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Hypersensitivity or hyperreactivity? An experimental investigation in Borderline Personality Disorder

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Abstract

Objective: Starting from the controversial results showed by empirical research on Linehan's Biosocial model of Borderline Personality Disorder (BPD), this study aims to empirically evaluate Linehan's conceptualization of emotional hypersensitivity and hyperreactivity, as well as to investigate the role of pre-existing emotional states in BPD altered physiological responsivity.

Methods: We asked 24 participants (BPD = 12; Healthy Controls = 12) to complete a self-reported questionnaire (Positive and Negative Affect Schedule) in order to assess their pre-task affective state. Subsequently, 36 emotional pictures from four valence categories (i.e. erotic, negative, positive, neutral) were administered while assessing participants self-reported and electrodermal responses.

Results: BPD patients showed higher levels of pre-task negative affectivity as well as an enhanced physiological response to neutral stimuli. No main BPD group effect was found for the physiological data. Moreover, pre-task negative affectivity levels were exclusively related to physiological responses among BPD subjects.

Discussion: Our findings supported the hypersensitivity hypothesis operationalized as an enhanced responsiveness to non-emotional cues. Hyperreactivity assumption was not supported. Conversely, our study revealed heightened physiological responses in relation to pre-existent negative emotional states in BPD. We discussed our results in the context of the putative pathological processes underlying BPD.

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1. Introduction

Borderline Personality Disorder (BPD) is a severe Personality Disorder (PD) which manifests a core pathological dysfunction in emotional processing and emotion regulation (Linehan, 1993). According to Linehan's Biosocial model (1993), BPD emotional dysregulation arises from an interaction between biological vulnerability and an invalidating environment. The first factor includes hypersensitivity and hyperreactivity to emotional cues, as well as, a slow return to emotional baseline (Zanarini & Frankenburg, 2007). There is a large consensus in identifying altered psychophysiological responses as a reliable biological marker of the previous dimensions (Cavazzi & Becerra, 2014). Further, Carpenter and Trull (2013) postulated that the biological aspects of emotional dysregulation are implicated in explaining core dysfunctional behaviors of BPD (i.e., impulsive, self-damaging and para-suicidal acts; Selby & Joiner, 2009).

Although Linehan's model seems to be well documented in clinical practice, empirical research did not fully support the model. A main problem is related to the operationalization of hypersensitivity and hyperreactivity. On the contrary, the slow return to emotional baseline seems to be the only assumption of the Linehan's model that was well supported by experimental studies, as manifested by an impaired habituation of emotional responses in BPD patients (e.g., Austin, Riniolo, & Porges, 2007; Dziobek et al., 2011; Ebner-Priemer et al., 2009; Weinberg, Klonsky, & Hajcak, 2009).

Hypersensitivity is characterized by a low threshold for eliciting emotional responses (Linehan, 1993). However, studies which experimentally tested it proposed different interpretations. First of all, some authors operationalized hypersensitivity as a basal condition of physiological hyperarousal (e.g. Kuo & Linehan, 2009; Linehan, 1993), even though this assumption was not definitely supported by experimental studies (e.g., for a review see: Cavazzi & Becerra, 2014; Koenig et al., 2016). Another possible definition of hypersensitivity is a higher probability to experience stimuli as emotional (Carpenter & Trull, 2013; Linehan, 1993). Consequently, it could be related to responsiveness to neutral stimuli, which are cues that should not produce specific emotional responses. Accordingly, neutral faces and stimuli seem to be particularly salient for BPD patients, who are likely to perceive neutral or ambivalent cues more negatively than healthy volunteers (e.g., Arntz & Veen, 2001; Domes et al., 2008; Hidalgo et al., 2016; Meyer, Pilkonis, & Beevers, 2004; Mier et al., 2012; Veen & Arntz, 2000; Wagner & Linehan, 1999) and consequently they might manifest a specific increased physiological responsiveness to such stimuli. Hence, given the previous evidences, the hypersensitivity hypothesis of BPD is not fully clarified.

