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Psychophysiological aspects of Borderline Personality Disorder reactivity to interpersonal stimuli: associations to components of childhood abuse

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Abstract

Background: Borderline Personality Disorder (BPD) is mostly characterized by emotional dysregulation manifested in subjective, behavioral, and physiological terms. Although, a huge number of studies conducted on this topic, empirical findings remain mixed, leading researchers to hypothesize that some manifestations of the disorder could be expressed in specific situations. Accordingly, we aimed to investigate components of emotional dysregulation in response to socio-relational clips in BPD by collecting self-reported and physiological data.

Methods: An emotional elicitation task was administered to 28 BPD patients and 28 healthy controls (HCs). The task consisted of 24 clips with explicit interpersonal contents categorized into positive, negative, erotic, and neutral stimuli. Self-reported emotional intensity elicited by each clip and ECG indexes were recorded during the task.

Results: Patients reported higher intensity of negative emotions in response to different relational contents compared to HCs. Moreover, we found an increase in HRV in BPD during the administration of the relational clips. Eventually, significant associations between scores of positive emotions and dimensions of emotional abuse and neglect were reported.

Conclusions: To summarize, our results support difficulties in emotional experience in BPD manifested both in subjective and physiological terms. Patients report a negative bias in the evaluation of relational contents, which is more pronounced when high scores of childhood abuse are taken into account. Eventually, relational contents engage a complex physiological response that could express a condition of physiological immobilization in response to social cues.

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1. Introduction

Among Borderline Personality Disorder (BPD) clinical features, emotional and interpersonal dysregulation seems to play a relevant role in the development and maintenance of the disorder (APA; 2020). BPD patients are characterized by marked difficulties in regulating emotions originating from transactional interactions between biological vulnerabilities and invalidating the environment (Linehan, 1993). According to this model (e.g., Linehan's Biosocial model), emotional vulnerabilities are manifested in enhanced sensitivity to emotional stimuli (hypersensitivity), high reactivity to emotional cues (hyperreactivity), and a slow return to emotional baseline (Carpenter & Trull, 2013; Linehan, 1993). Linehan's model defines hypersensitivity as a low threshold for emotional activation and quick response. Hyperreactivity means extreme reactions towards emotional stimuli manifested by a heightened stimulus-related change in emotional intensity. Finally, the slow return to emotional baseline refers to long-lasting emotional reactions, namely difficulties in decreasing emotional activation after the presentation of a cue. Relevantly, the three components of the Biosocial model can be manifested in different systems of emotional functioning such as subjective, behavioral, and physiological manifestations (Cavazzi & Becerra, 2014).

The huge number of empirical studies based on the Biosocial model showed support for two of the three components of emotional vulnerabilities; namely, hypersensitivity and the slow return to baseline (for a review see: Cavazzi & Becerra, 2014). Previous data described BPD patients as characterized by a basal psychophysiological condition of negative hyperarousal (Koenig et al., 2016), a fast physiological activation in emotional situations (Bortolla et al., 2019), and a tendency to respond to non-emotional stimuli (Mier et al., 2014; Bortolla et al., 2020b). Furthermore, the low return to emotional baseline seems associated with an alteration of habituation mechanisms leading the subject to maintain emotional activation for longer (Austin et al., 2007; Dziobek et al., 2011; Weinberg et al., 2009). On the other hand, emotional hyperreactivity showed inconsistent and mixed results both considering subjective responses and physiological data (for a meta-analysis on emotional reactivity see: Bortolla et al., 2020a). This result was unexpected given the fact that BPD is often described as a hyperreactive disorder (Crowell et al., 2009; Carpenter & Trull, 2013) characterized by intense emotions and reactions to emotional situations.

The lack of empirical support for hyperreactivity led some researchers to hypothesize that BPD subjects might be hyperreactive exclusively in specific situations that could be considered specific triggers for the disorder. Accordingly, a growing interest has been manifested in the

interpersonal domain, which seems to be particularly impaired in BPD (Gunderson, 2007). In detail, patients are characterized by repetitive, unstable, and intense interpersonal relationships and they show a marked fear of being abandoned (APA, 2013). In a review, Lazarus and colleagues (2014) showed that patients are characterized by a negative view of other's intentions and this could be related to the marked rejection sensitivity manifested in BPD (Berenson et al., 2009; Staebler et al., 2009). Moreover, BPD manifested marked difficulties in recognizing others' emotions (e.g., Domes et al., 2009) and their behavior in interpersonal relationships is often characterized by intense negative emotions such as anger and sadness (Stepp et al., 2009). Eventually, BPD typical dysregulated behaviors (e.g., self-harm, suicide attempt, and impulsive behaviors) are often manifested in response to interpersonal threats (Brodsky et al., 2006).

