schizophrenia can help appropriate treatment planning in the field of cognitive rehabilitation. This study attempted to predict cognitive planning in patients with schizophrenia based on response inhibition and spatial-visual ability.

Materials and Methods

This study was a descriptive-correlational, and its statistical population was men hospitalized with schizophrenia in Chaharmahal and Bakhtiari province, Iran. Sampling method was a convenience method. The study sample consisted of 30 male patients who ranged in age from 18 to 40 years and were diagnosed with chronic schizophrenia according to DSM-5 criteria by a psychiatrist in a psychiatric hospital. Entry criteria included the absence of acute psychiatric disorders at the same time as the study, no use of drugs and psychotropic substances, visual and motion health (hand and eye health), and satisfaction to respond to the tests.

Each subject was evaluated and tested individually at intervals (to prevent patient fatigue) in a calm and stress-free environment. Three tests were performed randomly for each patient, including the Hanoi Tower test, the Stroop color, word test, and the clock drawing test.

Tools

Hanoi tower test

The most famous organizing and planning test is the Hanoi Tower test (the new form of the Tower of London). This test consists of three bars connected to a flat base and three nuts of different sizes. The subject must convert the starting position to the target position by moving the nuts on the bars. With seven moves, the nuts can be moved from position A to position C. This test is used to evaluate the executive planning related to the function of the prefrontal lobe and introduces the conceptualization of information processing related to the function of the frontal lobe. The number of moves, the number of errors, and the time duration it takes for the subject to solve the problem are calculated to score the test. The fewer motions and time duration, the better the schizophrenia patient's function [9].

Stroop color and word test

The Stroop test was first developed by Stroop (1935) to measure selective attention and cognitive flexibility through visual processing. This test has been used in various studies in different clinical groups to measure the ability of response inhibition, selective attention, cognitive variability and cognitive flexibility. The first Stroop test has been translated into different languages, Chinese, German, Swedish, Japanese, Persian. It has been performed and scored by different researchers in various ways with changes in the initial test.

The steps of the software test are as follows: Phase 1. Preliminary: In this phase, the subject is asked to respond by pressing the button corresponding to the color of the circle he sees on the screen (circle will be given in four colors of red, blue, yellow, green). The purpose of this phase is only to practice and recognize the colors and the location of the keys on the keyboard, and it does not affect the final result. By each response, feedback on the correct or incorrect responses is provided on the screen. Phase 2. Experiment: This phase follows precisely the method described in the primary phase (next phase). The purpose of this phase is only to practice and get acquainted with the response method and the place of the keys on the keyboard, and it does not affect the final result. By each response, feedback on the correct or incorrect responses is provided on the screen. Phase 3: Performing the Stroop test: In this step, 48 consonant color words and

48 inconsonant words with red, blue, yellow, and green colors are displayed to the subject. Consonant words mean that the color of the word is the same as the meaning of the word, for example, the word green, which is showed by green. Inconsonant words mean that the color of the word differs from the meaning of the word, for example, the word green, which is indicated by red, blue, or yellow. In total, 96 consonant and inconsonant colored words are shown randomly and sequentially. The subject's task is to determine only the words' appearance, regardless of the meaning of the words. The word color task measures mental flexibility and response inhibition. The presentation time of each stimulus on the screen is 2 s, and the distance between the presentation of the two stimuli is 0.800 s. The degree of inhibition or interference is obtained by subtracting the correct number of inconsonant from the correct number of consonants (a higher score indicates high inhibition). Also, the longer means time duration of response to inconsonant stimuli is another indicator for evaluating interference (a higher score indicates more interference and less inhibition). This test's validity has been reported through retesting in the range of 0.80 to 0.91 [10].

Clock drawing test

The clock drawing test has been accepted as part of cognitive evaluation. This test is a simple tool for detecting dysfunction in executive functions (planning, sequencing, and abstract reasoning) and examining the function of the parietal lobe. This test has been increasingly used as a screening tool for a wide range of neuropsychiatric disorders over the past two decades. Since 1983, more than a dozen scoring systems have been listed for the test. Because this test has a set of visual-spatial capabilities and executive functions, it is a useful tool that reflects the function of the frontal and temporoparietal lobes. Most studies emphasize the drawing of a circle approximately 10 cm in diameter. The test instructions are as follows: Please draw a large circle. Imagine this circle is like a clock plate. Please mark the numbers inside this circle so that they look similar to a clock. Now show eleven 11:10 that the instruction is abstract and symbolic and indicates the time by drawing the hands, and the therapist should not say the word "hands" in the instructions to the patient. 11:10 is especially useful in that it covers both fields of vision and also examines the inhibition that must be exerted by the frontal lobe in the wrong traction to the number ten. Because the scoring system of this test each emphasizes different visual-spatial, executive, quantitative, and primarily qualitative capabilities, it is not possible to compare them with each other. The scoring of this test based on the system introduced and used by Ghamari Givi, and Ghasem Nejad [11] in Iran has 15 items. If the subject's function is proportional to the evaluation items, he receives a score of 1, and from the total scores of each item, the total score of the subject will be obtained. A maximum score of 15 and a higher score indicate better function [11-13].

