The wandering mind in borderline personality disorder: Instability in self- and other-related thoughts

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Abstract

Diagnostic criteria for borderline personality disorder (BPD) include instability in identity and interpersonal relationships. Here, we probed whether instability is already present in BPD patients' thoughts about themselves and others. We tested BPD patients (N=27) and healthy controls (N=25) with a mind-wandering task that assesses content and variability of stimulus-independent self-generated thoughts. Multi-level modeling revealed that while BPD patients and healthy controls mind-wander to a similar extent, BPD patients' thoughts are colored predominantly negatively. Most importantly, although their thoughts concerned the self and others as much as in controls, they fluctuated more strongly in the degree to which their thoughts concerned themselves and others and also gave more extreme ratings. Self- and other related thoughts that were more extreme were also more negative in valence. The increased variability supports current conceptualizations of BPD and may account for the instability in identity and interpersonal relationships.

Keywords: borderline personality disorders, mind-wandering, self-generated thought, identity, self-other representations, interpersonal relationships

1. Introduction

Borderline personality disorder (BPD) is a severe and debilitating mental disorder that affects between 0.7 and 2.7% of the general population (Torgersen et al., 2001; Trull et al., 2010). Patients with BPD are characterized by impulsivity and affective dysregulation, but also by instability in identity and interpersonal relations (American Psychiatric Association, 2013; Gunderson, 2007; Sanislow et al., 2002). The DSM-5 alternative model for BPD further highlights self and interpersonal problems as crucial for the disorder. These may play out in dramatic shifts in self-image or sense of self and unstable, intense relationships. Across the theoretical spectrum, unstable self-other representations are integral parts of etiological models of BPD (Beck et al., 2003; Horowitz, 2004; Levy et al., 2006; Livesley and Jang, 2000) and have also been hypothesized to constitute the fundamental impairment that gives rise to BPD symptomatology, including affective dysregulation and impulsivity (Bender and Skodol, 2007).

Empirical investigations of unstable self and other representations have mainly focused on self and observer evaluations (e.g., of interview or projective data; Porcelli et al., 2006; Tramantano et al., 2003) or specific stimulus-induced reactions of the patients (e.g., of others' facial expressions; Lerner and St Peter, 1984; Westen et al., 1990). Clinicians' ratings of their patients' self-concept, for example, revealed that BPD patients have a more incoherent and inconsistent self-concept compared to other personality disorder patients and non-clinical control groups (Wilkinson-Ryan and Westen, 2000). BPD patients' self-descriptions in questionnaires are typically very negative (Klein et al., 2001; Rüsch et al., 2007; Sieswerda et al., 2005), and they also report lower self-concept clarity (Roepke et al., 2011), increased alexithymia (i.e., an inability to identify one's own emotions New et al., 2012), and describe themselves more in terms of opposites than in terms of salient attributes in repertory grid tests (de Bonis et al., 1995). Using a card sorting task, Vater et al. (Vater et

al., 2015) recently showed that BPD patients have a more compartmentalized and negative self-concept, that is, they have a tendency to organize knowledge about the self into discrete, extremely negatively valenced categories (Showers, 1992).

BPD patients' representations of others also differ from healthy controls (HC) (Herpertz and Bertsch, 2014). Neutral or ambiguous facial expressions, for example, are evaluated as more negative (Domes et al., 2008; Domes et al., 2009; Dyck et al., 2009), as are film characters (Barnow et al., 2009; Sieswerda et al., 2013) and words, irrespective of comorbid depression (Kurtz and Morey, 1998). Moreover, their descriptions of others are characterized by multidimensional dichotomous thinking, a cognitive style that refers to the tendency to evaluate experiences in terms of mutually exclusive categories rather than falling along continua (Beck et al., 2001). Film characters, for example, are rated as either extremely negative or positive (Napolitano and Mckay, 2007; Veen and Arntz, 2000), as are real interaction partners (Arntz and ten Haaf, 2012).

The studies reported above investigated BPD patients' self-other representations at a given point in time and therefore represent a momentary snapshot. A direct test of instability would, however, require the assessment of self- and other-related thoughts at multiple points and explore how they change over time. Furthermore, if trait judgments are requested, momentary snapshots also reflect patients' own integration of previous experience and, therefore, rely on meta-cognitive capabilities. As has been demonstrated for affective dysregulation, as well as dissociation and paranoid ideation, interpersonal disturbances and suicidality, sampling from the actual momentary experience of participants and integrating the data statistically may give a more realistic and valid characterization of BPD patients' psychopathology (Ebner-Priemer et al., 2015; Ebner-Priemer et al., 2007; Santangelo et al., 2014).

Therefore, we utilized an established mind-wandering paradigm that, because of low task demands, induces stimulus-independent, self-generated thoughts and probed these at multiple points across the task (Ruby et al., 2013a). To increase the number of sampling points, the task was performed twice approximately ten days apart. In contrast to previous studies that tested participants' responses to specific stimuli such as faces, the mind-wandering paradigm gives an indication of patients' self-generated mental contents. In the general population, such self-generated thought, mind-wandering, is highly prevalent, occurring in up to 50% of waking time (Kane et al., 2007; Killingsworth and Gilbert, 2010). While mind-wandering has been linked to negative mental health outcome (Killingsworth and Gilbert, 2010; Smallwood and Schooler, 2015), we know little about mind-wandering activity and specific mind-wandering content in psychopathology (Ottaviani et al., 2015; Smallwood, 2013). So far, no studies have investigated mind-wandering in BPD.