BPD interpersonal problems are markedly manifested in intimate and romantic relationships. These relationships are characterized by lower duration, lower emotional satisfaction, and higher levels of hostility compared to non-BPD individuals (Bouchard et al., 2009; Christensen & Shenk, 1991; Navarro-Gómez et al., 2017). Additionally, BPD patients present a high number of romantic partners and relationship breaks (Bouchard & Sabourin, 2009; Bouchard et al., 2009; Korzekwa et al., 2008; Paris & Zweig, 2001) that could be associated to patients' perception of relational instability, difficulties in managing conflicts, high hostility levels and avoidance defensive mechanisms to avoid potential losses and rejection (Miano et al., 2013). Literature supports that BPD interpersonal dysfunction is strictly related to insecure attachment styles (Bender & Skodol, 2007). Relevantly, BPD patients' childhood is often characterized by trauma including physical, emotional, or sexual abuse (Bierer et al., 2003) that can severely impact the development of secure attachment relationships and on the creation of mistrust and problems in regulating closeness and distance to others (Agrawal et al., 2004), as well as on the onset of typical BPD symptoms such as self-harm behaviors and other typical manifestations (Christoforou & Ferreira, 2020; Sesar et al., 2022). Moreover, the insecure attachment style seems to mediate the relationship between BPD psychopathological manifestations and difficulties with intimate relationships (Bouchard & Sabourin, 2009; Bouchard et al., 2009; Helgeland & Torgersen, 2004; Oliver et al., 2008; Zanarini et al., 2002). Accordingly, typical BPD symptoms such as impulsivity, affective instability, and rejection sensitivity may directly contribute to interpersonal conflict increasing BPD difficulties in the interpersonal area (Lazarus et al., 2014).

Among interpersonal functioning, a specific area of interest for BPD patients is related to sexuality. Patients are characterized by sexual impulsivity, promiscuity, precocity, and higher

sexual risky behaviors (e.g., Lavan & Johnson, 2002, Sansone et al., 2008; Sansone & Wiederman, 2009; Sansone & Sansone, 2011). Although the increased sexual activity, previous studies reported lower sexual satisfaction and higher sexual preoccupation compared to HCs (Hurlbert et al., 1992; Schulte-Herbrüggen et al., 2009). Relevantly, BPD dysfunctional manifestations in the sexuality area are often correlated to the high rate of sexual abuse and emotional distress that can severely impact the possibility to have a satisfactory sexual life (Afifi et al., 2011; Hurlbert et al., 1992; Sansone et al., 2008; Schulte-Herbrüggen et al., 2009; Spokas et al., 2009; Westphal et al., 2013; Wiederman & Sansone, 2009).

Given these premises, BPD emotional reactivity might be manifested especially in interpersonal situations. Limited studies have been published in this field showing that female patients with BPD showed higher levels of stress in response to conflictual quarrels (Miano et al., 2017), as well as higher anger and sadness scores in interpersonal situations compared to healthy controls (Tragesser et al., 2008). From a physiological point of view, the few data available support a higher physiological reactivity in interpersonal contexts (Simeon et al., 2007; Walter et al., 2008). However, given the multifaced manifestations of hyperreactivity (i.e., subjective, behavioral, and physiological), more studies are needed to deepen BPD psychophysiological responses to interpersonal situations. In line with other studies, in these situations, patients could manifest a low sense of control that could contribute to the onset of dysfunctional regulation strategies and subsequently, to other psychological vulnerabilities (e.g., depressive symptoms, poor mental health) (Myles et al., 2020, 2021).

The main aim of this study was to evaluate BPD psychophysiological responses in social situations, given the inconsistent results of general hyperreactivity in these patients. In detail, during the administration of video clips with interpersonal contents (i.e., positive, negative, and erotic intimacy relationships and neutral stimuli) we collected self-reported (i.e., quality and intensity of emotional activation) and physiological data (i.e., heart rate (HR) and heart rate variability (HRV)) comparing a sample of BPD patients to HCs, age and gender-matched. Erotic stimuli were included given the well-documented relevance of sexuality vulnerabilities manifested in BPD.

We expected to find the higher intensity of negative emotions paired with increased HR and decreased HRV indexes during clips administration compared to baseline in BPD patients compared to HCs, independently from the clips category. Moreover, we hypothesized significant correlations between self-reported and physiological indexes and scores of childhood

abuse, in line with previous studies supporting associations between childhood abuse and altered autonomic functioning (De Bellis, 2005; Heim et al., 2020; Van der Kolk, 2003).

