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## Eye-tracking patterns in borderline personality disorder: findings from a relational dot-probe task

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### Abstract

**Background and objectives:** Among the main dysfunctions of borderline personality disorder, a topic of interest is the study of attentional mechanisms that evaluates which stimuli attracts patients' attention and how patients process incoming stimuli. Different attentional biases could be manifested in borderline personality disorder: hypervigilance of emotional cues, difficulties in disengaging attention or avoidance. Additionally, social contents could be particularly problematic for patients given their alterations in the interpersonal domain. The current study aimed to investigate alterations in attentional mechanisms in response to interpersonal stimuli (positive, negative, and erotic) in this clinical population.

**Methods:** A modified version of the dot-probe task using socio-relational pictures was administered to 31 patients with borderline personality disorder and 31 healthy controls. The relational stimuli had a positive, negative, and erotic valence to test possible difference related to specific contents administered. Reaction times and eye-tracking data were collected during the tasks.

**Results:** Borderline personality disorder patients showed low latency to negative and erotic contents supporting a condition of hypervigilance associated to these contents. Additionally, patients reported high bias score in response to erotic stimuli manifesting difficulties in disentangling attention from these contents. On the contrary, reduced bias score and low visual exploration were manifested by borderline personality disorder subjects in response to negative stimuli, supporting the use of avoidance mechanisms. Additionally, high levels of negative affectivity affected the previous processes increasing patients' alertness to potential threatening (or rejecting) situations.

**Conclusions:** As a whole our findings confirm the presence of altered attentional mechanisms in borderline personality disorder. These patients showed hypervigilance to erotic and negative relational situations, in line with well documented interpersonal problems. However, stimuli specific contents (e.g., erotic vs negative) differentiate later stage of attentional process bringing patients to manifest difficulties in disengaging attention in some cases and avoidance mechanisms in others.

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Borderline personality disorder; Eye-tracking; Attentional bias; Hypervigilance; Avoidance.

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## 1. Introduction

Borderline Personality Disorder (BPD) is a severe mental disorder mostly characterized by emotional dysregulation (Linehan, 1993) as manifested by altered emotional processing and by the use of dysfunctional emotion regulation strategies. Previous literature on emotional dysregulation in BPD suggested that one of the aspects that can be primarily associated to BPD is a biological emotional vulnerability especially in the form of enhanced emotional sensitivity (Bortolla et al., 2019 a; Bortolla et al., 2020 a). Linehan's Biosocial model (1993) defines hypersensitivity as a low threshold for emotional reaction and a quick response to emotional situations. According to the psychobiological formulation of the model, the construct is manifested both in subjective and in physiological terms.

Hypersensitivity has been extensively studied in past research, which underlined that it is not a unique construct, and it can be captured by several manifestations. First of all, the "low threshold" part of the construct is manifested as enhanced basal negative hyperarousal: from a physiological point of view, BPD subjects showed low heart rate variability (HRV) in resting state conditions (for a review, see Koenig et al., 2016) which is connected to a reduced flexible adaptability to environmental changes (Thayer et al., 2009). Moreover, patients often reported a higher intensity of negative emotions at rest (Elices et al., 2012; Bortolla et al., 2019; Bortolla et al., 2020). These two aspects bring BPD patients to be in a frequent state of enhanced negative activation, reducing their threshold to respond to environmental stimuli. Accordingly, another manifestation of hypersensitivity is represented by BPD enhanced response to unemotional stimuli that are perceived as negative by patients (Burklund et al., 2007; Fertuck et al., 2013; Miano et al., 2013). Additionally, the "quick response" part of Linehan's definition of hypersensitivity is manifested by a rapid physiological activation in response to emotional stimuli (Bortolla et al., 2019) and a condition of hypervigilance to emotional cues (e.g., a rapid shift of attention to emotional cues; Bertsch et al., 2013; Bertsch et al., 2017; Frick et al., 2012).

The last aspect is of particular interest in BPD; since it puts the focus on visual information processing mechanisms that characterize patients. Indeed, while most of the previous studies evaluated how subjects reacted to emotional cues, the study of visual information processing allows to explore an earlier phase of emotional processing: evaluating which stimuli attracts patients' attention and how patients actively process incoming stimuli. This field of research acquired importance with the increase of eye-tracking studies, which allow obtaining a direct estimation of visual processing patterns through eye-movements, promoting a reliable measure of attentional mechanisms (Pomplun et al., 1996; Rehder, & Hoffman, 2005; Wooding et al., 2002).

