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A Comparison of Problem Solving, Working Memory, and Selective Attention Executive Functions in Patients with Bipolar II Disorder, Borderline Personality Disorder, and Non-clinical Samples

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Abstract

Introduction: The distinction between Bipolar II Disorder (BD-II) and Borderline Personality Disorder (BPD) due to symptom overlap has always been a challenging issue among psychiatrists. In the present study, problem-solving functions, working memory and selective attention were compared in BD-II patients, BPD and non-clinical samples to distinguish the two disorders.

Method: For this purpose, 30 BD-II patients, 30 BPD and 30 non-clinical sample were selected by convenience sampling method. They were evaluated using Executive Function (EFs) tests. Data were analyzed using analysis of variance and Tukey's post hoc test.

Results: Except for selective attention, which was not significantly different in BD-II patients compared to the non-clinical group (P>0/05); BD-II patients and BPD in all EFs had significantly lower performance than the non-clinical group (P<0/01, P<0/05). Problem solving ability was significantly lower in BD-II patients than in BPD patients (P<0/05). There was no significant difference between the two patient groups in working memory and selective attention (P>0/05).

Conclusion: These findings, provides evidence of differences in some of the EFs in BD-II patients and BPD; which may be related to different impulsivity in these two disorders. Therefore, conducting research in other dimensions of EFs is recommended to distinguish between these two disorders.

Keywords: Bipolar II Disorder, Borderline Personality Disorder, Executive Functions

Introduction

Bipolar Disorder (BD) and Borderline Personality Disorder (BPD) are chronic mental disorders, whose overlapping symptoms and common comorbidity have made it difficult for clinicians to diagnose them based on clinical interviews [1]. BD and BPD share predisposing factors, clinical features, and similar response to medication with mood stabilizers. Childhood trauma and family history of bipolarity are two common factors found in both BD and BPD [2]. However, distinguishing BD-I from BPD seems relatively simple due to the existence of severe manic periods, often with psychotic features. But distinguishing BD-II from BPD is challenging due to common features such as mood instability and impulsivity [3].

So far, several studies have examined the differences between BD (especially type II BD) and

BPD from psychological [4], phenomenological [5], and response to treatment [6] approaches. But only few have directly compared the neuropsychological profile of the two groups [2].

This is while, numerous studies have compared the BD-II patients and BPD, with non-clinical groups in terms of neuropsychological profile [3]. The results of these studies have shown that compared to the non-clinical groups, BD-II patients and BPD have deficits in problem solving [2,7], working memory [8,9], and selective attention [10,11]. Impairments in memory and executive functions seem the most replicated findings across all mood states of BD [2]. Meta-analytic studies have proposed that deficits involving attention, memory and executive function could be trait-related in BD [2]. A most recent meta-analysis has proposed that these deficits in BPD could be dependent on co-morbidity, especially major depression, eating disorders, substance abuse, and other co-existing personality disorders [2].

Generally, it appears that neuropsychological impairments in BD and BPD, compared to the non-clinical groups, are associated with a common etiological pathway in relation to childhood trauma [2]. However, in spite of their apparent similarity, these common features of the two disorders may have different biological bases, as impulsivity is considered to be a common feature between BD and BPD. However, the impulsive behavior in patients with BD is more episodic and in patients with BPD is more a stable feature and, of course, more severe than patients with BD-II. Difference of impulsivity in patients with BPD and BD can also be tracked in the findings of biological studies. It seems that "episodic impulsivity" and "impulsivity trait" have different biological bases [12]. Therefore, the difference in impulsivity of the two disorders might have different effects on their Executive Functions (EFs) and distinguish the two disorders from each other.

However, a review of the evidence illustrates that most studies on the differential diagnosis of BD-II and BPD mainly focused on the clinical symptoms of the two disorders and how they responded to drug therapy, and little attention was paid to the distinction between them in terms of EFs; thus, there is very few and scattered research in this field. Hence, the questions arise are as follows: “Do problem-solving, working memory, and selective attention functions differ in BD-II patients and BPD?” “Can these EFs be helpful in differentiating the two disorders?” Therefore, the aim of the present study was to compare the problem-solving, working memory, and selective attention functions in BD-II patients, BPD and non-clinical samples.