2. Methods

2.1 Participants

BPD patients. The initial sample was composed of 31 BPD outpatients recruited from the Clinical Psychology and Psychotherapy Unit of San-Raffaele Hospital (Milan) from February 2019 to July 2021. Patients were involved in a project on the study of interpersonal functioning in BPD composed of two tasks (clip task and dot-probe task). Among the participants, 3 subjects did not complete the clip task. Accordingly, the final sample was composed of 28 female participants (mean age=24.78, *SD*=6.26). Clinical subjects met a BPD diagnosis according to DSM 5 criteria assessed by the *Structured Clinical Interview for DSM-5-Personality Disorder* (SCID-5-PD; First, 2014). SCID-5-PD was conducted during the routine diagnostic assessment by trained raters blinded to the hypotheses of this study. exclusion criteria were IQ lower than 70, psychotic disorders, and other active psychiatric symptomatology for at least one month before task administration (e.g., major depressive episode, current substance use, panic attacks). Lifetime co-diagnoses of other psychiatric disorders did not represent exclusion criteria from the study. The main lifetime co-diagnoses in this sample were Eating Disorder, Mood Disorder, and Substance Use Disorder. Most of the patients took stable pharmacological treatments for at least three months. The most commonly prescribed medications were benzodiazepines, anticonvulsants, neuroleptics, SSRIs, antipsychotics, antidepressants, and antiepileptics. However, we asked patients to refrain from taking benzodiazepines 48 hours before the experiment.

Healthy Controls. Twenty-eight community-dwelling volunteers age-matched (mean age=23.70, *SD*=1.07) with negative medical history for psychiatric or neurological disorders were included in the nonclinical sample. Participants were preliminarily screened by expert psychologists and psychiatrists for investigating the presence of certificated psychological, psychiatric and neurological diagnoses. Additional exclusion criteria were IQ lower than 70, current substance use, psychopharmacological treatments, and current psychological treatments. Ultimately, the Personality Inventory for DSM-5 (PID-5; Krueger et al., 2011; and the Difficulties in Emotion Regulation Scale (DERS; Giromini et al., 2012) were administered to exclude the presence of maladaptive personality features and emotional difficulties. Nonclinical subjects reported significantly lower scores for PID-5 domains and BPD facets as well as for DERS subscales and

total score. Results of group comparisons for PID-5 and DERS scores can be provided under request.

2.2 Instruments

Clips task. Twenty-four clips were administered during the experiment. Clips were extracted from commercial films and were selected by a previous validation study. A pool of 48 stimuli was selected by the authors, including contents that represented human social interactions within daily life contexts. The set was administered to 60 community-dwelling volunteers who rated each clip on four continuous bipolar sliding scales (arousal, valence, intimate relationship, sexual arousal; range 1-9). Six clips for each category (positive, negative, and erotic relationships and neutral stimuli) were selected considering the stimuli that were the most representative for that category. Positive interpersonal stimuli were characterized by high valence, high intimate relationship, and low sexual arousal scores; negative stimuli were characterized by low valence, high intimate relationship, and low sexual arousal scores; erotic stimuli were characterized by high intimate relationship and high sexual arousal scores. Eventually, neutral stimuli were selected by clips with medium valence, low intimate relationship, and low sexual arousal scores. Clips' presentation order was randomized. After the presentation of each clip, the participant was asked to complete the movie questionnaire described below. During the whole procedure, ECG was recorded.

Movie questionnaire. At the end of each video clip, subjects completed a self-administered questionnaire, earlier used in Maffei et al., 2014 to evaluate the quality and the intensity of emotional activation induced by each clip. Ten emotional states were assessed on an eight-point Likert scale, ranging from 0 ("not at all") to 7 ("very much"): serene, amused, happy, surprised, sad, scared, angry, disgusted, indignant, and tense. A global index of positive and negative emotions was computed by averaging the intensity reported for each positive and negative discrete emotions for each clip. Moreover, the valence of the global mood generated by each video clip, its intensity, dominance, and levels of sexual arousal were measured with a Likert scale ranging from 1 to 9 (Betella & Verschure, 2016). Eventually, participants were asked to rate the level of intimate relationship perceived for the couple shown in the clip.

Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988). The PANAS is a 20-item questionnaire developed for assessing the current positive (Positive Affect, PA) and negative (Negative Affect, NA) affectivity, using 10 positive and 10 negative adjectives. The original validation showed that the two scales are highly internally consistent, largely uncorrelated, and

stable over 2 months. In our sample, we administered the Italian version of the scale (Terracciano et al., 2003). The PANAS factor structure and solid psychometric proprieties were also confirmed for the Italian version.

