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Emotional Processing, Response Inhibition and Executive Planning in Borderline Personality Disorder

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Individuals with borderline personality disorder (BPD) have been described as highly vigilant for social stimuli, especially for facial emotional recognition. It has been argued that impulsivity and cognitive inflexibility are core features of BPD. The aim of this study was to investigate emotional processing and cognitive functions in individuals with BPD. An ex-post facto method with two groups is used. Forty-four outpatients with BPD, aged 18 to 55, were selected through the inclusion criteria and forty-four healthy participants were selected using convenient sampling method and matched based on their gender. Both groups completed Continuous Performance Test (CPT), Tower of London (TOL), Millon Clinical Multiaxial Inventory-III (MCMI-III) and the Ekman's 60 facial expressions test. The data was then analyzed by using MANOVA. The results showed that BPD group performed better than healthy group in recognizing fear, sadness and disgust (P=0.001), but there was no significant difference in the recognition of positive emotions such as surprise and happiness (P>0.05). Moreover, the healthy group was significantly better than the BPD group at recognizing anger (P=0.005). In addition, the results showed that the healthy group outperformed the BPD on CPT-commission error and TOL-scores (P=0.0001). It seems that there is a bias in emotional processing of participants with BPD, as they interpret neutral social cues negatively. Also, impaired response inhibition and executive planning could have a bidirectional interaction with emotional dysregulation which could be related to common underlying brain circuits. Thus, it is practical to include appropriate treatment strategies to target these domains.

Keywords: Borderline Personality Disorder (BPD), Cognitive Functions, Emotional Processing

Borderline personality disorder (BPD) is a chronic and debilitating syndrome with estimated median prevalence of 1.6% in the community (APA, 2013). Additionally, individuals with BPD are characterized by a pervasive pattern of negative emotional state, maladaptive cognitive processes (Kaplan et al., 2020), and emotion dysregulation which could be severe enough to result in hospitalization and suicide attempts (Linehan et al., 2015).

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Facial expression is informative about the inner state of a person and can yield information which seems necessary for social cognition and interactions (Daros et al., 2014). Emotional dysregulation and poor facial emotion recognition constitute the central characteristics of borderline personality disorder (Koenigsberg et al., 2009) which leads to disturbance of interpersonal interactions (Staebler et al., 2011). Indeed, this skill has been identified as a crucial capability for mental health (Cisler & Olatunji, 2012). Some studies indicated that individuals with BPD are less accurate in the recognition of negative facial expressions including anger, disgust, fear and sadness (Daros et al., 2013). Unkoa et al. (2011) also reported that individuals with BPD are less

sensitive to fear recognition and more sensitive to the feelings of disgust and surprise. In contrast, Scott et al. showed that facial emotion detection might be enhanced in individuals with BPD, as they have a tendency to perceive a negative emotion when presented with neutral facial expressions (Scott et al., 2011).

Execution function is a general term that refers to all higher-order cognitive processes which play a key role in directing and controlling behaviors (Hughes & Devine, 2019); the term also designates underlying anatomic structures such as dorsolateral prefrontal (DLPFC), orbitofrontal cortex (OFC), anterior cingulated and limbic system (Schulze et al., 2016; Soloff et al., 2015). In this regard, Ruocco, in a meta-analysis, showed that in all cognitive functions (cognitive flexibility, executive planning, attention, learning, set shifting and visual-spatial abilities) individuals with BPD performed worse than the healthy group, where the most impairment was seen in set-shifting and the least in flexibility (Ruocco, 2005).

Salavert (2011) also reported dysfunction of the frontal lobe in BPD by utilizing functional magnetic resonance imaging (FMRI). Damage to the frontal lobe and other regions such as the amygdala and prefrontal cortex can disturb executive function (Lis et al., 2007). Lawrence et al. also reported significant differences between BPD and healthy groups on sustained attention and response inhibition (Lawrence et al., 2010). However, several studies reported that neuropsychological functions in individuals with BPD are similar to healthy individuals and there are no differences between their frontal lobe functions (New et al., 2007).