Method

The present study is a causal-comparative research. The statistical population of the patients included all BD II and BPD patients (male and female) at the age of 18-40 with at least primary education, who referred to the Department of Psychiatric, Al-Zahra Hospital, Isfahan, in 2020-2021, and were diagnosed with BD II or BPD by a psychiatrist based on the DSM-5 criteria and semi-structured SCID-5 interviews.

The statistical population of the non-clinical samples included all out-of-hospital individuals (male and female) at the age of 18-40 with at least primary education who were evaluated based on a general health questionnaire and had no history of psychiatric illness, neither in themselves nor their first-degree relatives. To select the samples, members of the three groups (BD II, BPD, and non-clinical) were first matched using a researcher-made demographic questionnaire (based on age, gender, marital status, and educational). Finally, 30 BD-II patients, 30 BPD patients undergoing drug therapy with mood stabilizers, as well as 30 non-clinical sample were selected through the convenience sampling method.

The common inclusion criterion for the BD-II and BPD groups was the use of mood stabilizers. On the other hand, the inclusion criteria for the non-clinical group included no history of psychiatric illness in themselves and first-degree relatives and no use of any psychiatric drugs.

The common inclusion criteria for the three groups were written informed consent to participate in the tests, being at least 18 and at most 40 years of age, being literate (having at least primary education), normal vision and lack of color blindness due to the visual nature of EFs evaluation tests, no history of use or addiction to drugs (studies had shown chronic drug use causes the prefrontal cortex damage that underlies EFs [13], lack of serious physical and neurological diseases, and lack of suffering from epilepsy, since these diseases were effective in EFs deficit [14].

The exclusion criteria for all the three groups included unwillingness to cooperate and the lack of accuracy and attention in performing all tests and completing them.

In order to conduct the research after completing the required documents, the ethics code (1399.586) was obtained from the research ethics committee of Isfahan University of Medical Sciences (Iran). With the cooperation of a psychiatrist (thesis consultant professor), patients with BD-II and BPD and non-clinical samples who were informed about the research goal and met the criteria for participating in the research and completed the written consent form to participate in the research, were contacted according to a schedule. They were evaluated by a clinical psychologist using EFs tests at the psychiatric clinic of Al-Zahra Hospital in Isfahan. All tests by each participant lasted an average of 20 min, and at the end, those who wished to become aware of the results were informed.

The tools used in this study are as follows:

Researcher-made Demographic Questionnaire: The researcher-made questionnaire includes basic demographic information such as age, gender, marital status, level of education, history of substance use, history of hospitalization, history of shock, length of time since receiving a psychiatric diagnosis, and use of recent medications. It also includes a brief history of neurobiological conditions (such as head trauma, epilepsy, etc.). This questionnaire was designed for initial

screening and to control the inclusion criteria of the present study.

Tower of London Test: First used by Shallis [15], this test is one of the most widely used neurophysiological tests to determine problem-solving and planning abilities and to optimally measure problem-solving functions, problem-solving features, and problem-solving with minimal movements quickly and efficiently. The Tower of London test has good structural validity in measuring problem solving, planning, and organizing. A correlation of 0.41 has been reported between the results of this test and the Porteus Maze test. The Tower of London test has acceptable reliability of 0.79 [16]. This test has good construct validity in measuring the planning and organization of individuals. The correlation between the results of this test and the Porteus Maze test is reported to be r = 0.41 and its reliability obtained by Cronbach's alpha coefficient has been reported to be 0.74 [17]. The final result of this test was used to assess problem solving abilities in the present study.

N-Back Test: First introduced by Kirchner [18], the n-back test is widely used to assess working memory and is one of the most widely used culture-free tools. In this test, a number of visual stimuli appear consecutively on the computer screen, and the examinee must press the assigned key on the keyboard if any stimulus is similar or not similar to the previous one. This task is designed in such a way that at all stages, the examinee has to respond to all the stimuli. Therefore, the task requires constant monitoring and updating of the information in working memory. The validity of the n-back test as a measure of working memory performance is highly acceptable [19]. The reliability coefficients of this test have been reported in the range of 0.54 to 0.84 [20]. In Iran, this test is used as a valid test in studies and its content validity has been shown and its reliability coefficients with the retest method has been proven to be in the range between 0.71 to 0.84, which shows the high validity of this test [21]. The score of the number of correct answers in this test was used to measure working memory in the present study.

