The Temporal Relation of Arousal and Perceived Rejection in Patients with Borderline
Personality Disorder and Depressive Disorders: An Experience Sampling Approach

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Abstract

Borderline personality disorder (BPD) is characterized by high levels of arousal and perceived rejection by others. The temporal relation between these constructs, however, remains largely unclear. Based on predictions derived from the dynamic affect model and the rejection sensitivity model, we expected increases in arousal and perceived rejection to predict subsequent increases in perceived rejection and arousal, respectively. To investigate this topic, we assessed current self-reported affective arousal and perceived rejection in patients with BPD ($n = 42$), patients with depressive disorders (DD; $n = 43$), and healthy controls (HC; $n = 40$) for 52 times within 13 hours (ca. every 15 min). In line with previous studies, dynamic structural equation model results indicate significantly higher trait levels of arousal and perceived rejection in patients with BPD compared to participants in the DD and HC groups. In addition, we found substantial autoregressive and cross-lagged effects for arousal and perceived rejection. Other than expected, the magnitude of these effects did not significantly differ across diagnostic groups. Our findings suggest close temporal relations between arousal and perceived rejection. In patients with BPD, these effects unfold against the background of substantially elevated trait levels of arousal and perceived rejection. Future ambulatory assessment studies should provide additional context information (e.g., through monitoring rejection events) to investigate how patients with BPD perceive rejection in everyday life and how this affects subsequent levels of arousal.

Keywords: borderline personality disorder; arousal; rejection; rejection sensitivity model; dynamic affects theory

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Borderline personality disorder (BPD) is a highly prevalent and serious mental disorder with a high burden of disease (e.g., Chanen et al., 2017; Leichsenring et al., 2011). Numerous studies have shown that BPD is associated with high levels of arousal, an affective state characterized by unpleasant, high activation with no specification of distinct emotions such as anxiety, guilt, or anger (Barret & Russel, 1998; Stiglmayr et al., 2001; see Dixon-Gordon et al., 2020; Santangelo et al. 2014 for reviews), as well as high levels of rejection sensitivity, an increased tendency to anxiously expect and readily perceive rejection by others (Downey & Feldman, 1996; Renneberg et al., 2012; Rosenbach & Renneberg, 2011; Sato et al., 2020). In addition, studies have linked arousal and perceived rejection with dysfunctional behaviors and general symptom severity in patients with BPD (Miskewicz et al., 2015; Santangelo et al., 2020), pointing to the potential significance of these constructs in the psychopathology of BPD. With new research methods such as electronic diaries (e-diaries) that result in multiple momentary ratings and allow for the investigation of within-person processes becoming increasingly available, researchers have begun to investigate the temporal resolution of psychological constructs linked to BPD (see Dixon-Gordon et al., 2020; Moukhtarian et al., 2018; Trull & Ebner-Priemer, 2013, 2020 for a thorough discussion). Micro-assessments in daily life allow to model dynamic processes in near real time, (e.g., without retrospective biases; e.g., Solhan et al., 2009) and with high ecological validity. Few studies, however, have examined the interplay of arousal with perceived rejection using micro-assessments, although such investigations seem desirable to improve our understanding of the intra-personal processes that have been theorized

to precede dysfunctional behaviors in patients with BPD (e.g., Downey & Feldman, 1996; Santangelo et al., 2001). Our study aims at addressing this shortcoming by focusing on the temporal links between arousal and perceived rejection in BPD.

Arousal in Patients with BPD

Numerous existing e-diary studies in samples of patients with BPD have focused on the investigation of arousal, which has been described as an unspecific feeling of emotional distress (see Dixon-Gordon et al., 2020; Santangelo et al. 2014 for reviews), partly because many researchers place affective dysregulation at the core of the disorder (e.g., Ebner-Priemer et al., 2015; Linehan, 1993; Sievers & Davis, 1991; Trull et al., 2010). Importantly, arousal has been suggested to play a key role in explaining dysfunctional behavior in BPD because although arousal does not activate specific action tendencies (e.g., fight or flight), individuals have been described to experience a strong impulse to terminate the state that in extreme cases may lead to non-suicidal self-injuries (e.g., Hasking et al., 2017; Stiglmayr et al., 2001). In contrast to negative affectivity and neuroticism, arousal is conceptualized as a state, not a trait. Specifically, one e-diary studies show that higher trait levels of arousal predict dysfunctional behaviors in outpatients with BPD (mainly non-suicidal self-injuries; Santangelo et al., 2020). According to an adaptation of the dynamic affect model (Kuppens et al., 2010), patients with BPD are expected to be characterized by a negative affective homebase (i.e., high trait levels of arousal), high levels of affective variability (i.e., strong intraindividual fluctuations around trait levels of arousal), as well as slow returns to baseline (i.e., high inertia or strong autocorrelations for consecutive arousal reports; see Ebner-Priemer et al., 2015 for a discussion). There is a wealth of evidence to inform these hypotheses. First, several e-diary studies have shown that in- and

outpatients with BPD experience arousal more frequently and more intensely than healthy controls (e.g., Ebner-Priemer et al., 2015; also see Santangelo et al., 2018; Stiglmayr et al., 2001; Stiglmayr et al., 2005; Wolff et al., 2007). In addition, two e-diary studies report higher trait levels of arousal among in- and outpatients with BPD compared with depressed patients (Santangelo et al., 2016, study 2; Stiglmayr et al., 2008). Second, e-diary studies provide some evidence of elevated intraindividual fluctuations around trait levels of arousal when comparing in- and outpatients with BPD with healthy controls (Ebner-Priemer et al., 2015; Santangelo et al., 2016; see Santangelo et al., 2014 for a review of earlier findings). In addition, e-diary results indicate higher within-person variance in hostility, sadness, and fear among outpatients with BPD compared with depressed patients (Trull et al., 2008). Third, in a series of three e-diary studies, results from two studies using 15 min intervals between prompts indicate stronger autocorrelations in arousal among in- and outpatients with BPD compared with healthy controls, whereas the third study did not find such a difference using 60 min intervals (Ebner-Priemer et al., 2015). Two later e-diary studies found no differences in autoregressive coefficients in arousal (60 min intervals) when comparing in- and outpatients with BPD with posttraumatic stress disorder, bulimia nervosa, panic disorder, and depressed patients (Santangelo et al., 2016).

Rejection as a Predictor of Arousal in Patients with BPD

A strong body of evidence from retrospective studies shows that rejection sensitivity is closely linked to BPD (e.g., Downey & Feldman, 1996; Renneberg et al., 2012; Rosenbach & Renneberg, 2011; Sato et al., 2020). Specifically, cross-sectional results indicate that in- and outpatients with BPD report higher levels of rejection sensitivity compared with clinical controls (e.g., depressed patients) that generally report higher levels of rejection sensitivity than healthy

controls (Staebler et al., 2011; also see Domsalla et al., 2014). A current meta-analysis including 28 studies demonstrated a large difference between BPD and non-BPD groups in the disposition to expect rejection across several situations (Cohen's $d = 0.85$, 95% CI [0.80, 0.91], Cavicchioli & Maffei, 2020). In addition, results from e-diary studies suggest that exposure to rejection events increases in arousal among in- and outpatients with BPD (Stiglmayr et al., 2005), that increases in perceived rejection are followed by higher levels of intense rage in outpatients with BPD relative to healthy controls (Berenson et al., 2011), and that among outpatients with BPD more intense experiences of rejection relate to higher acute BPD symptoms in everyday live (Miskewicz et al., 2015). More so, a series of e-diaries has shown that experiences of rejection and disagreement predict feelings of hostility and sadness in outpatients with BPD (Hepp et al., 2018; also see Hepp et al., 2017; Hepp et al., 2020). One study that used daily retrospective measures linked higher BPD features and higher distress levels in undergraduates with more interpersonal conflicts in everyday live (Haliczer et al., 2020). Another e-diary showed that within a sample of outpatients with BPD, higher BPD symptoms were associated with more frequent perceptions of disaffiliative behavior (being criticized or ignored) and less frequent perceptions of affiliative behavior (being listened to or complimented), as well as that these perceptions related to higher within-person negative affect, particularly in interactions with romantic partners (Lazarus et al., 2018; also see Sadikaj et al., 2013). In line with this, laboratory experiments have demonstrated that patients with BPD report higher levels of negative affect following social interactions perceived as disagreeable compared with healthy controls (Sadikaj et al., 2010; also see Staebler et al., 2011), as well as that individuals scoring higher in BPD symptoms report higher levels of negative affect response to negative interpersonal stimuli

(Chapman et al., 2014). A current meta-analysis including 14 experimental studies shows that patients with BPD report substantially higher negative affect after exposure to rejection or exclusion cues compared with non-BPD groups (Cohen's $d = 0.81$, 95% CI [0.70, 0.92]; Cavicchioli & Maffei, 2020). Results from another laboratory experiment suggest that a sensitivity to rejection or abandonment may be linked to higher levels of distress in patients with BPD (Gunderson & Lyons-Ruth, 2008). In line with the above reviewed body of evidence and the rejection sensitivity model (Downey & Feldman, 1996), Berenson et al. (2011) explained that the processing of overt and covert acts perceived to communicate rejection or cues that individuals have learned to associate with rejection may be biased in patients with BPD, which results in intense affective reactions (e.g., arousal) and a reduced capacity for emotional regulation (also see Chapman et al., 2015; Foxhall et al., 2019; Haliczzer et al., 2020; Rosenbach & Renneberg, 2011). In this study, we go beyond previous cross-sectional, e-diary, and laboratory studies that examined perceived rejection in the context of BPD by comparing a clinical sample of patients with BPD with a clinical sample of depressed patients and a healthy control sample, while realizing a high sampling frequency (every 15 min) that is appropriate for investigating temporal dynamics at a high resolution (Ebner-Priemer et al., 2007). High sampling frequencies are particularly important to capture dynamical features of volatile affective and cognitive processes such as experiences of arousal and perceived rejection (Stiglmayr et al., 2005; also see Adolf et al., 2020; Dejonckheere & Mestdagh, 2021).