On the other hand, hyperreactivity is defined by changes in the intensity of emotional responses after the presentation of an emotionally-evocative cue (Linehan, 1993). However, empirical research showed several problems in its conceptualization when experimentally assessed (Nelson, Shankman, Olino, & Klein, 2011), including differences in control conditions (e.g. baseline or neutral), analytic methods for measuring change (e.g. change score, percentage change score, statistical control for group differences), as well as assessment outcomes (i.e. self-reported, physiological or behavioral scores). Nonetheless, physiological outcomes remain the most reliable and used measure to assess the biological dimension of Linehan's model of emotional dysregulation in BPD.

In line with the previous methodological inconsistencies, empirical studies on BPD emotional hyperreactivity showed extremely mixed results (for a review, see: Cavazzi & Becerra, 2013; Rosenthal et al., 2008). For instance, most of the physiological/behavioral studies showed that BPD patients did not manifest more intense reactions compared to HCs (Ebner-Priemer et al., 2005; Elices et al., 2012; Herpertz et al., 2001; Herpertz & Koetting, 2005; Kuo & Linehan, 2009; Kuo, Fitzpatrick, Metcalfe, & McMain, 2016; Lobbestael, Arntz, Cima, & Chakhssi, 2009; Taylor & James, 2009; Weber et al., 2009). Conversely, some research reported specific hyper-responsiveness to unpleasant stimuli (Ebner-Priemer et al., 2009; Dziobek et al., 2011; Herpertz, Kunert, Schwenger, & Sass, 1999), BPD related scripts (Limberg, Barnow, Freyberger, & Hamm, 2011; Schmahl et al., 2004) and social stressor tasks (Weinberg, Klonsky, & Hajcak, 2009).

Given the previous inconclusive findings, we could hypothesize that BPD patients are not persistently hyper-responsive to emotional situations. Indeed, consistently with Linehan's clinical considerations, heightened emotional reactions are often referred by BPD patients when they experience pre-existing unpleasant emotional states (Linehan, 1993). However, there are no studies that empirically evaluate whether physiological hyperreactivity exclusively emerges in the presence of specific affective states (e.g. negative vs. positive affectivity) that are experienced before emotional events.

Starting from these considerations this study aimed to address some key unsolved questions related to emotional dysregulation in BPD:

1) clarify the concept of emotional hypersensitivity as operationalized in three ways: a) an increased basal physiological activation, b) an enhanced responsiveness to neutral stimuli, c) a basal heightened negative emotionality;

2) evaluate the hyperreactivity assumption defined as an overall heightened response to emotional stimuli;

3) investigate the role of pre-task emotional states in modulating physiological responses to emotional cues

In line with the previous aims, we collected physiological (Electrodermal Activity, EDA) data during the administration of negative, positive, neutral and erotic pictures from the Nencki Affective Picture System (NAPS; Marchewka, Żurawski, Jednoróg, & Grabowska, 2014; Wierzba et al., 2015). Further, pre-task affectivity was assessed by the Positive and Negative Affective Schedule (PANAS; Watson, Clark, & Tellegen, 1988).

The choice to include erotic pictures was related to the fact that to our knowledge there are no data on the processing and responsiveness to erotic cues in BPD patients. However, sexuality seems to be particularly relevant for BPD patients who usually manifest greater sexual preoccupation, sexual depression, and sexual dissatisfaction (Hurlbert, Apt, & White, 1992). Other studies have reported stronger negative attitudes, sexual pressure by partners, and ambivalence toward sexuality in BPD subjects compared to controls (Bouchard, Godbout & Sabourin, 2009). These data lead us to assume that erotic stimuli could be particularly problematic for BPD patients.

