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Negative reward expectations in Borderline Personality Disorder patients: Neurophysiological evidence

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ABSTRACT

Borderline Personality Disorder (BPD) patients present profound disturbances in affect regulation and impulse control which could reflect a dysfunction in reward-related processes. The current study investigated these processes in a sample of 18 BPD patients and 18 matched healthy controls, using an event-related brain potentials methodology. Results revealed a reduction in the amplitude of the Feedback-Related Negativity of BPD patients, which is a neurophysiological index of the impact of negative feedback in reward-related tasks. This reduction, in the effect of negative feedback in BPD patients, was accompanied by a different behavioral pattern of risk choice compared to healthy participants. These findings confirm a dysfunctional reward system in BDP patients, which might compromise their capacity to build positive expectations of future rewards and decision making.

1. Introduction

Borderline Personality Disorder (BPD) is a complex and serious mental disorder with a characteristic pervasive pattern of instability on affect regulation, impulse control, interpersonal relationships and self-image, and severe functional impairment (Lieb, Zanarini, Schmahl, Linehan, & Bohus, 2004). Although it seems to be a heterogeneous and less stable diagnosis (Zanarini, Frankenburg, Reich, & Fitzmaurice, 2010), emotion dysregulation is the most permanent and frequent criterion (Carpenter & Trull, 2013; Glenn & Klonsky, 2009). Some influential accounts on the etiology of BPD propose that patients present an impairment in the processing of critical information in the adaptation of behavior to environmental contingencies (e.g., rewards and punishments associated with their actions) which would compromise their emotional self-regulation (Crowell, Beauchaine, & Linehan, 2009). Nevertheless, studies on the processing of rewarding outcomes as well the expectations of receiving a reward have been scarce in these patients.

Emotional reactivity and cognitive control have been proposed as two features of the BPD emotional difficulties and, additionally, have been related to their attachment style which plays a central role in the development of the disorder (Agrawal, Gunderson, Holmes, & Lyons-Ruth, 2004; Minzenberg, Poole, & Vinogradov, 2008; Steele & Siever, 2010). Rodent models and human neuroimaging have related the attachment system with the reward network due to a shared neural circuit which links a neuropeptide-sensitive mechanism (oxitocin/vasopressin), within the anterior hypothalamus, to the ventral tegmental area (VTA) and nucleus accumbens (see for a review Insel & Young, 2001). In addition, from a gene-environment perspective, the dopamine DRD4 polymorphism in children has been related to disorganized attachment patterns with parents (Lakatos et al., 2000). The reward system is related to a variety of motivated behaviors and cognitive processes, such as reinforcement learning, novelty processing, action monitoring, decision making or addiction (Camara, Rodriguez-Fornells, Ye, & Münte, 2009). Therefore, the interaction between these two systems (reward and attachment) may be especially important for mediating the rewarding properties of social interaction as salient-motivating cue, and for affect and stress regulation (Strathearn &

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Mayes, 2010; Vrticka, Andersson, Grandjean, Sander, & Vuilleumier, 2008).

The idea of a dysfunctional reward system in the BPD has received growing theoretical interest in recent years (Bandelow, Schmahl, Falkai, & Wedekind, 2010; Friedel, 2004). Previous research has reported impaired opioid activity, linked with the reward system (Prossin, Love, Koeppe, Zubieta, & Silk, 2010). Furthermore, empirical data show that the BPD individuals make impulsive choices that result in fast appetitive rewards (Dougherty, Bjork, Huckabee, Moeller, & Swann, 1999; Lawrence, Allen, & Chanen, 2010). Several studies have suggested a dysfunctional reinforcement processing during both reward and loss feedbacks (Kirkpatrick et al., 2007; Völlm et al., 2007). A recent event-related brain potential (ERP) study (Schuermann, Kathmann, Stiglmayr, Renneberg, & Endrass, 2011) showed reduced amplitude on the Feedback-Related Negativity (FRN) component in BPD patients (relative to controls) who were performing an Iowa Gambling Task. Interestingly, this ERP component is elicited 250–300 ms after the presentation of a feedback, indicating a monetary loss or incorrect action (Gehring & Willoughby, 2002; Miltner, Braun, & Coles, 1997). The dynamics of the FRN have been explained using the reinforcement learning model (Holroyd & Coles, 2002) which proposes that the FRN is indirectly reflecting the influence of decrease in VTA dopaminergic signals in the midbrain after unexpected punishments (Schultz, 1998). This reinforcing signal might be transmitted to the ventral striatum, as well as other cortical regions such as the medial prefrontal cortex. The FRN has been associated with a possible teaching signal concerning *worse than expected* consequences of actions. Considering this proposal, unexpected negative outcomes should elicit larger amplitude in the FRN component than unexpected positive outcome. In addition, several studies have described an enhancement of theta power activity after negative outcomes, which might not only be related to ACC activity, but also might reflect a broader neural network involved in orchestrating adaptive adjustments after errors or negative feedbacks (Cohen, Elger, & Ranganath, 2007; Marco-Pallares et al., 2008). No previous research has studied theta power modulations in the BPD.