Given the reported predominance of negative self and other evaluations, we hypothesized that patients in the BPD group would have more negative and less positive thoughts compared to healthy matched controls. Crucially, we also expected to find evidence for the hypothesized instability in self and other representations. This instability should be reflected in greater variation of the ratings of self- and other-related thoughts. Specifically, we explored two measures of variability, fluctuations in ratings between different, successive thought probes, and the extremity of the ratings. The reported negative self and other evaluations in BPD also gave rise to the hypothesis that self- and other-related thoughts and their variability during mind-wandering may be colored more negatively in the BPD group. We therefore related thought valence (negative, positive) to the ratings and variability of self- and other-related thoughts. Furthermore, we included additional ratings that asked for the temporal focus of the self-generated thoughts (past- or future-oriented). We had no explicit hypotheses regarding these ratings in BPD, but included them to more comprehensively

characterize the thought space (Smallwood and Schooler, 2015). To assess current mood, we also included mood ratings, hypothesizing more negative mood in BPD patients. Finally, in addition to testing differences between BPD patients and controls, we also tested whether the effects would be associated with symptom severity in BPD patients only.

2. Methods

2.1 Participants

2.1.1 BPD group

Thirty patients with Borderline Personality Disorder according to DSM-IV-TR (American Psychiatric Association, 2000; Saß et al., 2003) were recruited at the Department of Psychiatry, Charité – Universitätsmedizin Berlin, Germany. All were inpatients at the Charité hospital and admitted for specialized BPD treatment from a waiting list; all BPD patients had outpatient status before admission, none of the patients were transferred from another institution to our hospital or admitted for acute care. Testing was performed in the first two weeks after admission in a laboratory at the hospital. Because of technical and timing difficulties (specifically, a software problem with the experimental computer), three patients could not complete the mind-wandering protocol, yielding a final sample of 27 patients (for demographics, see Table 1).

2.1.2 Control group

Thirty-four healthy control participants were recruited and matched to the patients in age, gender, and education. Because of technical and timing difficulties (as for the patient group), data from nine control participants were missing, yielding a final sample of 25 healthy controls (see Table 1).

The presence or absence of individual diagnoses in patients and controls was established with the German versions of the Mini International Neuropsychiatric Interview (Ackenheil et al., 1999; Lecrubier et al., 1997) and the Structured Clinical Interview II (First et al., 1997; Wittchen et al., 1997). All interviewers were psychiatrists or clinical psychologists, trained in the application of the SCID II and MINI interview and received supervision on the SCIDs and MINIs. In a previous study, interrater reliability of SCID-II BPD diagnoses by the same interviewers employed in the current study was good, κ=0.82 (Ritter et al., 2014). Exclusion

criteria for the patients included any psychotic disorder, current substance abuse/ dependency, mental retardation, epilepsy/ organic brain disease, and age younger than 18. For controls, the same exclusion criteria applied and the presence of any current mental disorder additionally led to exclusion from the study.

All participants gave written informed consent prior to participation. The study was approved by the ethics committee of the Charité – Universitätsmedizin Berlin.

2.2 Task

We used an established mind-wandering paradigm that probes self-generated thoughts during a choice reaction time task (Baird et al., 2012; Ruby et al., 2013a; Smallwood et al., 2013a). A series of black digits between 1 and 8 was presented. One sixth of the digits (randomly selected) was presented in red, signaling to participants that they should indicate via button press if this number was odd or even. Black digits were presented for 1000 ms and red digits for 2000 ms. Responses had to be made while the colored digits were still present on the screen. Stimuli were separated by a fixation cross of variable duration (2200–4400 ms). Thought probes were presented between four and nine times at random intervals during the choice reaction time task. At each probe time point, participants were asked to rate their current thoughts using nine-point Likert scales on several separate dimensions including (1) how positive, (2) how negative, (3) how self-related, (4) how other-related, (5) how past-oriented, (6) how future-oriented, and (7) how off task their thoughts at that point in time had been. The extent to which participants rated their thoughts as off task is interpreted as an indicator of mind-wandering. Additionally, participants rated their current mood (i.e., how positive and how negative they felt). (For the exact phrasing of all rating questions, please see Ruby et al., 2013).

The entire task lasted approximately 20 min. Stimuli were presented using E-prime 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA, USA).

The time of day for testing was matched for the two groups (mean experiment start time was 1:42 pm for BPD patients and 1:26 pm for control participants).

In contrast to most previous mind-wandering studies, each participant completed the task twice in two identical sessions approximately 10 days apart (mean time difference 9.0 ± 8.2 days for BPD patients and 11.6 ± 9.4 days for healthy control participants; $t(50) = -1.1$, $p > .25$) to increase the number of thought probes (combined mean number of probes 11.2 ± 2.0 for BPD patients and 11.9 ± 2.5 for healthy controls; $t(50) = -1.1$, $p > .25$).

2.3 Questionnaire

The German version of the Personality Assessment Inventory - Borderline Features (PAI-BOR) was used to measure symptom severity in BPD patients (Groves and Engel, 2007; Hopwood et al., 2013; Morey, 1991). The PAI-BOR assesses core aspects of BPD, that is, affective instability, identity problems, negative relationships, and self-harm. Previous validation studies indicated good-to-excellent internal consistency and illustrated the usefulness of the PAI-BOR for determining features of BPD in clinical samples and the general population (e.g., (BellPringle et al., 1997; Gardner and Qualter, 2009; Stein et al., 2007). Internal consistency of the PAI-BOR in the present sample was excellent, with a Cronbach's alpha of 0.95.

2.4 Data analysis

All statistical analyses were performed using SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.).

2.4.1 Performance

We analyzed the reaction times and accuracy of participants' responses in the choice reaction time task with independent samples t-tests.