2. Methods

2.1 Participants

2.1.1 Individuals with BPD. Twelve BPD female outpatients were recruited from the Department of Psychiatry, Hospital de la Santa Creu i Sant Pau, Barcelona (Spain) from May 2016 to September 2016. Clinical subjects met BPD diagnosis in according to DSM-IV criteria evaluated by the *Structured Clinical Interview for DSM-IV axis II Personality Disorders, Version 2.0* (SCID-II, Gómez-Beneyto et al., 1994). SCID-II was conducted during routine diagnostic assessment by trained raters, who were blinded to the hypotheses of this study. Exclusion criteria were an IQ lower than 70 and the presence of other acute psychiatric symptomatology within one month before task administration (e.g. major depressive episode, active substance use). Nonetheless, lifetime co-diagnoses of other psychiatric disorders did not represent additional exclusion criteria. Moreover, patients were asked to refrain from using Benzodiazepines 24 hours prior to the experiment. The mean number of Personality Disorders (PDs) diagnoses was 2.00 (*SD* = 0.90, range 1-3). Dependent PD (*N*=4, 33.3%), Paranoid PD (*N* =4, 33.3%), Obsessive-Compulsive PD (*N* =3, 25%) and Avoidant PD (*N* =1, 8.3%) were the most recurrent PD co-diagnoses. Moreover, lifetime psychiatric comorbidities included Major Depression Disorder (*N* =7, 58.3%), Anxiety Disorders (*N* =2, 25%), Obsessive Compulsive Disorder (*N* =1, 8.3%), Eating Disorder (*N* =6, 50.0%), Substance Use Disorders (*N* =3, 25.0%). Pharmacological treatments did not also represent a study exclusion criterion.

Every patient took stable pharmacological treatments for at least three months. The number of medical prescriptions ranged from 2 to 3. The most commonly prescribed medications were SSRI, MAO, antiepileptics and neuroleptics/antipsychotics.

2.1.2 Healthy Controls. Twelve community dwelling female volunteers with negative medical history for psychiatric or neurological disorders were included in the nonclinical sample. Participants were screened using a self-report questionnaire specifically developed to investigate the presence of previous certificated psychological, psychiatric and neurological diagnoses and treatments. Additional exclusion criteria were an IQ lower than 70, substance use, psychopharmacological treatments and current or lifetime psychological treatments.

2.2 Measures

2.2.1 Pictures. Thirty-six pictures from the NAPS (Marchewka, Żurawski, Jednoróg, & Grabowska, 2014) were administered during the experiment. Pictures were divided according to the original ratings in 3 valence categories: a) Low Valence (Negative), b) High Valence (Positive) and c) Neutral Valence. Additionally, erotic pictures (ERO) from NAPS-ERO (Wierzba et al., 2015) were included in the set. As a whole, 9 pictures for each category were administered. Pictures were specifically selected considering different arousal levels to cover all valence and arousal dimensions.

2.2.2 Physiological data. EDA data were collected using *BITalino* (da Silva et al., 2014; Guerreiro et al., 2013) a biomedical data acquisition device with a sampling rate of 1000Hz. EDA was collected through two electrodes on the left palm. EDA results were analyzed using Ledalab (www.ledalab.de). A 2 Hz low-pass filter was used to pre-process the data (Mitra & Kuo, 2006). Moreover, a *Continuous Decomposition Analysis* (CDA, Benedek & Kaernbach, 2010a, 2010b) was applied and principal skin conductance indexes were extracted in a 5 seconds overlapping response window after the presentation of each picture. Indexes of Tonic (SCL) and Phasic Skin Conductance Response (SCR) were calculated from the physiological data and data were normalized using a log transformation.

2.2.3 Positive and Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988; Joiner et al., 1997). A twenty items questionnaire developed to assess the current positive (Positive Affect, PA) and negative (Negative Affect, NA) affectivity was administered. In our sample, the PANAS showed adequate reliability in both BPD (PA: α=.92; NA: α=.92) and HCs group (PA: α=.83; NA: α=.92).