Study Aim and Hypotheses

The aim of this study was to investigate the temporal relation of arousal and perceived rejection in the daily lives of patients with BPD and depressive disorders (DD). Specifically, we

hypothesize: (1) patients with BPD on average report higher trait levels of (a) arousal, as well as (b) perceived rejection than patients with DD and healthy controls (HC); (2) the autoregressive relations between (a) arousal and arousal on the following assessment, as well as (b) perceived rejection and perceived rejection on the following assessment are larger among patients with BPD compared with HC participants; (3) the cross-lagged relations between (a) arousal and higher perceived rejection on the following assessment, as well as (b) perceived rejection and higher arousal on the following assessment are larger among patients with BPD compared with patients with DD and HC participants.

Method

Data availability

The anonymized data set, statistical code and (additional) results are available at <https://osf.io/83b4x/>.

Sample

We recruited a total of 151 participants who were at least 18 years old. The sample comprised 49 inpatients with BPD, 50 in- and outpatients with DD, and 51 HC participants. All patients with BPD underwent a planned 12-week inpatient dialectical behavioral treatment program (DBT) in the Department of Psychiatry (Charité Berlin, Germany). Patients were not admitted for acute care. The German inpatient DBT is an adapted version of the original outpatient DBT program (Bohus et al., 2004; Linehan, 1993). All participants were interviewed using the German version of the Structured Clinical Interview for DSM-IV Axis I (SCID-I) and Axis II disorders (SCID-II; First et al., 1996; Wittchen et al., 1997). Clinical psychologists holding a master's degree in psychology conducted the clinical interviews. Interviewers were

trained in the use of these instruments and supervised by JE and SR. Participants recruited via public advertisements were initially screened by telephone. We only included participants in the BPD group who met DSM-IV diagnostic criteria for a borderline personality disorder. In the DD group participants had to meet DSM-IV diagnostic criteria for a current or chronic depressive disorder (see the table in the online supplement materials S1 for further details). HC participants were only included if they did not take any psychotropic medication and had neither a current nor a lifetime diagnosis of any mental or neurological disorders (e.g., traumatic diseases of the central nervous system). Exclusion criteria for BPD and patients with DD were comorbid diagnosis of past or present psychotic disorder, bipolar disorder, cognitive disorders (e.g., delirium, dementia), or neurological disorders as well as substance-associated disorders. BPD and DD inpatients were recruited at the Department of Psychiatry, Charité Universitätsmedizin Berlin. All other participants were recruited via public advertising. After data collection, we excluded participants from the HC group with a score > 14 ($n = 3$) in the Beck Depression Inventory (BDI-II; Beck et al., 1996). In addition, we excluded participants who answered less than 10 out of 52 prompts ($n = 7$ in each group) during the ambulatory assessment phase to ensure a minimum number of valid responses. Finally, one participant in the HC group was excluded due to zero variance in all outcomes in the ambulatory assessment phase. The final sample comprised 42 inpatients in the BPD group, 43 patients in the DD group (20 outpatients and 23 inpatients), and 40 individuals in the HC group. Simulation study results indicate that a sample size of 125 and a total of 4875 observations (expecting 25% missing observations) provide a dynamic structural equation model with a reasonable ability to detect non-null effect of between-level covariates on random coefficients (Bayesian analog of statistical power;

Schultzberg & Muthén, 2018). There was no significant difference between groups regarding gender, 36 females out of 42 participants in the BPD group compared with 27 out of 43 participants in the DD group and 30 females out of 40 participants in the control group, $\chi^2(2, N = 125) = 5.87, p = .053$. In addition, there was no significant age difference, 30 (range 18-46) in the BPD group compared with 31 (range 18-59) in the DD group and 30 (range 18-50) in the control group, $F(2, 122) = 0.52, p = .600$. Regarding the proportion of participants who received psychotropic medication, chi-square test results indicate no significant difference between the BPD group (30 out of 40 or 71.43%) and the DD group (25 out of 43 or 58.14%), $\chi^2(1, N = 83) = 1.11, p = .292, OR = 0.56, 95\% CI [0.23, 1.37]$. The most frequent comorbid diagnoses in patients with BPD were posttraumatic stress disorder (15 out of 42) and eating disorders (10 out of 42; see the table in the online supplement materials S1 for all comorbid diagnoses). The most frequent comorbid diagnoses in patients with DD were posttraumatic stress disorder (6 out of 43) and panic disorder (3 out of 43). Fisher's exact test results reveal a significant difference between groups for posttraumatic stress disorder, $p = .025, OR = 0.30, 95\% CI [0.08, 0.94]$. The numbers of patients with zero, one, two, three, and four comorbid diagnoses were 5, 16, 13, 7 and 1, in the BPD group ($n = 42$) compared with 22, 16, 5, 0, and 0 in the DD group ($n = 43$). Again, Fisher's exact test results reveal a significant difference between groups, $p < .001$. All participants were informed about the voluntary nature of their participation and data protection. Informed consent was signed prior to the start of the study (see document S2 in the online supplement materials for the original file and a translation). The institutional review board (Charité Berlin, Germany) approved the study (No EA4/138/15).

Measures

Prior to the e-diary assessment participants completed diagnostic instruments in rooms of the university clinic.

Questionnaires. We assessed the intensity of BPD specific cognitions using the German Questionnaire for Thoughts and Feelings (QTF; 14 statements; e.g., “close interpersonal relationships are threatening”; range 1-5; Renneberg et al., 2005; Renneberg & Seehausen, 2010). Mc Donald’s (1999) hierarchical omega was 0.96, 95% CI [0.95, 0.97] (computed using maximum likelihood robust as implemented in the R package MBESS; Kelley, 2007)¹. In addition, severity of depressive symptoms was assessed using the German version of Beck’s Depression Inventory (BDI-II; 21 items; e.g., sadness in the past two weeks; range 0-3; Beck et al., 1996; Hautzinger et al., 2009). Hierarchical omega was 0.96, 95% CI [0.95, 0.97]. In addition, we used the German version of the Rejection Sensitivity Questionnaire for adults (RSQ; Brookings et al., 2003; Feldman & Downey, 1994) to assess dispositional rejection sensitivity (9 situations; e.g., “you ask your parents or another family member for a loan to help you through a difficult financial time”; range 1-6). Participants were asked how anxious they would feel in each situation (anxiety subscale) and how likely a positive outcome would be

¹ Coefficient omega uses a confirmatory single-factor model to decompose the true (shared) and error (unshared) variances (see McDonald, 1999 for formulas). It denotes the proportion of the variance of the composite score due to the true score. The advantage of the coefficient omega over the more commonly reported coefficient alpha is that factor loadings in the underlying measurement model are not assumed to be equal across items but only that all items load on one common factor, which is a more tenable assumption in the context of our study. Hierarchical omega is reported because it is more general than coefficient omega, also accounting for variance due to correlations between error terms (see McDonald, 1999; Kelly & Pornprasertmanit, 2017 for formulas and a discussion).

(expectation subscale). Hierarchical omega was 0.88, 95% CI [0.85, 0.91] for the anxiety subscale and 0.87, 95% CI [0.84, 0.91] for the expectation subscale. Finally, we used the 95-item version of the German Borderline Symptom List (BSL-95; Bohus et al., 2007) to assess baseline severity of BPD psychopathology (e.g., “during the past week I thought about hurting myself”; range 0-4) and the revised German 90-items version of the Symptom Checklist (SCL-90R; Derogatis et al., 1973; Franke, 2000) to assess the severity of several psychopathological symptoms (e.g., nervousness in the past week; range 0-4). Hierarchical omega for the six subscales of the SCL-90R ranged from 0.85, 95% CI [0.81, 0.90] for paranoid ideation to 0.93, 95% CI [0.91, 0.95] for somatization. All coefficients are available at <https://osf.io/83b4x/>.

