

Relationships Between Borderline Personality Disorder Traits and Emotional Reactivity and Reinforcement Sensitivity Systems: Network and Mediation Analysis

Borderline Kişilik Bozukluğu Özellikleri ile Duygusal Tepkisellik ve Pekiştireç Duyarlılık Sistemleri Arasındaki İlişkiler: Ağ ve Aracılık Analizi

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ABSTRACT

Objective: This study aimed to examine the relationships between borderline personality disorder and emotional reactivity and reinforcement sensitivity systems through multidimensional analyses. Specifically, it was aimed to evaluate the mediating roles of the emotional reactivity in the relationships between borderline personality disorder and behavioral inhibition system and also the freeze.

Method: A total of 601 adults, 80% female (n = 481) and 20% male (n = 120), aged between 18 and 53 (M = 22.51, SD = 4.11), participated in the study. Based on the data obtained from the participants, the relationships among the personality disorder dimensions, reinforcement sensitivity systems (behavioral inhibition system, behavioral activation system, and fight-flight-freeze system), and emotional reactivity subdimensions were assessed using Pearson correlation-based and Gaussian partial correlation-based network analyses. Based on centrality measures obtained from the network analysis, the most influential variables were identified. Then, the mediating roles of the emotional reactivity subdimensions in the relationships between borderline personality disorder and the behavioral inhibition system and the freeze system were tested using PROCESS Macro Model 4.

Results: Gaussian graphical model findings indicated that borderline personality disorder occupies a central position within the network structure and that both the behavioral inhibition system and the freeze system established strong relationships with the emotional reactivity dimensions. Mediation analyses revealed that the negative activation and negative intensity subdimensions had a significant mediating role in the relationship between borderline personality disorder traits and both motivational systems.

Conclusion: The findings demonstrate the theoretical and clinical importance of considering the interaction between reinforcement sensitivity systems and negative emotional reactivity in the emergence and maintenance processes of borderline personality disorder.

Keywords: Borderline personality disorder, emotional reactivity, reinforcement sensitivity systems

ÖZ

Amaç: Bu çalışmanın amacı, borderline kişilik bozukluğu özellikleri ile duygusal tepkisellik ve pekiştireç duyarlılık sistemleri arasındaki ilişkileri çok boyutlu analizlerle incelemektir. Özellikle, davranışsal inhibisyon sistemi ve donma tepkisinin borderline kişilik bozukluğu özellikleri ile ilişkilerinde duygusal tepkisellik alt boyutlarının aracılık rollerinin değerlendirilmesi hedeflenmiştir.

Yöntem: Araştırmaya, yaşları 18 ile 53 arasında değişen (ortalama = 22,51, standart sapma = 4,11), %80'i kadın (n = 481) ve %20'si erkek (n = 120) olmak üzere toplam 601 yetişkin birey katılmıştır. Katılımcılardan elde edilen veriler doğrultusunda, kişilik bozukluğu boyutları, pekiştireç duyarlılık sistemleri (davranışsal inhibisyon sistemi, davranışsal aktivasyon sistemi ve dövüş-kaç-don sistemi) ve duygusal tepkisellik alt boyutları arasındaki ilişkiler Pearson korelasyon temelli ve Gaussian kısmi korelasyon temelli ağ analizleri ile değerlendirilmiştir. Ağ analizinden elde edilen merkezîyet ölçütlerine dayanarak en etkili değişkenler belirlenmiş, ardından borderline kişilik bozukluğu özellikleri ile davranışsal inhibisyon sistemi ve donma tepkisi arasındaki ilişkilerde duygusal tepkisellik alt boyutlarının aracılık rolleri PROCESS Macro Model 4 ile test edilmiştir.

Bulgular: Gaussian grafiksel model bulguları, borderline kişilik bozukluğu özelliklerinin ağ yapısı içerisinde merkezi bir konumda yer aldığını ve hem davranışsal inhibisyon sistemi hem de donma tepkisinin duygusal tepkisellik boyutlarıyla güçlü ilişkiler kurduğunu göstermiştir. Aracılık analizlerinde, negatif aktivasyon ve negatif yoğunluk alt boyutlarının, borderline kişilik bozukluğu özellikleri ile her iki motivasyonel sistem arasındaki ilişkide anlamlı düzeyde aracı role sahip olduğu tespit edilmiştir. **Sonuç:** Elde edilen bulgular, borderline kişilik bozukluğunun ortaya çıkış ve sürdürülme süreçlerinde pekiştireç duyarlılık sistemleri ile olumsuz duygusal tepkisellik arasındaki etkileşimin dikkate alınmasının kuramsal ve klinik açıdan önemli olduğunu ortaya koymaktadır.

Anahtar sözcükler: Borderline kişilik bozukluğu, duygusal tepkisellik, pekiştireç duyarlılık sistemleri

Introduction

Personality disorders are defined as personality structures characterised by rigid, persistent patterns of emotion, thought, and behaviour that significantly impair social, occupational, or personal functioning (American Psychiatric Association [APA] 2013). These disorders typically begin in adolescence or early adulthood, and are characterised by lifelong, enduring patterns (Millon et al. 2004, APA 2013). Personality disorders are associated with serious impairments in fundamental psychological domains such as self-perception, interpersonal relationships, emotional experiences, and impulse control. Frequently encountered in clinical practice, these disorders not only negatively affect individuals' quality of life but also create significant psychosocial burdens on those around them (Paris 2003). Therefore, comprehensive and systematic research is needed to better understand the causes of personality disorders, their perpetuating mechanisms, and their relationships with different psychological structures.

One of the personality disorders most extensively studied in the literature is borderline personality disorder (BPD) (McLaren et al. 2022, Bozzatello et al. 2024, Crotty et al. 2024). BPD is a complex and multidimensional mental disorder characterised by inconsistencies in emotional, cognitive, and interpersonal functioning, as well as by impulsive behaviours (APA 2013). Individuals with BPD often experience intense and rapidly changing moods, feelings of emptiness, identity confusion, recurrent suicidal thoughts or self-harming behaviours, outbursts of anger, and unstable close relationships (Linehan 1993). These characteristics create a persistent imbalance in both the individual's experience and their social relationships. Clinical observations indicate that BPD is particularly associated with excessive sensitivity to negative emotions, an inability to regulate emotions, and increased cognitive distortions in stressful situations (Leichsenring et al. 2024).

Although there are many biological, cognitive, and environmental explanations for the origins of borderline personality disorder (Linehan 1993, Bozzatello et al. 2021, Leichsenring et al. 2024, Giannoulis et al. 2025), the relationship between neuropsychological systems that regulate an individual's responses to environmental stimuli and personality structures has increasingly been investigated (DeYoung and Gray 2009, Massó Rodriguez et al. 2021). Given that core features of borderline personality disorder, such as emotional instability, intense anxiety, and impulsivity, may be related to sensitivity to positive and negative reinforcement, Reinforcement Sensitivity Theory (RST), one of the important approaches to explaining the neuropsychological basis of personality, has come to the fore.

RST was developed by Gray (1981) and later revised by Gray and McNaughton (2000). The theory explains interpersonal differences in emotion, thought, and behaviour through three primary motivational systems. These systems are modelled as: 1) the behavioural activation system (BAS), 2) the behavioural inhibition system (BIS), and 3) the fight/flight/freeze system (FFFS). According to RST, overactivation or underactivation of these systems creates differences in fundamental areas such as emotional reactivity, anxiety, impulsivity, and motivation, and these differences contribute to the development of personality disorders (Pickering and Corr 2008). The BIS regulates sensitivity to environmental stimuli such as threat, punishment, and uncertainty. Its overactivation leads to a state of constant vigilance, increased anxiety, and avoidance-based behaviours. The BAS promotes positive affect and motivation by regulating reward anticipation and approach-oriented behaviours. This system increases sensitivity to potentially rewarding stimuli and facilitates the initiation and maintenance of goal-directed behaviours. The FFFS, in conjunction with the sympathetic nervous system, is the system responsible for eliciting flight, freeze, or fight responses in the face of a dangerous stimulus (Gray and McNaughton 2000, Johnson et al. 2003).