Simple Stroop Test: This test was first developed by Stroop [22] to measure selective attention and cognitive flexibility. The Simple Stroop test, which has acceptable reliability and validity in neuropsychological studies, is used to measure the selective attention ability through a visual method. In this test, 48 matched color words and 48 mismatched ones are displayed in red, blue, yellow, and green. The phrase “matching words” means that the color of each word matches its meaning; for example, "the word green is shown in green." On the other hands, mismatched words mean that the color of each word differs from the meaning of the word; for example, "the word green is presented in red, blue, or yellow." The set of 96 matched and mismatched color words is displayed randomly and sequentially. The examinee’s task is to determine only the apparent color of the words, regardless of their meaning. The reliability of 0.80- 0.91 has been reported for the Stroop test through test-retest [23]. In Iran, research on this test has confirmed its appropriate validity in measuring interference and response inhibition in adults and children; its reliability has also been proven by retest method, since all three attempts of this test have been reported to be 0.76, 0.83, and 0.90, respectively [24]. The interference score of this test, obtained by subtracting the score of the correct number of mismatched words from that of the matched ones, was used to assess selective attention in the present research.

Data were analyzed using the SPSS-25 software. The three groups were compared based on demographic variables using the chi-square test. Data on problem-solving variables, working memory and selective attention were distributed using Kolmogorov-Smirnov test. Finally, descriptive statistics (mean and standard deviation) as well as inferential statistics (ANOVA) and Tukey post hoc test were applied to assess the three groups.

Results

In the present study, 30 BD-II patients, 30 BPD patients and 30 non-clinical sample were examined. Table 1 briefly indicates the demographic characteristics of the three groups. The data analysis showed that there was no significant difference in demographic variables between the three groups (all P> 0.05; P> 0.01). In order to use the ANOVA, the homogeneity of variance of the scores of the three groups in the variables of problem solving, working memory and selective attention was evaluated using Levene's test. The results of this test showed that there was no significant difference between the variance of the scores of the variables of the three studied groups (all P>0.05; P>0.01). Therefore, due to the homogeneity of the variances, the ANOVA was used. The results of evaluating the three variables of problem solving, working memory, and selective attention in the three groups are presented in Table 2.

As observed in Table 2, there was a statistically significant difference between the mean scores of the three groups in variables of problem solving (P <0.01, F = 57.41), working memory (P <0.01, F = 65.08), and selective attention (P <0.05, F = 3.80) variables. In the next step, Tukey pairwise comparison test was used to investigate the difference between the mean scores of the studied variables in the three groups in (Table 3).

The results of the Tukey test in Table 3 show that the problem solving abilities of the BD-II patients and BPD were significantly lower compared to the non-clinical group. Furthermore, the BD-II patients had significantly lower problem solving abilities than the BPD patients. Regarding the working memory, it was found that the BD-II patients and BPD had significantly lower functions than the non-clinical group, but there was no significant difference between the BD-II patients and BPD in terms of their working memory. As far as selective attention was concerned, no significant difference was observed between the BD-II patients and the non-clinical group and between the BD-II patients and BPD. However, selective attention of the BPD patients was significantly lower than the non-clinical group.

Table 1. Demographic Characteristics of BD II Patients, BPD and Non-clinical Group

Variables	BD-II (n=30)	BPD (n=30)	Non-clinical (n=30)	X2	P
Education				16.69	0.125
Elementary	0	3(10%)	2(6.7%)		
First High School	1(3.3%)	5(16.7%)	2(6.7%)		
Secondary High School	4(13.3%)	5(16.7%)	3(10%)		
Diploma	21(70%)	7(23.3%)	15(50%)		
Associate degree	1(3.3%)	3(10%)	5(16.7%)		
Bachelor's degree	3(10%)	5(16.7%)	2(6.7%)		
Master's degree	0	2 (6.7%)	1(3.3%)		
PhD	0	0	0		
Age				20.87	0.126
18-25 years	11(36.7%)	17(56.7%)	14(46.7%)		
26-32 years	3(10%)	6(20%)	5(16.7%)		
33-40 years	16(53.3%)	7(23%)	11(36.7%)		
Gender				0.62	0.441
Male	15(50%)	17(56.7%)	16(53.3%)		
Female	15(50%)	13 (43.3%)	14(46.7%)		
Marital status				0.49	0.131
Single	10(33.3%)	15(50%)	10(33.3%)		
Married	20(66.7%)	15(50%)	20(66.7%)		