Numerous neuropsychological studies have shown dysfunction of the prefrontal-limbic circuit in individuals with BPD in emotional recognition (New et al., 2007; Vandekerckhove et al., 2020), such that the amygdala is disconnected from the prefrontal cortex (PFC). This is considered as the underlying mechanism of emotional dysregulation and impulsivity (Vandekerckhove et al., 2020), which is related to those regions of the brain involved in cognitive functions. In this respect, some studies have reported the relationship between executive functions and impaired facial emotion recognition in individuals with sleep disorders (De Almondes et al., 2020) as well as those with schizophrenia and their siblings (Yang et al., 2015). In addition, research findings suggest the role of cultural differences in the recognition of facial emotions (Chen & Jack, 2017); hence, from one culture to another, the sensitivity of individuals in recognizing facial emotions changes. Furthermore, a review article of thirty-three trials (2256 participants) showed that although dialectical behavior therapy and psychodynamic approaches are effective for borderline symptoms, the effects are small and particularly unstable at follow-ups (Cristea et al., 2017). Therefore, it seems mandatory to study the facial emotion recognition in the Iranian population. The present study combines assessment of emotional processing along with cognitive functions in BPD participants. Thus, it requires a better understanding of the underlying psychopathology of the disorder to design new treatment approaches. The aim of this study was to identify and compare emotional processing and cognitive functions in BPD and healthy individuals. As a result, the study hypothesized that individuals with BPD would show a difference in emotional processing compared to healthy participants. Furthermore, it was assumed that this would be along with a deficit in executive functions.

Method

Participants

The statistical population of the study consisted of all the referred outpatients from the medical centers of 2, 3, and 4 districts of Tehran in 2019 who met the criteria for BPD based on psychiatric clinical interviews. Of these outpatients, 44 were selected according to the inclusion and exclusion criteria. In this study age and gender were considered as confounding variables. Therefore, participants of the healthy group were selected conveniently and matched the BPD group in terms of their age and gender. Each group consisted of 44 participants (β-1= 0.91, effect size = 0.35, α = 0.05 (Stevens, 2013)). Altogether, 35 participants of the BPD group were on outpatient treatment while 9 of them did not receive any treatment. The healthy group participants were selected by being interviewed and based on the inclusion and exclusion criteria. The participants who entered the healthy group scored lower than 70 (BR$\leq$70) in all Millon-III sub-scales, representing normal functioning (Groth-Marnat, 2009). The inclusion

criteria were 1) BPD diagnosis based on psychiatrist clinical interview and Millon-III (BR≥85) and 2) Scores lower than BR≤70 in other sub-scales of Millon-III. The exclusion criteria, on the other hand, were 1) comorbid psychiatric disorders, 2) epileptic seizures in the last two years, and 3) other medical conditions.

Measurement Instruments

Continuous Performance Test (CPT): The first version of a CPT was developed by Rosvold et al. in 1956. This test is generally characterized by rapid presentation of continuously changing stimuli with a designated "target" stimulus or "target" pattern; duration of the task varies but is intended to be sufficient to measure sustained attention. In this study the Persian CPT was used. Hadianfar et al. (2000) reported test-retest reliabilities of 0.93, 0.90 and 0.72 for Persian CPT's total correct, omission, and commission errors respectively. Persian CPT's total correct responses were used to assess sustained attention, and commission errors to evaluate response inhibition.

Tower of London Test (TOL): The Tower of London test was first introduced by Shalis in an article entitled "Specific Injuries in Planning." This test has appropriate construct validity in assessing planning and organization ability of individuals. Lezak et al. (1995) reported test-retest reliability of 0.79 for TOL. In this study, Persian TOL was used to assess executive planning. The validity of this test was also reported as 0.79 (Mashhadi et al., 2009).

Millon Clinical Multiaxial Inventory-III (MCMI-III): Designed by Millon in 1994 based on the fourth revision of diagnostic and statistical guideline of mental disorder (DSM-IV-R) to measure disorders of axes one and two, this test contains 175 "yes or no" questions, and 28 scales in 5 levels (validity indices, clinical personality patterns, severe pathology of personality, clinical syndromes, and severe symptoms). The coefficient of the test-retest reliability has been reported 0.91 and 0.75. Furthermore, retesting reliability of guideline of MCMI-III has been reported 0.89 for personality scales and 0.91 for clinical scales (Groth-Marnat, 2009).

Ekman's 60 Facial Expressions Computer-Based Test: The Ekman 60 Faces Test uses an array of photographs from the Ekman and Friesen series of Pictures of Facial Affect (Ekman, 1976), measuring six basic emotions (happiness, sadness, disgust, fear, surprise and anger). All photographs are presented in order, with each disappearing after 5 seconds; in addition, names related to main emotions appear on a black screen. Participants should, then, choose the name of a related emotion considering the situation that was explained to them. The Ekman 60 Faces Test can be used to assess recognition of facial expressions of basic emotions. The maximum test score indicating best performance is 60 for all six emotions and 10 for each basic emotion.