When the relationship between borderline personality traits and the Behavioral Inhibition System (BIS) and Behavioral Activation System (BAS) is evaluated within the context of Gray's Reinforcement Sensitivity Theory, symptoms such as emotional instability, outbursts of anger, and intense fear of abandonment, frequently observed in individuals with borderline personality traits, exhibit a pattern consistent with BIS hypersensitivity (Rosenthal et al. 2008, Corr et al. 2013). However, not only BIS but also BAS plays an important role in understanding borderline personality structure. In individuals with borderline personality disorder, increased BAS sensitivity may lead to behaviours such as impulsive reward seeking, risky decision-making, and short-term pleasure orientation (McLaren et al. 2022, Bozzatello et al. 2024, Crotty et al. 2024). The excessive activity of both systems can create inconsistencies in responses to stimuli, both in terms of avoidance and approach, paving the way for sudden mood swings, impulsive behaviours, and interpersonal conflicts observed in borderline personality disorder (Linehan 1993, APA 2013).

It is observed that not only neuropsychological systems but also an individual's responses to emotional stimuli play an important role in explaining personality structures (Rosenthal et al. 2008, Shapero et al. 2019, Preece et

al. 2023). At this point, emotional reactivity can be considered as one of the determining variables that play a role in the formation of personality traits and psychopathological patterns (Förster et al. 2022). Emotional reactivity is defined by the intensity, duration, and threshold of an individual's response to an emotional stimulus (Davidson 1998, Preece et al. 2019). It is known that there are significant differences in the activation level and continuity of emotional responses, as well as in the way emotion is processed among individuals, and that these differences affect both cognitive and behavioural functioning (Lucas and Baird 2004, Becerra and Campitelli 2013).

Recent research has revealed that individuals with high levels of emotional reactivity have difficulty processing negative emotions, in particular, and that this is associated with various psychological disorders (Rosenthal et al. 2008, Shapero et al. 2019). Silbersweig et al. (2007) found that individuals with borderline personality disorder exhibited decreased activation in the medial orbitofrontal cortex and subgenual anterior cingulate regions during tasks requiring behavioural inhibition in the presence of negative emotions, while exhibiting increased activation in limbic regions such as the amygdala and ventral striatum. It can be hypothesised that these functional impairments lead to the prefrontal cortex's inability to perform functions such as behavioural inhibition and impulse control, which in turn leads to increased impulsive behaviour. Similarly, recent neuroimaging findings have highlighted functional impairments in BPD, particularly in prefrontal-limbic circuits related to emotional processing and social cognition. In particular, imbalances between limbic structures such as the amygdala and regulatory regions such as the medial prefrontal and anterior cingulate cortex result in intense affect and inadequate metacognitive control (Krause-Utz et al. 2014, Massó Rodriguez et al. 2021). These neurobiological findings provide important clues for explaining the functional connectivity issues underlying clinical symptoms such as impulse control difficulties and emotional overreactivity in borderline individuals. At this point, it can be argued that experiencing intense, prolonged, and difficult-to-regulate negative emotions such as frustration or fear, along with overactivation of reinforcement sensitivity systems, may constitute specific risk profiles for borderline personality disorder (Bilge and Sertel Berk 2017). Consequently, in explaining the etiology of borderline personality disorder, considering the individual's responses to emotional stimuli and reinforcement sensitivity systems together will enable more comprehensive and functional explanations.

On the other hand, when looking at studies in the field of psychopathology, it is observed that such relationships are mostly examined using traditional statistical analysis methods (Bilge and Sertel Berk 2017, Bozzatello et al. 2021, Giannoulis et al. 2025). These methods generally include statistical techniques based on Pearson correlation coefficients, such as correlation analyses, regression models, or structural equation modelling. The most important advantage of traditional methods is their ability to statistically reveal the direction and strength of relationships between variables and provide summary indicators suitable for interpretation. However, these methods often address the relationships between pairs of variables independently, which limits their ability to visualise the interactional structure of the entire system and examine the complex network structure between variables. This limitation makes it difficult to fully understand the multidimensional and interactional nature of psychopathology. In order to eliminate these disadvantages, in recent years, the network analysis approach, which simultaneously considers the direct and indirect relationships between variables in explaining psychopathology, has begun to be used (Campbell and Osborn 2021, McNally 2021, Chavez-Baldini et al. 2023, Güreşen 2024).

Network analysis treats psychological variables as interconnected nodes and visualises the relationships between these nodes through edges. This method allows for a detailed examination of variables' structural positions within the system, centrality measures, and their direct relationships with other variables (Epskamp and Fried 2018). Gaussian-Based Network Models (GGM), in particular, can control for indirect effects by relying on partial correlations between psychological variables, thus providing more reliable relationship structures. Furthermore, the "expected influence" centrality measure, used to determine the relative influence of a variable within the network, contributes significantly to identifying which structures are more determinant of psychopathology (Robinaugh et al. 2016). In these respects, network analysis offers a more dynamic and functional framework for explaining the multiple interactions underlying personality disorders compared to classical analysis techniques.

This study aims to contribute to a more comprehensive understanding of the relationships between personality disorders and emotional and motivational systems. To this end, an approach combining structural and functional analyses was adopted to overcome the limitations of traditional methods, using data from Balaban's (2023) doctoral dissertation. This study aims to conduct two main analyses: (1) to examine the relationships among personality disorders, the Reinforcement Sensitivity System components [Behavioral Inhibition System (BIS), Behavioral Activation System (BAS), and Fight-Flight-Freeze system (FFFS)], and the sub-dimensions of

emotional reactivity using Pearson and Gaussian-based network models (GGM) and to identify the most central variables in the network; (2) to test the mediating roles of the BIS and Freeze components, selected from among the variables with high expected influence scores obtained from the GGM, in the relationships with borderline personality disorder traits.

In this regard, it can be said that the fundamental element that makes the present study original is the multilevel analysis of both the structural and functional relationships of borderline personality disorder traits. In particular, revealing the complex interaction patterns formed by BPD with psychological variables at the network level using Gaussian graphical models is an approach that has been addressed in a limited number of studies in the literature (Wang et al. 2024, Yun et al. 2024). Furthermore, the validation of the central variables identified in the network analysis using mediation models offers a more holistic and dynamic model as an alternative to classical approaches. In this respect, the study presents a unique methodological framework that contributes to both explaining the position of BPD in a psychopathological context and determining target variables in clinical intervention areas.

Method

Sample

Data were collected in accordance with the principles of accessibility and convenience. One of the inclusion criteria was that participants be at least 18 years of age. Additionally, any response other than "Strongly False" to either of the two control items (items 55 and 70) on the Coolidge Axis II Inventory Plus Turkish Short Form (CATI+TR-SF) used in the study was an exclusion criterion, as it could cast doubt on the reliability of the data. Therefore, a total of 631 participants were initially contacted for the study. However, the data of 30 participants who did not respond "Strongly False" to the CATI+TR-SF control items were excluded from the analysis. Consequently, the study sample consisted of 601 participants. Participants were 80% female ($n = 481$) and 20% male ($n = 120$), and their ages ranged from 18 to 53 ($M = 22.51$, $SD = 4.11$). Information on participants' gender, education level, marital status, socioeconomic level, and psychological help status is presented in Table 1.

Table 1. Socio-demographic characteristics of participants

Variable		n	%
Gender	Female	481	80.0
	Male	120	20.0
Education	Primary School	1	0.2
	High School	4	0.7
	University and above	596	99.2
Marital Status	Single	560	93.2
	Married	37	6.2
	Divorced	2	0.3
	Widowed	1	0.2
Socioeconomic Status	Low	33	5.5
	Middle	510	84.9
	High	54	9.0
Receiving Psychological Support	Yes	56	9.3
	No	541	90.0
Need for Psychological Support	Yes	301	50.1
	No	295	49.1

Procedure

Ethical clearance for this study was obtained from the Ethics Committee of Istanbul Sabahattin Zaim University, dated 31 December 2021, numbered 2021/12. The study was conducted at Istanbul Sabahattin Zaim University. The application process for the research was carried out by the researchers. The data obtained from the participants were used solely for research purposes, and were protected in accordance with the principle of confidentiality, and were not shared with third parties under any circumstances. Data collection was carried out entirely voluntarily. On the first page of the questionnaire containing the questions, an informed consent form was given to participants, and they were informed that they could withdraw their participation at any time. G*Power software (Erdfelder et al. 1996) was used to determine the sample size. With a significance level of 0.05, a medium effect size (0.30) and a power of 0.80, the minimum required sample size was calculated to be 246. A total of 601 individuals participated in the study, and the resulting power was found to be 0.99.