2.2.4 Self-report. Arousal, valence and dominance were rated from 0 to 1 using three digital sliders (Affective Sliders, AS; Betella & Verschure, 2016). The dominance slider was added to

the two original scales (arousal and dominance) for the purpose of this study, in accordance with the authors of the AS. The poles of the AS (Aroused/Relaxed; Positive/Negative; Dominant/Overwhelmed) are characterized by the presence of an emoticon (i.e., symbolic and stylized facial expression) in order to give a visual representation of the affective poles of the scales. Self-report results were not considered as primary outcomes of the current study.

2.2.5 Procedure

The whole process was carried out in a laboratory setting at Pompeu Fabra University, Barcelona. Participants were asked to refrain from drinking coffee or smoking cigarettes 2 hours before the experiment. Informed consent was signed prior to the experiment. Participants were required to complete the PANAS and the anamnestic questionnaire. Before the experiment, a 2 minutes baseline recording for physiological activity was performed. Subsequently, participants completed a short block of practice trails of images to familiarize with the experimental protocol. The experiment was composed of two blocks of 18 pictures each, with a small break of 5 minutes between them. The order of the pictures was randomized for each participant. Before each picture, a fixation cross was shown for 5 seconds on the screen and participants were instructed to look at the cross until the picture appeared. Pictures were presented for 30s. After that, the three AS rating scales (Arousal, Valence and Dominance) appeared on the screen. This assessment procedure was proposed to replicate the original picture validation (Marchewka, Żurawski, Jednoróg, & Grabowska, 2014; Wierzba et al., 2015). Subjects were instructed to rate each scale using the mouse and then move to the next picture clicking on a "*Continue*" button on the screen. During the whole procedure, EDA data were continuously recorded.

2.2.6 Data Analysis

Consistently with the small sample size and the non-normal distribution of several outcomes measures in the study, we used non-parametric procedures to analyze the data. In detail, we computed Mann-Whitney *U* tests to compare BPD and HC subjects based on the Exact Test to calculate *p*-values. Monte Carlo simulation 2-*tailed* 99% confidence interval (CI) based on 1000 independent samples was computed to support the robustness of the findings (Davison, 1997). When multiple comparisons were performed, we applied adequate Bonferroni's correction. We used *r* as the effect measure of the comparisons, following Rosenthal (1991) and Field (2013). Furthermore, to evaluate non-parametric interaction effects, we applied the Aligned Rank Transform to perform factorial ANOVA using the ARTool program (Wobbrock, Findlater, Gergle, & Higgins, 2011). Partial eta-squared ($_p\eta^2$) was used as an effect size measure for ANOVA results. Eventually, we estimated Spearman's correlation (ρ) (bootstrap 2-*tailed*

99% CI) between baseline measures and outcomes during the experiment to evaluate how pre-task conditions interact with task responses. We also proposed ϱ comparisons between groups using specific transformation of Spearman's correlation coefficient, to compute the Fisher z-transformation necessary to estimate the significance of the difference between the observed correlations (Myers & Sirois, 2004).

3. Results

Four BPD participants and 1 HC were excluded from the analyses due to technical problems in the EDA recording. The remaining sample was aged matched (BPD= 30.50 [9.11]; HCs=23.90 [3.64]) (U= 24.00, Z=1.66, *ns*). BPD excluded participants did not significantly differ from included subjects for age and other clinical variables (e.g., number of PDs traits, number of psychiatric disorders and specific co-diagnoses).

Table 1 shows detailed results of the comparisons performed in relation to the physiological data. With regard to self-report outcomes, in both groups negative images showed lower scores in valence ratings than neutral (BPD: Z=-2.52, p<.0167; HCs: Z=-2.93, p<.01) and positive images (BPD: Z=-2.52, p<.0167; HCs: Z=-2.93, p<.01), as well as positive pictures were rated significantly higher than neutral ones (BPD: Z=-2.52, p<.0167; HCs: Z=-2.93, p<.01) (Comparisons were based on a Wilcoxon test using Bonferroni correction .05/3 = .0167).