Procedures

The participants were asked to avoid any stimulant beverages and medication for at least 12 hours and sleep deprivation 72 hours before the assessment session. Assessment was performed from 3 to 6 P.M. to control the effect of time on cognitive and emotional processing. An informed consent was obtained from all the subjects and was included in the study so that all ethical principles would be considered in the present study. The participants were informed about the purpose of the research and a written consent form was obtained from all of them. They were also assured about the confidentiality of their information and were free to leave the study at any point they wished to. Moreover, they were informed that, at their request, the research results would be available to them.

Data Analysis

Data analysis was performed using SPSS 19.0 software with descriptive statistics (frequency, mean, and standard deviation) and MANOVA, with the significance level set at $P < 0.05$.

Results

According to Table 1, the total sample was composed of 55 participants with BPD and 44 healthy individuals. Analysis of demographic characteristics of the sample showed that there was no significant difference between the mean age of the BPD with the healthy group ($t = 0.812$, $P= 0.41$).

Table 1

Demographic characteristics for all participants

		BPD (N=44)	Healthy (N= 44)
Female (Percent)		68%	68%
Male (Percent)		32%	32%
Age (Mean± SD [a])		32.29 ± 8.222	33.72 ± 8.328
Marital Status (Percent)	Single	43.2	63.6
	Married	45.5	25
	Widow/Divorced	11.4	11.4
Education (Percent)	Diploma	25	18.2
	Associate	2.3	4.5
	Bachelor	47.7	40.9
	Master	20.5	29.5
	Doctoral	4.5	6.8

Note: SD=Standard Deviation, BPD= borderline personality disorder.

According to results of MANOVA (Pillai's trace = 0.753, F (9, 78) = 26.367, P< 0.001, Eta squared= 0.753), there was significant in combined dependent variables (cognitive functions and emotional recognition) based on group type (BPD and healthy). It is worth noting that Bartlett's test results (X^2 = 301.41, P<0.001) indicated that the assumption of this test was met (correlation between dependent variables). Also, the results of Box's M test showed that the homogeneity of covariance was not met (Box's M= 88.92, P<0.001) but according to equality of sample size in both groups, MANOVA was robust regarding violation of this assumption. In the following, the results of the Univariate ANOVAs based on each dependent variable are presented with Bonferroni correction (see Table 2).

As it is shown in Table 2, BPD group scored lower than healthy group on anger recognition (F= 8.12, P= 0.005) but in fear (F= 23.59, P < 0.001), disgust (F= 10.89, P= 0.001) and sadness (F= 21.70, P< 0.001) BPD group significantly recognize emotions better than healthy group. In positive emotion such as happiness (F= 0.191, P= 0.66) and surprise (F= 0.677, P= 0.41) no significant difference was found.

In addition, healthy group outperformed BPD group on commission error (F= 39.65, P< 0.001) and TOL scores (F= 138.19, P< 0.001). There was no significant difference between groups on forward digit span (F= 2.75, P= 0.10) and omission error (F= 3.18, P= 0.78).

Since the BPD group was heterogeneous in terms of treatment status, so that 35 participants were under treatment and 9 participants had not received any treatment so far, in order to analyze BPD subgroups in addition to the MANOVA parametric test, due to the difference in the number of participants in the subgroups, Kruskal-Wallis non-parametric test was also used. In both methods of analysis, the results show a significant difference between groups in the components of fear (P<0.001), anger (P<0.05), disgust (P<0.01), sadness (P<0.001), commission error (P<0.001) and TOL score (P<0.001). Moreover, no significant differences were observed in the components of surprise and happiness. According to the results of the post hoc test in Table 3, there was a significant difference between each of the BPD subgroups with the healthy group in the components of fear, sadness, commission error and Tol score. In the components of anger (P= 0.025) and disgust (P<0.006), only a significant difference was found between the BPD-treated subgroup and the healthy group, and no significant difference was observed in the other components.

