Neural Processing of Social Participation in Borderline Personality Disorder and Social Anxiety Disorder

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Patients with borderline personality disorder (BPD) and patients with social anxiety disorder (SAD) are known to be highly sensitive to social rejection. Social information processing is assumed to play a key role for this shared psychopathological phenomenon. The first steps in social information processing are to encode social cues and to create a mental representation of the social situation. The aim of the current study was to test whether the perception of social participation in patients with BPD and patients with SAD is biased in this initial stage of social processing. Focus was on the P3b, a brain potential related to stimulus evaluation that has been shown to be a sensitive indicator for the processes of interest. Twenty-five unmedicated patients with BPD, 25 unmedicated patients with SAD and 25 healthy controls (HC) played an EEG-compatible version of Cyberball, a virtual ball-tossing paradigm that experimentally induces social inclusion and exclusion. All participants showed a pronounced P3b when excluded. Only patients with BPD showed an enhanced P3b also during the inclusion condition, indicating altered processing of social inclusion. The EEG results for the BPD group were consistent with their self-report data. Patients with BPD felt more excluded during the inclusion condition of Cyberball than both HC and patients with SAD. Furthermore, heightened rejection expectancy (subscale of the Rejection Sensitivity Questionnaire) was associated with a smaller difference in the P3b amplitude between inclusion and exclusion. Results indicate a negatively biased perception of social inclusion in BPD already during the initial stage of social processing.

Keywords: borderline personality disorder, social anxiety disorder, rejection sensitivity, social exclusion, event-related brain potentials
that such behavior will have disastrous consequences in terms of loss of status, loss of worth, and rejection (Clark & Wells, 1995). According to a study by De Jong et al. (2009), social anxiety is associated with the tendency to overestimate the probability that ambiguous events are signs of rejection and to underestimate the probability that unpleasant events will result in approval. Downey and Feldman (1996) established the term “rejection sensitivity” (RS) to describe the disposition to anxiously expect, readily perceive, and overreact to rejection. By triggering both processing biases (perceiving rejection in ambiguous or even benign social situations) and maladaptive reactions (e.g., hostile, aggressive behavior, social withdrawal), the expectancy to be rejected acts as a self-fulfilling prophecy for future interpersonal problems and is therefore viewed as the core component of the RS dynamic (Downey, Freitas, Michaelis, & Khouri, 1998; Romero-Canayas & Downey, 2005). Rejection sensitivity can be assessed with the Rejection Sensitivity Questionnaire (RSQ; Downey & Feldman, 1996). Two subscales, rejection anxiety and rejection expectancy, measure the degree of concern/anxiety and the expectation of being rejected in the context of hypothetical situations in which rejection is possible. Patients with BPD reported the highest level of RS relative to other clinical samples and healthy controls; patients with SAD ranked second (Staebler, Helbing, Rosenbach, & Renneberg, 2011). Furthermore, RS has been shown to be positively associated with the development of borderline symptoms (Boldero et al., 2009; Rosenbach & Renneberg, 2011), and of social anxiety symptoms (Marston, Hare, & Allen, 2010; McCarty, Vander Stoe, & McCauley, 2007). Additionally, Miano et al. (2013) reported that RS acts as a mediator between BPD features and trust appraisal. Differentiating between the two subscales of the RSQ, rejection expectancy emerged as the stronger predictor of borderline symptoms (Rosenbach & Renneberg, 2014), whereas results of London, Downey, Bonica, and Paltin (2007) emphasize the importance of the anticipatory rejection anxiety in the etiology of social anxiety.

Cyberball, a paradigm suited to experimentally examine the sensitivity to rejection, is a virtual ball-tossing game that reliably induces social inclusion and exclusion (Williams, Cheung, & Zadro, 2000). Social exclusion triggered by Cyberball is referred to as social inclusion and exclusion (Williams et al., 2000). In Cyberball studies patients with BPD showed an increased tendency to experience ostracism compared to healthy individuals, which was most apparent during the inclusion condition of Cyberball (Domsalla et al., 2013; Renneberg et al., 2012; Staebler, Renneberg, et al., 2011). In BPD, a characteristic emotional response to perceived rejection is rage (Berenson et al., 2011). Thus, a negatively biased perception of social inclusion might contribute to the development and maintenance of BPD symptoms by fueling interpersonal conflicts.

With regard to SAD, Cyberball studies conducted with analogue samples (Oaten, Williams, Jones, & Zadro, 2008; Zadro, Boland, & Richardson, 2006) suggest that postevent, rather than online processing of social interaction, is altered in SAD. Compared with individuals with low social anxiety, highly socially anxious individuals did not differ in the immediate response to social exclusion induced by Cyberball, but showed a pattern of prolonged need threat and regulatory impairment (Oaten et al., 2008; Zadro et al., 2006). However, to our knowledge, no published study has examined the perception of social inclusion and exclusion in clinical samples with SAD, even though the cognitive model of SAD assumes that the fearful expectations of patients with SAD lead to biases in the processing of social events, and hence, perpetuate their social fears (Clark & Wells, 1995).