E-diary assessment. E-diary data were collected during patients’ daily clinic routine or daily lives between July 2016 and September 2018. Participants used their own smartphones and installed a specially developed software by Blue Bird Technologies Ltd. If necessary, participants received a smartphone (LG Nexus 5X H791). JE thoroughly instructed and trained all inpatients regarding the use of the e-diary (as recommended by Trull & Ebner-Priemer, 2020). The e-diary emitted a prompting signal according to a time-sampling schedule in intervals of 15 min (+/- 5 min) from 8 am to 9 pm (e.g., Ebner-Priemer & Sawitzki, 2007; Kockler et al., 2020). Participants were prompted 52 times within one day. Each response was automatically time-stamped. At each prompt participants rated their current arousal and perceived rejection. Specifically, participants indicated their momentary arousal (German: “angepannt”) using a visual analog scale ranging from 0 (“no arousal at all”) to 100 (“extreme arousal”). Participants were instructed to use values between 0 and 29 to indicate mild arousal (“feeling relaxed and balanced”), values between 30 and 69 to indicate moderate arousal (“feeling clearly tense and

somewhat to clearly restless”), and values between 70 and 100 to indicate extreme arousal (“feeling unbearably tense, being unable to think clearly, perceived loss of control”). Momentary perceived rejection was assessed using two items asking participants to what extent they feel rejected and accepted on a visual analog scale ranging from 0 (“*not at all rejected*” or “*completely rejected*”) and 100 (“*completely accepted*” or “*not at all accepted*”). We built a composite score reflecting the mean value for each measurement occasion across both items and used this score for all further analyses. The item assessing perceived acceptance was recoded prior to the aggregation such that high composite values indicate high rejection. Multilevel composite reliability (Lai, 2020; also see Geldhof et al., 2014) for the overall composite was 0.86, 95% CI [0.82, 0.89] (Bayesian credible intervals computed using *Mplus*; see Muthén & Asparouhov, 2012 for technical details). On the within-level the estimate was 0.77, 95% CI [0.75, 0.79] and on the between-level 0.88, 95% CI [0.83, 0.91]². In some cases, participants entered delayed responses that led to two or more assessments within a brief time span (e.g., a participant missed the 10:00 am prompt and received the next prompt at 10:15 am). Because prior prompts were not deleted automatically, some participants successively answered the accumulated prompts (e.g., the 10:00 am prompt at 10:16 and the 10:15 prompt at 10:18). In such cases, we only considered the first entry as valid. In addition, participants were able to enter

² Ambulatory assessment leads to observed scores that can be decomposed in true (shared) and error (unshared) variances at both the within- and the between-levels. Multilevel composite reliability uses a multilevel factor model to decompose true (shared) and error (unshared) variances at both levels (see Lai, 2020 for formulas). The overall reliability coefficient denotes the proportion of the variance of the composite score due to the true score on the within- and between-levels (overall), whereas the within-level coefficient only considers the within-level and the between-level coefficient only considers the between-level (also see Geldhof et al., 2014).

responses on demand, which in some cases also led to repeated entries within a brief time span. Again, we only considered the first entry within the 15 min (+/- 5 min) interval period as valid.

Statistical Analysis

We tested our hypotheses using dynamic structural equation models (dynamic SEM) that separate interindividual, time-stable, between-person differences (trait levels) from within-person fluctuations around this value and allow to investigate interindividual differences in autoregressive and cross-lagged associations (Asparouhov et al., 2018; Asparouhov & Muthén, 2020; see Santangelo et al., 2020 for a recent application using patients with BPD). Specifically, all models in our study estimate the latent person-specific means of arousal and perceived rejection across measurement occasion (trait levels), and these estimates were averaged either across all participants or across diagnostic groups. In addition, all models include autocorrelations of order 1 (AR[1]) and cross-lagged effects of arousal and perceived rejected at the within-person level (see Hamaker et al., 2018 for a similar model). The autoregressive associations of order 1 describe the speed with which a person returns to his or her trait level since the last measurement occasion (i.e., 15 minutes earlier), whereas the cross-lagged associations describe the degree to which perceived rejection or arousal are predictive of arousal or perceived rejection on the following measurement occasion (i.e., 15 minutes later). Autoregressive and cross-lagged effects were averaged either across all participants or across diagnostic groups (fixed effects) with person-specific deviations from these averages (random-effects variances). Our models also allow for person-specific random innovation variances (i.e., level 1 residual variances) that capture interindividual differences in the reactivity to unobserved influences (see Jongerling et al., 2015 for a thorough discussion). A graphical display of the

models used in our analyses is shown in the figure in the online supplement materials S3. In our first model, a grouping variable ($BPD = 1$, $DD = 2$, $HC = 3$) was used to predict differences in trait levels of arousal and perceived rejection, as well as to predict autoregressive and cross-lagged coefficients. Group-specific model parameters were computed using three additional models based on the responses from participants in the BPD, DD, and HC group only. We report within-person standardized parameters averaged across clusters to compare the strength of cross-lagged coefficients (as recommended by Schuurman et al., 2016). The dynamic SEMs in this study take varying time intervals between assessments into account. This is particularly important because the strength of effects may depend on the time interval between assessments (Deboeck & Preacher, 2016; Gollob & Reichardt, 1987). We created a data set including 52 rows for each participant, which corresponds to the number of quarter-hourly prompts in the time between 8 am and 9 pm (as recommended by Asparouhov et al., 2018). For omitted prompts, missing observations were inserted. The estimation of our models is based on Bayesian methods and uses the default Markov Chain Monte Carlo algorithm based on the Gibbs sampler (Asparouhov et al., 2018; see Asparouhov & Muthén, 2010 for technical details). Missing values were generated from available information in the context of this algorithm (see Asparouhov & Muthén, 2010 for technical details; Asparouhov et al., 2018 report evidence from simulation studies showing that although the quality of parameter estimates decreases with an increasing amount of missing data, results are acceptable even if 80% of values are missing). All Bayesian analyses were conducted using the *Mplus* default priors (Asparouhov et al., 2018). Because the success of the Gibbs sampler estimation process depends on correctly diagnosing convergence to construct the posterior distributions of parameters, we carefully checked model

convergence. We assumed convergence if the potential scale reduction factor fell below the default cut-off of 1.10 for all parameters (Asparouhov & Muthén, 2010). In addition, we checked convergence by visual inspection of Bayesian posterior parameter trace plots for each parameter. We used *Mplus* 8.5 (Muthén & Muthén, 1998-2017) to compute the multilevel reliability coefficients, estimate the models for our hypothesis tests, and for sensitivity and additional analyses. Preliminary analyses and all other reliability estimates were computed using R version 4.0.3 (R Core Team, 2020).

Results

Preliminary analyses

Prior to testing hypotheses, we conducted ANOVAs to test whether participants in the BPD, DD, and HC groups differ in their baseline scores on questionnaire measures. As expected, results indicate differences between conditions in the rejection sensitivity anxiety subscale, $F(2,118) = 25.92, p < .001, \omega = 0.31, 95\% \text{ CI } [0.19, 0.40]$, and expectation subscale, $F(2,118) = 24.82, p < .001, \omega = 0.30, 95\% \text{ CI } [0.18, 0.39]$. In addition, ANOVA results reveal expected significant group differences in severity of borderline symptoms, $F(2,121) = 91.01, p < .001, \omega = 0.60, 95\% \text{ CI } [0.51, 0.66]$, depressive symptoms, $F(2,114) = 142.2, p < .001, \omega = 0.71, 95\% \text{ CI } [0.64, 0.76]$, intensity of borderline specific cognitions, $F(2,119) = 129.02, p < .001, \omega = 0.60, 95\% \text{ CI } [0.60, 0.73]$, and psychopathological symptoms, $F(2,121) = 118.02, p < .001, \omega = 0.61, 95\% \text{ CI } [0.58, 0.71]$. Tukey's HSD test results are reported in Table 1 and intercorrelations are displayed in the table in the online supplement materials S4. Because we allowed participants to enter responses on demand, we were unable to calculate a compliance rate based on the proportion of answered prompts. Instead, we calculated the proportion of valid responses within

the 13 hours assessment period. A valid response was defined as the first entry within a 15 min period (+/- 5 min) starting at 8 am and ending at 9 pm. The maximum number of valid responses was 52. The average number of realized responses was 23.31 (SD = 10.06) in the BPD group, 26.42 (SD = 8.90) in the DD group, and 27.13 (SD = 9.77) in the HC group. Overall compliance was satisfactory: 60.70% valid responses on the arousal item and 59.80% valid responses on the perceived rejection composite across groups. Compliance in the BPD group was 53.20% for arousal and 52.20% for perceived rejection, in the DD group 61.60% and 60.70%, and in the HC group 68.30% and 68.50%. According to scale reduction factor values and visual inspection of trace plots, all dynamic SEMs converged well.