The variables to be included in the mediation analysis were selected based on centrality measures obtained from the Gaussian Graphical Model (GGM). First, to assess the network structure in general terms, strength, closeness, and betweenness centrality measures were calculated. The strength centrality measure represents the sum of the absolute edge weights attached to a node and indicates how strongly a variable is directly connected to others. Closeness, on the other hand, indicates how easily and quickly a variable can be reached from other nodes in the network. The betweenness centrality measure indicates the probability that a node acts as a bridge between other nodes (Freeman 1977). It is argued that high-betweenness nodes often function as "mechanisms" connecting different symptom clusters or psychological constructs (Jones et al. 2021).

However, as recommended in psychological network analyses, Expected Influence (EI) was used as the primary selection criterion. Expected influence is a centrality measure that takes into account both positive and negative edge weights and allows for a more comprehensive assessment of a node's connectivity than the strength centrality measure. Therefore, expected influence is widely considered an important indicator used to identify influential nodes in network analyses (Borsboom and Cramer 2013, Robinaugh et al. 2016).

In determining the variables to be included in the mediation analysis, the variable with the highest EI value for each domain (reinforcement sensitivity systems, emotional reactivity components, personality disorders) was identified and compared with other variables within the same domain. Analyses revealed that the scores for the BIS, Freeze, Borderline Personality Disorder, and emotional reactivity components (except Positive Duration) were suitable for mediation analysis. Based on these findings, BIS and Freeze were included as independent variables in the mediation model, with Borderline Personality Disorder as the dependent variable, and all other emotional reactivity components (except Positive Duration) as mediators.

Measures

Demographic Information Form

A form containing information about participants' gender, age, education level, marital status, economic status, and whether they had received psychological or psychiatric help was prepared by the researchers.

Coolidge Axis II Inventory Plus Turkish Short Form (CATI+TR-SF)

CATI+TR-SF (Bilge 2018) is the Turkish adaptation and shortened version of the 250-item CATI+. It consists of a total of 78 items and is a four-point Likert-type scale (1 = strongly false, 2 = more false than true, 3 = more true than false, 4 = strongly true). In the Turkish validity and reliability study, 648 individuals (49.8% male, 50.2% female; mean age = 34.89 ± 11.08) were included as the community sample and 138 individuals (35.5% male, 64.5% female; mean age = 31.01 ± 10.03) were included in the study as the clinical sample. Cronbach's alpha values for the personality disorder subscales of CATI+TR-SF ranged from 0.66 to 0.77. In the test-retest analysis, correlation coefficients were found to be between 0.77 and 0.89.

Reinforcement Sensitivity Questionnaire (RSQ)

The Turkish validity and reliability study of the scale, which was developed in accordance with the Reinforcement Sensitivity Theory (RST) revised by Smederevac et al. (2014), was conducted by Balaban and Bilge (2021a). The scale consists of 27 items and is a four-point Likert-type scale (1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree). In the original version of the scale, Cronbach's alpha values for the subscales were 0.86 for BIS, 0.78 for BAS, 0.82 for Fight, 0.69 for Flight, and 0.87 for Freeze. In the Turkish adaptation study, these values were found to be 0.81 for BIS, 0.71 for BAS, 0.78 for Fight, 0.83 for Flight, and 0.82 for Freeze. In convergent validity analyses, it was determined that the correlation coefficients between the RSQ subscales and the Eysenck Personality Inventory, the STAI-II Anxiety Inventory, and the BIS/BAS Scale ranged from 0.22 to 0.65.

Perth Emotional Reactivity Scale-Short Form (PERS-SF)

The Perth Emotional Reactivity Scale-Short Form (PERS-SF) was developed by Preece and colleagues (2019). The scale consists of 18 items and is a five-point Likert-type scale (1 = strongly disagree, 5 = strongly agree). It includes two composite scales (general negative emotional reactivity, general positive emotional reactivity) and six subscales (negative activation, negative intensity, negative duration, positive activation, positive intensity, positive duration). In the Turkish validity and reliability study conducted by Balaban and Bilge (2021b), Cronbach's alpha values for the subscales were found to range from 0.76 to 0.92. Higher scores on the scale indicate that individuals' emotions are activated more quickly, experienced more intensely, and persist longer.

Statistical Analysis

All analyses were conducted using IBM SPSS version 25 and the R programming language. First, an independent samples t-test was conducted to determine whether variables differed significantly by gender. In this context, subscales related to reinforcement sensitivity systems (BIS, BAS, Fight, Flight, Freeze), emotional reactivity components (negative and positive duration, intensity, and activation), and personality disorders were compared by gender. Analyses related to gender were conducted for exploratory purposes to observe the potential effects of an unbalanced distribution in the sample, particularly due to the high proportion of female participants.

Centrality measures derived from the Gaussian Graphical Model (GGM) and the Pearson correlation-based network structure were used to select variables for inclusion in the mediation models. GGM analysis was conducted using the Least Absolute Shrinkage and Selection Operator (LASSO) method. Variables included in the network analyses included reinforcement sensitivity subscales, emotional reactivity components, and personality disorder scores. In addition to centrality measures such as strength, closeness, and betweenness, expected influence (EI) values, recommended in psychological network analyses, were also considered in the assessment of network structures.

Two methods were used to determine the sub-dimension with the highest EI value in each theoretical domain (reinforcement sensitivity systems, emotional reactivity, personality disorders) and to test whether it differed significantly from the other sub-dimensions: (i) A one-sample t-test was used to test whether the variable with the highest EI value was significantly higher than the mean EI value of other sub-dimensions in the same construct. (ii) Bootstrap difference tests were conducted with 2000 resamples, and confidence intervals were obtained. Holm-Bonferroni correction was applied for multiple comparisons. To examine the differences between the expected influence (EI) values, a paired-samples t-test was applied between variables with the highest EI value and the other sub-dimensions.

Mediation analyses were conducted using SPSS v.25 and based on PROCESS Macro Model 4 (Hayes 2018). Each analysis was conducted using 5,000 bootstrapped samples, and the indirect effect was considered statistically significant if the 95% confidence interval did not include zero. In the mediation models, the independent variables were "BIS" and "Freeze," the mediator variables were the emotional reactivity subscales (negative intensity, negative duration, negative activation, positive activation, positive intensity), and the borderline personality disorder score was the dependent variable.

Results

Comparison Analysis by Gender

An independent samples t-test was conducted to examine whether the subscales of the CATI+TR-SF, RSQ, and PERS-SF scales differed by gender. The analysis results revealed that male participants scored significantly higher than female participants on the Schizotypal Personality Disorder ($t(599) = -4.20, p < .001$), Schizoid Personality Disorder ($t(599) = -2.86, p = .004$), Antisocial Personality Disorder ($t(162.04) = -5.53, p < .001$), BAS ($t(218) = -2.33, p = .021$), and Fight ($t(599) = -2.74, p = .006$) subscales.

Female participants scored significantly higher than male participants on Avoidant Personality Disorder ($t(599) = 2.43, p = .015$), BIS ($t(599) = 3.38, p = .004$), Flight ($t(599) = 7.16, p < .001$), Freeze ($t(208.44) = 5.23, p < .001$), Negative Activation ($t(599) = 2.52, p = .012$), Negative Intensity ($t(599) = 2.13, p = .033$), Negative Duration ($t(599) = 3.05, p = .002$), Positive Activation ($t(599) = 3.12, p = .002$) and Positive Intensity ($t(599) = 1.97, p = 0.050$) subscales. No statistically significant differences were found for the other subscales (Table 2).