Previous studies on visual attentional processing in BPD focused on three hypotheses: the hypervigilance, the attentional bias, and the attentional avoidance hypotheses. Previous research aimed at confirming the presence of hypervigilance mechanisms in BPD as manifested by faster orientation towards negative emotional stimuli (Frick et al., 2012), as well as by rapid shifts of attention towards the eyes of angry and neutral faces in a task of facial visual exploration (Bertsch et al., 2013; 2017). A second focus of research, supported an attentional bias in BPD as manifested by difficulties in disentangling attention from emotional stimuli. Other works showed support for a negative attentional bias for negative stimuli (Kaiser et al., 2017) and especially for threatening information (Kaiser et al., 2018). In contrast with previous studies, a third group of research focused on avoidance mechanisms in BPD as supported by a reduced visual exploration of prolonged emotional stimuli (e.g., Bortolla et al., 2019, 2020).

The attentional bias and the attentional avoidance seem to be opposite hypotheses that need to be clarified. A possible explanation is related to the emotional contents of the stimuli administered in the previous studies: for example, patients could have difficulties in disentangling the attention from negative stimuli and at the same time, they might show marked avoidance for positive stimuli (or vice versa). However, no previous studies tested the two hypotheses together using different valence categories of stimuli. On the contrary, there is not an explicit contrast between the hypervigilance and the others two hypotheses. It is possible that after an initial fast allocation of attention on emotional cues (i.e., hypervigilance), BPD subjects might maintain the attention on the same cues (i.e., attentional bias) or avoiding them (i.e., attentional avoidance) in the later stages of visual processing.

Most of the current studies on BPD attentional mechanisms relied on social stimuli such as facial expressions and social pictures (e.g., Bertsch et al., 2013; 2017; Bortolla et al., 2019; 2020). Interpersonal context acquired a growing interest in BPD literature given patients' difficulties in interpersonal relationships (APA, 2013) and the fact emotional dysregulation manifestations are often showed in social situations (Frick et al., 2012; Lis & Bohus, 2013; Minzenberg et al., 2006). As a whole, patients are characterized by intense and unstable relationships and marked fear of being abandoned (APA, 2013): patients desperately look for intimate relationships that can respond to their emotional need, but at the same time their relationships are often characterized by continuous by idealization and devaluation, continuous breaks and reconciliations. Moreover, one of the most relevant aspects is a marked rejection sensitivity (Berenson et al., 2009; Staebler et al., 2009) which describes a disposition to "anxiously expect, readily perceive and intensely react to rejection" (Downey et al., 2004). Relevantly, rejection sensitivity could be well related to hypervigilance, since patients might be rapidly attracted by potential threatening social cues in the environment. From one side, patients could avoid the

stimuli representing intimacy of a close relationship or, on the contrary, being inevitably attracted by these aspects, reproducing the previous contradiction between approach and avoidance. Moreover, these manifestations could be particularly marked when the sexual aspects of a relationship are taken into account. Patients are characterized by sexual impulsivity, promiscuity, and precocity, and higher sexual risk (e.g., Lavan & Johnson, 2002; Sansone, & Wiederman, 2009; Sansone et al., 2008; Sansone & Sansone, 2011) paired with lower sexual satisfaction and higher sexual preoccupation compared to HCs (Hurlbert et al., 1992; Schulte-Herbrüggen et al., 2009). Relevantly, BPD dysfunctional aspects in sexuality is often correlated to higher rate of sexual abuse and emotional distress (Sansone et al., 2008; Hurlbert et al., 1992; Spokas et al., 2009; Schulte-Herbrüggen et al., 2009; Wong et al., 2010; Afifi et al., 2011; Westphal et al., 2013). Given these premises, BPD patients should have severe difficulties in processing interpersonal stimuli, especially with relational contents.

In order to evaluate the previous assumptions this study used a modified dot-probe task paired with an eye-tracking methodology in order to assess both the early allocation of attention and the visual processing in BPD patients, compared to healthy controls (HCs). In detail, we administered a relational version of the dot probe using negative, positive, and erotic relational stimuli paired with neutral stimuli. Eye-tracking data were included in order to have a reliable measurement of attention allocation both at the early stage of visual processing and at later stages.