Test of Hypotheses

Group Differences in Trait Arousal and Perceived Rejection

According to our first hypothesis, we expected that patients with BPD on average report the highest trait levels of (a) arousal and (b) perceived rejection. As shown in Table 2, average arousal was 55.26, 95% CI [49.70, 60.64], on a scale ranging from 0 to 100 in the BPD group compared with 34.37, 95% CI [27.11, 41.78], in the DD group and 15.73, 95% CI [8.98, 22.32], in the HC group. We note that these estimates were calculated using three separate models based on responses from the BPD, DD, and HC groups, respectively. In line with our first hypothesis, we found that in the full model diagnostic group was a significant predictor of differences across

participants, -17.49, 95% CI [-20.92, -14.01]³. In addition, Table 2 shows that perceived rejection was 52.40, 95% CI [43.36, 61.60], in the BPD group compared with 35.17, 95% CI [24.85, 45.83], in the DD group and 13.04, 95% CI [7.75, 18.41], in the HC group. Again, diagnostic group was a significant predictor of differences across participants, -16.48, 95% CI [-20.90, -11.97] (also see Figure 1).

Group Differences in Autoregressive Temporal Relations

According to our second hypothesis, we expected group differences in autoregressive relations of (a) arousal and (b) perceived rejection. Table 2 shows that the unstandardized (fixed) effect that regresses arousal on arousal on the previous assessment (15 min earlier) was estimated at 0.49, 95% CI [0.35, 0.61], in the BPD group. In other words, for every 1.00 points increase in arousal on a 0 to 100 points scale, arousal 15 min later is expected to increase by 0.49 points. The estimate was 0.52, 95% CI [0.37, 0.66] in the DD group, and 0.35, 95% CI [0.21, 0.49] in the HC group. Other than expected, in the full model diagnostic group was not a significant predictor of differences across participants, -0.06, 95% CI [-0.14, 0.02]. The random-effects variance across diagnostic groups is displayed in Figure 1. In addition, Table 2 shows that a the unstandardized (fixed) effect that regresses perceived rejection on perceived rejection at the

³ Average differences between groups are equidistant because we used one grouping variable (1=BPD, 2=DD, 3=HC) as a predictor. The estimated difference between the BPD and the HC groups is $2 * (-17.55) = -35.10$. Multi-group models would have allowed us to test exact group differences for significance within a single model. At the time we ran our analysis, however, such analyses were not available in *Mplus*. We computed additional models including dummy-coded variables to investigate group differences (see our sensitivity and additional results section). Taking all results into account, we are confident that group differences in trait levels across groups are meaningful and cannot be solely explained by random fluctuations or some degree of (fundamentally inescapable) unreliability of our models.

previous assessment (15 min earlier) was estimated at 0.30, 95% CI [0.11, 0.47], in the BPD group, compared with 0.33, 95% CI [0.25, 0.40] in the DD group, and 0.22, 95% CI [0.07, 0.38] in the HC group. Again, in the full model diagnostic group was no significant predictor of differences across participants, -0.05, 95% CI [-0.14, 0.04] (see Figure 1 for random-effects variance).

Group Differences in Cross-Lagged Temporal Relations

According to our third hypothesis, we expected group differences in the cross-lagged relations between (a) arousal and higher perceived rejection on the following assessment, as well as (b) perceived rejection and higher arousal on the following assessment. Table 2 shows that the unstandardized (fixed) effect that regresses perceived rejection on arousal on the previous assessment (15 min earlier) was estimated at 0.28, 95% CI [0.03, 0.55] in the BPD group. In other words, for every 1.00 points increase in arousal on a 0 to 100 points scale, perceived rejection 15 min later is expected to increase by 0.28 points among patients with BPD. The estimate was 0.15, 95% CI [0.01, 0.32], in the DD group, and 0.15, 95% CI [0.01, 0.31] in the HC group. Other than expected, we found that in the full model diagnostic group was no significant predictor of differences across participants, 0.02, 95% CI [-0.03, 0.07]. The random-effects variance across diagnostic groups is displayed in Figure 1. In addition, Table 2 shows that the unstandardized (fixed) effect that regresses arousal on perceived rejection on the previous assessment (15 min earlier) was estimated at 0.07, 95% CI [-0.00, 0.15], in the BPD group, compared with 0.07, 95% CI [-0.03, 0.19], in the DD group, and 0.18, 95% CI [0.01, 0.38] in the HC group. Again, in the full model diagnostic group was no significant predictor of differences across participants, 0.02, 95% CI [-0.04, 0.09] (see Figure 1 for random-effects variance).

Sensitivity and Additional Analyses

To test the robustness of our effects, we conducted several sensitivity and additional analyses⁴. First, we repeated our main analysis using three dynamic SEMs including dummy-coded variables as predictors to separately investigate differences when directly comparing the BPD and HC groups, the BPD and DD groups, as well as the DD and HC groups in subsets of our data (e.g., for the comparison between the BPD and DD groups only responses from patients with BPD and DD were included). In addition, we ran three dynamic SEMs using the full data set including dummy-coded variables as predictors to investigate differences when comparing the BPD vs combined DD and HC groups, the DD vs combined BPD and HC groups, as well as the HC vs combined BPD and DD groups. In all analyses, the general pattern of results from our hypothesis tests (significant group differences in trait levels but not autoregressive and cross-lagged effects) was confirmed. Second, we repeated our main analysis using one dynamic SEM with 30 min intervals between prompts to examine the influence of greater time lags. The total number of prompts in this model was 26. The general pattern of results remained unchanged. Third, we repeated our main analysis using two dynamic SEMs using single item responses to indicate levels of acceptance and rejection instead of composite scores, and fourth, we ran one dynamic SEM excluding patients with a comorbid diagnosis of posttraumatic stress disorder and

⁴ The models used in our sensitivity and additional analyses resemble the models used for our hypothesis tests. In some of the models we omitted person-specific random innovation variances and/or individual random-effects variances to ensure that convergence criteria are met.

one dynamic SEM excluding outpatients. In all these analyses, the main results remained unchanged. Fifth, because the group differences between patients with BPD and patients with DD may reflect differences in general psychopathology rather than distinct diagnostic entities (Widinger, 2005), we repeated our main analysis using one dynamic SEM including self-reported general psychopathology (SCL-90R) as a covariate. Results indicate that while controlling for general psychopathology at baseline, difference between diagnostic groups (BPD vs. DD) in trait levels of arousal and perceived rejection no longer reached significance. Sixth, because discrete categorical syndromes such as BPD and DD have been criticized for their lack of accuracy and high heterogeneity (e.g., Conway et al., 2018; Woods et al., 2020), we repeated our main analysis using one dynamic SEM including baseline scores on self-reported borderline specific cognitions (QTF) and depressive symptoms (BDI-II) as predictors. In line with results from our hypothesis tests, results show that borderline specific cognitions significantly related to trait level differences in arousal and perceived rejection, and that depressive symptoms significantly related to trait level differences in perceived rejection. The scores did not significantly relate to differences in autoregressive and cross-lagged associations. Finally, we repeated our main analysis using one dynamic SEM including the baseline trait rejection sensitivity anxiety and expectation subscales as predictor. Results show that higher anxiety subscale scores significantly predicted higher trait levels of arousal and perceived rejection. Expectation subscale scores, however, did not. Neither anxiety nor expectation subscale scores predicted differences in autoregressive or cross-lagged effects.

Discussion

The aim of this study was to investigate the temporal relation of arousal and perceived rejection in patients with BPD and DD to provide insights that may help to further develop theories and clinical interventions (e.g., Dixon-Gordon et al., 2020; Trull et al., 2010).

Group Differences in Trait Arousal and Perceived Rejection

In support of our first hypothesis and in line with predictions derived from an adaptation of the dynamic affect model (Ebner-Priemer et al., 2015), we found that patients with BPD report substantially higher trait levels of arousal than patients with DD and HC participants. As in previous studies, the point estimate of trait arousal in patients with BPD was more than double the value in HC participants (e.g., Stiglmayr et al., 2005; Santangelo et al., 2016; Wolff et al., 2007), whereas the difference was smaller when compared with patients with DD (e.g., Hepp et al., 2020; Stiglmayr et al., 2008). Because arousal is conceptualized as a highly unpleasant affective state (Stiglmayr et al., 2001), our finding corresponds to theoretical and empirical accounts of heightened levels of negative affect in patients with BPD (see Haskings et al., 2017 for a review). In addition, we found that patients with BPD report substantially elevated trait levels of perceived rejection, which aligns well with current meta-analytic evidence demonstrating a heightened disposition to expect rejection among patients with BPD (Cavicchioli & Maffei, 2020; also see Lazarus et al., 2018; Rosenbach & Renneberg, 2011, 2014; Staebler et al., 2011). We would like to point out that sensitivity analysis results indicate that differences between diagnostic groups (BPD vs DD) in trait levels of arousal and perceived rejection are no longer significant after controlling for self-reported levels of general psychopathology at baseline. One explanation for this finding is that as severity of psychopathology increases, individuals generally experience more difficulties with the

modulation of thought processes, affect, and arousal, relatively independent of their diagnostic status (Caspi et al., 2013; also see Heinrich et al., 2020).