Cyberball neuroimaging studies indicate that the sensitivity to rejection is associated with the responsiveness of a neural network involved in the processing of social exclusion (Way, Taylor, & Eisenberger, 2009; Masten et al., 2009). Within this network, the dorsal anterior cingulate cortex (dACC) is assumed to function as a neural alarm system for social threat (Eisenberger & Lieberman, 2004). The dACC is known to act as a conflict or discrepancy detector, activated by expectancy violation, goal conflicts, and behavioral response conflicts (Kerns et al., 2004; Weissman, Giesbrecht, Song, Mangun, & Woldorff, 2003). The advantage of electroencephalography (EEG) compared with functional MRI (fMRI) is the high temporal resolution. The EEG records stimulus-evoked voltage changes from the human scalp, which can be related to specific stages of social information processing (Bar-tholow & Dickter, 2007).

In a modified EEG version of Cyberball, social exclusion can be induced by a reduced probability of getting the ball (Gutz et al., 2011). This version of Cyberball resembles the characteristics of the oddball paradigm, wherein an infrequent target is presented against a background of frequently occurring standard stimuli. The rare target stimulus (oddball) reliably evokes the P3b potential, a positive voltage deflection that occurs ~300 ms after the onset of the target stimulus (Donchin, 1981). The amplitude of the P3b is maximized parietaIy and is assumed to be elicited when the discrepancy detection system (dACC) recruits neocortical regions (posterior parietal cortex, temporo-parietal areas) for further stimulus evaluation to resolve the discrepancy (Linden, 2005; Menon & Uddin, 2010; Polich, 2007). The P3b is sensitive to stimulus probability and meaning (stimulus value and stimulus complexity) and is associated with attentional processes and memory operations (Donchin, 1981; Johnson, 1986). Numerous studies revealed that the P3b amplitude is inversely related to the subjective probability of the stimulus, and therefore, indicate that the P3b is also sensitive to changes in expectancies (Donchin, 1981; Duncan-Donchin & Donchin, 1977; Johnson, 1986; Squires, Wickens, Squires, & Donchin, 1976). An integrative interpretation of the cognitive meaning of P3b is provided by the context updating theory (Donchin & Coles, 1988; Polich, 2007), emphasizing its association with stimulus encoding. According to this theory, the P3b indexes an attention-driven memory comparison process that determines whether the incoming stimulus is consistent with the current mental model of the stimulus context. If a stimulus attribute change is detected, the P3b component is generated, indicating the revision or updating of the pre-existing mental model of the environment and related expectancies. Results of previous EEG-Cyberball studies with nonclinical participants suggest that receiving the ball during the low probability condition (exclusion) is unexpected and associated with a greater need to update the mental representation of one’s social inclusionary status than the inclusion condition (Gutz et al., 2011; Weschke & Niedeggen, 2013). The P3b was significantly enhanced in the exclusion condition relative to the inclusion condition of Cyberball and was significantly correlated with perceived ostracism intensity (Gutz et al., 2011). Therefore, the P3b seems to be a useful measure for examining the first steps of social information processing.
and in particular neural processes that are associated with social expectations and their online evaluation.

In the current study, the EEG version of Cyberball was applied to test whether the perception of social interaction in patients with BPD and patients with SAD is altered in the initial stage of social processing. Because previous self-report findings indicate a negatively biased perception of social inclusion in BPD, it was hypothesized that the P3b amplitude in patients with BPD would not only be present during the exclusion condition, as it was found in healthy participants before, but also during the inclusion condition of Cyberball. With regard to SAD, biased processing of social events is assumed to be a maintaining factor. However, Cyberball studies with analogue samples have so far failed to provide supporting evidence. Thus, it was assumed that patients with SAD exhibit alterations in the P3b response pattern similar to but less pronounced than patients with BPD. Furthermore, based on the RS model, it was hypothesized that impairment in the ability to discriminate between being excluded and being included is related to the disposition to expect rejection. Higher rejection expectancy, measured by the RSQ, was assumed to be associated with a smaller P3b amplitude difference between inclusion and exclusion.

Method

Participants

Seventy-five participants were included in this study. Twenty-five inpatients from the Department of Psychiatry (Charité Berlin, Germany) with the diagnosis of BPD, 25 patients with SAD from two university outpatient departments (Freie Universität Berlin and Humboldt-Universität zu Berlin) and 25 healthy controls agreed to participate in the study. All patients with BPD were in the first 2 weeks of a 12-week inpatient dialectical behavioral treatment program (DBT). Before admission to the inpatient program, all of the BPD patients were on a waiting list and none were admitted for acute care. The German inpatient DBT is an adapted version of the original outpatient DBT program and is a commonly used treatment approach for BPD in Germany (Bohus et al., 2004; Linehan, 1993). Outpatients with SAD were informed about the study and asked to participate by e-mail. Healthy controls (HC) were recruited through an online classified advertisement Web site and an online newsletter of the Cluster Languages of Emotion. The German versions of SCID I and SCID II (Wittchen, Zaudig, & Fydrich, 1997) were used to assess Axis I and II diagnoses. All interviewers were clinical psychologists, trained in the application of the SCID I and II interview and received supervision on the SCIDs. In the BPD and SAD groups, interviews were conducted at the respective treatment site, whereas healthy controls were interviewed before the experiment. In a previous study, interrater reliability of SCID-II BPD diagnoses by the same interviewers used in the current study was good, $\kappa = 0.82$ (Ritter et al., 2014). With regard to the SCID-I SAD diagnoses, videotaped SCID interviews of a randomly selected quarter of the SAD group of the current sample were rated by two independent trained interviewers, who were blind to the diagnoses of the patients. The percentage of agreement between the interviewers was excellent (100%). Exclusion criteria for the patients included any psychotic disorder, current substance abuse/dependency, mental retardation, epilepsy/organic brain disease, intake of psychotropic medication within the last 2 weeks (fluoxetine 6 weeks), and age younger than 18 or older than 40 years. HC participants were matched on age range and level of education to that of the patient groups, and were excluded if they had any Axis I or Axis II disorder.