Table 1. Physiological data: descriptive statistics and non-parametric comparisons

	BPD patients (*N*= 8)		HCs (*N*=11)					
	M(SD)	Mean Rank	M(SD)	Mean Rank	*U*	*Z*	*p*	*r*
SCL-baseline	814.92 (94.75)	8.38	854.87 (63.84)	11.18	31.00	-1.07	.31	-.24
SCR-baseline	2.09 (.46)	10.57	1.87 (.46)	8.82	31.00	-.68	.90	-.15
SCL erotic	684.62 (186.11)	7.63	818.72 (94.68)	11.73	25.00	-1.57	.13	-.36
SCL positive	688.42 (175.95)	7.88	825.14 (58.74)	11.55	27.00	-1.40	.18	-.32
SCL negative	673.87 (170.31)	7.25	824.30 (64.05)	12.00	22.00	-1.82	.08	-.42
SCL neutral	698.32 (177.48)	7.63	823.07 (77.80)	11.73	25.00	-1.57	.13	-.36
SCR erotic	.94 (.65)	11.63	.74 (.41)	8.82	31.00	1.07	.31	.24
SCR positive	.81 (.52)	9.75	.82 (.43)	10.18	42.00	-.16	.90	-.04
SCR negative	.92 (.45)	9.88	.91 (.33)	10.09	43.00	-.08	.97	-.02
SCR neutral	1.31 (.32)	13.88	.78 (.43)	7.18	13.00	2.56*	.009	.59

Note: SCL: Skin Conductance Level; SCR: Skin Conductance Response; p-value was computed on exact significance procedures (2-tailed); multiple comparisons Bonferroni correction was applied (α = 0.0125)

*p < .0125

3.1 Hypersensitivity hypothesis

We did not find significant differences between groups when baseline physiological measures were considered. Conversely, we observed a significant and moderate to large difference in levels of self-reported Negative Affect (NA) (U= 19.00; Z = 2.07; p = .009, [Monte Carlo simulation 99% CI: .035-.045]) measured before task administration. Specifically, BPD subjects showed higher levels of NA than HCs. Additionally, BPD individuals showed a significant and large difference in phasic response when neutral stimuli were presented (*U*= 13.00; *Z* = 2.56; *p* = .009, [Monte Carlo simulation 99% CI: .007-.012]). In detail, BPD subjects exhibited a physiological heightened response to neutral affective stimuli. These results supported the emotional hypersensitivity assumption in BPD patients in terms of an enhanced basal negative affectivity and a heightened physiological response to neutral stimuli.

3.2 Hyperreactivity hypothesis

Considering EDA measures, we did not find a main effect of group and category for SCR [*F* (1,17) = 2.97; *p* = .10; $_p\eta^2$ = .15]. On the other hand, a large and significant interaction effect was revealed [*F* (3,15) = 4.11; *p* = .03; $_p\eta^2$ = .45]. In detail, as previously mentioned, BPD subjects showed a specific increased phasic response in relation to neutral stimuli (*U*= 13.00; *Z* = 2.56; *p* = .009, [Monte Carlo simulation 99% CI: .007-.012]) (Bonferroni correction: .05/4 = .0125). We did not find a main effect of group and category for SCL [*F* (1,17) = 2.95; *p* = .10; $_p\eta^2$ = .15] nor a interaction effect [*F* (3,15) = 1.48; *p* = .26; $_p\eta^2$ = .23]. These findings did not support the hypothesis of an overall hyperreactivity in BPD.