Results of Network Analysis

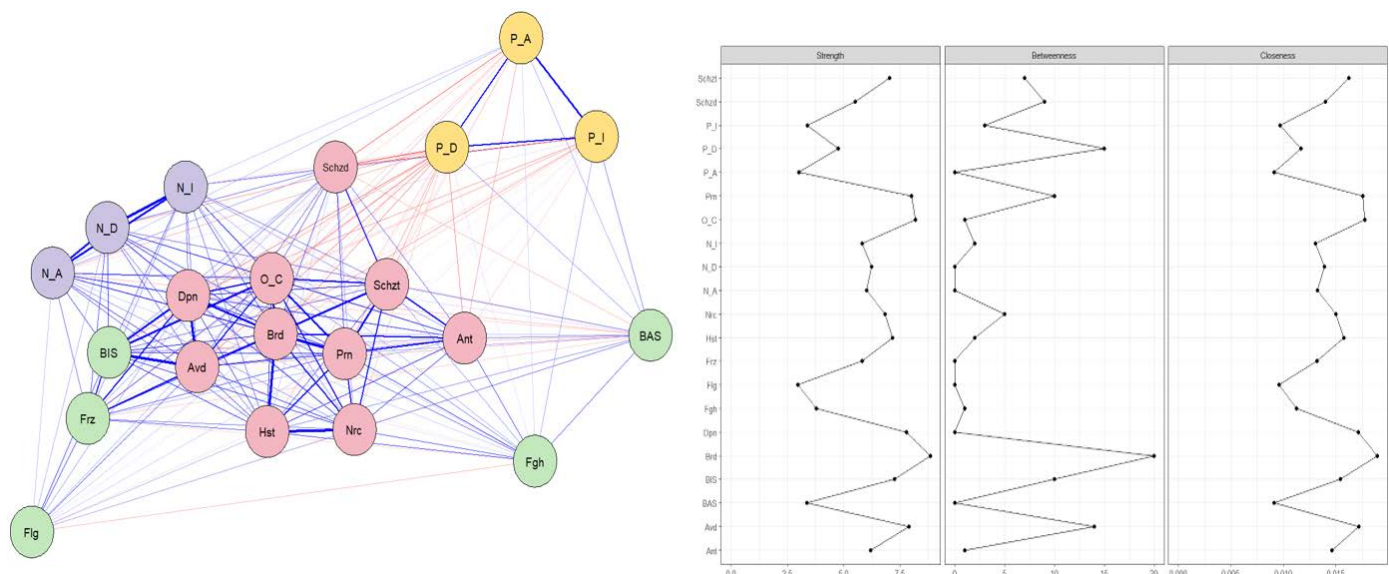
Pearson-Based Network Analysis

The analysis revealed 21 nodes with 117 non-zero edges out of a possible 210, and the model had a network density of 0.56. The network analysis revealed a high degree of connectivity, indicating that most variables are directly or indirectly related to each other. In the overall topology, variables related to personality disorders and emotional reactivity were clustered in close proximity, while the BAS and Fight subscales of the Reinforcement Sensitivity Systems were positioned distinctly from the other components of the Reinforcement Sensitivity Systems.

Table 2. Comparison of subscales by gender

Variables	Subscales	Female		Male				95% CI	
		M	SD		M	SD	t	p	Lower
CATI+TR-SF	Paranoid	16.89	4.83	17.57	4.74	-1.37	.171	-1.638	0.291
	Schizoid	15.53	3.72	16.62	3.85	-2.86	.004	-1.842	-0.341
	Schizotypal	14.14	4.56	16.09	4.48	-4.20	.000	-2.859	-1.037
	Antisocial	12.46	3.57	14.82	4.31	-5.53	.000	-3.197	-1.514
	Borderline	19.33	5.62	19.74	5.69	-0.71	.481	-1.535	0.723
	Histrionic	16.71	3.84	16.42	3.79	0.73	.466	-0.483	1.053
	Narcissistic	20.56	4.39	20.98	4.59	-0.94	.348	-1.312	0.463
	Avoidant	18.18	4.77	17.02	4.48	2.43	.015	0.224	2.112
	Dependent	13.65	4.06	13.60	4.20	0.12	.908	-0.772	0.868
	Obs_Comp	20.92	4.91	21.26	4.98	-0.67	.502	-1.324	0.649
RSQ	BIS	17.74	4.90	16.08	4.48	3.57	.001	0.744	2.580
	BAS	13.52	3.05	14.14	2.48	-2.06	.040	-1.209	-0.029
	Fight	11.98	3.38	12.91	3.22	-2.74	.006	-1.607	-0.264
	Flight	15.10	2.84	12.97	3.21	7.16	.000	1.547	2.715
	Freeze	10.98	3.85	9.17	3.28	4.76	.000	1.066	2.566
PERS-SF	Neg_Act	10.24	2.99	9.48	2.79	2.52	.012	0.169	1.352
	Neg_Int	10.58	3.17	9.90	2.90	2.13	.033	0.054	1.303
	Neg_Dur	9.67	2.88	8.76	3.08	3.05	.002	0.324	1.494
	Pos_Act	11.79	2.48	11.02	2.20	3.12	.002	0.286	1.257
	Pos_Int	11.60	2.49	11.11	2.29	1.97	.050	0.001	0.983
	Pos_Dur	10.61	2.56	10.12	2.41	1.90	.059	-0.018	0.996

Neg_Act = Negative Activation, Neg_Int = Negative Intensity, Neg_Dur = Negative Duration, Pos_Act = Positive Activation, Pos_Int = Positive Intensity, Pos_Dur = Positive Duration, Obs_Comp = Obsessive-Compulsive Personality Disorder, CATI+TR-SF = Coolidge Axis II Inventory Plus Turkish Short Form, RSQ = Reinforcement Sensitivity Questionnaire, PERS-SF = Perth Emotional Reactivity Scale, BIS = Behavioral Inhibition System, BAS = Behavioral Activation System

**Figure 1. Pearson correlation-based network analysis and centrality measures**

Prn = Paranoid Personality Disorder; Schzd = Schizoid Personality Disorder; Schzt = Schizotypal Personality Disorder; Ant = Antisocial Personality Disorder; Brd = Borderline Personality Disorder; Hst = Histrionic Personality Disorder; Nrc = Narcissistic Personality Disorder; Avd = Avoidant Personality Disorder; Dpn = Dependent Personality Disorder; O_C = Obsessive Compulsive Personality Disorder; BIS = Behavioral Inhibition System; BAS = Behavioral Activation System; Fgh = Fight; Flg = Flight; Frz = Freeze; N_A = Negative Activation; N_I = Negative Intensity; N_D = Negative Duration; P_A = Positive Activation; P_I = Positive Intensity; P_D = Positive Duration

In the Pearson correlation-based network analysis, three centrality measures were used to evaluate nodes: Strength, Closeness, and Betweenness. In terms of the strength centrality measure, the highest scores were found for Borderline Personality Disorder, Obsessive-Compulsive Personality Disorder, and Paranoid Personality Disorder. Other notable nodes with high strength included Avoidant Personality Disorder, Dependent Personality Disorder, and Histrionic Personality Disorder. When closeness centrality measure, which

indicates the proximity of a node to other nodes in the network, was assessed, the most central nodes were found to be Borderline Personality Disorder, Obsessive-Compulsive Personality Disorder, and Paranoid Personality Disorder. In terms of the betweenness centrality measure, Borderline Personality Disorder showed the highest value. This result suggests that Borderline Personality Disorder is centrally located and that personality traits associated with this disorder may act as a mediator between different clusters. Paranoid Personality Disorder, BIS, Positive Duration, and Avoidant Personality Disorder can also be considered significant mediating variables. Additionally, nodes such as Flight, BAS, Positive Activation, and Dependent Personality Disorder were found to have low centrality values across all three centrality measures (Table 3). The distribution of strength, closeness, and betweenness centrality measures for each node are presented in Figure 1.

Gaussian Partial Correlation Network Analysis

The Gaussian Graphical Model (GGM) was applied to examine the partial correlations among the variables included in the study. All partial correlations were generated using a graphical LASSO regularisation approach with standardised data. Four centrality measures were calculated to identify the most influential variables in the Gaussian Graphical Model (GGM): strength, closeness, betweenness, and expected influence. When strength centrality values were examined, it was found that "Borderline Personality Disorder," "Obsessive-Compulsive Personality Disorder," and "Paranoid Personality Disorder" had the highest scores. Furthermore, "Flight" and "Positive Activation" were identified as the variables with the lowest strength centrality values. In terms of the closeness centrality measure, the highest values were found in "Borderline Personality Disorder," "Obsessive-Compulsive Personality Disorder," and "Paranoid Personality Disorder." This result suggests that these personality disorders occupy a central position within the network structure. The lowest closeness values were observed in the "Positive Activation" and "BAS" variables. When examining the betweenness centrality measure, "Borderline Personality Disorder," "Positive Duration," and "Avoidant Personality Disorder" were identified as the main bridge nodes within the network. These findings suggest that traits associated with specific personality disorders may have a mediating role between different psychological and emotional variables. In addition to traditional centrality measures, expected influence (EI) was also calculated to provide a more comprehensive overview of each node's importance within the network. In this analysis, "Borderline Personality Disorder" was found to have the highest expected influence, while "Obsessive-Compulsive Personality Disorder", "Paranoid Personality Disorder", and "Avoidant Personality Disorder" also showed high expected influence scores. However, nodes such as Flight, BAS, and Freeze had low expected influence scores (Table 3)(Figure 2).