Table 1 displays demographic characteristics of the three groups, as well as comorbidity rates of BPD and SAD participants. According to the SCID I and II, no participant in the control group met criteria for any mental disorder. Groups did not differ with regard to age and years of education (all $p > .20$, all $d < .48$). Participants with excessive EEG artifacts were excluded, and a replacement was recruited to maintain proper sample size and equal group sizes (number of excluded participants: 3 BPD, 4 SAD, 3 HC). All participants signed informed-consent forms. Outpatients and healthy controls received a financial compensation for their time and travel expenses (30 €). Inpatients received free

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic Characteristics, Axis I and II Comorbidity of Participants Included</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BPD ($n = 25$)</td>
</tr>
<tr>
<td>Female, $n$ (%)</td>
<td>23 (92)</td>
</tr>
<tr>
<td>Age in years, $M$ (SD)</td>
<td>25 (6.56)</td>
</tr>
<tr>
<td>Education in years, $M$ (SD)</td>
<td>11.57 (1.50)</td>
</tr>
<tr>
<td>Comorbid mild MDE current, $n$ (%)</td>
<td>3 (12)</td>
</tr>
<tr>
<td>MDE lifetime, $n$ (%)</td>
<td>12 (48)</td>
</tr>
<tr>
<td>Dysthymia, $n$ (%)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>Social anxiety disorder, $n$ (%)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>PTSD, $n$ (%)</td>
<td>6 (24)</td>
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<td>Any eating disorder, $n$ (%)</td>
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</tr>
<tr>
<td>Any anxiety disorder except SAD, $n$ (%)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Obsessive-compulsive disorder $n$ (%)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Any somatoform disorder $n$ (%)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Borderline personality disorder, $n$ (%)</td>
<td>25 (100)</td>
</tr>
<tr>
<td>Obsessive-compulsive personality disorder, $n$ (%)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Avoidant personality disorder, $n$ (%)</td>
<td>2 (8)</td>
</tr>
</tbody>
</table>

Note. BPD = borderline personality disorder; SAD = social anxiety disorder; HC = healthy controls; MDE = major depression episode; PTSD = posttraumatic stress disorder.
transport to the lab. The study was approved by the ethics committee of the Freie Universität Berlin.

**Ostracism Manipulation**

Cyberball is a virtual ball-tossing computer game that makes participants believe they are playing with other persons through the Internet (Williams & Jarvis, 2006). In fact, the other participants are computer generated, and the participants’ probability of getting the ball is experimentally manipulated. In the present study, we utilized the EEG-compatible version of Cyberball (Gutz et al., 2011). E-Prime 2 (Psychology Software Tools, Inc.) was used to present standardized instructions, the Cyberball game, and to trigger EEG recording. Following the instructions and 10 training trails, all participants went through two blocks of the Cyberball game. As in the original version of Cyberball, the cover story informs the participant that Cyberball aims to test visual imagination capabilities. In line with the cover story, before each block, a picture was presented on the computer screen along with the instruction to imagine that the ball tossing game would take place at the depicted location. The pictures either showed a meadow or a gymnasium. The order was counterbalanced across participants. In the first block (inclusion), the participant received the ball in about one-third of all ball throws (33%); in the second block (exclusion), the probability of getting the ball was reduced to 16%. The partial exclusion was necessary to record the ERP evoked by the event “ball possession.” We have shown previously that partial exclusion was sufficient to induce a significant ostracism effect (Gutz et al., 2011; Weschke & Niedeggen, 2013). Ball possessions were defined as discrete events (self vs. other). The onset of ball possession was clearly indicated by the appearance of the ball next to a player (see Figure 1) and served as the time stamp for the EEG trigger. On occasions in which the participant was in possession of the ball (event “self”), the ball remained next to the player until the participant selected the coplayer to whom he or she wanted to throw the ball by pressing a corresponding button. Before the ball appeared next to the picture of the chosen player, it was presented in the middle of the screen for 500 ms. When one of the coplayers was in possession of the ball (event “other”), the time the ball remained next to the player randomly varied between 500 and 2,500 ms to enhance participants’ belief that they were playing with humans. Each block started with the participant in possession of the ball (event self), consisted of 200 ball throws, and lasted about 7 min.

**Measures**

**Rejection Sensitivity Questionnaire, German Version.** In the Rejection Sensitivity Questionnaire (RSQ), hypothetical situations in which rejection is possible are described, and respondents are asked to indicate the degree of (a) rejection anxiety and (b) rejection expectation. The degree of concern or anxiety (e.g., “How concerned would you be over whether or not your friend would want to help you out?”) and the expectation of being rejected (e.g., “I would expect that he or she would willingly agree to help me out.”) are both rated on a 6-point scale. The overall RSQ score is calculated as follows: (a) the score for degree of rejection anxiety is multiplied by (b) the reverse score for expectation of acceptance (rejection expectancy = 7 – expectancy of acceptance) for each hypothetical situation. The sum of the scores for each situation is then divided by the number of situations. A German translation and adaptation of the English RSQ (Downey & Feldman, 1996) was utilized. Internal consistency (Cronbach’s α = .88 for healthy controls and .94 for patients) and test–retest reliability (rtt = .90 after 2 weeks in a student sample) of the German version (Staebler, Helbing, et al., 2011) proved to be very satisfactory.