2.4.2 Thought probes

2.4.2.1 Principal components analysis

To test for congruency with previous reports on the contents of self-generated thoughts in healthy participants, we first calculated a principal components analysis (as described in Ruby et al., 2013a), which yielded a three-component solution that conformed with the literature (see Supplementary Table 1; Ruby et al., 2013b; Smallwood et al., 2013b). Specifically, component 1 mainly includes positive and negative ratings, component 2 includes past and other ratings, and component 3 includes future and self ratings. For a more fine-grained characterization of self-generated thought in BPD, we here focused on analyzing the ratings individually.

2.4.2.2 Rating levels

To analyze the ratings, we used multi-level models because they take correlated observations within individuals into account and perform well with missing data or unequal numbers of data points within individuals (Jahng et al., 2008). The models were specified to test for associations of the group factor (BPD group vs. control group, coded as 0 and 1, respectively) with the thought probe ratings. The ratings on each dimension (i.e., how other-related, self-related, negatively valenced, positively valenced, past-oriented, future-oriented and how off task the thoughts were) were entered as dependent variable to be predicted in separate models. The main predictor was the group factor. Significant effects of group would indicate that BPD is, for instance, associated with higher levels of negative thoughts. Additional covariates included the number of the particular sampling point within the session (e.g., sample count 5, indicating that this rating value was obtained during the fifth probe for this participant) to control for changes due to the repetition of the rating questions, and session (i.e., session 1 or 2) to control for changes due to the repetition of the whole procedure.

2.4.2.3 Fluctuations in ratings

In addition to the rating level (e.g., to what extent a certain thought was negative), we investigated two indices of instability: fluctuations and extremity of ratings. To obtain a

measure of how much individuals fluctuate in their ratings from one thought probe to the next, we calculated squared successive differences, an established procedure in experience sampling studies (Ebner-Priemer et al., 2007; Jahng et al., 2008; Skirrow et al., 2014; Trull et al., 2008). As for the rating levels, we then calculated multi-level models with fluctuations as dependent variable and group (BPD group vs. control group) as predictor. Sample count and session were again included as covariates.

2.4.2.4 Extremity of ratings

To obtain a measure of the extremity of the individual ratings, we calculated the squared difference of each rating from the mean for that variable. While this measure is naturally related to the fluctuations (e.g., very strong fluctuations will also lead to high extremity), it does not take into account the extent of these successive changes, but rather indicates the degree to which a certain rating differs from the "norm" (e.g., fluctuations may be low, but extremity still high if ratings are uniformly high during the first half and low during the second half of a session). As for the rating levels, we then calculated multi-level models with extremity as dependent variable and group (BPD group vs. control group) as predictor. Sample count and session were included as covariates.

2.4.2.5 Testing the valence of self- and other-related thoughts

A new set of models tested for relations between the variables that showed significant differences between BPD patients and controls. For instance, we tested whether extremity of self-related ratings was related to negativity. To this end, rating levels, fluctuations, and extremity of self and other ratings were entered as dependent variable in separate models. Again, group (BPD group vs. control group) was used as a predictor, but the ratings on how positive and negative the thoughts were, were entered as additional predictors. Crucially, the interaction of group with the additional predictors was included to test, for instance, if the

association of extremity in self-relatedness and negativity of a thought was stronger/weaker in BPD patients.

2.4.3 Mood probes

The ratings of how positive and how negative participants' current mood was were analyzed in the same way as the ratings, fluctuations, and extremity of the thought probes.

2.4.4 Relation to symptom severity

For models where group was a significant predictor, follow-up analyses were used to examine symptoms severity as a predictor in the BPD group only. We included the PAI-BOR scores as covariates in the models described above, only testing BPD patients in this analysis and replacing group (BPD group vs. control group) with the PAI-BOR scores as a predictor. All multi-level models included a random intercept and random effects for sample count and order. Maximum Likelihood (ML) was used as estimation method.

3. Results

3.1 Performance

Independent samples t-tests of performance measures in the choice reaction time task showed no significant differences between BPD patients and HCs in accuracy ($t(50) = -0.17$, $p > 0.85$; BPD: 89.2 % ± 14.5, HC: 89.9 % ± 15.1) or reaction times ($t(50) = 0.86$, $p > .35$; BPD: 904.8 milliseconds (ms) (169.4), HC: 869.4 ms (120.5)).

3.2 Thought probes

3.2.1 Rating levels

Multi-level models revealed that BPD patients did not differ from HCs in the extent of off-task thoughts, that is, in the amount of reported mind-wandering (see Fig.1A and Table 2). However, the content of the self-generated thoughts differed. BPD patients rated their thoughts to be more negative (Cohen's $d = 1.85$) and less positive than HCs (Cohen's $d = 1.70$). While HCs showed a positive bias (i.e., more positive than negative thoughts; $t(24) = -8.2$, $p < 0.001$), BPD patients showed a negative bias (i.e., more negative than positive thoughts; $t(26) = 2.1$, $p < 0.05$). Including current mood (see below) as a covariate (positive mood: $b = 0.594$, S.E. $= 0.037$, $p < 0.001$, negative mood: $b = 0.483$, S.E. $= 0.032$, $p < 0.001$) showed significant relations between mood and thought valence, but did not change the group differences in positive ($b = -13.265$, S.E. $= 2.844$, $p < 0.001$) and negative thoughts ($b = 21.869$, S.E. $= 2.970$, $p < 0.001$). There were no group differences regarding how self- and other-related or past- and future-oriented the rated thoughts were.