We aimed to: 1) Test the hypervigilance hypothesis as manifested by earlier allocation of attention towards relational stimuli compared to HCs; 2) evaluate whether BPD patients are characterized by an attentional bias (i.e., difficulties in disentangling the attention from social stimuli) or an avoidance bias (i.e., marked avoidance of social cues at a later stage of visual processing); 3) assess potential differences between relational stimuli categories (positive, negative, and erotic stimuli); 4) evaluate associations between the previous variables and scores positive and negative affectivity measured before the task.

## **2. Methods**

### **2.1 Participants**

In the next section, participants will be presented divided into a clinical group with BPD patients and a control group in which physicians recruited healthy participants.

#### **2.1.1 BPD patients**

The clinical sample was composed by 31 BPD outpatients (mean age=23.19,  $SD=3.74$ ; 27 females and 4 males) 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 by two tasks (passive view task and dot-probe task). Clinical subjects met a BPD diagnosis in 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 mental retardation, 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. Main lifetime co-diagnoses in this sample were Eating Disorder, Mood Disorder, and Substance Use Disorder. Most 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.

### **2.1.2 Healthy Controls**

Thirty-one community-dwelling volunteers age and gender matched (mean age=22.87,  $SD=1.87$ , 27 females and 4 males) 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 mental retardation, 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 in order 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**

### **2.2.1 Dot probe task**

A selective attention task based on the dot-probe task was used with emotional photographs with interpersonal contents (positive, negative, and erotic relationships) as stimulus material (MacLeod et al., 1986). The dot-probe task was composed by two blocks of 192 trials each. In blocks 1 (*b1*) and 2 (*b2*), the interpersonal pictures were paired with pictures displaying neutral faces. Additionally, neutral-neutral picture pairs served as control items. Overall, *b1* and *b2*

included 4 conditions of 48 trials each: 1) positive vs. neutral (P0), 2) negative vs. neutral (N0), 3) erotic vs. neutral (E0), and neutral vs. neutral (NN). Pictures were selected by a previous validation study. A pool of 206 stimuli was selected by the authors including pictures that clearly represented human social interactions within daily life contexts. The set was administered to 211 community-dwelling volunteers who rated each picture on four continuous bipolar sliding scales (valence, intimate relationship, sexual arousal; range 1-9). Twenty-four pictures 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 pictures with medium valence, low intimate relationship and low sexual arousal scores. Each category included 8 pictures with heterosexual relationships and 16 pictures with homosexual relationships (8 men and 8 women).

In the dot-probe task a fixation cross was presented for 1s in the center of a computer screen. Further, 2 pictures (either a neutral picture paired with an affective picture, or 2 neutral pictures) were presented concurrently, left and right to the central fixation point. Two different presentation times were included ( $b1$ ,  $b2$ : 500 ms;  $b2$ : 1500 ms) as it has been demonstrated that they capture different stages of attentional processing (Baum et al., 2013). The 500 ms presentation period was used because it represents the most common presentation period and represents both preconscious and conscious attentional processing. The 1500 ms presentation was used in line with the use of eye-tracking methodologies during dot-probe task (Schofield et al., 2012). The orders of presentation times, affective picture categories, and sides of appearance of the affective picture at the screen were randomized.

Immediately after the concurrent presentation of the 2 pictures, a probe (X) appeared in the same position as 1 of the 2 pictures. The participants were instructed to indicate as quickly as possible the side the X had appeared pressing “q” if the X was on the left and “p” if the X was on the right. Once the participant responded, the next trial started. Before the beginning of the experiment, a 26 trials practice block was administered. During the whole procedure eye-tracking data were recorded. Number of correct responses, reaction time, as well as main eye-tracking indexed according to Price et (Price et al., 2015) were calculated.

### 2.2.2 Eye-tracking data

Eye-tracking data were collected during the dot probe task by using *The Eye-Tribe*. Eye position was calculated based on the x- and y-coordinates of the recorded eye-gaze minus a corneal-reflection signal, which accounts for small head movements, and individually scaled and offset based on each individual's calibration parameters collected at the beginning of the session. Eye fixations were defined as eye positions stable within 1° of visual angle for at least 100ms and were used to calculate the following gaze pattern indices: percentage of trials with initial fixations falling within regions of interest - defined by the pictures' boundaries - (an index of initial attentional capture; *allocation*); latency to interpersonal stimuli (an index of vigilance; *latency*); percentage of time spent fixating on positive, negative and erotic interpersonal pictures (positive, negative and erotic) compared to neutral one (an index of overall attentional preference; *time in*); mean duration of the first fixations on positive, negative, and erotic interpersonal vs. neutral contents (an index of initial attraction vs. avoidance; *duration*).