Table 3. Centrality measures and predictability estimates for each node across Pearson and Gaussian networks

Variable	Pearson			Gaussain			
	Strength	Closeness	Betweenness	Strength	Closeness	Betweenness	Expected Influence
Paranoid	8.01	0.0175	10	1.18	0.0041	8	1.18258
Schizoid	5.51	0.0140	9	1.24	0.0039	14	0.07212
Schizotypal	7.03	0.0162	7	1.28	0.0041	13	1.17477
Antisocial	6.19	0.0146	1	1.09	0.0038	3	0.59000
Borderline	8.84	0.0189	20	1.45	0.0044	30	1.27753
Histrionic	7.16	0.0157	2	1.20	0.0039	11	0.92063
Narcissistic	6.82	0.0150	5	0.98	0.0037	5	0.95986
Avoidant	7.90	0.0172	14	1.33	0.0040	19	0.95061
Dependent	7.77	0.0171	0	1.12	0.0040	15	0.82851
Obs_Comp	8.18	0.0177	1	1.06	0.0039	9	1.03789
BIS	7.25	0.0154	10	1.27	0.0040	23	0.99503
BAS	3.35	0.0091	0	1.14	0.0038	4	0.43423
Fight	3.78	0.0112	1	1.09	0.0038	7	0.55525
Flight	2.95	0.0096	0	0.71	0.0029	1	0.35948
Freeze	5.81	0.0132	0	0.83	0.0032	5	0.73279
Neg_Act	6.02	0.0132	0	1.16	0.0036	24	0.76721
Neg_Int	5.82	0.0130	2	1.05	0.0034	14	1.00278
Neg_Dur	6.24	0.0139	0	1.04	0.0033	5	0.89422
Pos_Act	3.00	0.0091	0	0.97	0.0032	1	0.63480
Pos_Int	3.38	0.0097	3	1.25	0.0034	16	0.96261
Pos_Dur	4.76	0.0117	15	1.06	0.0033	6	0.32807

Obs_Comp = Obsessive Compulsive Personality Disorder; BIS = Behavioural Inhibition System; BAS = Behavioural Activation System; Neg_Act = Negative Activation; Neg_Int = Negative Intensity; Neg_Dur = Negative Duration; Pos_Act = Positive Activation; Pos_Int = Positive Intensity; Pos_Dur = Positive Duration

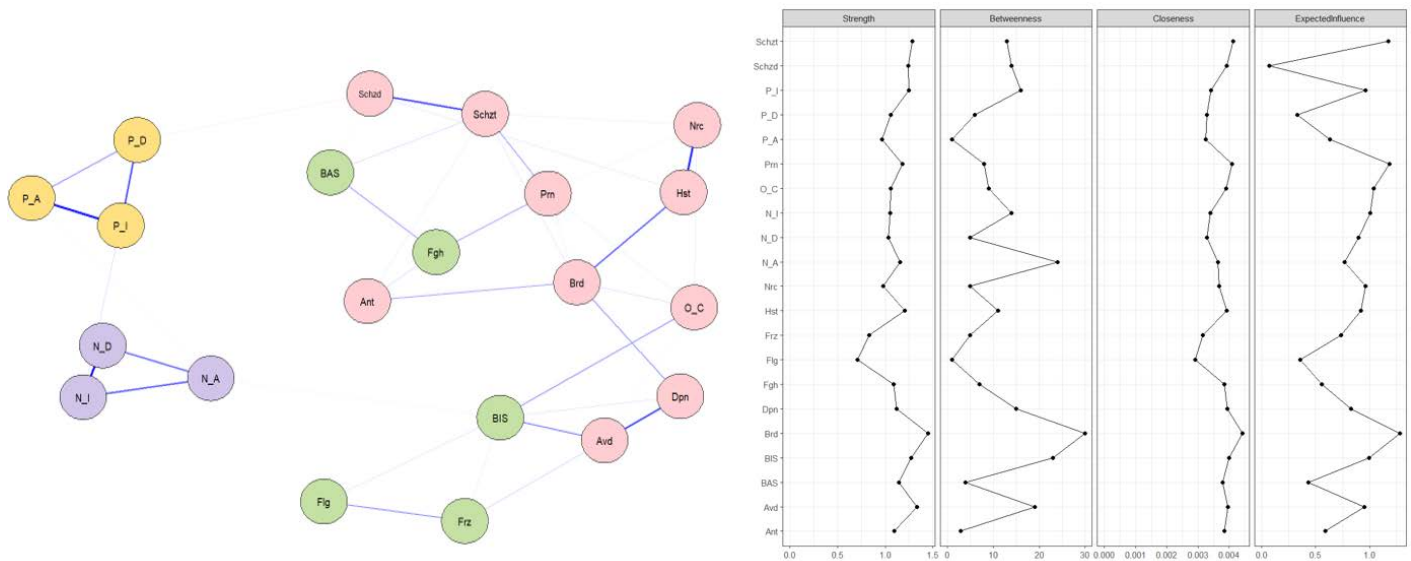


Figure 2. Gaussian partial correlation-based network analysis and centrality measures

Prn = Paranoid Personality Disorder; Schzd = Schizoid Personality Disorder; Schzt = Schizotypal Personality Disorder; Ant = Antisocial Personality Disorder; Brd = Borderline Personality Disorder; Hst = Histrionic Personality Disorder; Nrc = Narcissistic Personality Disorder; Avd = Avoidant Personality Disorder; Dpn = Dependent Personality Disorder; O_C = Obsessive Compulsive Personality Disorder; BIS = Behavioral Inhibition System; BAS = Behavioral Activation System; Fgh = Fight; Flg = Flight; Frz = Freeze; N_A = Negative Activation; N_I = Negative Intensity; N_D = Negative Duration; P_A = Positive Activation; P_I = Positive Intensity; P_D = Positive Duration

Mediation Analysis

The variables included in the mediation model were determined based on centrality measures obtained from the Gaussian Graphical Model (GGM) analysis. Although strength, closeness, and betweenness centralities were examined to evaluate the overall network structure, the primary criterion for variable selection was expected influence (EI). Similar to strength centrality, expected influence considers a variable's total connections in the network, but unlike strength centrality, EI also assesses whether these connections are positive or negative. This allows for a more accurate reflection of a variable's overall impact on the network (Robinaugh et al. 2016). Closeness and betweenness centralities, however, have some statistical limitations. In particular, these measures are significantly affected by small changes in network structure and exhibit low reliability. Because they are not designed to work with weighted and negative connections, they are not always suitable for the nature of psychological networks (Bringmann et al. 2019). For these reasons, these two centrality measures were considered only as supporting secondary information in this study, and variable selection was based on the EI criterion.

To determine the variables to be included in the mediation analysis, each conceptual domain (Reinforcement Sensitivity Systems, Emotional Reactivity Components, and Personality Disorders) was evaluated independently. First, the variables with the highest expected influence values for each domain were identified, and then these variables were compared with other variables in the same domain. Comparisons were made using a one-sample t-test, applied to the differences in expected influence in pairwise comparisons, and the mean difference was tested for significance greater than zero.

According to the results of the one-sample t-test analysis, the "BIS" variable in the Reinforcement Sensitivity Systems was found to have a significantly higher expected influence value compared to all other variables ($EI = 0.995$; $t(3) = 5.83$; $p = .010$). In the emotional reactivity domain, "Negative Intensity" was found to have the highest value, but it did not show a significant difference compared to the other variables ($EI = 1.003$; $t(4) = 2.54$; $p = .064$). In the personality disorders domain, "Borderline Personality Disorder" showed a significantly higher expected influence value compared to all other personality disorders ($EI = 1.278$; $t(8) = 3.65$; $p = .006$).

In addition, pairwise bootstrap difference tests were applied to more reliably test the centrality differences between variables. These analyses, conducted on the expected influence values obtained from the Gaussian Graphical Model, determined the difference between the two variables using the bootstrap method with 2000 resamples. The resulting p-values were adjusted with the Holm-Bonferroni correction to reduce the margin of error arising from multiple comparisons.