3.2.2 Fluctuations in ratings

As a measure of how much individuals fluctuate in their ratings from one thought probe to the next, squared successive differences (Ebner-Priemer et al., 2007; Jahng et al., 2008; Skirrow et al., 2014; Trull et al., 2008) were subjected to multi-level models (see Fig. 1B and Table 2). The results show increased fluctuations in BPD patients compared to HCs in self-

and other-related thoughts (Cohen's d = 0.89 and d = 0.45, respectively). There were no further differences between the groups.

3.2.3 Extremity of ratings

As a measure of the extremity of the individual ratings, the squared differences of each rating from the mean were subjected to multi-level models (see Fig. 1C and Table 2). As for fluctuations, we also observed significantly increased extremity of self- and other-related thoughts in BPD patients compared to HCs (Cohen's d = 2.15 and d = 1.79, respectively). Additionally, BPD patients showed more extreme ratings of off-task thoughts (Cohen's d = 0.60).

3.2.4 Testing the valence of self- and other-related thoughts

The previous analyses showed increased negative and decreased positive thoughts in BPD patients, as well as increased fluctuations and extremity of self- and other-related thoughts. Here we tested whether the valence of thoughts (negative, positive) was associated with the rating levels, fluctuations, and extremity of self- and other-related thoughts (Table 3).

The results show that the more negative a thought, the more it was also self-related. This was true across both BPD patients and HCs, there was no interaction with group. There was no relation to positive thoughts or between other-related thoughts and the level of positive and negative thoughts.

With regard to fluctuations in self- and other-related thoughts, there were no significant relations to the level of negative or positive thoughts.

Regarding the extremity of self- and other-related thoughts, interactions of group and negative thoughts indicated greater extremity of how self- and other-related the negative thoughts were in BPD patients, that is, self- and other-related thoughts that were more extreme were also more negative in valence in BPD patients compared to HCs (see Fig. 2). The interaction of group and positive thoughts was not significant.

negative valence of thoughts positively predicted the extremity ratings of self and other relatedness, that is, self- and other-related thoughts that were more extreme were also more negative in valence.

3.3 Mood probes

Multi-level models revealed that BPD patients showed elevated levels of negative and decreased levels of positive mood (see Supplementary Fig. 1 and Table 2). Fluctuations and extremity of mood ratings were not significantly different between groups.

3.4 Relation to symptom severity

To test for a relation of the observed effects to symptom severity in the BPD group, we included the PAI-BOR scores as covariates in the models (only testing BPD patients in this analysis). PAI-BOR was a predictor of increased levels of negative thoughts ($b = 1.377$, S.E. $= 0.520$, $p = 0.014$) and of extremity of other-related thoughts ($b = 21.537$, S.E. $= 9.590$, $p = 0.028$). Numerically, but not significantly, PAI-BOR also predicted reduced levels of positive thoughts ($b = -0.896$, S.E. $= 0.439$, $p = 0.051$), reduced positive mood ($b = -0.861$, S.E. $= 0.467$, $p = 0.077$), and fluctuations in self- ($b = 23.941$, S.E. $= 14.196$, $p = 0.093$) and other-related thoughts ($b = 35.156$, S.E. $= 20.099$, $p = 0.095$). All other effects were not significantly related to PAI-BOR scores (all $p > 0.30$).

4. Discussion

The present study aimed at investigating the self-generated thoughts of patients with BPD and utilized a standard mind-wandering task that probes the amount and specific content of self-generated thoughts (Ruby et al., 2013a). The results reveal that BPD patients and HCs mind-wander to a similar extent. BPD patients also think of the past, the future, themselves, and others as often as healthy individuals; however, their thoughts are colored predominantly negatively, while the thoughts of HCs are colored positively. Crucially, BPD patients are more unstable in their self- and other-related thoughts, as indicated by increased fluctuations between successive thought probes and by more extreme values of these ratings. The more these ratings of self- and other-related thoughts differed from the mean, the more negative they were in BPD patients.

The observation of more negative thoughts in BPD patients is in line with previous reports of a negative bias in emotional face recognition (Dyck et al., 2009) and in questionnaire evaluations of themselves and others (Klein et al., 2001; Rüsch et al., 2007; Sieswerda et al., 2013). Critically, it extends these findings to more negative self-generated mental content, as assessed with multiple probes of ongoing mind-wandering. As previously reported, BPD patients also showed more negative mood (Nisenbaum et al., 2010). The negative bias in thought contents remained, however, when controlling for current mood, which suggests some specificity of mood and thought contents. Given the negative biases in information processing across different psychopathologies (e.g., in major depressive disorder (Raes et al., 2006), generalized anxiety disorder (Mogg and Bradley, 2005), or social anxiety disorder (Joormann and Gotlib, 2006)), it is possible that the predominance of negative thoughts observed here in BPD patients is a more general characteristic of psychopathology, which should be tested in future studies (for a recent report in depression, see Hoffmann et al., 2016). Nevertheless, it may represent an important problem also in BPD. While studies

on the consequences of specific thought patterns are still rare, there is some indication that more negative thoughts increase the stress-related cortisol response to psycho-social stressors (Engert et al., 2014). Future studies should therefore elucidate if a negative bias constitutes a psychopathogenic factor and how it may be improved.