**Need Threat Questionnaire, German Version (Gryzb, 2005).** The Need Threat Questionnaire (NTQ) was developed to assess effects of social exclusion evoked by the computer game Cyberball (Williams et al., 2000). It consists of four scales to measure the extent to which the following needs are threatened: belonging, self-esteem, meaningful existence, and control. The total combined scale is need satisfaction (the inverse of which is interpreted as need threat), with reliability of α = .92 obtained in a sample of 135 students (van Beest & Williams, 2006). Three items per scale are answered on a 5-point scale (1 = not at all to 5 = very much so). Higher values indicate more need fulfillment. Additionally, there are three questions to check the manipulation of the game: “Assuming that the ball should be thrown to each person equally (33%), what percentage of the throws was directed to you?” (open answer), “I was ignored” and “I was excluded” (5-point scale, where 1 = not at all and 5 = very much so). Ostracism intensity scores were created by calculating the sum of the last two manipulation check items.

**Achievement Measure System (LPS), German Version “Leistungsprüfsystem.”** The Achievement Measure System (LPS), German Version “Leistungsprüfsystem” (Horn, 1962) is a common German standardized intelligence test based on a factor analytic intelligence model for measuring general intelligence. Subtest 4 for nonverbal reasoning (LPS-4) was administered, which contains 40 items (rows) with eight elements each (digits

![Figure 1](http://www.fes-fu-berlin.de/cyberball/). The display imitated an Internet screen including the photos of two ostensibly human connected coplayers. In case of participants’ ball possession (1), ball was passed by pressing a corresponding button. The ball was then displayed at a central position for 500 ms (2), and before it appeared next to the photo of the chosen coplayer (3). After a computer-generated interval of 500–2,500 ms, the ball was passed back to the other coplayer or the participant again with a stopover (500 ms) at the central position.
and letters). The participant has to identify the rule by which the elements are arranged in a row and mark the element in each row that violates the rule. Sum scores of the subtest (number of correctly marked elements) can be converted into IQ scores with a mean of 100 and a SD of 15.

**Procedure**

After the electrodes were attached, participants completed a short sociodemographic questionnaire, the LPS-4 and the Vividness of Visual Imagery Questionnaire to support the cover story (Marks, 1973). They were then seated in front of a computer (7° × 7° at a viewing distance of 140 cm) and 10 training trials were presented to familiarize participants with the handling of the response pad. Then participants played two rounds of Cyberball. The first experimental block was inclusion (33% ball possession) and the second experimental block was exclusion (16% ball possession). Afterward, the participants completed one NTQ for each block of Cyberball. The NTQ referring to the first block was not handed out between the two rounds of Cyberball to preserve the cover story and to avoid potential influence on the participants’ perception of social participation. Then the electrodes were removed and the participant completed the RSQ. Subsequently, participants received an extensive debriefing that outlined the aims of the study and reassured them that the other players were computer-generated and were programmed to include or ostracize.

**Recording and Analysis of Event-Related Potentials**

Electrodes were attached to the scalp according to the 10–20-system (Jasper, 1958) at frontal (Fz), central (Cz) and parietal (Pz) positions (impedance <10 kΩ). The ERP analyses were restricted to the midline electrodes as they are sufficient for recording the P3b amplitude, which typically increases in magnitude from the frontal to parietal electrode sites (Polich, 2007). Linked earlobes were used as reference and the ground electrode was positioned at the prefrontal position (impedance <5 kΩ). In addition, the vertical and horizontal electrooculogram (EOG) were recorded to control for ocular artifacts (<20 kΩ). EEG data were recorded continuously with EEG BioAmplifiers and PsyLab recording software (Contact Precision Instruments, London), sampled at 501 Hz, and band-pass filtered offline (0.3–30 Hz). An analog 50-Hz notch filter was enabled. Offline, EEG was analyzed using “Brain Vision Analyzer” (Brain-Products GmbH, Munich, Germany). Stimulus-locked EEG segments were created (100 to 800 ms after the player received the ball) according to the condition (inclusion or exclusion) and baseline adjusted to a 100 ms prestimulus epoch. Trials with muscular or ocular artifacts were excluded from analysis, as well as trials defined by high α activity. Because there were more segments for the event self in the inclusion than in the exclusion condition, trials in the inclusion condition were randomly selected to obtain a comparable number of trials (minimum number of trials: 20), and thereby comparable signal-to-noise ratios. Accordingly, the number of other trials was matched for both conditions. Subsequently, averages and grand averages were calculated, separately for the three experimental within-subject factors (condition, ball possession, and electrode), and for the groups (BPD, SAD, and HC).

On the basis of the Grand Averages (GA) (see Figure 2), a distinct temporal window was defined: 310–390 ms (P3b). For each participant, mean amplitudes were determined within this predefined time range, exported and analyzed using SPSS (version 19, IBM). Repeated measures analysis of variances (ANOVAs) were calculated including the between-subjects factor “group” (BPD vs. SAD vs. HC) and the within-subject factors “condition” (inclusion vs. exclusion), “ball possession” (self vs. other), and “electrode position” (Fz vs. Cz vs. Pz). Bonferroni correction was applied in analyses of ERP data, as in the analyses of self-report data, to correct for inflation in Type I error rate caused by multiple comparisons. Degrees of freedom and p values were corrected according to Greenhouse-Geisser, if indicated, and corrected p values will be reported in the following.