### 2.2.3 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 a 2-month time period. In our sample, we administered the Italian version of the scale (Terraciano et al., 2003). The PANAS factor structure and solid psychometric properties were also confirmed for the Italian version.

### 2.3 Procedure

The complete experimental procedure was carried out at San-Raffaele Hospital – Turro, Milan in two different days. Informed consent was signed prior to the experiment. Participants completed two experiments of interpersonal functioning: the dot probe task described in this study and a clip task described in another study (Bortolla et al, 2022). 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.

### 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 using ARTool program (Wobbrock et al., 2011) was applied in order to evaluate non-parametric main

effect of group and interaction effects *group × condition* (i.e., negative, positive, neutral) and *group × block* (i.e., 500 and 1500), taking into account self-report and eye-tracking indexes. The same procedure was used to evaluate three ways *group × condition × block* interactions. 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  $\eta^2$  ( $\rho\eta^2$ ) was utilized as an effect measure of non-parametric main and interaction effects. Post-hoc comparisons were based on Mann-Whitney *U* tests. Spearman's correlation was used to evaluate associations among pre task emotional state (PA and NA) and dot-probe indexes during the task.

### 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 ( $F(1,60) = 6.80; p = .012; \rho\eta^2 = .11$ ) and NA ( $F(1,60) = 8.68; p = .005; \rho\eta^2 = .13$ ). In detail, BPD group reported higher NA ( $U = 289.00; Z = -2.27; p = .011$ ) and lower PA ( $U = 296.00; Z = -2.10; p = .017$ ) at the beginning of the experiment, as well as significantly higher NA ( $U = 207.00; Z = -3.38; p = .011$ ) and lower PA ( $U = 259.50; Z = -2.50; p = .007$ ) at the end on the clip task. A significant *phase* effect was found for PA ( $F(1,60) = 16.05; p < .001; \rho\eta^2 = .22$ ) with both groups decreasing positive affectivity from pre to post evaluation (BPD:  $Z = -2.31, p = .009$ ; HCs:  $Z = 3.03, p = .001$ ).

Descriptive statistics and group comparisons for PANAS scale scores were presented on table 1.

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

		BPD (N=31)	HCs (N=31)		
		M(SD)	M(SD)	<i>U</i>	<i>Z</i>
PANAS <i>pre-task</i>	PA	27.53 (8.84)	32.54 (7.50)	296.00**	-2.10
	NA	18.64 (8.80)	14.48 (7.32)	289.00^	-2.27
PANAS <i>post-task</i>	PA	23.92 (7.89)	29.63 (8.39)	259.00^	-2.50
	NA	19.75 (9.01)	12.90 (5.657)	207.00^	-3.38

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

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

### 3.2 Dot probe task: correct responses and bias score

A 3 (conditions) x 2 (groups) x 2 (blocks) ANOVA was used to evaluate condition, group and block effects as well as group x category, group x block and group x category x block interactions for each variable included in the study.

When correct responses were taken into account, no significant effects nor interaction were found. However, patients reported slightly lower correct responses in the negative condition of 1500ms presentation time ( $U = 341.50$ ;  $Z = -1.95$ ;  $p = .025$ ) compared to HCs.

A significant *group x condition* interaction was reported for bias score ( $F(2,58) = 3.25$ ;  $p = .05$ ;  $\eta^2 = .10$ ), with patients reporting higher bias score in the erotic condition ( $U = 362.00$ ;  $Z = -1.67$ ;  $p = .05$ ) as well as lower bias score in the negative condition ( $U = 317.00$ ;  $Z = -3.30$ ;  $p = .010$ ) compared to HCs. For both conditions the group difference is particularly manifested for 1500 presentation time (erotic:  $U = 308.00$ ;  $Z = -2.27$ ;  $p = .011$ ; negative:  $U = 289.00$ ;  $Z = -2.54$ ;  $p = .007$ ).

Descriptive statistics for correct responses and bias score are reported in Table 2.