Table 2. Evaluating Three Variables of Problem Solving, Working Memory, and Selective Attention in BD II Patients, BPD and Non-clinical Groups

	Mean ±SD			Test	
EFs	BD-II	BPD	Non-clinical	F	P
Problem solving	19.93±5.68	23.57±5.36	32.53±3.35	57.41	0.001
Working memory	52.17±25.87	59.27±20.68	111±18.14	65.08	0.0001
Selective attention	6.07±10.47	6.50±12.15	0.57±1.10	3.80	0.026

Table 3. Pairwise Comparison of Mean Scores of Problem Solving, Working Memory, and Selective Attention in BD II patients, BPD and Non-clinical Group with Tukey Post Hoc Test

EFs	Group	Group	Tukey Post Hoc Test	
			Mean difference	P
Problem solving	BD-II	Non-clinical	-12.60*	0.0001
	BPD	Non-clinical	-8.96*	0.0001
	BD-II	BPD	-3.63**	0.020
Working memory	BD-II	Non-clinical	-58.83*	0.0001
	BPD	Non-clinical	-51.73*	0.0001
	BD-II	BPD	-7.10	0.421
Selective attention	BD-II	Non-clinical	5.50	0.062
	BPD	Non-clinical	5.93**	0.040
	BD-II	BPD	-0.43	0.982

*P<0.01 **P<0.05

Discussion

Since placing BD and BPD in a single group can have therapeutic consequences for patients and even deprive them of the necessary treatments [12], clarifying the difference between BD and especially BD-II with BPD due to common features such as impulsivity and mood instability [3] is extremely important. Despite numerous investigations on the similarities and differences of BD-II and BPD in various fields of symptomatology, pathology and etiology, there are few studies comparing these two disorders regarding their neurological functions [25]. Therefore, the present study attempted to compare and explain the neurological functions of these two disorders in order to differentiate them.

Therefore, the present study aimed to compare problem solving, working memory, and selective attention functions of the BD-II patients, BPD and Non-clinical samples.

The results of the present study showed that the patients with BD-II and BPD have significantly lower performance in problem-solving and working memory than the non-clinical group. However, the selective attention function of the patients with BD-II was not significantly different from that of the non-clinical group. Meanwhile, the patients with BPD had significantly lower performance than the non-clinical group in terms of the selective attention function. According to the findings, the BD-II patients had significantly lower performance in problem solving than the BPD ones, but regarding the working memory and selective attention functions, the two groups of patients performed similarly.

These findings are consistent with the results of the study by Akbari et al. [25]. They found that the patients with euthymic BD-II and BPD had significantly lower performance than the non-clinical group in some EFs such as problem solving and selective attention. However,

there was no significant difference between the two patient groups in problem solving and selective attention. As mentioned previously, the BD-II patients in the present study did not significantly differ from the non-clinical group in terms of the selective attention function. In addition, they performed significantly lower than the BPD patients in terms of problem solving. Therefore, in this respect, it is inconsistent with the results of the research by Akbari et al. [25].

In addition, in a study by Gvirts et al. [26], it was determined that the problem solving ability of the BD-I patients and BD-II was not significantly different from the non-clinical group and the BPD patients. In addition, the working memory function was not significantly different in the patients with BD-I, BD-II, and BPD compared with the non-clinical group. These findings are not in line with the present research. They also found that the BPD patients had significantly lower performance than the non-clinical group in terms of problem solving. Furthermore, there was no significant difference between the two patient groups in working memory, which is consistent with the results of present study.

The significant point about the findings of the present study is some common features in these two disorders, such as childhood traumas that may be related to cognitive impairment in these patients. Evidence suggests that childhood traumas, such as emotional abuse and neglect, which are present in patients with BD and BPD, are particularly associated with their emotion regulation problems and disability as well as a tendency to impulsivity [3]. Emotion regulation disability is directly related to EFs impairments [27], and probably affects these patients' EFs.

In addition, neuroimaging studies prove that patients with BD and BPD show fronto-limbic dysfunction [2]. The prefrontal cortex and related neural circuits are involved in many underlying EFs components and automatic emotion regulation [25]. Studies show that the prefrontal cortex and its association with limbic structures develop reassessment strategies that can modulate the activities in multiple emotion processing systems [27]. Given the central role of the prefrontal areas and their relationship to other cortical and subcortical-limbic structures, successful emotion regulation strongly affects a wide range of cognitive domains, including attention, executive ability, and memory [27].