**Results**

**Group Characteristics**

No group differences were found for IQ scores, all $p > .99$, all $d < .21$ (see Table 2). Rejection Sensitivity was more pronounced in both patient groups than in healthy controls (BPD vs. HC $p < .001$, $d = 1.91$, SAD vs. HC $p < .001$, $d = 1.24$). Replicating the results of Staebler et al. (2011), rejection sensitivity in patients with BPD was even higher than in patients with SAD ($p < .031$, $d = 0.69$). Comparing the ratings of the RSQ subscales between groups, different results emerged for rejection anxiety and rejection expectancy. Patients with BPD did not differ from patients with SAD in rejection anxiety ($p > .150$, $d = 0.58$), but reported higher rejection expectancy ($p < .050$, $d = 0.62$). Compared with HC, rejection anxiety and rejection expectancy were increased in the clinical groups (BPD vs. HC: RSQexp and RSQanx $p < .001$, $d > 1.32$, SAD vs. HC: RSQexp $p < .001$, $d = 1.41$, RSQanx $p < .017$, $d = 0.75$).

**Need Threat Questionnaire**

To test whether the manipulation of the probability of getting the ball, and therefore, being socially included, affected the perception of participation and whether groups differed in their perception, three repeated-measures ANOVAs 2 (condition: inclusion 33%, exclusion 16%) × 3 (group: BPD vs. SAD vs. HC) for
estimated percentage of ball tosses received, ostracism intensity, and need threat were conducted (see Table 3).

Results revealed a significant main effect of condition on every variable. Social exclusion caused a considerable decrease in estimated percentage of ball tosses received and an increase in ostracism intensity and need threat. Therefore, the ostracism manipulation was successful.

Across conditions, patients with BPD felt more ostracized than patients with SAD and HC. Patients with BPD reported lower rates of received ball tosses (p < .005, d = .99), higher ostracism intensity (p < .004, d = .93), and higher need threat (p < .001, d = 1.13) than healthy controls. Furthermore, ostracism intensity in the BPD group was higher than in the SAD group (p < .010, d = 0.81), whereas “estimated percentage of ball tosses received” (p > .28, d = 0.40) and need threat (p > .08, d = 0.70) did not differ between the clinical groups. No significant differences were found between patients with SAD and HC (all p > .15, all d < 0.61).

Significant interactions between condition and group obtained for estimated percentage of ball tosses received, and ostracism revealed that differences between the BPD group and both other groups were significant only for the inclusion condition (exclusion: all p > .41, all d < .45). In comparison to healthy controls and patients with SAD who estimated their amount of ball possession rather accurately, patients with BPD underestimated the amount of ball tosses received (BPD vs. HC p < .001, d = 1.24, BPD vs. SAD p < .023, d = .74), and experienced high ostracism intensity during the inclusion condition of Cyberball (BPD vs. HC p < .001, d = 1.26, BPD vs. SAD p < .002, d = 1.15). No group differences between patients with SAD and healthy controls were found for social inclusion (all p > .49, all d < 0.41).

The effect of condition on need threat was also moderated by group. In the inclusion condition, the level of reported need threat in patients with BPD was higher than in patients with SAD and HC (BPD vs. SAD p < .004, d = 1.03, BPD vs. HC p < .001, d = 1.10). In the exclusion condition, however, need threat was heightened in patients with BPD relative to HC only (p < .005, d = 0.93). Patients with SAD showed a strong increase in need threat during the social exclusion condition, exhibiting a high level of need threat that is comparable with that of patients with BPD (BPD vs. SAD p > .97, d = 0.18, SAD vs. HC p < .057, d = 0.81).

### Event-Related Brain Potentials

For each group and condition, grand-averaged ERPs for the events, “participant in possession of the ball” (self) and “co-player in possession of the ball” (other) are depicted in Figure 2 (see also Table 4 for means and SDs). In all groups, the P3b component was clearly visible in cases in which the participant was receiving the ball. In patients with SAD and in HC, the P3b effect was primarily observed in the exclusion condition. As expected, ERP recordings of patients with BPD also showed a noticeable P3 complex during the inclusion condition.

### Table 3

**Means and SDs of the Need Threat Questionnaire and Results of the ANOVAs**

<table>
<thead>
<tr>
<th>Condition</th>
<th>BPD (n = 25)</th>
<th>SAD (n = 25)</th>
<th>HC (n = 25)</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>F</td>
</tr>
<tr>
<td><strong>EPB % inclusion</strong></td>
<td>24.48 (7.74)</td>
<td>30.25 (7.82)</td>
<td>33.21 (6.30)</td>
<td>235.87</td>
</tr>
<tr>
<td><strong>EPB % exclusion</strong></td>
<td>14.32 (6.68)</td>
<td>13.69 (7.55)</td>
<td>17.08 (7.10)</td>
<td>5.58</td>
</tr>
<tr>
<td><strong>Ostracism inclusion</strong></td>
<td>5.58 (2.56)</td>
<td>3.25 (1.29)</td>
<td>3.00 (1.35)</td>
<td>86.79</td>
</tr>
<tr>
<td><strong>Ostracism exclusion</strong></td>
<td>7.08 (2.48)</td>
<td>6.17 (2.65)</td>
<td>6.04 (2.29)</td>
<td>7.02</td>
</tr>
<tr>
<td><strong>Need Threat inclusion</strong></td>
<td>29.42 (8.42)</td>
<td>21.13 (7.69)</td>
<td>20.17 (8.45)</td>
<td>6.57</td>
</tr>
<tr>
<td><strong>Need Threat exclusion</strong></td>
<td>36.31 (9.57)</td>
<td>34.65 (8.34)</td>
<td>26.92 (10.54)</td>
<td>9.16</td>
</tr>
</tbody>
</table>