Data were collected and analyzed using SPSS software, version 16 using the Pearson correlation coefficient, and stepwise regression.

Findings

The mean age of schizophrenic men participating in this study was 38.4 ± 4.5. Ten of them (33.33%) had primary education, 7 (23.3%) had secondary education, and the rest had higher education up to associates degrees. Table 1 shows the descriptive characteristics of the variables in this study.

Variables	Sub-scales	Mean	Max	Min	SD
Cognitive planning	Number of motions	14.30	23	8	4.52
	Time duration	139.03	300	12	80.17
Response inhibition	Interference score	8.07	20	0	5.69
	Interference time	102.40	320	3	74.75
Spatial-visual ability	Clock drawing (first phase)	8.13	14	4	2.54
	Clock drawing (second phase)	10.53	15	6	2.43

Table 1: *Descriptive characteristics of cognitive planning (Hanoi Tower test), response inhibition (Stroop word color test) and spatial-visual ability (clock drawing test) in schizophrenia patients.*

As can be seen in table 2 (correlation matrix of research variables), there was no significant relationship between cognitive planning in the dimension of the number of motions with response inhibition dimensions (interference score and interference time) as well as the visual-spatial ability (clock drawing in the first phase) and (clock drawing in the second phase).However, there was a significant negative relationship between the time duration in the Hanoi Tower test and the interference time in the Stroop test ($r = -0.41$ and $p < 0.05$) and clock drawing in the second phase ($r = 0.42$ and $p < 0.05$). In other words, with the increase in the Hanoi Tower task's time duration, the interference time in the Stroop test, as well as the score of the clock drawing, are decreased.

Cognitive planning		Spatial-visual ability		Response inhibition			
Time duration	Number of motions	Clock drawing (second phase))	Clock drawing (first phase)	Interference time	Interference score		
					1	Interference score	Response inhibition
				1	0.06	Interference time	
			1	0.11	-0.48**	Clock drawing (first phase)	Spatial-visual ability
		1	0.74**	0.16	-0.50**	Clock drawing (second phase)	
	1	0.06	0.15	-0.11	10.00	Number of motions	Cognitive planning
1	0.39*	-0.42*	-0.23	-0.41*	0.27	Time duration	

Table 2: *Correlation matrix of variables.*

It should be noted that a higher interference time indicates a weaker response inhibition. Therefore, it can be said that there was a positive relationship between cognitive planning (time duration) and response inhibition (interference time). On the other hand, a higher score on the clock drawing score indicates a better spatial-visual ability function. Therefore, it can be said that there was a positive relationship between cognitive planning and spatial-visual ability. However, there was no significant relationship between the time duration with the interference score and clock drawing (in the first phase).

Before performing the regression analysis, the assumptions of this analysis were examined. These assumptions included the independence of errors and the absence of multiple collinearities, which were statistically confirmed.

As can be seen in table 3, there was a significant relationship between clock drawing (in the second phase) and time interference with time duration in a stepwise manner ($p < 0.01$). The R-square, which indicates the overlap of variances, shows that in the first step about 14% and the second step 24% of the scores overlapped between the clock drawing (in the second phase) and the time interference with the time duration, and the time duration changes result from them. The Tolerance coefficient varies between 0 and 1. The larger the value (close to 1), the lower the degree of overlap with the other variables and, consequently, the less collinearity. Values close to zero mean that the variable is almost a linear combination of the other predictor variables, resulting in high collinearity. If tolerance is in the range of 0.4, there is a concern. It is also problematic if the tolerance is < 0.1.

Steps	R	R-square	F	Df_1	Df_2	P value	VIF	Tolerance
Step 1	0.420 [a]	0.176	5.99	1	28	0.02	-	-
Steps 2	0.546 [b]	0.298	5.73	2	27	0.008	1.02	0.97

Table 3: *Multiple correlations between response inhibition (dimension of interference time) and spatial-visual ability (dimension of clock drawing in the second phase) with cognitive planning (dimension of time duration) in a stepwise manner.*
a. Clock drawing (second phase); b. Clock drawing (second phase), interference time.