Childhood Trauma Questionnaire (CTQ; Bernstein & Fink, 1998) The CTQ is a 28-item self-report inventory that retrospectively assesses five categories of childhood trauma: emotional abuse, physical abuse, sexual abuse, emotional neglect, minimization, and physical neglect (Bernstein & Fink, 1998). The psychometric properties of the CTQ have been extensively validated in several samples (Bernstein & Fink, 1998). The Italian validation was proposed by Innamorati et al., 2016.

Physiological data. Cardiac activity was recorded by electrocardiography (ECG). For each participant, an ECG was collected using *BITalino* (Da Silva et al., 2014; Guerreiro et al., 2013), a biomedical data acquisition device with a sampling rate of 1000 Hz. The ECG signal was amplified and sampled at 500 Hz. The ECG was obtained from three disposable Ag/AgCl electrodes that were positioned on the left side of the participant's chest. Python was used to run all ECG data and inter-beat intervals (IBIs) were obtained. After obtaining inter-beat intervals (IBIs), data were then exported in Kubios-Premium software (University of Kuopio, Kuopio, Finland) to further correct for possible artifacts with an automatic interpolation method that generates missing or corrupted values into the IBIs series. HRV was extracted from the ECG recordings. In particular, the following indexes were calculated: heart rate (HR), respiratory sinus arrhythmia (RSA), the square root of the mean squared differences of successive NN intervals (RMSSD), and the standard deviation of normal-to-normal intervals (SDNN). RSA and RMSSD were analyzed to investigate vagal-mediated HRV (Malik, 1996) SDNN displays the cyclic components accountable for the variability of HR and is an index of the total heart rate variability. The natural logarithms of all physiological data were calculated to normalize the distributions. Delta scores (clips – baseline) for each condition were calculated for physiological variables to have a measure of subjective reactivity to relational stimuli.

2.3 Procedure

The complete process was carried out at the local hospital on two different days. Informed consent was signed before the experiment. Participants completed two experiments on interpersonal functioning: the clip task described in this study and a dot-probe task described in another paper currently under review. (Before each experiment participants completed the PANAS and other pre-task questionnaires (e.g., additional clinical, personal, and medical information). Subsequently, the dot-probe task or the clips task was administered. The order of

the two tasks was randomized in the two meetings. After each task, participants completed the PANAS. Before completing the clip task, participants performed a two-minute baseline recording, in which physiological data at resting state were collected. During the recording of the baseline state, participants were asked to sit still and relax. Eventually, before the experiment participants were asked to complete a short part of 2 clips to become acquainted with the tasks.

2.4 Statistical analysis

Non-parametric procedures were proposed to analyze data, in line with the violations of normal distribution for several measures included in the study. The Aligned Rank Transform (Wobbrock et al., 2011) was applied to evaluate the non-parametric main effect of *group* and interaction effects *group x category* (i.e., negative, positive, neutral, erotic), taking into account self-reported and physiological indexes. The aligned transformation refers to a preprocessing procedure that aligns the data for each effect (main or interaction) before assigning ranks, averaged in the case of ties. After the aligned rank transformation of data for each effect, factorial ANOVA was conducted to evaluate the significance of main and interaction effects, which was estimated using the *F*-test (Wobbrock et al., 2011). Partial η^2 ($_p\eta^2$) was utilized as an effect measure of non-parametric main and interaction effects. Post-hoc comparisons were based on Mann-Whitney *U* tests. About posthoc analyses, adequate Bonferroni's correction was applied when multiple comparisons were performed. Wilcoxon test was used to compute within-group comparisons for physiological data (baseline vs clips). Spearman's correlation was used to evaluate associations between CTQ scores and self-report and physiological task responses.

3. Results

3.1 Positive and Negative Affect: group and pre-post comparisons

Comparing Positive (PA) and Negative Affect (NA) assessed pre and post-task, we found a significant *group* effect both for PA ($F(1,55) = 6.38$; $p = .015$; $_p\eta^2 = .11$) and NA ($F(1,55) = 5.99$; $p < .018$; $_p\eta^2 = .11$). In detail, BPD group reported slightly higher NA ($U = 258.00$; $Z = -1.69$; $p = .04$) and lower PA ($U = 252.00$; $Z = -1.76$; $p = .04$) at the beginning of the experiment, as well as significantly higher NA ($U = 212.00$; $Z = -2.40$; $p = .009$) and lower PA ($U = 198.00$; $Z = -2.56$; $p = .004$) at the end on the clip task. No *phase* effect nor *group x phase* interactions were reported for PANAS scores. Descriptive statistics and group comparisons for PANAS scale scores were presented in table 1.