**Note.** BPD = borderline personality disorder; SAD = social anxiety disorder; HC = healthy controls; EPB = estimated percentage of ball tosses received; η² = partial eta-squared.
Table 4  
P3b Mean Amplitudes Separately for Group (BPD vs. SAD vs. HC), Condition (Inclusion vs. Exclusion), and Ball Possession (Self vs. Other)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Self</td>
<td>Fz</td>
<td>4.46 (3.02)</td>
<td>5.34 (4.92)</td>
<td>1.98 (1.91)</td>
<td>5.82 (4.23)</td>
<td>3.12 (2.41)</td>
<td>4.36 (2.93)</td>
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<tr>
<td></td>
<td>Cz</td>
<td>6.68 (4.21)</td>
<td>9.18 (4.70)</td>
<td>2.49 (2.54)</td>
<td>8.46 (5.66)</td>
<td>4.75 (2.13)</td>
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<td></td>
<td>Pz</td>
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<td>12.41 (14.3)</td>
<td>4.09 (2.09)</td>
<td>10.88 (4.33)</td>
<td>5.23 (1.85)</td>
<td>10.02 (4.31)</td>
</tr>
<tr>
<td>Other</td>
<td>Fz</td>
<td>2.88 (2.56)</td>
<td>1.56 (1.78)</td>
<td>3.72 (2.63)</td>
<td>1.44 (1.82)</td>
<td>4.15 (1.69)</td>
<td>1.32 (1.56)</td>
</tr>
<tr>
<td></td>
<td>Cz</td>
<td>2.02 (2.94)</td>
<td>0.99 (2.12)</td>
<td>3.59 (2.66)</td>
<td>0.54 (1.87)</td>
<td>3.63 (1.71)</td>
<td>0.41 (1.70)</td>
</tr>
<tr>
<td></td>
<td>Pz</td>
<td>1.60 (2.81)</td>
<td>0.81 (1.84)</td>
<td>2.94 (2.29)</td>
<td>0.54 (1.64)</td>
<td>3.42 (1.25)</td>
<td>0.96 (1.98)</td>
</tr>
</tbody>
</table>

Note. BPD = borderline personality disorder; SAD = social anxiety disorder; HC = healthy controls; self = participant receiving the ball; other = coplayer receiving the ball.

To examine whether group moderated the effect of condition on the P3b component elicited by the event self, a repeated measures ANOVA was conducted. The ANOVA included between-subjects factor group (BPD vs. SAD vs. HC) and the within-subjects factor condition (inclusion 33% vs. exclusion 16%), ball possession (self vs. other), and electrode (Fz vs. Cz vs. Pz). Results showed that the P3b amplitude had a parietal maximum, F(2, 144) = 61.78, p < .001, partial η² = .46 (electrode), and was higher during exclusion than during inclusion, F(1, 72) = 24.20, p < .001, partial η² = .25 (condition). The highest increase because of exclusion was observed at the parietal electrode site, F(2, 144) = 23.01, p < .001, partial η² = .24 (condition x electrode).

Significant main effects emerged for group, F(2, 72) = 3.31, p < .026, partial η² = .10, and ball possession, F(1, 72) = 120.00, p < .001, partial η² = .63. The P3b amplitude was higher for the event self than for the event other. The interaction between group and ball possession, F(2, 72) = 8.44, p < .001, partial η² = .20, revealed that the P3b responses of the groups differed for participant receiving the ball, F(2, 72) = 8.44, p < .001, partial η² = .19, whereas no group differences were found for coplayer receiving the ball, F(2, 72) = 1.13, p > .32, partial η² = .03. P3b amplitudes elicited by the event self were higher in patients with BPD than in patients with SAD (p < .017, d = 0.73) and HC (p < .001, d = 1.17), but comparable between patients with SAD and HC (p > .79, d < .37). However, in line with the hypothesis and the results of the self-report data, group differences in the ERP data depended on the condition of Cyberball, F(1, 72) = 11.46, p < .001, partial η² = .24 (Group x Condition x Ball possession).

Differences between the BPD group and both other groups for the event self emerged during social inclusion only, F(1, 72) = 21.28, p < .001, partial η² = .37 (inclusion: BPD vs. SAD p < .001, d = 1.29, BPD vs. HC p < .001, d = 1.57, exclusion: all p > .43, all d < 0.45).

Independent of the factor group, the effect of ball possession was most pronounced at the parietal electrode position, F(2, 144) = 123.61, p < .001, partial η² = .63 (Ball possession x Electrode). Consistent with the reduced probability of the event self and the enhanced probability of the event other during social exclusion, the effect of social exclusion differed between both events, F(1, 72) = 205.94, p < .001, partial η² = .74 (Condition x Ball possession). Social exclusion was associated with an increase in the P3b for participant receiving the ball and a decrease in the P3b for coplayer receiving the ball. Furthermore, the condition effect on the P3b elicited by the event self was moderated by electrode position (showing a parietal maximum), whereas the condition effect on the P3b elicited by the event other was not, F(2, 144) = 17.42, p = .85, p < .001, partial η² = .20 (Electrode x Condition x Ball possession).