BPD patients also showed more variability in self- and other-related thoughts. Variability was measured as within-subject fluctuations between successive thought probes and as the extremity of these ratings, the latter being related to particularly negative thoughts in BPD patients. The increased variability points towards instability in self- and other-related mental representations and supports accounts of BPD across the theoretical spectrum that posit these instabilities as central to the disorder (Beck et al., 1961; Horowitz, 2004; Levy et al., 2006; Livesley and Jang, 2000). However, it also extends these accounts by showing that BPD patients already differ in how much they vary in thinking of themselves and others, not only in whether their thoughts of themselves and others vary more strongly in valence. It is conceivable that this variability is related to other characteristics of BPD such as diminished self-concept clarity (Roepke et al., 2011). In contrast to previous empirical investigations of disturbed self (de Bonis et al., 1995; Roepke et al., 2011; Vater et al., 2015; Wilkinson-Ryan and Westen, 2000) and other representations in BPD (Arntz and ten Haaf, 2012; Napolitano and Mckay, 2007; Veen and Arntz, 2000), the present study tested (a) the contents of self-generated mental activity and (b) sampled ongoing mental activity at multiple time points. Testing at multiple time points may be more valid than single measurements, as has been demonstrated for affective dysregulation in BPD (Ebner-Priemer et al., 2015; Ebner-Priemer et al., 2007), and it also allows a direct test of instability because participants are not asked to integrate across experiences themselves in their judgments.

A better understanding of the self-generated thoughts of BPD patients is also important because of the high prevalence of mind-wandering, occurring in 25 to 50% of

waking time (Kane et al., 2007; Killingsworth and Gilbert, 2010). Beyond impairment in current task performance, which is mainly affected by the extent of off-task thoughts (Smallwood et al., 2003; Smallwood et al., 2007), the content of this prevalent mental activity may also have far-reaching consequences, as indicated by studies on stress reactivity or on the effects of habitual rumination styles (Engert et al., 2014; Hertel, 1998; Schick et al., 2013). Investigating the specific consequences of instability in self- and other-related thoughts, as observed here for BPD patients, could elucidate their etiological role for the disorder, for example by linking unstable other-related thoughts to problems in social cognition and ultimately in interpersonal relationships.

Neuroimaging studies have found that mind-wandering is associated with increased activity in the default-mode network of cortical regions that are active during resting state, where the amount of self-generated thought correlates with activation (Mason et al., 2007). Patients with BPD show increased "trait-level" functional connectivity within the default-mode network at rest (Kluetsch et al., 2012; Wolf et al., 2011), and it would be interesting to test the association between this increased connectivity and the increased variability in thought content. During external stimulation, however, in particular when reasoning about the affective states of others, activity within this network is reduced in BPD (Dziobek et al., 2011; Mier et al., 2013). Future research could investigate whether the altered trait activity within this network, which may be due to instability in self- and other-related thoughts, hampers the functioning of this network under external demands, leading to impaired social cognition.

While BPD patients' self-generated thoughts showed a negative bias and increased variability in how self- and other-related they were, the extent of off-task thoughts and the degree to which thoughts were past- or future-oriented did not differ from healthy controls. First and foremost, this speaks for specificity of the observed alterations. Given that

borderline personality features have been linked to increased rumination (Baer and Sauer, 2011), increased overall off-task thoughts, that is, mind-wandering, with a past focus could have been expected in addition to a negative bias. As rumination in BPD has so far only been studied with trait questionnaires, the results may suggest that BPD patients momentary and trait self-judgments diverge, which should be explicitly tested in future investigations.

Because of the methodological difficulties associated with studying the content of stimulus-independent mental activity, the investigation of mind-wandering has only really gained momentum in the last decade (Smallwood and Schooler, 2015). Regarding psychopathology, this advancement offers the chance to gain better understanding not only of the amount of mind-wandering, as has been attempted in depression (Watts et al., 1988), ADHD (Shaw and Giambra, 1993), and schizophrenia (Elua et al., 2012), but also of the specific content of self-generated thoughts, which has so far not been investigated. The present study demonstrates the feasibility of using mind-wandering tasks as a tool in clinical psychological research. Furthermore, while the mind-wandering literature has so far focused on the extent of off-task thoughts and increasingly also its content (Smallwood, 2013), the present study shows that investigating the variability of mind-wandering across time yields an additional interesting characteristic of self-generated thoughts and allows insight into the (in)stability of mental representations.

There are some limitations to the present study. We could not include a matched clinical control group. Therefore, the specificity of the observed results to BPD could not be tested. The correlation of the observed effects to symptom severity, as measured with the PAI-BOR, is some indication of a relation to BPD, but future studies should probe whether the effects remain specific in comparison to other clinical groups. Furthermore, a larger sample would have been advantageous, in particular with regard to analyzing subgroups with different comorbidities or medication. As most BPD patients were treated with psychotropic

medication, influence of medication on the data could not be evaluated. Similarly, the subgroups with or without different comorbidities (e.g., current or past depression, PTSD, eating disorder) were very small. Future studies should include larger samples that allow comparison of these subgroups, because comorbidity or medication may impact the effects, for instance the observed negativity bias. Additionally, the small number of men in the present sample hampers generalizations of the results to all BPD patients irrespective of gender.

The present results have several clinical implications. An increasing body of research investigates the effects of mindfulness practices for stabilizing the mind (Lutz et al., 2007), and mindfulness exercises are also implemented in one of the most effective psychotherapeutic treatments for BPD, dialectical behavioral therapy (Linehan, 1987; Linehan et al., 2006). Given that mindfulness training has been shown to reduce mind-wandering (Mrazek et al., 2013), the present results suggest that mindfulness exercises are an important component of BPD treatment, possibly through their effect on mind-wandering. Mentalization-based therapy for BPD, in contrast, focuses on elaborating the capacity to implicitly and explicitly interpret the actions of oneself and others (Bateman and Fonagy, 2004, 2010). As an element of increasing the patient's mentalization capacity, it may necessary to also stabilize the thoughts related to self and others. It may also prove fruitful to directly target the negative bias in self-generated thoughts observed in BPD, because a negative cognitive bias has been consistently linked to negative outcome and targeted interventions are available, such as "cognitive bias modification" or mental imagery based interventions (see e.g. Beck et al., 2003; Hallion and Ruscio, 2011; Lang et al., 2012).