Table 4. Comparison of Expected Influence (EI) values

	Mean Difference	95% CI	p
Borderline – Paranoid PD	0.30	[0.1497. 0.4668]	< .001
Borderline – Schizoid PD	0.86	[0.7190. 1.0035]	< .001
Borderline – Schizotypal PD	0.27	[0.1148. 0.4258]	< .001
Borderline – Antisocial PD	0.73	[0.5881. 0.8857]	< .001
Borderline – Histrionic PD	0.60	[0.4248. 0.7714]	< .001
Borderline – Narcissistic PD	0.52	[0.3757. 0.6672]	< .001
Borderline – Avoidant PD	0.47	[0.3362. 0.6128]	< .001
Borderline – Dependent PD	0.47	[0.3103. 0.6351]	< .001
Borderline – Obsessive-Compulsive PD	0.39	[0.2257. 0.5567]	< .001
BIS – BAS	0.56	[0.2103. 0.5567]	< .001
BIS – Fight	0.44	[0.2294. 0.5631]	< .001
BIS – Flight	0.64	[0.2204. 0.5651]	< .001
BIS – Freeze	0.26	[-0.0743. 0.3192]	.259
Negative Intensity – Positive Duration	0.67	[0.3239. 0.6609]	< .001
Negative Intensity – Negative Duration	0.11	[-0.0594. 0.3247]	.174
Negative Intensity – Negative Activation	0.24	[-0.0295. 0.3842]	.087
Negative Intensity – Positive Intensity	0.04	[-0.2412. 0.0933]	.448
Negative Intensity – Positive Activation	0.37	[-0.0192. 0.3413]	.077

BIS = Behavioral Inhibition System, BAS = Behavioral Activation System, PD = Personality Disorder.

To examine the differences between expected influence (EI) values, a paired-samples t-test was applied. Analyses revealed that the EI score for Borderline Personality Disorder was significantly higher than that for all other personality disorders. Furthermore, the EI value for the BIS variable was significantly higher than those for the BAS and Fight and Flight variables, but no significant difference was observed with the Freeze variable. Among the emotional reactivity subscales, a significant difference was found only between Negative Intensity and Positive Duration, while other comparisons were not statistically significant (Table 4). Based on these results, BIS and Freeze were included in the mediation analysis as independent variables (X), Borderline Personality Disorder traits as dependent variables (Y), and all emotional reactivity components except Positive Duration as mediating variables (M).

Table 5. Mediation analysis for the role of emotional reactivity components in the relationship between BIS and borderline personality disorder traits

	B	SE	β	t	p	95% CI
Total Effect	0.608	0.040	0.524	15.08	< .001	[0.5285. 0.6868]
Direct Effect	0.404	0.044	0.349	9.27	< .001	[0.3187. 0.4901]
Total Indirect Effect	0.203	0.028	0.176	—	—	[0.1502. 0.2623]
BIS → Negative Activation	0.290	0.022	0.475	13.22	< .001	[0.2470. 0.3332]
BIS → Negative Intensity	0.223	0.025	0.346	9.04	< .001	[0.1743. 0.2711]
BIS → Negative Duration	0.270	0.022	0.448	12.25	< .001	[0.2270. 0.3138]
BIS → Positive Intensity	-0.061	0.021	-0.120	-2.97	.003	[-0.1012. -0.0207]
BIS → Positive Activation	-0.010	0.021	-0.020	-0.50	.619	[-0.0505. 0.0301]
Negative Activation → BPD	0.208	0.091	0.110	2.28	.023	[0.0293. 0.3878]
Negative Intensity → BPD	0.403	0.092	0.224	4.40	< .001	[0.2232. 0.5835]
Negative Duration → BPD	0.164	0.097	0.085	1.69	.092	[-0.0269. 0.3541]
Positive Activation → BPD	-0.258	0.098	-0.112	-2.63	.009	[-0.4501. -0.0650]
Positive Intensity → BPD	-0.099	0.100	-0.044	-1.00	.320	[-0.2963. 0.0969]
BIS → Negative Activation → BPD	0.060	0.030	0.052	—	—	[0.0039. 0.1226]
BIS → Negative Intensity → BPD	0.090	0.023	0.078	—	—	[0.0475. 0.1360]
BIS → Negative Duration → BPD	0.044	0.026	0.038	—	—	[-0.0064. 0.0978]
BIS → Positive Activation → BPD	0.003	0.006	0.002	—	—	[-0.0087. 0.0160]

BIS = Behavioural Inhibition System, BPD = Borderline Personality Disorder

Mediating Role of Emotional Reactivity in the Relationship between BIS and Borderline Personality Disorder Traits

PROCESS Macro Model 4 (Hayes 2018) was used to test the mediating role of emotional reactivity in the relationship between BIS and borderline personality disorder (BPD) traits. The analysis revealed significant total effects ($p < .001$), direct effects ($p < .001$), and total indirect effects ($p < .001$) of BIS on BPD traits.

When specific indirect effects were examined, Negative Activation ($p < .05$) and Negative Intensity ($p < .001$) components were found to have significant mediating roles. Other indirect paths were not statistically significant ($p > .05$) (Table 5) (Figure 3).

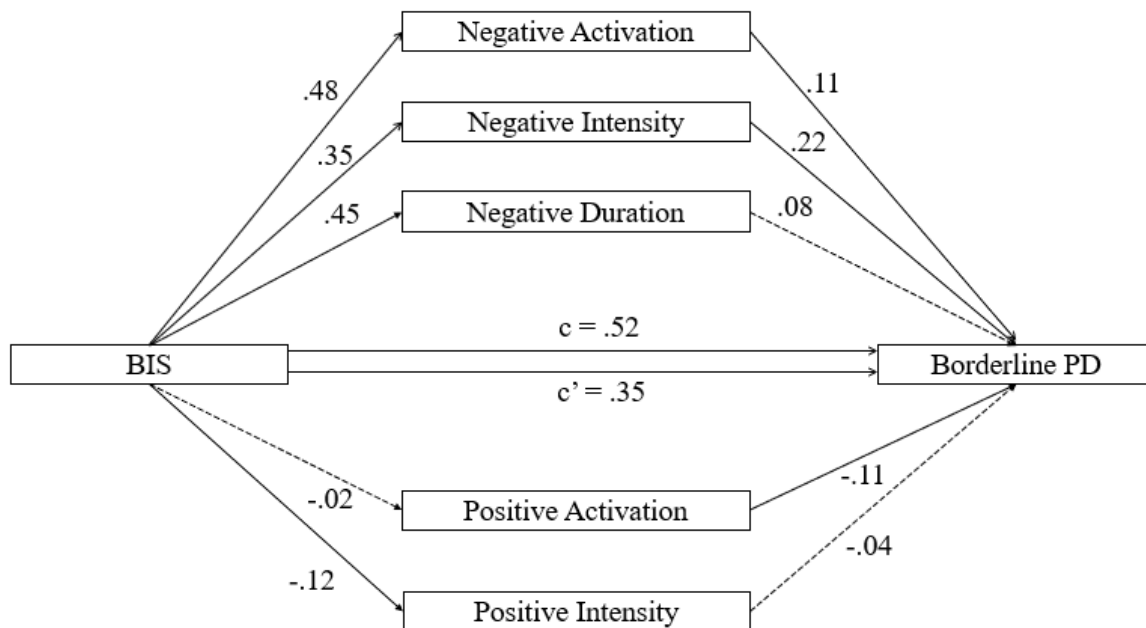


Figure 3. Mediation analysis for BIS, emotional reactivity components and borderline personality disorder

Note. The standardized coefficients are given in the figure. BIS = Behavioural Inhibition System, PD = Personality Disorder

Table 6. Mediation analysis for the role of emotional reactivity components in the relationship between freeze and borderline personality disorder traits