Self-Reported Rejection Expectancy and Neural Processing of Social Participation

To examine the incremental validity of rejection expectancy for predicting the social exclusion-related change in the parietal P3b controlling for group, a hierarchical regression analysis was conducted. The difference between the P3b amplitude for the event self in the exclusion condition and the amplitude in the inclusion condition served as the dependent variable (condition effect on P3b amplitude). As predictors in the model, the dummy-coded group factor with healthy controls as the reference group was entered in the first step (method: enter) and the RSQ subscales of rejection expectancy and rejection anxiety were entered in the second step (method: enter). As a third step, the interactions between both RSQ subscales and group were entered in the equation model (method: enter). The third step failed to increase the variance explained and is, therefore, not reported below, R² change = .002, F(4, 66) = 0.04, p > .99. Variance inflation factors (VIF) were below 3, suggesting that multicollinearity was not a problem in this analysis.

As in the ANOVA reported earlier, group accounted for a significant amount of the variance in EEG data, R² = .114, F(2, 72) = 4.55, p < .014, f² = .13. Beta values of the dummy variables confirmed that the increase in P3b amplitude from inclusion to exclusion was reduced in BPD patients relative to healthy controls, β = −.36, t(70) = −2.78, p < .007 (Model 1, Table 5). The second step of the analysis revealed that the addition of rejection expectancy and rejection anxiety increased the amount of explained variance, R² = .208, R² change = .095, F(2, 70) = 4.13, p < .020, f² = .26 (Model 2, Table 5). As hypothesized, heightened rejection expectancy was associated with a smaller increase in P3b amplitude from inclusion to exclusion, β = −.39, t(70) = −2.15, p < .035, whereas rejection anxiety did not influence the effect of condition on P3b amplitude β = −.02,
n(70) = −.12, p > .90. Notably, the dummy coded factor group was no longer a significant predictor once the RSQ subscales were entered into the model, β = −.07, n(70) = −.41, p > .68 (BPD vs. HC). This decrease in predictive power indicated that a considerable part of the variance explained by group in Model 1 is shared with other observed variables. By partitioning the variance explained (\( R^2 = 20.8\% \)) in Model 2 (Mood, 1969; Nimon & Reio, 2011), commonality analysis revealed that 3.2% was uniquely explained by group, whereas rejection expectancy uniquely explained 5.3% of the variance. Rejection anxiety had no unique effect.

**Discussion**

Neurophysiological results indicate a negatively biased perception of social inclusion in patients with BPD during the initial stage of social information processing. The P3b response to receiving the ball during social inclusion was increased in patients with BPD relative to patients with SAD and healthy controls, indicating a biased mental representation of the current participatory status. Furthermore, self-reports confirmed that patients with BPD experienced being excluded even during the inclusion condition. Patients with SAD did not differ from HC in their perception of participation. Consistent with the rejection sensitivity model, rejection expectancy that was significantly higher in BPD than in both other groups, proved to be a valuable predictor of altered cerebral processing of social participation.

Replicating previous studies (Gutz et al., 2011; Weschke & Niedeggen, 2013), the low probability of receiving the ball during the exclusion condition elicited a considerable P3b component in all groups and was associated with an increase in self-reported ostracism intensity, need threat, and a decrease in estimated amount of ball tosses received. Thus, receiving the ball during the exclusion condition of Cyberball seemed to be inconsistent with the mental representation of one’s current participatory status (sequence of the events self and other) and, therefore, associated with a greater need for memory updating.

As hypothesized, differences in the P3b amplitude between groups emerged exclusively in the inclusion condition of Cyberball. Despite receiving the same amount of ball tosses as their coplayers, getting the ball triggered a pronounced P3b potential in patients with BPD, which was significantly higher than in patients with SAD and in HC. In patients with BPD receiving the ball seemed to be an unexpected event that deviates from their current mental model of participation independent of condition. Because being included conflicts with negative BPD core beliefs, it might produce cognitive dissonance and increase the processing difficulty. This assumption is supported by the schema-inconsistency hypothesis (Horsley, de Castro, & Van der Schoot, 2010). The hypothesis states that strong pre-existing cognitive schemata influence the encoding of current social stimuli. According to Horsley et al. (2010), the greater need of processing capacities in patients with BPD during encoding of schema-inconsistent information (being included) might reflect an attempt to verify unexpected information in light of an already existing mental model of the situation (being ostracized), resulting in a stabilization of their negative beliefs.

Consistent with the ERP results, self-reports showed that during inclusion patients with BPD felt more excluded, as indicated by significantly greater perceived ostracism and a lower estimate of received ball tosses than HC and patients with SAD. As proposed by the RS model, this negative perception bias might cause situation-inappropriate overreactions in daily life, and consequently prompt expectation-confirming rejection behavior by others. A recent study indicated that it is the negative perception of others that triggers elevated negative affect and quarrelsome behavior in patients with BPD (Sadikaj, Moskowitz, Russell, Zuroff, & Paris, 2013).