**Table 2.** Descriptive statistics related to behavioral data

	BPD (N=31)			HCs (N=31)		
	M(SD)			M(SD)		
	<i>Negative</i>	<i>Positive</i>	<i>Erotic</i>	<i>Negative</i>	<i>Positive</i>	<i>Erotic</i>
<i>500ms</i>						
Correct	47.42(.81)	45.50(7.75)	44.48(9.12)	47.42(.807)	47.00(1.39)	47.03(1.32)
Bias Score	-.016(.05)	-.010(.04)	-.016(.05)	-0.01(0.02)	-0.01(0.04)	-.013(0.36)
<i>1500ms</i>						
Correct	45.27(7.94)	45.73(8.33)	44.77(9.63)	45.52(.625)	47.45(.859)	47.26(1.18)
Bias Score	-.02(.04)	-.017(.04)	.013(.04)	-.004(0.03)	-.013(0.3)	-.009(.032)

### 3.3 Dot-probe task: eye tracking indexes

No group differences nor significant interactions were reported for initial allocation and latency. Considering specific differences between groups, small but significant reduced latency was reported by BPD patients for erotic and negative conditions both at 500 (erotic:  $U = 326.00$ ;  $Z = -1.65$ ;  $p = .05$ ; negative:  $U = 325.00$ ;  $Z = -1.54$ ;  $p = .05$ ) and 1500ms presentation (erotic:  $U = 324.00$ ;  $Z = -1.67$ ;  $p = .05$ ; negative:  $U = 308.00$ ;  $Z = -1.72$ ;  $p = .044$ ).

Two separate 3 (conditions) x 2 (groups) ANOVAS (500 ms and 1500 ms) were conducted for the total time spent in relational pictures compared to the neutral one. No group effects nor significant interaction were reported. However, considering group comparisons, a specific

group difference was found for time spent in negative pictures in negative conditions at 1500ms ( $U = 295.00$ ;  $Z = -1.93$ ;  $p = .029$ ) with patient spending less time comparing to HCs.

Interestingly, when initial duration is taken into account (time spent in the relational picture the first time the subject moves the gaze on that cue) significant differences between groups were found for erotic stimuli at 500ms ( $U = 313.00$ ;  $Z = -1.85$ ;  $p = .033$ ) and negative cues at 1500ms ( $U = 338.00$ ;  $Z = -1.28$ ;  $p = .04$ ) with patients reporting reduced latency compared to HCs.

Descriptive statistics for eye data are reported in table 3

**Table 3.** Descriptive statistics related to eyes data

	BPD (N=31)			HCs (N=31)		
	M(SD)			M(SD)		
	<i>Negative</i>	<i>Positive</i>	<i>Erotic</i>	<i>Negative</i>	<i>Positive</i>	<i>Erotic</i>
<i>500ms</i>						
Allocation	.45(.11)	.39(.15)	.42(.18)	.41(.13)	.38(.14)	.35(.14)
Latency	.17(.08)	.13(.08)	.17(.07)	.19(.07)	.18(.09)	.17(.08)
Time in	.20(.08)	.18(.09)	.17(.09)	.19(.06)	.18(.06)	.18(.06)
Duration	.18(.06)	.16(.07)	.15(.07)	.19(.07)	.19(.06)	.18(.07)
<i>1500ms</i>						
Allocation	.34(.17)	.39(.11)	.34(.17)	.41(.09)	.40(.11)	.32(.13)
Latency	.40(.16)	.43(.15)	.48(.20)	.46(.19)	.47(.18)	.55(.21)
Time in	.27(.21)	.28(.19)	.26(.18)	.30(.11)	.30(.12)	.27(.11)
Duration	.25(.15)	.26(.16)	.24(.13)	.31(.13)	.31(.13)	.27(.12)

### 3.4 Association between pre task positive and negative affect and task scores

Small but significant associations were found in the clinical group between scores of pre task negative affect and task scores. In detail high levels of negative affect resulted associated with lower correct responses in the erotic condition ( $\rho = -.51$ ,  $p = .01$ ). The same variable was significantly correlated with latency manifested to negative ( $\rho = -.57$ ,  $p = .004$ ) and positive ( $\rho = -.52$ ,  $p = .01$ ) conditions as well as to initial allocation in the erotic ( $\rho = .42$ ,  $p = .04$ ), negative (negative:  $\rho = .42$ ,  $p = .04$ ) and positive ( $\rho = .46$ ,  $p = .02$ ) conditions.

## 4. Discussion

This study was carried out to investigate alterations in attentional mechanisms in BPD in response to interpersonal stimuli, focusing on four main aspects:

- evaluating a condition of hypervigilance to relational stimuli in BPD;
- testing whether patients are characterized by an attentional bias or an avoidance bias;

- assessing differences between stimuli categories (positive, negative, and erotic relational stimuli);
- evaluate associations between the previous variables and scores of positive and negative affectivity measured before the task.