3.3 Baseline-task relationships

Considering self-reported Positive Affect (PA) measured before task administration, we did not find significant relations with phasic and tonic responses during experiment. However, we observed a significant difference between groups in the correlation of pre-task PA and Phasic SCR responses to erotic stimuli (ϱ_{BPD} = -.67; ϱ_{HC} = .27; *Z* = -2.81; *p* = .007) (Bonferroni correction .05/4 = .0125). As a whole, pre-task PA was related to lower SCR in BPD subjects; conversely, the same dimension showed a small opposite effect in HCs.

Pre-task levels of Negative Affect (NA) were exclusively related to SCR to positive stimuli in the BPD group (ϱ = .98; *p* < .001, [bootstrap 99% CI: .53-1.00]). Furthermore, we found significant differences between groups in the correlation with erotic (ϱ_{BPD} = .79; ϱ_{HC} = -.69; *Z* = 4.78; *p* < .001), positive (ϱ_{BPD} = .98; ϱ_{HC} = -.54; *Z* = 7.35; *p* < .001) and negative (ϱ_{BPD} = .71; ϱ_{HC} = -.47; *Z* = 3.60; *p* < .001) stimuli. Specifically, pre-task NA was related to higher SCR in BPD subjects; conversely, the same dimension demonstrated an opposite effect in HCs.

4. Discussion

The current study sought to clarify two aspects of emotional vulnerability postulated by Linehan's emotional dysregulation model of BPD (i.e. physiological hypersensitivity and hyperreactivity). In line with Linehan's Biosocial theory, we hypothesized that hypersensitivity could be adequately described by different emotional functioning: an increased activation in baseline condition or higher physiological responses in relation to neutral emotional stimuli. Additionally, we considered two possible aspects of physiological hyperreactivity: an overall heightened response or an affective-related hyper-responsiveness.

Our results supported the emotional hypersensitivity hypothesis in BPD in terms of an enhanced basal negative affectivity and a heightened phasic physiological response when neutral stimuli were presented. The relevance of heightened basal negative affectivity is coherent with previous findings (Elices et al., 2012; Feliu-Soler et al., 2014; Kuo & Linehan, 2009; Scott, Levy, & Granger, 2013). In addition, altered physiological response to neutral stimuli is consistent with neuroimaging data which demonstrated that BPD individuals show greater amygdala activation than HCs in relation to the presentation of neutral facial expressions (Donegan et al., 2003). Moreover, our finding is in line with well-documented deficits in emotion recognition in BPD, especially to ambiguous emotional stimuli (Daros, Zakzanis, & Ruocco, 2013; Domes et al., 2008). On the contrary, hypersensitivity hypothesis was not manifested by an increased basal physiological activation, in line with other studies showing counter-intuitive results in relation to Linehan's assumption (e.g., for a review see: Cavazzi & Becerra, 2014).

The assumption of an overall hyperreactivity to emotional cues was not supported as demonstrated by the absence of significant differences between groups in the physiological responses to emotional pictures. As previously reported, this result is consistent with previous studies which demonstrated that BPD patients show similar physiological responses to different emotional stimuli compared to HCs. A possible explanation might be related to the type and the content of our emotional stimuli (i.e., general emotional pictures). Indeed, several studies which used general emotional stimuli showed small or null differences in SCR among BPD patients compared to HCs (Bichescu-Burian et al., 2016; Kuo & Linehan, 2009; Kuo, Neacsiu, Fitzpatrick, & MacDonald, 2014; Lobbestael, Arntz, Cima, & Chakhssi, 2009). Conversely, previous studies which revealed enhanced physiological responses presented BPD related stimuli (i.e., interpersonal stressors and trauma related cues; Limberg, Barnow, Freyberger, & Hamm, 2011; Schmahl et al., 2004; Weinberg, Klonsky, & Hajcak, 2009). In line with these results, future research should compare BPD physiological responses to general emotional stimuli and disorder related cues, within the same study, in order to clarify this inconsistency.