Interestingly, additional analysis results suggest that baseline differences in dispositional anxiety regarding social interactions (e.g., “I would be very concerned or anxious over whether or not my friend would want to help me out”; Downey & Feldman, 1996) but not expectations of rejection or acceptance (e.g., “I would expect that he/she would willingly agree to help me out”) significantly predicted differences in perceived rejection throughout the ambulatory assessment phase, whereby patients with BPD reported the highest baseline levels of both the anxious and the expectations component of rejection sensitivity (as in previous studies; e.g., Staebler et al., 2011). Thus, habitual expectations regarding affective outcomes rather than the prospect of being rejected per se appear to be related to heightened perceptions of rejection in patients with BPD. It could be that anxious expectations of rejection make individuals particularly sensitive for rejection cues, bringing them to deploy more attention to potentially threatening aspects of social situations, and/or perceiving rejection cues more readily as intentional rejection, resulting in higher levels of perceived rejection (Downey & Feldman, 1996; also see Gross, 1998; Webb et al., 2012). In line with this, laboratory and e-diary studies have shown that patients with BPD report particularly high levels of distress following social rejection cues (e.g., Chapman et al., 2014; Sadikaj et al., 2010).

Group Differences in Autoregressive Relations

Other than expected in our second hypothesis, we found no significant differences in autoregressive relations, that is the degree to which a person’s current level of arousal (or perceived rejection) can be predicted by prior arousal (or perceived rejection), across diagnostic

groups. Our results, however, do indicate that momentary arousal (or perceived rejection) substantially depends on arousal (or perceived rejection) 15 minutes earlier, which is consistent with earlier e-diary studies (e.g., Santangelo et al., 2020). Our results indicate that while autoregressive relations and within-person variability appear to be stronger in BPD patients compared with HC participants for distress and negative valence, or distinct emotions such as hostility, fear, and sadness (Ebner-Priemer et al., 2015, studies 1 and 2; Santangelo et al., 2016; Trull et al., 2008), they may be comparable across BPD, DD, and HC participants for arousal and perceived rejection.

Group Differences in Cross-Lagged Relations

Our results suggest a significant temporal relation between arousal and perceived rejection. Specifically, increases in arousal were shown to perpetuate perceptions of rejection 15 minutes later across diagnostic groups. Other than expected in our third hypothesis, we found no significant group differences in cross-lagged relations. Before discussing results further, one limitation of this study should be mentioned. Our data set contain no information regarding what triggered changes in arousal or perceived rejection and claims regarding the temporal relations between arousal and perceived rejection are complicated by the fact that various triggers may lead to different processes. With this limitation in mind, descriptive results show that, as expected, the unstandardized (fixed) regression of perceived rejection on arousal was larger in the BPD compared with the DD and HC groups. Interestingly, the unstandardized (fixed) regression of arousal on perceived rejection was smaller in the BPD compared with the DD and HC groups and did not even reach statistical significance. There was, however, substantial (random) variation for this effect within the BPD group, indicating that for some patients in the

BPD group levels of arousal did depend on previous perceptions of rejection, while for others this was not the case. Thus, our hypothesis may still hold true in a subset of patients with BPD. A robust body of evidence including e-diary studies (e.g., Berenson et al., 2011; Hepp et al., 2018; Stiglmayr et al., 2005) and laboratory experiments (see Cavicchioli & Maffei, 2020 for a meta-analysis and review) indicates a heightened affective reactivity to rejection experiences in patients with BPD. Our finding suggests that this effect may not hold for all patients with BPD and/or under all circumstances (also see Stepp et al., 2009). Rather, our results speak to the heterogeneity of patients diagnosed with BPD—at least regarding the temporal relation between arousal and perceived rejection (Conway et al., 2018; Woods et al., 2020). Earlier e-diary studies focused on responses to rejection events rather than feelings of rejection or acceptance (Stiglmayr et al., 2005) or assessed distinct emotions such as hostility, sadness, or rage as outcomes (Berenson et al., 2011; Hepp et al., 2018), which may explain deviating results.

Limitations and Future Research

Several limitations and perspectives for future research should be mentioned. First, it remains unclear how many (if any) and which types of rejection events participants experienced throughout the 13 hours of ambulatory assessment. Without knowledge regarding the events that participants responded to, it is difficult to draw firm conclusions regarding the temporal relations between arousal and perceived rejection because it remains unclear how changes in arousal are being triggered. Future studies should explicitly assess which situations participants respond to (e.g., interpersonal experiences; Haliczzer et al., 2020; Lazarus et al., 2018) and describe potential differences between the contexts in which data were collected (e.g., inpatient clinic vs. daily life at home). In addition, we encourage assessments over the course of several days to cover more

rejection events. Second, roughly one third of our e-diary assessment data were missing because participants did not respond to prompts. Although we used a state-of-the-art analysis approach to account for missing responses and used sensitivity analyses to ensure the robustness of our results, parameter estimates may be biased (Asparouhov et al., 2018; Schuurman & Hamaker, 2019). In addition, due to the higher-than-expected number of missing observations, the sample size of our study may have been too small to provide our models with a reasonable ability to detect non-null effects (3317 realized observations for arousal and 3283 for perceived rejection compared to an ideal number of at least 4875 observations; Schultzberg & Muthén, 2018). Future research with e-diary data should aim to realize larger samples and implement procedures known to enhance compliance (see Trull & Ebner-Priemer, 2020 for recommendations). Third, the categorical approach we used may have been too crude to reliably capture differences in the relation between affects and cognitions across participants with different levels of psychopathology (also see Conway et al., 2018). Future studies should use clinician-rated continuous measures of relevant symptoms as predictors (e.g., using the Zanarini Rating Scale for Borderline Personality Disorder; Zanarini et al., 2003). Fourth, more than two thirds of the BPD sample used prescribed psychotropic medication, which may have influenced findings regarding affective dynamics through alterations of amygdala activation (Schulze et al., 2019). Finally, there were more women in the BPD group compared with the DD and HC groups. We did not perform subgroup analyses because given the complexity of our statistical models and the limited sample size, results from such analyses were not expected to be reliable. Potential gender differences may be the focus of future research. In addition, we did not assess personality traits and researchers should control for baseline differences in neuroticism in future studies as

individuals higher in neuroticism can be expected to be more easily distressed (Caspi et al., 2013).

Conclusion

This study examined the temporal relations between arousal and perceived rejection. Results indicate elevated trait levels of arousal and perceived rejection in patients with BPD, as well as substantial autoregressive and cross-lagged effects. The magnitude of autoregressive and cross-lagged effects however, appeared to be comparable across patients with BPD, patients with DD, and healthy controls.

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Table 1

Mean, Standard Deviations, and 95% Confidence Intervals of Mean Differences for the BSL-95, QTF, BDI-II, RSQ, and SCL-90R in the BPD ($n = 42$), DD ($n = 43$) and HC ($n = 40$) Groups

Measure	<i>M</i>	<i>SD</i>	BPD vs DD: Diff [95% CI]	BPD vs HC: Diff [95% CI]	DD vs HC: Diff [95% CI]
Borderline Personality Disorder (BPD)					
1. BSL-95	2.31	0.70	0.88 [0.57, 1.18]	1.95 [1.64, 2.27]	1.08 [0.77, 1.38]
2. QTF	3.66	0.81	1.49 [1.12, 1.85]	2.46 [2.10, 2.83]	0.97 [0.62, 1.33]
3. BDI-II	36.71	9.96	13.26 [8.46, 18.06]	34.08 [29.20, 38.96]	20.82 [16.22, 25.41]
4. RSQ anx	4.80	0.89	1.07 [0.56, 1.58]	1.54 [1.02, 2.05]	0.46 [0.08, 0.97]
5. RSQ exp	4.25	0.86	1.19 [0.71, 1.68]	1.33 [0.84, 1.82]	0.14 [-0.34, 0.62]
6. SCL-90R	2.01	0.70	0.82 [0.53, 1.10]	1.87 [1.58, 2.16]	1.05 [0.77, 1.34]
Depressive Disorder (DD)					
1. BSL-95	1.43	0.68			
2. QTF	2.17	0.80			
3. BDI-II	23.44	11.06			
4. RSQ anx	3.73	0.89			
5. RSQ exp	3.06	0.78			
6. SCL-90R	1.20	0.61			
Healthy Control (HC)					
1. BSL-95	0.36	0.30			
2. QTF	1.20	0.32			
3. BDI-II	2.62	3.33			
4. RSQ anx	3.26	1.10			
5. RSQ exp	2.92	1.09			
6. SCL-90R	0.14	0.18			

Note. *M* = mean; *SD* = standard deviation; Diff = mean difference; CI = confidence interval based on Tukey's HSD tests; BSL-95 = Borderline Symptoms List; QTF = Thoughts and Feelings Questionnaire; BDI-II = Beck Depression Inventory; RSQ Anx = Rejection Sensitivity Questionnaire anxiety subscale; RSQ Exp = Rejection Sensitivity Questionnaire expectation subscale; SCL-90R = Symptom Checklist.