As the results of table 4 show, clock drawing (t = -2.20 and p < 0.01) and the interference time (t = -2-164 and p < 0.05) in two steps were in the positive predictor direction of cognitive planning (dimension of time duration). Beta coefficients have shown that by increasing one unit of score in terms of the standard deviation to clock drawing in the first and second phases, 0.420 and 0.360 units of the score are added to the cognitive planning variable (dimension of time duration), respectively. In the second step, by adding a unit of score according to the standard deviation to the interference time, 0.354 unit of the score is added to the time duration variable. Also, the table above shows that the predictive power of clock drawing for cognitive planning (dimension of time duration) is higher than the interference time in the Stroop test.

Steps		Standard coefficients		Beta	T	P value
		B	Standard error			
Step 1	Constant value	284.69	60.99	-	4.66	0.001
	Clock drawing (second phase)	-13.82	5.64	-0.420	-2.44	0.02
Step 2	Constant value	302.82	57.948	-	5.226	0.001
	Clock drawing (second phase)	-11.85	5.386	-0.360	-2.20	0.036
	Interference time	10.380	0.175	-0.354	-2.164	0.04

Table 4: *Stepwise regression coefficients for predicting cognitive planning (time duration) by clock drawing (second phase) and interference time.*

Discussion

The purpose of the present study was to predict cognitive planning in men with schizophrenia based on response inhibition and spatial-visual ability. Based on the findings of table 2 and 4, it was shown that there was a significant relationship between the score of the second phase in the clock drawing test and the interference time in the Stroop test with the time duration of the Hanoi Tower test. On the other hand, the predictive power of clock drawing for cognitive planning (dimension of time duration) is higher than the predictive power of interference time in the Stroop test for cognitive planning in patients with schizophrenia.

In the research background, most similar studies have compared executive functions in patients with schizophrenia with healthy people or those with other mental disorders. Their results have shown that schizophrenia patients have weaker executive and cognitive function in cognitive planning than other patients [14]. This weaker function can be correlated with their lower insight [15]. Response inhibition [16,17] and spatial-visual memory [18-20] also showed significant deficiencies in schizophrenia patients. In the present study, the relationship between cognitive planning (in the time dimension) and spatial-visual memory and response inhibition can be examined from a physiological perspective. It can be said that executive functions' common origin causes damage in the areas involved in neurological and executive functions to affect all these functions at the same time. Research has shown that spatial-visual memory deficiencies are related to possible damage to the pre-forehead cortex and upper temporal g, and the lack of improvement in schizophrenia patients after training and observing the tester's work may be related to damage to this part of the brain [11]. Because of this, when a schizophrenic patient observes how the tester draws a clock, he will still not be able to draw it himself or herself or perform this redrawing (the second phase of the clock drawing test) slowly with repeated errors. Planning also depends on the function of the prefrontal cortex, and, as studies have shown, the destruction of this part of the brain structure has a useful role in causing the signs of schizophrenia [21].

On the other hand, clock drawing test requires a correct understanding of the position of the numbers inside the plate, understanding the spatial relationships, a correct understanding of the position of each number on the plate and the position of each number about each other and to the viewer [11]. In other words, it requires some kind of cognitive planning based on spatial-visual memory. Therefore, the planning background for setting the clock drawing steps requires a kind of spatial-visual reminder. It seems that patients suffering from spatial-visual memory deficiencies cannot plan better and do tasks in less time. The same is true of the ability of planning and response inhibition. Planning requires flexibility and the ability to adapt behavior regarding changing situations in this complex world. In other words, planning requires a kind of response inhibition and flexibility in providing adaptive responses. Therefore, the inability of schizophrenia patients in response inhibition (in the Stroop test) can explain weaker planning (in the Hanoi Tower test), which leads to an increase in response time duration.

Patients in this study did not control the variables of education and the dose of drugs. It can be said that this limitation has made it impossible to explain in detail some of the relationships that were expected to be significant (including drawing the first phase of the clock test with patients function on the Hanoi Tower test, or the number of Stroop test errors and their relationship to patients' function in the Hanoi Tower test). The possible interpretation is that such cases are related to the level of education of patients, and more importantly, the period of use of various antipsychotic drugs. It is suggested that in future research, considering the acute or chronic course of schizophrenia and variables such as education and family factors and heredity, the severity of functional and cognitive impairments of patients should be examined using these tests.

Conclusion

According to this study it can be concluded that planning, as a neurocognitive function, requires a kind of response inhibition and flexibility in providing adaptive responses. Therefore, the inability of schizophrenia patients in response inhibition (in the Stroop test) can explain weaker planning (in the Hanoi Tower test), which leads to an increase in response time duration.

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Conflict of Interest

The authors declare no conflict of interest.

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