Contrary to the hypothesis patients with SAD did not differ significantly from HC with regard to P3b amplitude or self-reports. Findings imply that receiving the ball during the inclusion condition was consistent with SAD patients’ mental representation of their own current inclusionary status. Therefore, their threshold for perceiving ostracism in the behavior of others may not be as low as in patients with BPD.

In accordance with the results discussed above and previous findings, rejection sensitivity, measured by the RSQ, was significantly higher in the BPD than in the SAD group and was significantly more pronounced in both clinical groups than in HC. However, differentiating between the RSQ subscales, rejection anxiety in SAD patients was comparable with the high level reported by patients with BPD, emphasizing the relevance of the anticipatory affect in SAD pathology (London et al., 2007). In contrast, rejection expectancy was significantly more pronounced in patients with BPD than in patients with SAD.

In line with the assumption that pre-existing cognitive schemata affect encoding processes in a self-fulfilling way (Horsley et al., 2010), results of the regression analysis indicate that the disposition to expect rejection is associated with impairment in the ability to discriminate between being excluded and being included. Rejection expectancy predicted the difference in P3b amplitude between inclusion and exclusion over and above group; whereas rejection anxiety had no predictive power. Thus, group differences in the accuracy of social perception may depend in part on differences in the level of rejection expectancy.

The RS model states that the development of rejection expectancy relies on the extent to which individuals experience rejection during their formative years (e.g., exposure to family violence, emotional neglect, and conditional love by parents; Romero-Canyas, Downey, Berenson, Ayduk, & Kang, 2010). Hence, the

| Table 5 |
|———|
| Incremental Validity of Rejection Expectancy for Predicting the Social Exclusion-Related Change in Parietal P3b Amplitude |
| | B | SE | β | R² (adj. R²) | ΔR² |
| Model 1 | | | | | |
| SAD vs. HC | −0.49 | 1.20 | −0.05 | | |
| BPD vs. HC | −3.34 | 1.20 | −0.36*** | | |
| Model 2 | | | | | |
| SAD vs. HC | 1.27 | 1.31 | 0.14 | | |
| BPD vs. HC | −0.62 | 1.50 | −0.07 | | |
| RSQanx | −2.42 | 1.12 | −0.39** | | |
| RSQexp | −0.09 | 0.75 | −0.02 | | |

*Note.* HC = healthy controls; SAD = social anxiety disorder; BPD = borderline personality disorder; RSQanx = rejection anxiety; RSQexp = rejection expectancy; RSQanx = rejection anxiety.

* p < .05. ** p < .01.
pronounced rejection expectancy in patients with BPD compared with patients with SAD, as well as the lack of an observable negative social processing bias in the SAD group might be a result of the extremely high prevalence of childhood abuse and neglect experienced by patients with BPD (Zanarini et al., 1997). A study by Taylor and Alden (2005) supports the assumption that the negative bias in the perception of social interactions is not absent in SAD, but rather depends on specific internalized social learning experiences.

As a limitation of our study, it should be mentioned that a nonsocial control condition was lacking. Current results do not allow us to infer whether the increased P3b amplitude in response to self-relevant stimuli in BPD patients is specific to the social participation context. However, the Cyberball paradigm modified for the EEG resembles the characteristics of the oddball paradigm. Therefore, oddball studies conducted with patients with BPD might provide valuable information. Two auditory (Meares, Melkonian, Gordon, & Williams, 2005; Meares, Schore, & Melkonian, 2011) and two visual oddball studies (Ceballos, Houston, Hesselbrock, & Bauer, 2006; Houston, Ceballos, Hesselbrock, & Bauer, 2005) did not find an effect of BPD diagnosis on either P3b amplitude or latency. Therefore, the P3b response pattern found for patients with BPD in the current study may be specific to the processing of social participation. A second methodological limitation may be that the NTQ for block one (inclusion) and block two (exclusion) of the Cyberball game were both completed after the second block. Nevertheless, current results are supported by a study in which patients with BPD and healthy controls were randomly assigned to the inclusion or exclusion condition (Staebler, Renneberg, et al., 2011). Furthermore, inpatient/outpatient status and financial compensation were confounded with diagnostic group. It should be noted that inpatient DBT is a common psychotherapeutic treatment setting for BPD in Germany, and none of the BPD patients were admitted for acute care. Therefore, inpatient/outpatient status might be less confounded with symptom severity in Germany than it is in other countries. With regard to the financial compensation received by the SAD outpatients and the HC, the amount represents reimbursement for actual expenses, rather than a financial incentive.

Results of this study have implications for clinical practice. The present findings suggest that RS in BPD is associated with negatively biased mental representations of one’s participatory status, especially in benign social interactions. Thus, to increase the potential for positive social experiences in patients with BPD it is important to provide them and their significant others with information about their biased processing of participation. In addition, negative core beliefs associated with rejection expectancy and hence biased processing of those events should be identified and modified. Psychoeducation should emphasize that the perception of rejection by itself is not a proof of reality, but might instead be a reactivation of previous experiences of rejection and abandonment.

In conclusion, ERP results indicate a negatively biased perception of social inclusion in BPD during the initial stage of social information processing that is associated with high rejection expectancy. In contrast, patients with SAD did not differ from HC in the processing of social participation. Because stimulus encoding and mental stimulus representation are assumed to affect all further processing steps including emotional and behavioral responses, this study contributes to a better understanding of why patients with BPD show maladaptive reactions in social interactions and thereby reinforce their interpersonal problems.

References


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