To conclude, using a mind-wandering paradigm we observed more negatively colored thoughts and more instability in self- and other-related thoughts in patients with BPD. In BPD patients, more extreme ratings of self- and other-related thoughts were also more

negative. Given the high prevalence of such self-generated thoughts, these alterations may have consequences, for example on patients' stress responsivity and interpersonal relationships, and may thereby play an important etiological role for BPD.

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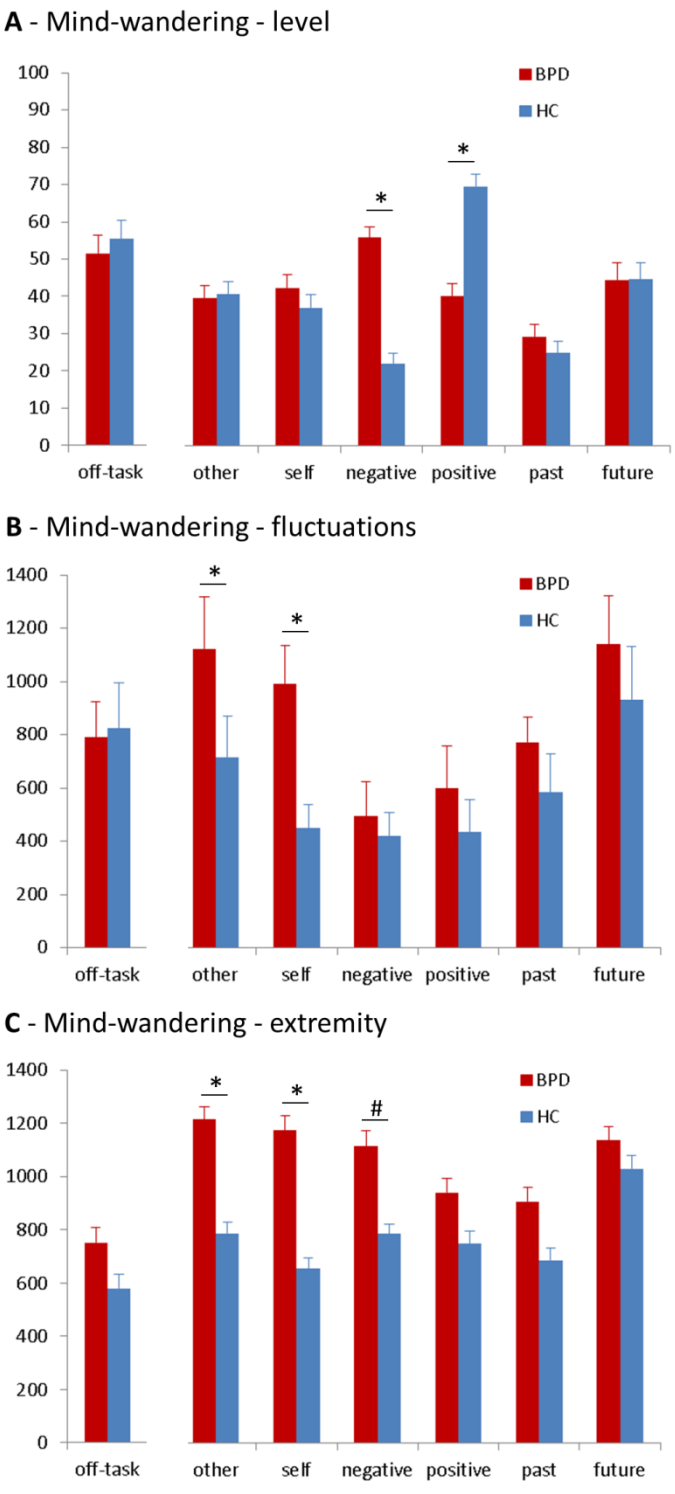
Figure captions

Figure 1: (A) Level of reported off-task thoughts, other- and self-related, positive and negative, and future- and past-oriented thoughts (rating scale numbers without unit varying between 0 and 100). (B) Fluctuations between thought probes (squared successive differences). (C) Extremity of ratings (squared deviations from mean ratings). * $p < 0.05$; # $p < 0.10$

Figure 2: Scatterplot depicting the relation of the level of negative thoughts to the extremity (squared deviations from mean ratings) of (A) self-related and (B) other-related thoughts, separately for BPD patients and HCs. Intra-individual standard errors are displayed in grey and model predictions from the multi-level model as lines in the respective color.