Table 1. Descriptive statistics and non-parametric comparisons related to PANAS scales

		BPD (N=28)	HCs (N=28)			
		M(SD)	M(SD)	*U*	*Z*	*r*
PANAS *pre-task*	PA	28.80 (6.81)	32.92 (7.99)	252.00*	-1.76	.19
	NA	16.50 (7.91)	13.37 (5.64)	258.50*	-1.69	.21
PANAS *post-task*	PA	26.20 (9.87)	32.11(7.29)	198.00^	-2.56	.10
	NA	16.08 (8.26)	12.07 (3.60)	212.00**	-2.40	.07

Note: PANAS= Positive and Negative Affect Schedule; PA=Positive Affectivity; NA=Negative Affectivity

*p < .05; ** p < .01; ^ p < .005; ^^ p < .001

3.2 Subjective responses to clip administration

No *group* effect was found for arousal, valence, and dominance scores reported after each clip. However, a significant *group x category* interaction was found for arousal ($F(3,52) = 3.39$; $p = .025$; ${}_p\eta^2 = .17$). Descriptive statistics and group comparisons for arousal, valence and dominance scores are reported in table 2.

Table 2. Descriptive statistics related to self-reported data

	BPD (N=28) M(SD)				HCs (N= 28) M(SD)			
	Negative	*Positive*	*Neutral*	*Erotic*	*Negative*	*Positive*	*Neutral*	*Erotic*
Arousal	5.04 (2.21)	4.55 (2.31)	3.59 (2.03)	5.37 (2.08)	5.12 (1.86)	5.12 (1.86)	3.16 (1.38)	5.50 (1.85)
Valence	3.77 (1.55)	7.02 (1.31)	6.24 (1.04)	6.24 (1.33)	3.31 (1.15)	7.30 (1.55)	5.95 (1.15)	6.59 (1.48)
Dominance	3.14 (2.18)	2.45 (2.08)	2.12 (1.86)	3.20 (2.13)	2.59 (1.62)	2.32 (2.03)	1.86 (1.87)	2.73 (1.99)
Positive emotions	1.17 (1.13)	3.39 (1.95)	2.91 (1.29)	2.22 (1.64)	.98 (.76)	4.27 (1.51)	3.46 (1.36)	2.92 (1.55)
Negative emotions	1.76 (1.59)	.46 (.67)	.48 (.60)	.76 (.99)	1.35 (.75)	.14 (.21)	.11 (.15)	.21 (.25)

When the intensity of discrete emotions was taken into account a significant *group* effect was found for the intensity of negative emotions ($F(1,55) = 5.61$; $p = .022$; ${}_p\eta^2 = .10$). Higher level of negative emotions was reported by patients in response to erotic ($U = 219.50$; $Z = -2.68$; $p = .003$), positive ($U = 203.50$; $Z = -2.97$; $p = .001$) and neutral ($U = 198.00$; $Z = -3.06$; $p = .002$)

clips (Bonferroni correction: α=.0125). No *group* effect nor *group x category* interaction was found for the intensity of positive emotions.

Considering difference in the intensity of specific emotions reported after each clips category, in the erotic condition BPD patients reported higher scores of sadness (U = 237.50; Z= -2.59*; p* = .004), fear (U = 285.00; Z= -2.33*; p* = .004), anger (U = 246.00; Z= -2.58*; p* = .004) and indignation (U = 247.00; Z= -2.64*; p* = .003) compared to HCs (Bonferroni correction: α=.005). In the positive condition, clinical subjects reported higher scores of sadness (U = 279.00; Z= -3.59*; p* < .001, Bonferroni correction: α=.005). For negative clips, no significant difference was found. Eventually, higher scores of sadness (U = 242.00; Z= -2.39*; p* = .005), anger (U = 223.00; Z= -3.33*; p* < .001) and tension (U = 242.00; Z= -2.41*; p* = .005) was found in the clinical group compares to HCs for neutral clips (Bonferroni correction: α=.005).

3.3 Physiological responses to clips administration

Considering physiological data, no significant differences between groups were found comparing baseline measurement. Delta scores (clips – baseline) were computed for each physiological index (HR, RSA, RMSSD, SDNN) for each condition. Descriptive statistics for physiological variables are reported in Table 3.