Table 2

Results of the Dynamic SEM of the Relations Between Arousal (A) and Perceived Rejection (PR) in Patients with Borderline Personality Disorder (BPD), Depressive Disorders (DD) and Healthy Control (HC)

	All Participants		BPD Patients		DD Patients		HC Participants	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Unstandardized parameter estimates								
$E(\mu_A)$	70.10	[62.55, 77.60]	55.26	[49.70, 60.64]	34.37	[27.11, 41.78]	15.73	[8.98, 22.32]
$E(\mu_{PR})$	66.40	[56.65, 76.06]	52.40	[43.36, 61.60]	35.17	[24.85, 45.83]	13.04	[7.75, 18.41]
$SD(\mu_A)$	15.31	[13.27, 17.88]	16.53	[12.27, 23.53]	21.23	[15.78, 30.41]	19.95	[14.74, 28.55]
$SD(\mu_{PR})$	20.20	[17.42, 23.79]	27.18	[20.55, 38.56]	32.38	[24.52, 45.01]	16.25	[12.11, 23.32]
Fixed effects								
$\gamma_{\varphi A}$	0.58	[0.41, 0.75]	0.49	[0.35, 0.61]	0.52	[0.37, 0.66]	0.35	[0.21, 0.49]
$\gamma_{\varphi PR}$	0.45	[0.24, 0.64]	0.30	[0.11, 0.47]	0.33	[0.25, 0.40]	0.22	[0.07, 0.38]
$\gamma_{\varphi PRonA}$	0.12	[-0.05, 0.27]	0.28	[0.03, 0.55]	0.15	[0.01, 0.32]	0.15	[0.01, 0.31]
$\gamma_{\varphi AonPR}$	0.06	[-0.05, 0.27]	0.07	[-0.00, 0.15]	0.07	[-0.03, 0.19]	0.18	[0.01, 0.38]
Random-effects variances								
φ_A	0.07	[0.05, 0.11]	0.11	[0.05, 0.26]	0.16	[0.08, 0.34]	0.14	[0.07, 0.32]
φ_{PR}	0.11	[0.07, 0.16]	0.21	[0.10, 0.48]	0.19	[0.09, 0.40]	0.19	[0.10, 0.41]
φ_{PRonA}	0.02	[0.01, 0.03]	0.02	[0.01, 0.06]	0.16	[0.06, 0.40]	0.09	[0.02, 0.33]
φ_{AonPR}	0.04	[0.02, 0.09]	0.39	[0.14, 1.01]	0.06	[0.02, 0.16]	0.13	[0.04, 0.41]
$\ln(\sigma_{\zeta A}^2)$	6.78	[5.05, 9.62]	9.78	[4.30, 23.36]	5.69	[2.83, 14.05]	21.35	[12.23, 43.52]
$\ln(\sigma_{\zeta PR}^2)$	8.31	[6.31, 11.12]	6.23	[3.37, 12.76]	10.62	[5.94, 20.89]	16.64	[9.10, 34.54]
$\ln(\sigma_{\zeta A-PR}^2)$	8.99	[6.79, 12.18]	5.82	[3.03, 12.34]	10.58	[5.45, 21.81]	21.24	[11.68, 41.67]
Group as predictor								
$\beta_E(\mu_A)$	-17.49	[-20.92, -14.01]	-	-	-	-	-	-
$\beta_E(\mu_{PR})$	-16.48	[-20.90, -11.97]	-	-	-	-	-	-
$\beta_{\gamma\varphi A}$	-0.06	[-0.14, 0.02]	-	-	-	-	-	-
$\beta_{\gamma\varphi PR}$	-0.05	[-0.14, 0.04]	-	-	-	-	-	-
$\beta_{\gamma\varphi PRonA}$	0.02	[-0.03, 0.07]	-	-	-	-	-	-
$\beta_{\gamma\varphi AonPR}$	0.02	[-0.04, 0.09]	-	-	-	-	-	-
Standardized parameter estimates								
Within-person standardization (averaged across clusters)								
φ_A	0.47	[0.43, 0.51]	0.49	[0.41, 0.57]	0.52	[0.45, 0.58]	0.35	[0.27, 0.42]
φ_{PR}	0.34	[0.30, 0.39]	0.30	[0.18, 0.39]	0.40	[0.34, 0.47]	0.22	[0.15, 0.30]
φ_{PRonA}	0.13	[0.08, 0.17]	0.12	[0.03, 0.21]	0.14	[0.07, 0.22]	0.17	[0.10, 0.24]
φ_{AonPR}	0.11	[0.08, 0.15]	0.11	[0.04, 0.18]	0.07	[0.01, 0.13]	0.13	[0.06, 0.19]
$\ln(\sigma_{\zeta A}^2)$	0.40	[0.36, 0.44]	0.28	[0.21, 0.36]	0.38	[0.31, 0.44]	0.55	[0.49, 0.60]
$\ln(\sigma_{\zeta PR}^2)$	0.51	[0.47, 0.55]	0.52	[0.45, 0.59]	0.44	[0.37, 0.51]	0.51	[0.44, 0.59]
R^2								
Within-level (averaged across clusters)								
A	0.60	[0.56, 0.64]	0.72	[0.64, 0.79]	0.63	[0.56, 0.69]	0.45	[0.40, 0.51]
PR	0.49	[0.45, 0.53]	0.48	[0.41, 0.55]	0.56	[0.49, 0.63]	0.49	[0.41, 0.56]

Note. Within-person standardized parameters are within-person-level standardized estimates averaged across clusters. Unstandardized parameters denote posterior medians and the 95% CIs denote Bayesian credibility intervals. R^2 measures refer to explained variance in A and PR on the within-level. β = regression coefficients of regressing the respective parameters on group (1 = BPD, 2 = MDD, 3 = HC); μ_A = person-specific mean of arousal across measurement occasions, μ_{PR} = person-specific mean of perceived rejection across measurement occasions, $\gamma_{\varphi A}$ = average autoregressive effect (fixed effect) of arousal, $\gamma_{\varphi PR}$ = average autoregressive effect (fixed effect) of perceived rejection, $\gamma_{\varphi PRonA}$ = average slope (fixed effect) of the regressions of perceived rejection on arousal at time $t-1$, $\gamma_{\varphi AonPR}$ = average slope (fixed effect) of the regressions of arousal on perceived rejection at time $t-1$, φ_A = random, person-specific autoregressive effect of arousal, φ_{PR} = random, person-specific autoregressive effect of perceived rejection, φ_{PRonA} = random, person-specific slope of the regressions of perceived rejection on arousal at time $t-1$, $\ln(\sigma_{\zeta A}^2)$ = logarithm of the random, person-specific innovation variance of arousal (including measurement error), $\ln(\sigma_{\zeta PR}^2)$ = logarithm of the random, person-specific innovation variance of perceived rejection (including measurement error), $\ln(\sigma_{\zeta A-PR}^2)$ = mean of the log of covariance between the random innovations of arousal and perceived rejection at the same time point.

Figure 1

Fixed Effects and Random-Effects Variances for Arousal and Perceived Rejection

Note. This figure displays fixed effects and random-effects variances for trait values of arousal and perceived rejection in the healthy control (HC) group, the depressive disorder (DD) group, and the borderline personality (BPD) group. In addition, fixed effects and random-effects variances for the AR(1) autoregressive relations for arousal and perceived rejection, as well as the cross-lagged relations between these constructs are shown. Estimates are derived from the dynamic structural equation model (DSEM) used for our hypothesis tests.