Our findings related to a significant relation between pre-task levels of NA and physiological responses during the task might suggest a context-specific hyperarousal hypothesis. In detail, we found different associations between NA and phasic responses in BPD patients and HCs, with BPD patients who reported higher phasic responses to emotional pictures when negatively activated before the task administration. Interestingly, these relations were significantly different in BPD and HCs. In line with our hypothesis, it might be possible that BPD patients exclusively manifested intense physiological responses due to pre-existent negative emotional states. This effect was particularly relevant when BPD individuals were exposed to positive emotional stimuli. The increased physiological response to positive stimuli when BPD patients experience high levels of negative affectivity might be consistent with a demonstrated tendency to suppress positive emotions (Beblo et al., 2013). It is well known that suppression produces an increase of physiological responses (Gross, 1998; Gross & Levenson, 1993, 1997). Consequently, it could be possible that BPD individuals use suppression as a maladaptive emotion regulation strategy (for a meta-analytic review see: Cavicchioli, Rugi & Maffei, 2015), especially when they experience contradictory emotional states, leading to heightened phasic responses. Additionally, the high levels of negative affectivity in BPD (Chu, Victor, & Klonsky, 2016; Krueger et al., 2012; Mena, Macfie, & Strimpfel, 2016) might represent itself one of the most robust vulnerability factors to emotional physiological hyperreactivity. This has been already demonstrated in studies with nonclinical individuals (Zellars et al., 2009) and it is also supported by our results related to a significant increase of baseline NA in BPD patients compared to HCs. Conversely, it seems that positive affectivity might induce a reduced response to erotic stimuli, in BPD patients. Indeed, pre-task PA was related to lower SCR exclusively in BPD subjects. Unexpectedly, erotic pictures did not elicit enhanced emotional reactions in BPD patients, compared to HCs. As a whole, our data seems to support the crucial role of pre-existing hypersensitivity to affective stimuli in modulating the physiological response of BPD subjects to emotional cues.

The current study has several limitations. First, our sample was exclusively composed by women. Consequently, we have no insight in gender effects. Nevertheless, this sampling bias was related to the BPD population which is mainly composed of females as reported by several clinical trials for this disorder (for a review see: Leichsenring et al., 2011). Secondly, we enrolled a small number of participants. Even though our data were appropriately analyzed with statistical methods for such a condition and our results are robust, the small sample size might affect the relationships observed between pre-task traits and experimental responses. Indeed, the strong association between NA and SCR to emotional stimuli, especially to positive stimuli, would be certainly reduced with a larger sample. Consequently, our findings should be replicated

with a more representative sample size of such population. Further sampling limitations were related to co-diagnoses and pharmacological treatments in the BPD group. Specifically, the high co-occurrence of other psychiatric disorders, especially Major Depressive Disorder, might influence physiological responses to emotional cues. However, the co-diagnoses between BPD and other clinical conditions are the norm rather than the exception (e.g., Grant et al., 2008). Consequently, it was not possible to carry out a study which exclusively considered BPD subjects without other psychiatric conditions. Consistent with the large heterogeneity of additional psychiatric disorders, our participants necessarily took medications and the interruption of treatment for experimental reasons is counterproductive regarding clinical goals. Eventually, another limitation was related to the content of the stimuli. Although our stimuli are ecologically valid by showing real-life situations, it could be possible that they are not sufficiently personally relevant for BPD individuals. Lastly, since emotion eliciting techniques vary, our results may not be directly comparable to other studies which have used different methods for emotional elicitation (e.g. films, sounds, or autobiographical memories). However, we consider our results representative given the well-established properties of the emotional image database we used.

In conclusion, our results mainly support the emotional hypersensitivity hypothesis in BPD rather than an overall hyperreactivity assumption. In particular, we showed that baseline self-reported explicit affective states are connected to the physiological responses to affective stimuli in BPD. Our results thus point towards suggesting an alternative conceptualization of emotional hyper-reactivity in BPD, which resulted manifested exclusively when patients are negatively aroused.

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