Table 3. Descriptive statistics related to physiological data

	BPD (N=28) M(SD)					HCs (N=28) M(SD)				
	Baseline	*Negative*	*Positive*	*Neutral*	*Erotic*	*Baseline*	*Negative*	*Positive*	*Neutral*	*Erotic*
HR (ln)	4.35 (.14)	4.34 (.12)	4.33 (.13)	4.33 (.13)	4.33 (.11)	4.31 (.16)	4.29 (11)	4.29 (.10)	4.29 (.14)	4.28 (.12)
RMSSD (ln)	3.85 (.54)	4.10 (.40)	4.09 (.33)	4.08 (.34)	4.22 (.40)	3.89 (.37)	4.03 (.28)	4.04 (.29)	3.98 (.26)	4.06 (.30)
RSA (ln)	1.85 (.21)	1.86 (.21)	1.91 (.10)	1.88 (.11)	1.93 (.11)	1.85 (.15)	1.86 (.13)	1.87 (.10)	1.87 (.10)	1.88 (10)
SDNN (ln)	4.06 (.47)	4.06 (.38)	4.09 (.31)	4.09 (.34)	4.20 (.42)	4.20 (.25)	4.02 (.23)	4.05 (.26)	4.01 (.22)	4.02 (.25)

No significant *group* effect, nor *group x category* interaction were found for ΔHR. ΔRMSSD showed a significant *group* effect (F(1,55) = 3.77; p = .05; $_p\eta^2$ = .08). Finally, ΔSDNN reported a significant *group* effect (F(1,55) = 6.98; p = .01; $_p\eta^2$ = .08) as well as a *group* x *category* interaction (F(3,52) = 3.56; p < .022; $_p\eta^2$ = .20).

More in detail, patients reported higher changes in RMSSD and SDNN for erotic (ΔRMSSD: U = 196.00; Z= -1.86*; p* = .030; ΔSDNN: U = 180.00; Z= -2.19*; p* = .015) and neutral

(ΔRMSSD: U = 205.00; Z= -1.68*; p* = .04; ΔSDNN: U = 203.00; Z= -1.71*; p* = .044) stimuli compared to HCs.

Considering inter group differences between baseline and clips physiological responses, BPD patients showed an increase of RSA in the erotic stimulus compared to the baseline assessment (Z=-2.22, p=.012). RMSSD scores significantly increased in all the relational stimuli conditions compared to the baseline measurement both in the BPD group (erotic: Z=-3.43, p > .001; positive: Z=-3.00, p = .001; negative: Z=-2.65, p = .004; neutral: Z=-3.71, p = .003) and in the HC group (erotic: Z=-2.63, p = .005; positive: Z=-2.38, p = .001; negative: Z=-2.25, p = .013; neutral: Z=-1.84, p = .003) (Bonferroni correction: α=.0125). No significant difference between clips and baseline assessment was found for SDNN.

3.4 Associations between childhood abuse and task scores

Significant correlations between CTQ scales and task scores were exclusively manifested in the clinical group. In detail, in the erotic condition a significant association was reported between CTQ emotional abuse and valence score (ϱ=-.59, p = .004, Bonferroni correction: α=.01). In the positive condition, significant correlations were found for CTQ emotional abuse (ϱ=-.56, p = .007), emotional neglect (ϱ=-.65, p = .005), CTQ tot (ϱ=-.64, p = .001) and valence score; Bonferroni correction: α=.01.

Considering the intensity of positive and negative emotions reported after each clip, in the erotic condition significant relations were found between CTQ emotional abuse (ϱ=-.69, p < .001) and CTQ tot (ϱ=-.50, p = .01) and positive emotions; Bonferroni correction: α=.01. In the positive condition, CTQ emotional neglect significantly correlated with levels of positive emotions (ϱ=-.53, p = .01); Bonferroni correction: α=.01. Eventually, in the neutral condition significant associations were found between CTQ emotional abuse and positive emotions (ϱ=-.30, p = .01); Bonferroni correction: α=.01.

Considering physiological indexes, no association with CTQ scores remained significant after Bonferroni correction.

4. Discussion

The main aim of this study was to evaluate alterations in subjective and physiological reactivity in response to socio-relational stimuli in a sample of BPD patients compared to HCs. The choice to exclusively include socio-relational stimuli was related to previous inconclusive data related to a condition of hyperreactivity in BPD (Bortolla et al., 2020a) and the subsequent

hypothesis of a context-related hyperreactivity that is expressed only in situations that are triggering the disorder, such as interpersonal context.

In detail, during the presentation of a passive view task composed of relational clips with different contents (positive, negative, erotic, and neutral) we aimed to investigate possible differences in subjective (i.e., arousal, valence and dominance, and emotional intensity) and physiological activations (i.e., HR and HRV) in response to different clips categories between BPD patients and HCs. Moreover, we were interested in testing associations between self-reported and physiological indexes and scores of childhood abuse.