Obtained results showed lower visual exploration latency in erotic and negative conditions manifested by BPD patients compared to HCs in a dot probe task. This finding supports the hypothesis of hypervigilance in BPD (e.g., Bertsch et al., 2013; Bertsch et al., 2017; Frick et al., 2012), bringing patients to move rapidly the attention toward stimuli that are potential triggers for the disorder. These mechanisms could be particularly manifested in response to relational cues since typical BPD interpersonal difficulties -such as marked rejection sensitivity (Berenson et al., 2009; Staebler et al., 2009), fear of abandonment, unstable and unsatisfactory relationships (APA, 2013)- might impact on patients' alertness. Additionally, these results were exclusively manifested in response to negative and erotic stimuli. Whether research on the processing of negative stimuli is well-documented in BPD patients (e.g., Bortolla et al., 2019, 2020; Frick et al., 2012), showing increased responsivity to such emotional situations (Reichenberger et al., 2017; Stepp et al., 2016), there are only few studies on the processing of erotic contents. Data on the elaboration of erotic contents in general population showed that sexual stimuli are particularly engaging for the subject (Bradley et al., 2001; Sarlo et al., 2005), requiring the involvement of appetitive motivational systems. Moreover, it is well known that BPD is often associated to sexual impulsivity, promiscuity, and precocity (Allan et al., 1998; Lavan et al., 2002, Sansone et al., 2008, 2009, 2011) that could impact on the appealing feature of the erotic cue even more, bringing these patients to orient the attention towards them. On the other hand, the sexual experience of patients is also characterized by high levels of sexual dissatisfaction and preoccupation (Hulbert et al., 1992; Schulte-Herbrüggen et al., 2009) and high scores of sexual abuse (Sansone et al., 2008; Hurlbert et al., 1992; Spokas et al., 2009; Schulte-Herbrüggen et al., 2009; Wong et al., 2010; Afifi et al., 2011; Westphal et al., 2013). These aspects could both determine the condition of alertness to these stimuli found in our study that are evaluated as potential threat, and impact on subsequent phases of visual exploration.

It is interesting to notice that, although negative and erotic contents both triggered a hypervigilance manifestation, subsequent phases of visual exploration of these stimuli were opposite for BPD patients. According to our findings, BPD patients reported a higher bias score for erotic conditions and a reduced bias score for negative contents compared to HCs. Moreover, visual processing of negative contents was characterized by reduced visual exploration (low time in and duration). In line with our results, patients seem to be rapidly

attracted by erotic pictures, and subsequently they show difficulties to disengage the attention to these contents. On the contrary, the fast shift of attention towards negative stimuli manifested by BPD patients was immediately followed by a rapid shift of attention away from the same contents. Whether the first condition is in line with the attentional bias hypothesis (e.g., Kaiser et al., 2017), the second confirms previous data related to the marked use of attentional avoidance mechanisms in BPD especially when interpersonal contents are taken into account (Bortolla et al., 2019; 2020a). These data are particularly interesting and support the idea that patients show altered attentional biases that are different with regard to the typology of contents involved. As reported before, erotic stimuli are appealing for nature (Bradley et al., 2001; Sarlo et al., 2005) but patients might manifest difficulties in disengaging attention due to their typical symptoms in this area (e.g., sexual preoccupation, dissatisfaction, and abuse). In this case BPD subjects could have difficulties in processing the erotic stimulus given its ambiguous nature: from one hand they recognize its appetitive nature that attracts attention and interest, at the same time the contents of the stimulus could activate distress and intrusive negative thoughts in line with subjective previous experiences, resulting in problems in disengaging attention from the sexual contents. On the other hand, negative stimuli are processed in a different way: patients might show extreme vigilance associated with heightened sensitivity for negative information (Reichenberger et al., 2017; Stepp et al., 2016) that could result in intense emotional states, bringing the subject to engage in abnormal behavioural strategies to avoid threats, resulting in avoidance manifestations. Relevantly, the negative clips reported contents related to abandonment, quarrels, breakups, that are strictly connected to typical BPD interpersonal difficulties (Tahirovic et al., 2016; Sesar et al., 2022) and could even more activate this hypervigilance-hyperactivation-avoidance pattern suggested by our data. It is interesting to notice that the negative condition is the only one in which patients reported lower numbers of correct responses. This result could be in line with Linehan's biosocial model assumptions (Linehan, 1993) sustaining that the intense emotional state elicited by negative stimuli could interfere with cognitive processes bringing patients to make more errors to the task.