Figure 1


A - Mind-wandering - level
BPD
HC
100
90
80
70
60
50
40
30
20
10
0
*
*
off-task
other
self
negative
positive
past
future
B - Mind-wandering - fluctuations
BPD
HC
1400
1200
1000
800
600
400
200
0
*
*
off-task
other
self
negative
positive
past
future
C - Mind-wandering - extremity
BPD
HC
1400
1200
1000
800
600
400
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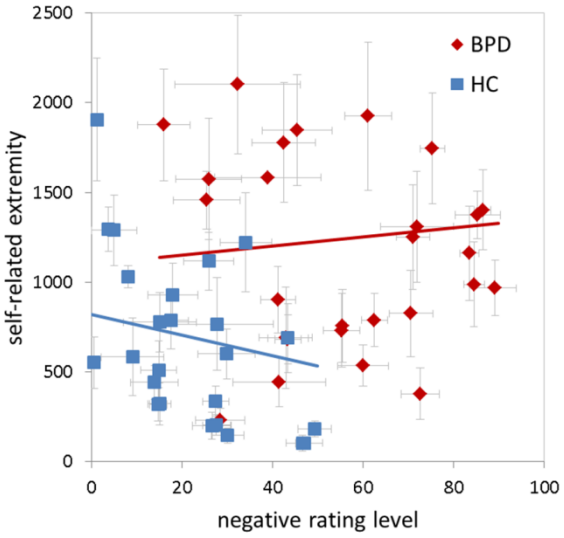
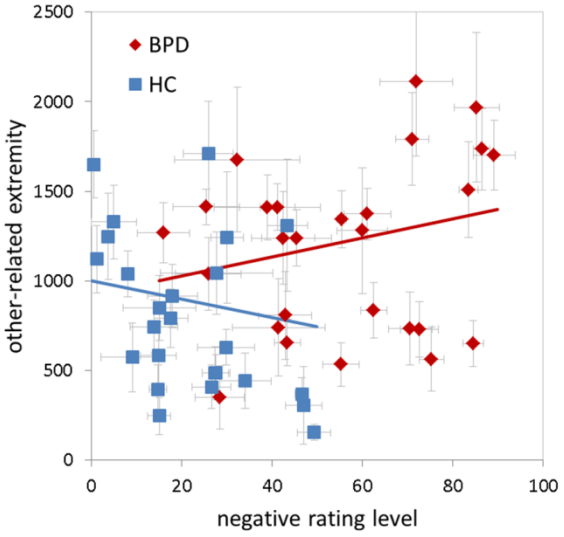
off-task
other
self
negative
positive
past
future

Figure 2

A - Negativity and extremity of self- related thoughts



B - Negativity and extremity of other-related thoughts



Tables

Table 1: Demographics and clinical characteristics of BPD patients and matched healthy control participants (means and standard deviations or absolute number and percent are given without and with parentheses, respectively).

	BPD	HC	statistic
N	27	25	
Gender (female/male)	25/2	21/4	$X^2(1) = .33, p > 0.40$
Age	32.1 (9.7)	31.2 (10.1)	$t(50) = .35, p > 0.70$
Years of education	11.3 (2.3)	12.5 (2.6)	$t(50) = -1.82, p > 0.07$
PAI-BOR	78.7 (7.5)	44.4 (10.9)	$t(50) = 13.2, p < 0.001$
MDE			
Lifetime	21 (77.8)	-	-
Current	5 (18.5)	-	-
Current dysthymia	1 (3.7)	-	-
Substance use disorder	9 (33.3)	-	-
Any anxiety disorder	2 (7.4)	-	-
Current PTSD	9 (33.3)	-	-
Any eating disorder	9 (33.3)	-	-
Any cluster A PD	0	-	-
Any other Cluster B PD	1 (3.7)	-	-
Any cluster C PD	4 (14.8)	-	-
No psychotropic medication	7 (25.9)	-	-
Current medication			
Antidepressants	15 (55.6)	-	-
Atypical antipsychotics	6 (22.2)	-	-
Mood stabilizer	2 (7.4)	-	-

Table 2: Differences between BPD patients and HCs in rating levels, fluctuations in ratings, and extremity of ratings as estimated with multi-level modeling. Model parameters for the group predictor are displayed. For full model information, see Supplementary Table 2.

	rating levels			fluctuations in ratings			extremity of ratings		
	b	S.E.	p-value	b	S.E.	p-value	b	S.E.	p-value
off-task	2.794	6.016	0.644	115.281	164.766	0.485	168.021	79.384	0.035
other	-3.080	5.094	0.548	402.132	152.093	0.008	320.553	93.109	0.001
self	4.693	4.962	0.349	571.535	124.799	0.000	468.330	95.780	0.000
negative	32.633	5.063	0.000	22.618	99.668	0.821	320.778	166.038	0.059
positive	-27.821	4.704	0.000	143.081	156.439	0.361	67.784	101.421	0.504
past	5.151	4.714	0.280	204.707	152.534	0.186	211.564	140.037	0.137
future	-0.938	5.729	0.871	232.985	261.637	0.373	82.129	139.681	0.559
negative mood	21.536	5.590	0.000	-15.397	117.913	0.896	-59.828	120.937	0.622
positive mood	-24.178	5.648	0.000	191.759	104.121	0.070	-18.824	173.275	0.914

Table 3: Differences between BPD patients and HCs in the relation of rating levels, fluctuations, and extremity of self- and other-related ratings to the negativity of thoughts estimated as interactions in mutli-level models. Model parameters for valence predictors and their interaction with group are displayed. For full model information, see Supplementary Table 3.

		rating levels			fluctuations in ratings			extremity of ratings		
	Predictors	b	S.E.	p-value	b	S.E.	p-value	b	S.E.	p-value
self	negative	0.143	0.065	0.028	4.958	4.124	0.230	-5.686	2.157	0.009
	negative*Group	0.061	0.091	0.503	-6.791	5.172	0.190	8.184	2.706	0.003
other	negative	-0.035	0.080	0.657	-0.705	5.336	0.895	-5.173	2.277	0.023
	negative*Group	0.128	0.104	0.221	-1.389	6.799	0.838	10.491	2.873	0.000
self	positive	-0.069	0.073	0.344	-6.355	3.974	0.110	1.661	2.004	0.408
	positive*Group	0.029	0.093	0.751	8.820	5.128	0.086	-4.954	2.602	0.057
other	positive	-0.017	0.081	0.836	-8.515	5.524	0.124	1.973	2.264	0.384
	positive*Group	0.013	0.104	0.897	11.606	7.037	0.100	-5.681	2.908	0.051

Supplement

Supplementary Table 1: Principal components analysis showing the component loadings for each rating question. Three components were observed: The affect component positively weighted on positive ratings and negatively on negative ratings, the socio-temporal past other component weighted positivelyon other and past ratings, and the socio-temporal future self component weighted positively on self and future.