Considering self-reported responses assessed by the Movie Questionnaire, no significant differences were found comparing BPD and HCs scores in arousal, valence, and dominance scores. However, patients reported significantly higher intensity of negative emotions in erotic, positive, and neutral conditions. These results are in line with other studies showing a negative bias in the evaluation of emotional stimuli in BPD especially when social contents are taken into account (Bortolla et al., 2019; Domes et al., 2009; Dyck et al., 2009; Fenske et al., 2015; Scott et al., 2011). Considering positive relational clips, our data is in line with the few studies published on this topic showing that individuals with BPD reported reduced pleasantness and more negative emotions toward positive cues compared to HCs (Elices et al., 2012; Reichenberger et al., 2017). Moreover, patients reported higher sadness scores compared to HCs: this finding could be associated with documented difficulties manifested by patients in maintaining stable and positive close relationships that are perceived as unsatisfactory (Bender et al., 2007) and characterized by frequent break-ups (Zeigler-Hill & Abraham, 2006). On the other hand, the negative emotions reported during the erotic condition (especially sadness, indignation, and anger) could be in line with data showing reduced sexual satisfaction and increased sexual preoccupation in BPD patients (Hurlbert et al., 1992; Schulte-Herbrüggen et al., 2009). Furthermore, these findings might be linked to previous experiences of sexual abuse and emotional distress (Hurlbert et al., 1992; Sansone et al., 2008; Wiederman & Sansone, 2009) that might affect a positive evaluation of the erotic stimuli. Eventually, neutral stimuli are particularly relevant for BPD patients who, in line with our results, tend to over-attribute negative emotions to neutral stimuli (Daros et al., 2014; Fenske et al., 2015). Indeed, patients reported high intensity of sadness, anger, and tension in response to neutral stimuli confirming BPD's tendency to misinterpret such signals as threatening and untrustworthy (Fertuck et al., 2013; Miano et al., 2013). This manifestation may be also related to a marked rejection sensitivity in BPD (Staebler et al., 2011) that could bring to read rejection information even in neutral conditions.

No differences were found for baseline physiological measurements comparing BPD patients and HCs, in line with previous mixed results on this topic (for a review see Cavazzi & Becerra, 2014). Considering physiological responses to clips, our findings showed a significant increase of RSA during the erotic stimulus compared to a baseline assessment in the BPD group, as well as marked increases of RMSSD during all clip categories compared to baseline both in BPD and the control group. Moreover, when delta scores were taken into account significant group effects were reported for RMSSD and SDNN, with patients manifesting higher changes compared to HCs. Although these findings are not fully in line with our hypotheses, they allow introducing further interesting considerations on BPD physiological functioning.

First of all, the interpersonal stimulus is notoriously described as engaging (Bradley et al., 2001; Sarlo et al., 2005) and consequently it should bring the subject to undergo a physiological state functional to appetitive behaviors (Porges, 2007, 2011). Accordingly, HRV increase in response to clips in BPD could represent an attempt to regulate emotions in line with Thayer's emotion regulation theory (2000) and the social engagement function of cardiac variability well described in Polyvagal theory (Porges, 2007). Otherwise, these manifestations could be related to a complex physiological response to interpersonal cues in BPD that could involve a co-activation of the sympathetic (SNS) and parasympathetic nervous system (PNS). Indeed, in addition to the higher HRV reported during clip administration, our data showed higher HR manifested by patients compared to HCs (albeit group comparisons did not reach statistical significance). This pattern of response in patients could be related to a condition of physiological breakdown generated by the emotional contents of the clips (Porges, 2007). Indeed, HRV is an index of parasympathetic influences of the autonomic nervous system, that evolutionary is representative of a functional sympathetic brake. BPD patients could manifest an initial activation of SNS followed by a PNS break. In line with this hypothesis, the typical fight or flight response would not be manifested, although the triggering nature of the presented stimuli, and would be substituted by a physiological immobilization response, associated with stimulus intake (Sarlo et al., 2005).