	B	SE	β	t	p	95% CI
Total Effect	0.640	0.054	0.433	11.75	< .001	[0.5328. 0.7467]
Direct Effect	0.414	0.052	0.280	7.90	< .001	[0.3114. 0.5175]
Total Indirect Effect	0.225	0.034	0.152	—	—	[0.1600. 0.2942]
Freeze → Negative Activation	0.242	0.030	0.311	8.02	< .001	[0.1830. 0.3018]
Freeze → Negative Intensity	0.209	0.032	0.255	6.46	< .001	[0.1457. 0.2730]
Freeze → Negative Duration	0.291	0.029	0.378	9.99	< .001	[0.2341. 0.3487]
Freeze → Positive Intensity	0.001	0.026	0.001	0.01	.993	[-0.0512. 0.0517]
Freeze → Positive Activation	-0.045	0.026	-0.069	-1.70	.089	[-0.0964. 0.0068]
Negative Activation → BPD	0.360	0.090	0.190	4.00	< .001	[0.1833. 0.5376]
Negative Intensity → BPD	0.420	0.093	0.233	4.50	< .001	[0.2367. 0.6036]
Negative Duration → BPD	0.147	0.099	0.076	1.47	.142	[-0.0492. 0.3424]
Positive Activation → BPD	-0.262	0.099	-0.114	-2.63	.009	[-0.4586. -0.0664]
Positive Intensity → BPD	-0.162	0.101	-0.071	-1.60	.110	[-0.3608. 0.0368]
Freeze → Negative Activation → BPD	0.087	0.027	0.059	—	—	[0.388. 0.1462]
Freeze → Negative Intensity → BPD	0.088	0.023	0.060	—	—	[0.0448. 0.1355]
Freeze → Negative Duration → BPD	0.043	0.029	0.029	—	—	[-0.0148. 0.1006]
Freeze → Positive Activation → BPD	-0.001	0.008	0.000	—	—	[-0.0171. 0.0172]
Freeze → Positive Intensity → BPD	0.007	0.007	0.005	—	—	[-0.0026. 0.0248]

BPD = Borderline Personality Disorder

Mediating Role of Emotional Reactivity in the Relationship Between Freeze and Borderline Personality Disorder Traits

PROCESS Macro Model 4 (Hayes 2018) was used to test the mediating role of emotional reactivity in the relationship between Freeze and borderline personality disorder (BPD) traits. The analysis revealed statistically significant total effects ($p < .001$), direct effects ($p < .001$), and total indirect effects ($p < .001$) of Freeze on BPD traits. When specific indirect paths were examined, mediating roles were found for Negative Activation ($p < .05$), Negative Intensity ($p < .001$), and Positive Activation ($p < .01$). Indirect paths through emotional reactivity components were not statistically significant ($p > .05$) (Table 6) (Figure 4).

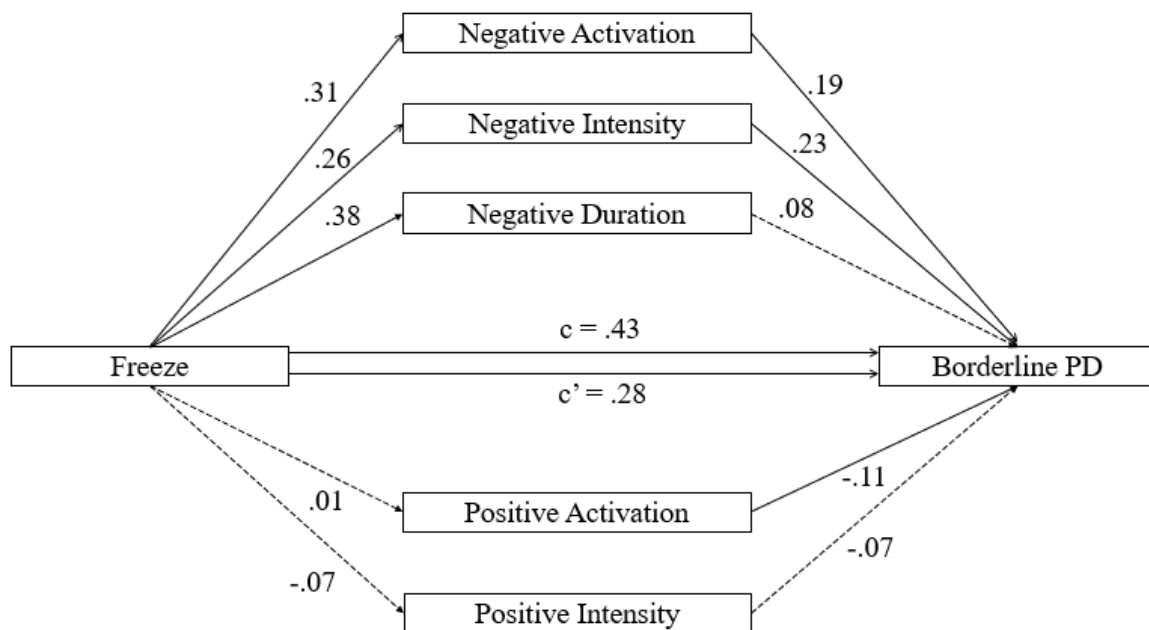


Figure 4. Mediation analysis for freeze, emotional reactivity components and borderline personality disorder

Note. The standardized coefficients are given in the figure.; PD = Personality Disorder

Discussion

In this study, the relationships between borderline personality disorder (BPD) traits and emotional and motivational systems were comprehensively examined using a variety of statistical modelling techniques. Specifically, network analyses based on Pearson correlation and Gaussian partial correlation were applied to examine both the direct relationships among variables and the relationships observed when other variables were held constant. In the resulting network structures, central variables, connection density and interaction patterns were evaluated through various centrality measures. Furthermore, mediation analyses were conducted to explore the directional nature of the structural relationships identified in the network analyses, as well as the potential mediating roles of emotional reactivity components in the associations between BPD traits and other variables. By combining a holistic approach with network analyses that reveal the structural patterns of the relationships between variables and mediation analyses that test the mechanisms by which these relationships operate, a more comprehensive and explanatory model of the links between BPD and motivational and emotional processes is presented.

The gender comparison findings obtained in this study showed that certain dimensions of personality disorders, components of the reinforcement sensitivity system, and subdimensions of emotional reactivity differed significantly. The significantly higher scores observed among male participants in schizotypal, schizoid, and antisocial personality disorders are consistent with previous literature reporting a greater prevalence of these characteristics in men, including antisocial or aggressive behavioral tendencies, social withdrawal and isolation, and cognitive-perceptual disturbances such as impaired reality testing, paranoid ideation, or bizarre beliefs (Klonsky et al. 2002, Sher et al. 2015). It can be said that the higher prevalence of antisocial personality disorder in men is the result of the interaction of biological (Tully et al. 2024) and social (Cooper 2022) factors. Additionally, the significantly higher scores observed in men on the Behavioural Activation System (BAS) and Fight subscales suggest that reward sensitivity is more pronounced in males, potentially leading to a heightened tendency to respond to motivational cues (Cardoso et al. 2023). Moreover, the finding that men are more likely to respond aggressively or confrontationally to threatening stimuli (Fahlgren et al. 2022) further supports this interpretation.

The fact that female participants scored significantly higher than males on the Avoidant Personality Disorder, BIS, Flight, and Freeze subscales suggests that higher sensitivity and avoidance-based reactions to stimuli such as threat, punishment, and uncertainty may be more prevalent among women. This pattern may be related to the higher incidence of anxiety disorders in women (Farhane-Medina et al. 2022). Furthermore, the greater prevalence of the freezing response among women implies that passive defensive reactions may occur more

frequently under intense stress and may be linked to involuntary bodily freezing (Young 2011). With regard to emotional reactivity, the finding that women scored higher on Negative Activation, Negative Intensity, and Negative Duration indicates a tendency to respond to negative emotional stimuli with greater intensity and prolonged duration. Similarly, higher scores for Positive Activation and Positive Intensity among women suggest that overall emotional responsiveness is more pronounced in females. This pattern may be associated with the modulatory effects of estrogen and progesterone on mood regulation (Sharma et al. 2021).

In addition to biological explanations, the influence of measurement bias and cultural norms should not be overlooked when interpreting gender-based differences. Particularly in self-report data collection instruments, individuals' response patterns can be influenced by gender role expectations (Brody 1993). For instance, in some cultures, women are encouraged to express their emotions more openly, whereas men may be more likely to suppress such expressions (Chaplin 2015). This may lead women to report higher levels of traits such as emotional reactivity or introversion, while men may underreport socially undesirable responses, such as experiencing intense emotional reactions (Löffler and Greitemeyer 2023). In this context, it can be argued that the gender differences observed in the studies are not solely individual or biologically based, but may also reflect culturally shaped behavioural patterns.