Table 2

Comparing Cognitive Functions and Emotional Recognition between BPD and Healthy Groups

Scales	Group	Mean ± SD	F	P	η^2
Fear [a]	BPD	8.27±1.207	23.59	<0.001	0.215
	Healthy	6.27±1.654			
Anger [a]	BPD	6.52±1.320	8.12	0.005	0.86
	Healthy	7.25±1.059			
Disgust [a]	BPD	8.63±0.966	10.89	0.001	0.112
	Healthy	7.90±1.095			
Sadness [a]	BPD	8.75±0.866	21.70	<0.001	0.202
	Healthy	7.79±1.047			
Surprise [b]	BPD	8.40±1.063	0.677	0.41	0.008
	Healthy	8.22±1.008			
Happiness [b]	BPD	8.93±0.997	0.191	0.66	0.002
	Healthy	9.02±0.952			
CPT: commission error	BPD	3.15±2.101	39.65	<0.001	0.316
	Healthy	0.93±1.041			
CPT: omission error	BPD	0.95±0.861	3.18	0.78	0.036
	Healthy	0.63±0.809			
TOL Score	BPD	21.59±3.014	138.19	<0.001	0.616
	Healthy	29.06±2.952			

Note: CPT= Continues Performance Test, TOL= Tower of London, a= Negative Emotion, b= Positive Emotion, BPD= Borderline Personality Disorder, SD=Standard Deviation, η2= Partial Eta Square.

Table 3

Results of Post-Hoc Tests by Pairwise Comparisons

Scale		Mean Difference	P [a]	Cohen's d
Fear	BPD-A Vs. BPD-B	-0.495	0.999	0.437
	BPD-B Vs. Healthy	1.894	0.002	1.385
	BPD-A Vs. Healthy	1.399	<0.001	0.954
Anger	BPD-A Vs. BPD-B	-0.041	0.999	0.032
	BPD-B Vs. Healthy	-0.694	0.356	0.634
	BPD-A Vs. Healthy	-0.736	0.025	0.598
Disgust	BPD-A Vs. BPD-B	0.102	0.999	0.107
	BPD-B Vs. Healthy	0.646	0.278	0.650
	BPD-A Vs. Healthy	0.748	0.006	0.713
Sadness	BPD-A Vs. BPD-B	-0.454	0.624	0.548
	BPD-B Vs. Healthy	1.316	0.001	0.887
	BPD-A Vs. Healthy	0.826	<0.001	0.567
Surprise	BPD-A Vs. BPD-B	-0.603	0.360	0.574
	BPD-B Vs. Healthy	0.662	0.246	0.641
	BPD-A Vs. Healthy	0.058	0.999	0.057
Happiness	BPD-A Vs. BPD-B	-0.365	0.958	0.329
	BPD-B Vs. Healthy	0.199	0.999	0.223
	BPD-A Vs. Healthy	-0.166	0.999	0.167
CPT: commission error	BPD-A Vs. BPD-B	0.619	0.963	0.345
	BPD-B Vs. Healthy	1.735	0.016	1.604
	BPD-A Vs. Healthy	2.354	<0.001	1.326
CPT: omission error	BPD-A Vs. BPD-B	0.083	0.999	0.098
	BPD-B Vs. Healthy	0.253	0.999	0.317
	BPD-A Vs. Healthy	0.335	0.246	0.394
TOL Score	BPD-A Vs. BPD-B	0.603	0.999	0.176
	BPD-B Vs. Healthy	-7.957	<0.001	2.282
	BPD-A Vs. Healthy	-7.354	<0.001	2.564

Discussion

The aim of this study was to investigate the differences between individuals with BPD and healthy individuals in emotional processing and cognitive functions.

The results revealed the high sensitivity of individuals with BPD in recognizing negative facial emotions (fear, sadness, hatred, except anger), but not in recognizing positive facial emotions (happiness and surprise) in comparison to the healthy individuals. This finding is consonant with the results of Ferreira et al. (2018) that reported higher recognition of negative emotions, especially fear, and the results of Hepp et al. (2017) which found higher sadness level in individuals with BPD. This finding could point out the difference between brain circuits related to the process of recognizing positive and negative emotions; that is, recognizing positive emotions requires higher cerebral cortex processes, which phylogenetically are newer areas in the brain (Williams, 2017).