Considering results on the associations between components of childhood abuse and task responses, significant correlations were found exclusively between CTQ scales score and self-reported scores of valence and positive emotions. In detail, patients reported reduced valence and positive emotions scores to erotic, positive, and neutral relational clips in association with high emotional abuse and neglect. These findings are in line with other studies showing decreases in positive emotional intensity in response to relevant triggers in BPD (e.g., interpersonal cues; Glaser et al., 2008), as well as the typical predisposition to rejection sensitivity

(Berenson et al., 2009; Staebler et al., 2009) bringing patients to overinterpret social stimuli as rejecting and manifesting a negative or hostile attitude in response to them. Furthermore, it would have been foregone that these manifestations resulted in enhanced responses to high scores of emotional abuse. Indeed, according to Linehan's model (1993), BPD patients' childhood is often characterized by negative and invalidating environments, that is punishing and neglecting and do not support the subject's emotional growth. Accordingly, the child does not learn how to understand, label, regulate, or tolerate emotional responses and this could affect the child's ability to socialize effectively. The more the environment is invalidating, the harder it should be for BPD subjects to develop effective emotional and social skills, resulting in difficulties in processing interpersonal contents that should be perceived as positive by the subject (e.g., positive and erotic relational stimuli), as manifested by previous studies (e.g., Derryberry & Rothbart, 1997).

To conclude, BPD difficulties with interpersonal stimuli found in our study could be also strictly associated with other typical BPD dysfunctional features. From one side, the altered processing of social situations can severely affect BPD subjects' approach to intimate relationships, favoring, for example, intimacy avoidance and relational closure (e.g., Sinnaeve et al., 2015). On the other side, emotional responses manifested in interpersonal situations could bring the patients to use dysfunctional regulation strategies to decrease emotional activation, such as substance use and other dysfunctional behaviors. This hypothesis could be also in line with data showing strong comorbidity between BPD and substance-related disorders and other addiction disorders (Aftab et al., 2017; Lu et al., 2017; Trull et al., 2000) that seems even more pronounced when trauma and especially emotional abuse conditions are taken into account (Dalbudak et al., 2014). Future studies should deepen this topic, carefully evaluating the role of interpersonal functioning in the co-occurrence between BPD and substance-related and addiction disorders.

Another interesting point is related to current data published on the association between BPD features and low levels of sense of control. Accordingly, we could hypothesize that the altered emotional activation manifested in the interpersonal situation could be associated with BPD reduced perception of control. In line with this, BPD could benefit from current interventions focusing on increasing perceived control to alleviate their symptoms (Myles & Merlo, 2022; Merlo et al., 2022).

Several limitations have to be considered in interpreting our results. Regarding sample limitations, our sample was composed of female participants and we could not control results for possible confounding effects of gender on emotional responsivity, as demonstrated in

previous studies (Bradley et al., 2001; McRae et al., 2008). The generalization across genders needs to be addressed in further experiments. Secondly, it is not possible to definitively ascribe our findings to BPD pathology given the high co-occurrence of other psychiatric disorders (e.g., major depressive disorder, anxiety disorders). Future studies should include a clinical control group to address this aspect. Additionally, most of our participants took medications and the interruption of treatment for experimental reasons was counterproductive to clinical goals. Future studies should replicate our findings in medication-free BPD samples. Considering limitations related to stimuli, we should replicate our study including non-relational contents to confirm that BPD dysfunctions found in our study are specific to social stimuli. Eventually, we administered standardized clips taken from famous films whose contents are not personally relevant to the subject: future studies should evaluate BPD self-reported and physiological reactivity considering personalized stimuli. Moreover, future studies should focus on analyzing the complex physiological response over time we report in this paper, to finally shed light on BPD patients' emotional reactivity on a physiological level.

Despite these limitations, our results support difficulties in emotional experience in BPD manifested both in subjective and physiological terms. This manifestation is particularly manifested in response to social stimuli, supporting the well-documented difficulties of BPD patients in the interpersonal domain (APA, 2013; Lazarus et al., 2014). Data support a negative bias in the evaluation of relational contents, which is in line with a condition of hypersensitivity often reported in BPD (Bortolla et al., 2020c) that could be associated toa misinterpretation socio-emotional cues, anticipating rejection and threat (Domes et al., 2008; Miano et al., 2013). This evaluation bias seems to be more pronounced when high scores of emotional abuse and neglect are taken into account. Eventually, relational contents engage a complex physiological response: contrary to our expectation, patients are characterized by an increase of HRV in response to social cues that could express a condition of physiological immobilization response to social cues.

Ethical approval

This study was conducted in line with the American Psychological Association's Ethical Standards for Research and Publication. Informed consent was obtained from all individual participants included in the study.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author, [RB], upon reasonable request.

Conflict of interest statement: The authors declare that they have no competing interests

Authors contribution:

RB, GES and MG participated in the design of the study, carried out the study, performed the statistical analysis and drafted the manuscript. CM contributed to the theoretical background of the study and revised the manuscript.

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