Table A8

Latent Correlations Between Random Effects in the Dynamic SEM Investigating the Relations Between Arousal (A) and Perceived Rejection (PR) in the HC Group (n = 40)

	μ_A	μ_{PR}	φ_A	φ_{PR}	φ_{PRonA}	φ_{AonPR}	$\ln(\sigma_{\zeta A}^2)$	$\ln(\sigma_{\zeta PT}^2)$	$\ln(\sigma_{\zeta A-PR}^2)$
μ_A	1	[-0.08; 0.68]	[-0.34; 0.64]	[-0.51; 0.44]	[-0.62; 0.46]	[-0.48; 0.52]	[0.21; 0.80]	[0.06; 0.75]	[-0.02; 0.77]
μ_{PR}	0.35	1	[-0.39; 0.55]	[-0.22; 0.69]	[-0.37; 0.61]	[-0.60; 0.49]	[-0.15; 0.64]	[0.20; 0.80]	[-0.20; 0.69]
φ_A	0.19	0.10	1	[-0.46; 0.53]	[-0.51; 0.70]	[-0.58; 0.53]	[0.07; 0.81]	[-0.45; 0.51]	[0.06; 0.86]
φ_{PR}	-0.05	0.30	0.06	1	[-0.63; 0.53]	[-0.61; 0.40]	[-0.70; 0.12]	[-0.35; 0.56]	[-0.50; 0.45]
φ_{PRonA}	-0.14	0.16	0.17	-0.10	1	[-0.49; 0.63]	[-0.74; 0.67]	[-0.17; 0.74]	[-0.44; 0.76]
φ_{AonPR}	0.03	-0.09	-0.04	-0.14	0.10	1	[-0.23; 0.62]	[-0.71; 0.50]	[-0.56; 0.51]
$\ln(\sigma_{\zeta A}^2)$	0.57	0.29	0.54	-0.36	-0.05	0.22	1	[-0.18; 0.61]	[0.29; 0.85]
$\ln(\sigma_{\zeta PT}^2)$	0.47	0.57	0.03	0.13	0.35	-0.21	0.26	1	[0.04; 0.78]
$\ln(\sigma_{\zeta A-PR}^2)$	0.47	0.31	0.59	-0.03	0.29	-0.05	0.65	0.51	1

Note. Posterior medians of the latent correlation coefficients are given below the diagonal. The respective posterior 95% credibility interval (CI) limits are presented above the diagonal. SEM = structural equation model; HC = healthy control participants; μ_A = person-specific mean of arousal across measurement occasions; μ_{PR} = person-specific mean of perceived rejection across measurement occasions; φ_A = random, person-specific autoregressive effect of arousal; φ_{PR} = random, person-specific autoregressive effect of perceived rejection; φ_{PRonA} = random, person-specific slope of the regressions of perceived rejection on arousal at time $t-1$; $\gamma_{\varphi_{AonPR}}$ = average slope (fixed effect) of the regressions of arousal on perceived rejection at time $t-1$; $\ln(\sigma_{\zeta A}^2)$ = logarithm of the random, person-specific innovation variance of arousal (including measurement error); $\ln(\sigma_{\zeta PR}^2)$ = logarithm of the random, person-specific innovation variance of perceived rejection (including measurement error); $\ln(\sigma_{\zeta A-PR}^2)$ = mean of the log of covariance between the random innovations of arousal and perceived rejection at the same time point.

Table A7

Latent Correlations Between Random Effects in the Dynamic SEM Investigating the Relations Between Arousal (A) and Perceived Rejection (PR) in the DD Group (n = 43)

	μ_A	μ_{PR}	φ_A	φ_{PR}	φ_{PRonA}	φ_{AonPR}	$\ln(\sigma_{\zeta A}^2)$	$\ln(\sigma_{\zeta PT}^2)$	$\ln(\sigma_{\zeta A-PR}^2)$
μ_A	1	[-0.16; 0.81]	[-0.03; 0.79]	[-0.58; 0.32]	[-0.22; 0.72]	[-0.63; 0.41]	[-0.39; 0.55]	[-0.22; 0.58]	[-0.28; 0.61]
μ_{PR}	0.56	1	[-0.26; 0.60]	[-0.28; 0.60]	[-0.41; 0.54]	[-0.57; 0.50]	[-0.65; 0.19]	[-0.01; 0.70]	[0.04; 0.73]
φ_A	0.48	0.21	1	[-0.84; -0.09]	[-0.17; 0.73]	[-0.57; 0.53]	[-0.52; 0.41]	[-0.37; 0.54]	[-0.49; 0.44]
φ_{PR}	-0.17	0.22	-0.56	1	[-0.79; -0.01]	[-0.14; 0.76]	[-0.43; 0.50]	[-0.37; 0.50]	[-0.17; 0.69]
φ_{PRonA}	0.31	0.06	0.36	-0.50	1	[-0.63; 0.40]	[-0.75; 0.16]	[-0.26; 0.59]	[-0.33; 0.58]
φ_{AonPR}	-0.16	-0.05	-0.03	0.42	-0.17	1	[-0.50; 0.52]	[-0.73; 0.51]	[-0.52; 0.67]
$\ln(\sigma_{\zeta A}^2)$	0.12	-0.29	-0.07	0.03	-0.38	0.02	1	[-0.35; 0.51]	[-0.35; 0.53]
$\ln(\sigma_{\zeta PT}^2)$	0.21	0.40	0.10	0.07	0.20	-0.17	0.10	1	[0.51; 0.94]
$\ln(\sigma_{\zeta A-PR}^2)$	0.22	0.45	-0.04	0.31	0.16	0.11	0.12	0.82	1

Note. Posterior medians of the latent correlation coefficients are given below the diagonal. The respective posterior 95% credibility interval (CI) limits are presented above the diagonal. μ_A = person-specific mean of arousal across measurement occasions; μ_{PR} = person-specific mean of perceived rejection across measurement occasions; φ_A = random, person-specific autoregressive effect of arousal; φ_{PR} = random, person-specific autoregressive effect of perceived rejection; φ_{PRonA} = random, person-specific slope of the regressions of perceived rejection on arousal at time $t-1$; $\gamma_{\varphi_{AonPR}}$ = average slope (fixed effect) of the regressions of arousal on perceived rejection at time $t-1$; $\ln(\sigma_{\zeta A}^2)$ = logarithm of the random, person-specific innovation variance of arousal (including measurement error); $\ln(\sigma_{\zeta PR}^2)$ = logarithm of the random, person-specific innovation variance of perceived rejection (including measurement error); $\ln(\sigma_{\zeta A-PR}^2)$ = mean of the log of covariance between the random innovations of arousal and perceived rejection at the same time point.

Table A6

Latent Correlations Between Random Effects in the Dynamic SEM Investigating the Relations Between Arousal (A) and Perceived Rejection (PR) in the BPD Group (n = 42)

	μ_A	μ_{PR}	φ_A	φ_{PR}	φ_{PRonA}	φ_{AonPR}	$\ln(\sigma_{\zeta A}^2)$	$\ln(\sigma_{\zeta PR}^2)$	$\ln(\sigma_{\zeta A-PR}^2)$
μ_A	1	[-0.19; 0.61]	[-0.50; 0.51]	[-0.35; 0.62]	[-0.58; 0.39]	[-0.61; 0.47]	[-0.58; 0.29]	[-0.13; 0.65]	[-0.35; 0.55]
μ_{PR}	0.25	1	[-0.09; 0.77]	[-0.44; 0.53]	[-0.59; 0.33]	[-0.60; 0.47]	[-0.23; 0.64]	[-0.20; 0.60]	[-0.29; 0.55]
φ_A	0.02	0.42	1	[-0.57; 0.54]	[-0.60; 0.53]	[-0.63; 0.47]	[-0.59; 0.52]	[-0.50; 0.39]	[-0.44; 0.51]
φ_{PR}	0.19	0.05	-0.02	1	[-0.68; 0.35]	[-0.70; 0.55]	[-0.46; 0.59]	[-0.51; 0.38]	[-0.48; 0.44]
φ_{PRonA}	-0.12	-0.18	-0.03	-0.21	1	[-0.72; 0.35]	[-0.91; -0.08]	[-0.37; 0.53]	[-0.55; 0.36]
φ_{AonPR}	-0.12	-0.11	-0.12	-0.12	-0.26	1	[-0.55; 0.68]	[-0.63; 0.35]	[-0.13; 0.65]
$\ln(\sigma_{\zeta A}^2)$	-0.20	0.26	-0.10	0.08	-0.63	0.08	1	[-0.54; 0.32]	[-0.44; 0.50]
$\ln(\sigma_{\zeta PR}^2)$	0.30	0.25	0.07	-0.09	0.09	-0.19	-0.12	1	[0.26; 0.87]
$\ln(\sigma_{\zeta A-PR}^2)$	0.13	0.16	0.04	-0.02	-0.12	-0.18	0.04	0.67	1

Note. Posterior medians of the latent correlation coefficients are given below the diagonal. The respective posterior 95% credibility interval (CI) limits are presented above the diagonal. SEM = structural equation model; BPD = borderline personality disorder; μ_A = person-specific mean of arousal across measurement occasions; μ_{PR} = person-specific mean of perceived rejection across measurement occasions; φ_A = random, person-specific autoregressive effect of arousal; φ_{PR} = random, person-specific autoregressive effect of perceived rejection; φ_{PRonA} = random, person-specific slope of the regressions of perceived rejection on arousal at time $t-1$; $\gamma_{\varphi_{AonPR}}$ = average slope (fixed effect) of the regressions of arousal on perceived rejection at time $t-1$; $\ln(\sigma_{\zeta A}^2)$ = logarithm of the random, person-specific innovation variance of arousal (including measurement error); $\ln(\sigma_{\zeta PR}^2)$ = logarithm of the random, person-specific innovation variance of perceived rejection (including measurement error); $\ln(\sigma_{\zeta A-PR}^2)$ = mean of the log of covariance between the random innovations of arousal and perceived rejection at the same time point.