When PANAS scores were taken into account, patients reported high levels of negative affectivity and low levels of positive affectivity at the beginning and at the end of the task. This is coherent with previous data related to a condition of hypersensitivity manifested by increased negative arousal at baseline that could be considered as a nuclear feature of BPD (Koenigsberg et al., 2002; Trull, 2001; Yen et al., 2002). Interestingly, pre task negative affectivity resulted associated with dot probe indexes exclusively in the BPD group. In detail, patients reported a lower number of correct responses, lower latency to negative, and positive stimuli, as well as higher allocation to negative, positive and erotic stimuli in association to high levels of negative

affectivity. It could be hypothesized that this baseline condition could bring patients to be particularly alerted to a potential threat. Indeed, they bring rapidly the attention to relational cues compared to a neutral one, probably to detect signals of danger independently from the content of the stimulus, confirming the role of affective context in the modulation of attentional biases (Smith et al., 2006). Furthermore, high negative affectivity also affected patients' ability to correctly complete the task, fully in line with the emotional interference on cognitive processes presented before (Linehan, 1993).

Even if we did not find significant block effects on task variables, most of our results related to group comparisons were enhanced when the 1500s block is presented. Previous findings showed that BPD difficulties are marked when prolonged stimuli presentations are considered (Bortolla et al., 2019; 2020; 2020a): 1500ms presentations could allow the patient to consciously process the stimulus activating dysfunctional regulation mechanisms (e.g., attentional bias and avoidance) (Cavicchioli et al., 2015; Selby & Joiner, 2009; Selby et al., 2013). For example, difficulty in disengaging attention is a process based on both automatic and strategic process and this it could be manifested in response to medium to long presentation time (Cisler & Koster, 2010). Furthermore, effort avoidance is a strategic and controlled process that is mainly observed at long presentation time. On the contrary, hypervigilance is mostly an automatic and uncontrolled process and thus it is observable even at very short presentation time (Cisler & Koster, 2010): indeed, hypervigilance manifestations emerged both at 500ms and at 1500ms presentation time.

As a whole, our findings confirmed the presence of altered attentional mechanisms in BPD patients. BPD seems characterized by hypervigilance to erotic and negative relational situations, in line with well documented interpersonal problems. However, stimuli specific contents (e.g., erotic vs negative) seems to differentiate later stage of the attentional process bringing patients to manifest difficulties in disengaging attention in some cases and avoidance mechanisms in others. Eventually, high levels of negative affectivity may affect the previous processes increasing patients' alertness to potential threatening (or rejecting) situations, such as social stimuli.

Although the relevance of these results, some limitations need to be taken into account. Sample composition needs to be carefully taken into account since it does not allow to control results for possible gender effects. Moreover, our sample showed high co-occurrence of other psychiatric disorders (e.g., major depressive disorder, anxiety disorders) that did not allow to definitively ascribe our findings to BPD pathology. It is well known that similar attentional biases underlie anxiety and depressive disorders, and future studies with clinical controls groups

should be conducted to differential attentional biases across disorders. However, obtained outcomes are in line with previous aforementioned researches showing BPD hypersensitivity and hyper-reactivity to specific stimuli. Given the well-known interpersonal dysfunction in BPD, further researches should account for this gap investigating the effect of possible confounding clinical comorbidities. Additionally, most of our participants took medications, and consequently future studies should replicate our findings comparing medicated participants versus unmediated participants. Eventually, detailed analysis should be conducted considering sexual orientation as a possible confounding factor. We considered this aspect during the construction of the task, including pictures representing both heterosexual and homosexual couples. However, the small number of homosexual and bisexual participants did not allow to run different analyses for each sub-sample.

**Ethical approval:** This study was conducted in line with the American Psychological Association's Ethical Standards for Research and Publication.

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

**Data Availability Statement:** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Conflict of interest statement:** The authors declare no conflict of interest.

**Author Contributions:** RB and GES participated in the design of the study, carried out the study, performed the statistical analysis and drafted the manuscript. EL participated to subjects' recruitment and testing. CM contributed to the theoretical background of the study and revised the manuscript.

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