In the present study we evaluated the neurophysiological correlates (ERPs and theta oscillatory activity) associated with reward processing in a sample of BPD patients. In contrast to previous studies (Schuermann et al., 2011), we used a paradigm where the outcomes were not predictable, a monetary gambling task in which participants had to choose between two numbers in order to win or lose real money. In this paradigm the behavior is not guided by objective probabilities of receiving a reward or punishment (as for example, in reversal learning tasks or the Iowa Gambling Task; Schuermann et al., 2011), but by internal expectations as rewards and punishments are delivered at random. Therefore, we aimed to study the differences between BPD and healthy subjects associated with an uncertain environment or contexts in which clear predictions about the outcome of their actions were not possible. In addition, this paradigm has been shown to provide a very reliable FRN component and theta oscillatory activity in loss trials (Gehring & Willoughby, 2002; Marco-Pallares et al., 2008; Marco-Pallarés et al., 2009). We hypothesized that the characteristics of the present gambling task, in which there is neither correct response nor objective rule, could induce a differential behavioral pattern in BPD patients compared to healthy participants, especially in their risky choice patterns (that is, the tendency to increase their risk after certain outcomes; Gehring & Willoughby, 2002; Pedrão, Mallorquí, Cucurell, Marco-Pallarés, & Rodríguez-Fornells, 2013). In addition, given the tendency of BPD to form unrealistic goals and negative expectations about the outcomes of their actions (Crowell et al., 2009), we hypothesized that monetary losses would have less impact in BPD patients than in healthy participants (reduced negative prediction error), yielding a reduction in the amplitude of the FRN component and theta oscillatory activity.

All these hypotheses were tested in a group of BPD women (double diagnostic interview by independent evaluators). Complementarily to the clinical instruments, and in order to better characterize the reward system in the sample and to control the individual differences in reward processing between patients and healthy participants, we used the Sensitivity to Reward and Punishment scales (Torrubia, Ávila, Moltó, & Caseras, 2001), to measure approach-avoidance conflicts at cognitive level which could bias feedback processing (for a review on decision making and emotion regulation see Mitchell, 2011). Finally, as previous studies have shown that certain psychopharmacological drugs could affect the ERPs' components as well as the responsiveness of the reward brain system (see for example: Abler, Grön, Hartmann, Metzger, & Walter, 2012; Johannes, Wieringa, Nager, Dengler, & Münte, 2001) a protocol to assess total medication load, previously used in psychiatric samples (Vederman et al., 2012), was used to control possible confounding effects.

2. Methods

2.1. Participants

Thirty-six women ranging in age from 18 to 45 years old were included in the study. The BPD participants were 18 outpatients of the Psychiatry Department of the Hospital of Igualada (Barcelona, Spain) who met the diagnostic criteria according to DSM-IV-TR (APA, 2000). The Healthy Control (HC) group consisted of 18 healthy women recruited via local advertisement without history of any psychiatric disorder. The exclusion criteria were the presence of brain injury, psychotic, bipolar, or current major depressive disorder, drug or alcohol abuse in the previous month, and an Intelligence Quotient (IQ) below 80. Groups were matched by age and IQ. The participants were paid, and the study followed the Declaration of Helsinki and was approved by the local Scientific and Ethics Committee.

The BPD patients underwent a double diagnostic interview by independent evaluators trained in the administration of the Spanish validation of the Diagnostic Interview for Borderlines-Revised (Barrachina et al., 2004), in order to ensure the diagnosis. Both BPD and HC groups were assessed with a Spanish adaptation of the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (Pérez-Prieto, Alvarez, Monros, Sarria, & Pérez-Marín, 2008) and for DSM-IV Axis I (First & Gibbon, 1997). The BPD depressive symptoms ranged from 4 to 17 ($M = 11.55$, $SD = 4.27$) in the Hamilton Depression Rating Scale (HDRS, Hamilton, 1960). Medication prescription in the BPD group was stable along the study ($M = 2.33$, $SD = 1.84$, range: 0–5). The selective serotonin reuptake inhibitors ($N = 10$) and benzodiazepines ($N = 9$) were the most used, followed by mood stabilizers ($N = 7$), atypical antipsychotics ($N = 4$) and another type of drugs such noradrenergic and serotoninergic antidepressants ($N = 5$). Demographic and clinical variables can be observed in Table 1.

2.2. Materials

2.2.1. Self-report measures

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ, Torrubia et al., 2001) is a questionnaire developed and validated directly on Gray's personality model (Corr, 2004) and consists of two scales: the Sensitivity to Punishment scale (SP), which measures individual differences on Behavioral Inhibition System functioning, and the Sensitivity to Reward scale (SR), which measures individual differences on Behavioral Activation System functioning.

To assess the assigned value given by participants to a determined amount of money, a scale was created *ad hoc*. It consisted of four visual analog scales (VAS) which ranged from 0 to 100 points. The first two aimed to assess the subjective impact produced by the possibility of receiving a certain amount of money (100 euro and 0.50 euro cent), and the others were used for the assessment of the subjective impact produced by the possibility of losing a given amount of money (100 euro and 0.50 euro cent). High scores indicated that participants evaluated the impact of a possible loss/gain as very important for themselves. This measure aimed to capture the impact of possible economic feedbacks considering four possibilities (depending on valence and magnitude) in a daily virtual scenario.

2.2.2. Medication load

This scale is a protocol to assess total medication load, previously used in psychiatric samples (Vederman et al., 2012). For the implementation, antidepressant, anxiolytic, mood stabilizer, and anti-psychotic medications were coded as absent = 0, low = 1, or high = 2, based on previously employed methods to convert each medication to a standardized dose (Almeida et al., 2009; Sackeim, 2001). Antipsychotics were converted into chlorpromazine dose equivalents (Davis & Chen, 2004). As a result, we obtained a composite measure of total medication load by