Table A5

Latent Correlations Between Random Effects in the Dynamic SEM Investigating the Relations Between Arousal (A) and Perceived Rejection (PR) in all Participants (n =125)

	μ_A	μ_{PR}	φ_A	φ_{PR}	φ_{PRonA}	φ_{AonPR}	$\ln(\sigma_{\zeta A}^2)$	$\ln(\sigma_{\zeta PR}^2)$	$\ln(\sigma_{\zeta A-PR}^2)$
μ_A	1	[-0.18; -0.55]	[-0.09; -0.45]	[-0.23; -0.26]	[-0.18; 0.41]	[-0.38; 0.40]	[0.06; 0.47]	[0.17; 0.54]	[0.17; 0.57]
μ_{PR}	0.38	1	[-0.07; -0.52]	[-0.03; -0.47]	[-0.3; 0.23]	[-0.39; 0.42]	[-0.11; 0.30]	[0.21; 0.56]	[0.15; 0.54]
φ_A	0.20	0.31	1	[-0.45; 0.13]	[-0.29; 0.36]	[-0.36; 0.52]	[0.03; 0.50]	[-0.19; 0.29]	[-0.04; 0.47]
φ_{PR}	0.02	0.24	-0.15	1	[-0.45; 0.18]	[-0.33; 0.45]	[-0.41; 0.07]	[-0.04; 0.43]	[-0.06; 0.41]
φ_{PRonA}	0.12	-0.04	0.03	-0.15	1	[-0.37; 0.59]	[-0.79; -0.28]	[-0.04; 0.43]	[-0.19; 0.38]
φ_{AonPR}	0.01	0.01	0.07	0.09	0.13	1	[-0.20; 0.48]	[-0.58; 0.54]	[-0.34; 0.65]
$\ln(\sigma_{\zeta A}^2)$	0.28	0.10	0.28	-0.18	-0.59	0.15	1	[-0.04; 0.37]	[0.25; 0.62]
$\ln(\sigma_{\zeta PR}^2)$	0.37	0.40	0.05	0.20	0.20	-0.05	0.17	1	[0.68; 0.87]
$\ln(\sigma_{\zeta A-PR}^2)$	0.39	0.36	0.23	0.18	0.09	0.18	0.46	0.80	1

Note. Posterior medians of the latent correlation coefficients are given below the diagonal. The respective posterior 95% credibility interval (CI) limits are presented above the diagonal. SEM = structural equation model; μ_A = person-specific mean of arousal across measurement occasions; μ_{PR} = person-specific mean of perceived rejection across measurement occasions; φ_A = random, person-specific autoregressive effect of arousal; φ_{PR} = random, person-specific autoregressive effect of perceived rejection; φ_{PRonA} = random, person-specific slope of the regressions of perceived rejection on arousal at time $t-1$; $\gamma_{\varphi_{AonPR}}$ = average slope (fixed effect) of the regressions of arousal on perceived rejection at time $t-1$; $\ln(\sigma_{\zeta A}^2)$ = logarithm of the random, person-specific innovation variance of arousal (including measurement error); $\ln(\sigma_{\zeta PR}^2)$ = logarithm of the random, person-specific innovation variance of perceived rejection (including measurement error); $\ln(\sigma_{\zeta A-PR}^2)$ = mean of the log of covariance between the random innovations of arousal and perceived rejection at the same time point.

Table A4

Intercorrelations for the BSL-95, QTF, BDI-II, RSQ, and SCL-95R in the BPD (n = 42), DD (n = 43) and HC (n = 40) Groups

Measure	BSL	QTF	BDI	RSQ Anx	RSQ Exp	SCL
Borderline Personality Disorder (BPD)						
1. BSL-95	1					
2. QTF	.83***	1				
3. BDI-II	.62***	.45**	1			
4. RSQ Anx	.35**	.33**	.15	1		
5. RSQ Exp	.55***	.60***	.43**	.54**	1	
6. SCL-90R	.87***	.82***	.71***	.31**	.54***	1
Major Depressive Disorder (MDD)						
1. BSL-95	1					
2. QTF	.78***	1				
3. BDI-II	.82***	.65***	1			
4. RSQ Anx	-.02	-.19*	.20*	1		
5. RSQ Exp	-.02	-.34**	.08	.45**	1	
6. SCL-90R	.92***	.70***	.80***	.06	-.01	1
Healthy Control (HC)						
1. BSL-95	1					
2. QTF	.71***	1				
3. BDI-II	.58***	.71***	1			
4. RSQ Anx	.09	.29**	.24	1		
5. RSQ Exp	.06	.17*	.13	.63***	1	
6. SCL-90R	.83***	.75**	.58***	.24*	.06	1

Note. Pearson correlation coefficients. BSL-95 = Borderline Symptoms List; QTF = Thoughts and Feelings Questionnaire; BDI-II = Beck Depression Inventory; RSQ Anx = Rejection Sensitivity Questionnaire anxiety subscale; RSQ Exp = Rejection Sensitivity Questionnaire expectation subscale; SCL-90R = Symptom Checklist.

*p < .05. **p < .01. ***p < .001.

Note. Dynamic structural equation modeling of arousal (A) and perceived rejection (PR). The constructs are decomposed into their respective between-person (μ_{A_i} and μ_{PR_i}) and within-person (A_{it} and PR_{it}) parts. The model includes random autoregressive effects (φ_{iA} and φ_{iPR}) and cross-lagged effects (φ_{iAonPR} and φ_{iPRonA}) of order 1 on the within-person level. Specifically, A_{it} at time point t is regressed on $A_{i(t-1)}$ and $PR_{i(t-1)}$, whereas PR_{it} at time point t is regressed on $PR_{i(t-1)}$ and $A_{i(t-1)}$. Note that the time interval between measurement occasions was 15 minutes and constructs are assessed as “at the moment”. Autoregressive and cross-lagged regression slopes are modeled as random effects. In addition, we modeled the variance of the innovation terms of arousal ($\zeta_{A_{it}}$) and perceived rejection ($\zeta_{PR_{it}}$) as random effects. Note that the innovation terms depict unexplained variance due to measurement error and interindividual differences in the reactivity to unobserved influences.

Table A1

Main and Comorbid Mental Disorders of Patients in the BPD (n = 42) and DD (n = 43) Groups

	BPD		DD	
	n	%	n	%
Main diagnosis (ICD-10; DSM-IV)				
Borderline personality disorder (F60.31; 301.83)	42	100%	0	0%
Mild depressive episode (F32.0; 296.21)	0	0%	2	4.65%
Moderate depressive episode (F32.1; 296.22)	0	0%	12	27.91%
Recurrent depressive disorder, current episode mild (F33.0; 296.31)	0	0%	2	4.65%
Recurrent depressive disorder, current episode moderate (F33.1; 296.32)	0	0%	16	37.21%
Recurrent depressive disorder, current episode severe without psychotic symptoms (F33.2; 296.33)	0	0%	4	9.3%
Dysthymia (F34.1; 300.4)	0	0%	7	16.28%
Comorbid diagnoses (ICD-10; DSM-IV)				
Harmful use of alcohol (F10.10; 305.00)	2	4.76%	0	0%
Harmful use of cannabinoids (F12.10; 305.20)	1	2.38%	0	0%
Dependence on sedatives or hypnotics (F13.20; 304.10)	1	2.38%	0	0%
Recurrent depressive disorder, current episode mild (F33.0; 296.31)	1	2.38%	0	0%
Recurrent depressive disorder, current episode moderate (F33.1; 296.32)	2	4.76%	0	0%
Recurrent depressive disorder, currently in remission (F33.4; 296.36)	22	52.38%	0	0%
Agoraphobia (F40.0; 300.22)	0		1	2.33%
Agoraphobia with panic disorder (F40.01; 300.21)	1	2.38%	0	0%
Social anxiety disorder (F40.1; 300.23)	2	4.76%	3	6.98%
Panic disorder (F41.0; 300.01)	2	4.76%	3	6.98%
Obsessive-compulsive disorder, predominantly compulsive acts (F42.1; 300.3)	0	0%	1	2.33%
Post-traumatic stress disorder (F43.1; 309.81)	15	35.71%	6	13.95%
Somatization disorder (F45.0; 300.81)	0	0%	1	2.33%
Hypochondriacal disorder (F45.2; 300.7)	0	0%	1	2.33%
Bulimia nervosa (F50.2; 307.51)	2	4.76%	1	2.33%
Atypical bulimia nervosa (F50.3; 307.51)	3	7.14%	0	0%
Eating disorder, unspecified (F50.9; 307.50)	5	11.9%	1	2.33%
Histrionic personality disorder (F60.4; 301.50)	1	2.38%	0	0%
Anxious personality disorder (F60.6; 301.82)	3	7.14%	1	2.33%
Dependent personality disorder (F60.7; 301.6)	1	2.37%	0	0%
Personality disorder, unspecified (F60.9; 301.9)	1	2.38%	0	0%
Mixed and other personality disorders (F61.0; 301.9)	1	2.38%	0	0%
ADHD (F90.0; 314.0)	1	2.38%	0	0%

Note. Assessed using structured clinical interviews based on DSM-IV diagnostic criteria. BPD = borderline personality disorder; DD = depressive disorders.