By relying on the raised issues, the low performance of patients with BPD and BD-II in EFs in comparison to non-clinical group, as well as the lack of significant differences in working memory functions and selective attention between BD-II patients and BPD can be supposed to be related to these common features in both disorders.

Although the findings showed that selective attention function in patients with BD-II was not significantly different from the non-clinical group, however; these patients obtained lower scores in the selective attention test (Stroop) than the non-clinical group. What seems important about this finding is that the degree of attention deficit in the patients with BD-II might vary at different stages of the disease. A study conducted by Mousavizadegan and Maroufi [28] suggested that the patients with BD-I had lower performance at the manic phase than euthymic and depressed patients. Attention deficit disorder in BD-II might also be associated with the phases.

Thus, high performance in the selective attention function of the patients with BD-II might be due to using drugs and mood stabilizers and being at the euthymic phase. Furthermore, the exposure of these patients to the selective attention test (Stroop) and their preparedness due to the implementation of the experimental stage before the main stage of the test as well as their attempt to do better in the test process could be considered as other factors improving their performance in the selective attention function. Regarding the better function of patients with BPD than patients with BD-II in problem solving in the present study, as mentioned in the introduction, the common features between the two disorders including impulsivity, may have different biological and nature bases, despite the apparent similarity [12]. Impulsivity in patients with BD is episodic and in patients with BPD is an impulsivity trait [12]. Moreover, patients with BD are specified with attention impulsivity, but the impulsivity in patients with BPD is of the motor type [27]. Evidence proves that impulsivity is closely related to some mental activities such as rapid information processing [29]. According to the studies, on the other hand, performing higher cognitive tasks such as planning and problem solving is closely related to quick information process ability [30]. This is while evidence has proven that cognitive processing speed in patients with BPD is higher than in patients with BD [31]. Therefore, compared to patients with BD-II, the better performance of patients with BPD in problem solving may be due to their higher cognitive processing speed, which originates from these patients' trait of impulsivity, which has a different nature from impulsivity in patients with BD [12].

Like most neuroscience studies, the present research had some limitations although attempts were made to apply scientific principles in all stages in order to obtain reliable results. Thus, the limitations of this study could be emphasized. Firstly, the prevalence of Covid-19 disrupted the research process. Secondly, the patient sample groups in this study were only from one hospital. Therefore, it is suggested to select patient samples from several hospitals for better generalization of the results. Thirdly, the present research examined only problem solving, working memory, and selective attention functions. Thus, considering a large number of EFs components, it is recommended to conduct research on other EFs. Finally, the computer software developed by Sina Institute was used to measure attention functions. Therefore, the use of other advanced neuroscience tools is recommended to more precisely examine the structural and functional similarities and differences brains between BD-II patients and BPD.

Conclusion

Overall, based on the results of the present study, the low performance of BD-II patients and BPD in EFs compared

to the non-clinical group and also the lack of significant differences between the two groups in working memory and selective attention is probably associated with common underlying factors such as childhood trauma, serious and common damage to the prefrontal cortex, as well as disorders of the limbic system in these patients. However, there was no significant difference between the BD-II patients and the non-clinical group in terms of their selective attention. It seems that severe attention deficit in BD patients often occurs during the manic phase. The BD-II patients in the present study were all euthymic patients. Taking drugs and mood stabilizers seemed to greatly improve attention deficit in these patients. In addition, despite the apparent similarity of the features of these two disorders, such as impulsivity, some of these features seem to have different biological bases that can have different effects on the EFs of these patients. As shown in the present study, the BPD patients had better performance in problem solving than the BD-II patients, which is probably due to BPD patients' impulsivity. Therefore, distinguishing between these two disorders by relying on executive functions could be helpful. However, proving these findings requires neuroimaging with advanced imaging tools.

Conflict of Interest

The authors declare that they have no conflicts of interest and no financial benefits from this study.

Ethical Approval

This study was approved by the ethics committee of the Isfahan University of Medical Sciences and received the moral code from the Isfahan University of Medical Sciences (R.UI.REC.1399.586).

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