The results of the Pearson correlation-based network analysis revealed a dense and complex interaction network formed by direct correlations between variables. As shown in Figure 1, Borderline PD, Obsessive-compulsive PD, Paranoid PD and Histrionic PD emerged as central nodes with high degrees of connectivity in the network structure, demonstrating numerous associations with reinforcement sensitivity system components and emotional reactivity dimensions. The high expected influence (EI) values observed for Obsessive-Compulsive PD and Paranoid PD, alongside BPD, suggest that these variables are structurally central within the psychopathology network and may play a decisive role in shaping network interaction patterns by establishing numerous and strong direct connections with other variables. The fact that negative intensity, negative activation, and negative duration variables of emotional reactivity have high centrality values suggests that these variables may have a mediating role between personality disorders and reinforcement sensitivity systems. Behavioural Inhibition System and Freeze, components of the reinforcement sensitivity system, stand out as key variables in the functional integrity of the network, exhibiting numerous direct correlations with both personality disorder dimensions and emotional reactivity sub-dimensions.

Gaussian partial correlation-based network analysis enables the evaluation of relationships between variables while controlling for the influence of all other variables, resulting in a more simplified and interpretable network structure. As illustrated in Figure 2, variables such as BAS, Flight, and Positive Activation, which had high connectivity in the Pearson-based network, were located in more peripheral positions in the Gaussian network. This finding suggests that the connections of these variables in the Pearson network are largely due to indirect associations mediated by other variables. Borderline PD, Obsessive-Compulsive PD, Paranoid PD, and Histrionic PD maintained their central positions within the Gaussian network, but with a more limited number of connections representing only the strongest statistically significant and direct relationships. The variables BIS and Freeze also maintained their centrality in the Gaussian model, showing particularly strong and direct associations with the emotional reactivity components. This pattern supports the conceptual rationale for considering these variables as independent variables in mediation analyses.

In terms of emotional reactivity dimensions, negative intensity and negative activation, which showed high centrality in the Pearson network, were found to establish strong direct connections with each other and with negative duration in the Gaussian network, although their associations with personality disorder dimensions were limited to the strongest ones. Positive emotional reactivity dimensions, on the other hand, demonstrated high interconnectivity within the Gaussian network, while their direct connections with personality disorders were weakened. Overall, while Pearson correlation-based network analysis provided a comprehensive map of direct relationships between variables, the Gaussian partial correlation-based network analysis more clearly revealed the core structure of the network by emphasising only partial correlations and the most statistically robust connections.

Findings from Gaussian partial correlation-based network analysis indicate that BPD is central to the network both structurally and functionally, establishing strong direct connections with other personality disorder dimensions and psychological variables. Notably, the fact that BPD scores significantly higher than all other personality disorders in the expected influence metric underscores its central role within the psychopathology network. These results further support the view that BPD is strongly linked to a general psychopathology factor (Choate et al. 2023), interacting with multiple symptom clusters and reflecting imbalances across emotional, cognitive, and interpersonal processes. Moreover, features such as emotion dysregulation, impulsivity, and

interpersonal instability, which are considered hallmark characteristics of BPD (Linehan 1993, McLaren et al. 2022, Bozzatello et al. 2024, Crotty et al. 2024), are also commonly seen in other personality disorders as transdiagnostic variables (Defoe et al. 2022, Fitzpatrick et al. 2023). Therefore, it can be said that the centrality of Borderline Personality Disorder traits in the network is since they have common symptom clusters that structurally overlap with different personality disorders.

In terms of reinforcement sensitivity systems, the centrality of the BIS and Freeze components within the network and their strong connections with BPD suggest that these systems play a critical role in understanding the emotional and behavioural patterns of BPD. Specifically, the rapid activation of the BIS may underlie the anxiety, hypervigilance, and avoidance tendencies frequently observed in individuals with BPD, while the Freeze component likely reflects the immobilisation responses that emerge under conditions of intense psychological stress (Gray and McNaughton 2000, Rosenthal et al. 2008). In this context, the findings obtained are parallel to theoretical explanations, indicating that both BIS and Freeze may play a role in the emergence of impulsive and inconsistent reactions seen in BPD (Bilge and Emiral 2022, Bilge and Balaban 2023).

The results of the mediation analysis revealed that negative activation and negative intensity, as components of negative emotional reactivity, significantly mediated the relationships between both the behavioural inhibition system (BIS) and the freezing response (Freeze) with borderline personality traits. These findings suggest that the intense negative affect and emotional instability commonly observed in individuals with BPD (Linehan 1993, McLaren et al. 2022, Bozzatello et al. 2024, Crotty et al. 2024) may be linked to neuropsychological processes reflecting hypersensitivity to environmental stimuli (Gray and McNaughton 2000, DeYoung and Gray 2009, Massó Rodríguez et al. 2021). Specifically, negative activation refers to the rapid triggering of negative emotions, while negative intensity refers to the more intense and prolonged experience of these emotions (Preece et al. 2023). The presence of these mediating pathways indicates that both components may act as mechanisms through which BIS and Freeze contribute to maladaptive behavioural outcomes such as avoidance, immobilisation, and impulsivity. These processes may underlie core features of BPD, including interpersonal conflict, overwhelming internal distress, and abrupt mood shifts (Linehan 1993). In addition, the fact that direct effects remained significant in both mediation models suggests that indirect effects mediated by negative emotional reactivity only partially explain the relationship between BIS and Freeze with BPD. This suggests that high activation of the BIS and Freeze variables is not a sole determinant in the development and maintenance of BPD, but may play an important role in interaction with the emotional reactivity components, negative intensity and negative activation.

In contrast, the negative duration component did not emerge as a significant mediator in either model, suggesting that the duration of the emotional response may have a more limited role in explaining BPD symptoms compared to emotional intensity or rapid activation. Similarly, the mediating roles of the positive emotional reactivity components (positive activation and positive intensity) were not found to be significant. This finding indicates that emotional processes in BPD are predominantly shaped by negative affect, and positive emotions do not constitute a determining mechanism in these relationships. Indeed, prior research suggests that individuals with BPD experience positive emotions less frequently, with reduced intensity and duration, thereby limiting their regulatory or protective roles in behavioural and interpersonal functioning (Waite et al. 2024, Mehrotra et al. 2025). Even in the presence of high positive emotional reactivity, these emotions prevent a regulatory interaction with the behavioural inhibition and freezing systems. Furthermore, individuals with borderline personality traits may have lower sensitivity to positive experiences or an inconsistent approach to motivation toward reward, making it difficult for positive emotional processes to functionally interact with behavioural systems (Selby and Joiner 2009). Therefore, a significant indirect relationship through positive emotional reactivity may not have emerged.

Finally, several limitations of the present study should be taken into consideration. Although the sample size was adequate for statistical analysis, the overrepresentation of young and female participants restricts the generalizability of the findings to broader age ranges, different gender identities, and particularly to clinical populations. Moreover, since all measures used in the study were based on self-report forms, participants' responses may have been influenced by individual and contextual factors such as social desirability, level of insight, or conformity to cultural norms. Therefore, future studies should employ diverse samples and experimental methods to broaden the scope of the findings.

Conclusion

In this study, the relationship between borderline personality disorder traits and emotional and motivational systems is examined at both structural and functional levels, offering an integrative perspective that has been

relatively underexplored in the existing literature. The findings demonstrate that network analysis and mediation models are valuable tools for better understanding risk profiles and identifying treatment targets in BPD. Results from the Gaussian partial correlation-based network analysis revealed that BPD holds a central position within the psychopathology network, forming strong direct associations with other personality disorder dimensions and psychological variables. Moreover, mediation analyses showed that negative activation and negative intensity, as components of negative emotional reactivity, play significant roles, particularly in the relationships between the behavioural inhibition system and the freezing response, and borderline personality traits. In contrast, the association between positive emotional reactivity and BPD appeared to be limited. These multilevel findings highlight the importance of considering neuropsychological systems and emotional reactivity processes together in explaining the etiology and maintenance of BPD.

The findings of this study may contribute to more precise identification of risk profiles and clarifying treatment targets in clinical assessments. In particular, it is recommended that therapeutic interventions designed to regulate the intense and chronic negative affect, commonly observed in BPD, also target individuals' heightened sensitivity to the behavioural inhibition system and freeze responses. In this context, the present findings offer valuable insights for intervention approaches that aim to enhance emotion regulation skills by identifying specific cognitive and neuropsychological targets. It is suggested that such interventions can be made more effective by considering not only surface emotional reactions but also the motivational system dynamics underlying these reactions. Furthermore, the use of longitudinal research designs and the inclusion of clinical samples in future studies will facilitate the exploration of causal mechanisms and enable comparative analyses across various domains of psychopathology.

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