Also, Furthermore, the BPD group performed the worst in recognizing anger, which is consistent with the findings of Bland et al. (2004), but there are also studies indicating that individuals with BPD are more sensitive to anger recognition and tend to perceive anger in vague images (Veague, 2003). In addition, these results can be explained from a cultural perspective. The importance of facial emotion recognition may vary in different cultures. Thus, conflicting results of facial recognition in different cultures could be expected. At the same time, dysfunction in some brain structures may prevent the proper recognition of anger in these participants. Similarly, Staebler et al. (2011) showed that individuals with BPD are more prone to negative perception of vague facial stimuli. Therefore, it could be said that individuals with BPD have a tendency to perceive negative emotion even when they are exposed to neutral faces. Moreover, the developmental psychopathology viewpoint indicated that emotion recognition, especially negative emotions, plays an important role in increasing a person's chances of survival (Ferretti & Papaleo, 2019). Added to the point, due to parenting style and parent-child relationships of individuals with BPD, being more authoritarian and abusive (Hernandez et al., 2012), their greater sensitivity to negative emotions can be expected. Still, there would be a difference in the importance of which negative emotion is more important to be perceived in different cultures or families.

In general, the performance of individuals with BPD in recognition of fear, disgust and sadness could be explained by the dysfunctional fronto-limbic model (Malhi et al., 2013). According to this model, when individuals with BPD are confronted with negative facial stimuli, emotion recognition occurs through an automatic process (Koenigsberg et al., 2009). Among basic emotions, anger requires more effort to process, which is why individuals with BPD perform worse in recognizing this emotion (Adolphs et al., 2005). Further, Matzke et al. (2014) reported that there is no significant emotion recognition deficit in BPD, and the deficit would occur only under specific circumstances. As emotion recognition could be affected by emotional context, instability of affect, which is fundamental psychopathology of BPD, could account for inconsistent findings in studies. Also, bias and sensitivity to negative emotions in individuals with BPD can be due to amygdala hyperactivity (Sicorello & Schmahl, 2020). Altogether, individuals with BPD tend to perceive neutral facial stimuli as negative stimuli, and this factor causes them to anticipate fear and threat. These findings have some clinical implications with particular relevance for psychotherapy in BPD. Given this pattern of emotional processing in BPD, therapists must be more aware of their own facial expressions and should provide feedback on the clients' possible misinterpretations in every session.

Continued in the same vein, the results showed that the healthy group outperformed BPD group on sustained attention and response inhibition, which is consistent with the previous studies (Gvirts et al., 2012; Hagenhoff et al., 2013). Jacob et al. (2013) by using FMRI showed that individuals with BPD have defects in the prefrontal-amygdala network, which is involved in the response inhibition. One added point is that Lazzaretti et al. (2012) have reported dysfunction on sustained attention in individuals with BPD. Furthermore, the results showed that the healthy group outperformed the BPD group on executive planning. Considering the impairment of the frontal lobe and other regions

such as the amygdala and prefrontal in individuals with BPD (Salavert et al., 2011), and the role of these structures in the sustained attention, response inhibition and executive planning (Lis et al., 2007), one could explain their deficits in cognitive functions in connection with fronto-limbic regions (Eling et al., 2008). This could have a negative effect on effective communication (Ruocco, 2005). Although DBT techniques address emotional dysregulation in individuals with BPD, but a specified approach is yet to be defined for rehabilitation of executive functions. The clinical implication of these findings is that cognitive dysfunctions might influence the success of the treatment and prognosis of BPD.

Limitation

One of the most important limitations of the present study is with regards to generalizability of its results; that is, due to the convenient sampling, the results would be generalized only to members of this group. Therefore, it is suggested that in the future, a random sampling method could be used in sample selection. Moreover, medication intake could limit the external validity of the findings of this study. Also, using biological indicators such as EEG and fMRI would be preferable to achieve more precise results.

Conclusion

All in all, it could be concluded that BPD leads to high sensitivity in recognition of negative emotion (especially disgust, sadness, fear), as individuals with BPD interpret even neutral social cues negatively, which could be due to overactive amygdala. Furthermore, healthy individuals outperformed participants with BPD on cognitive functions such as response inhibition and executive planning, which may be due to disturbance in the frontal cortex of individuals with BPD. Since the underlying brain structures and circuits involved in cognitive functions and face emotion recognition are similar, it could be expected that using cognitive rehabilitation-focused techniques, in addition to cognitive functions would also improve the emotional recognition skills in individuals with BPD. Further research is needed to clarify this hypothesis. More specific neuropsychological tests and functional imaging studies should be performed to specify the underlying brain pathology of BPD and differentiate it from other comorbid psychiatric conditions.

Author Note:

All the authors actively participated in conceptualization, methodology, editing & review; Zeynab Alimadadi and Azam Baktashian contributed in administering the investigation, preparing the resources, original draft preparation, and visualization; Saeed Azami contributed in supervision and data analysis.

Statements:

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