	F1 affect	F2 past-other	F3 future-self
off-task	0,273	-0,622	-0,326
other	0,019	0,797	0,284
self	-0,073	0,067	0,727
negative	-0,920	0,159	0,071
positive	0,940	-0,096	0,001
past	-0,147	0,754	-0,207
future	0,022	0,101	0,866

Supplementary Table 2: Differences between BPD patients and HCs in ratings levels, fluctuations in ratings and extremity in ratings as estimated with multi-level modelling

	Model parameters								
		rating levels			fluctuations in ratings			extremity of ratings	
	Predictors	b	S.E.	p-value	b	S.E.	p-value	b	S.E.	p-value
off task	Intercept	52.694	5.662	0.000	799.759	212.261	0.000	500.623	100.018	0.000
	Group	2.794	6.016	0.644	115.281	164.766	0.485	168.021	79.384	0.035
	Session	10.736	3.384	0.003	-61.119	180.354	0.735	258.725	79.688	0.001
	Sample	-1.586	0.425	0.000	-9.323	33.358	0.780	-9.796	17.333	0.572
other	Intercept	40.773	4.875	0.000	499.961	191.175	0.009	902.185	84.858	0.000
	Group	-3.080	5.094	0.548	402.132	152.093	0.008	320.553	93.109	0.001
	Session	-6,436	3.316	0.057	-1.858	152.772	0.990	-261.131	61.667	0.000
	Sample	1.123	0.417	0.007	58.301	37.207	0.118	12.894	18.744	0.493
self	Intercept	31.156	4.309	0.000	313.413	156.867	0.046	757.377	81.636	0.000
	Group	4.693	4.962	0.349	571.535	124.799	0.000	468.330	95.780	0.000
	Session	5.672	3.667	0.128	212.037	125.356	0.091	-151.509	75.389	0.047
	Sample	1.056	0.383	0.006	5.434	30.530	0.859	-4.759	18.250	0.795
negative	Intercept	22.456	3.366	0.000	436.059	125.278	0.001	866.964	132.635	0.000
	Group	32.633	5.063	0.000	22.618	99.668	0.821	320.778	166.038	0.059
	Session	-2.524	2.804	0.372	137.093	100.113	0.171	-158.732	56.232	0.005
	Sample	0.226	0.299	0.450	-16.314	24.382	0.504	-2.854	12.447	0.819
positive	Intercept	70.455	3.805	0.000	460.652	161.947	0.005	898.414	80.079	0.000
	Group	-27.821	4.704	0.000	143.081	156.439	0.361	67.784	101.421	0.504
	Session	-0.370	2.561	0.886	-177.552	122.879	0.152	-206.513	90.510	0.026
	Sample	-0.372	0.303	0.221	15.588	25.556	0.542	-2.580	18.857	0.891
past	Intercept	23.931	3.916	0.000	547.808	165.580	0.001	719.115	127.268	0.000
	Group	5.151	4.714	0.280	204.707	152.534	0.186	211.564	140.037	0.137
	Session	-2.105	3.462	0.546	27.019	144.032	0.852	-47.705	117.659	0.687
	Sample	0.592	0.369	0.109	3.573	28.403	0.900	2.618	12.985	0.840

future	Intercept	43.085	5.202	0.000	903.833	258.846	0.000	1068.024	128.088	0.000
	Group	-0.938	5.729	0.871	232.985	261.637	0.373	82.129	139.681	0.559
	Session	-2.680	3.461	0.442	294.698	192.771	0.127	-58.920	120.316	0.626
	Sample	0.941	0.426	0.027	-36.194	36.399	0.320	-3.418	13.240	0.796
negative	Intercept	27.779	4.603	0.000	411.628	141.951	0.004	1146.016	93.681	0.000
mood	Group	21.536	5.590	0.000	-15.397	117.913	0.896	-59.828	120.937	0.622
	Session	0.796	2.621	0.762	72.666	105.024	0.492	-215.965	167.026	0.196
	Sample	1.063	0.264	0.000	-8.574	23.917	0.720	-4.396	9.926	0.658
positive	Intercept	70.052	4.694	0.000	88.677	94.822	0.351	959.761	139.883	0.000
mood	Group	-24.178	5.648	0.000	191.759	104.121	0.070	-18.824	173.275	0.914
	Session	-3.418	2.611	0.197	129.848	69.235	0.072	-242.025	97.640	0.016
	Sample	-1.059	0.236	0.000	18.717	25.114	0.458	4.291	10.328	0.678

Supplementary Table 3: Differences between BPD patients and HCs in the relation of rating levels, fluctuations and extremity of self- and other-related ratings to the negativity of thoughts as estimates as interactions in mutli-level models

	Model parameters								
		rating levels			fluctuations in ratings			extremity of ratings	
	Predictors	b	S.E.	p-value	b	S.E.	p-value	b	S.E.	p-value
self	Intercept	27.570	3.870	0.000	211.055	178.000	0.236	818.476	89.658	0.000
	Group	-3.086	6.882	0.658	785.220	235.179	0.001	282.939	132.881	0.034
	Session	6.656	4.617	0.155	192.240	126.606	0.129	-123.647	84.836	0.153
	Sample	1.020	0.367	0.006	6.196	30.585	0.840	-0.006	12.993	1.000
	negative	0.143	0.065	0.028	4.958	4.124	0.230	-5.686	2.157	0.009
	negative*Group	0.061	0.091	0.503	-6.791	5.172	0.190	8.184	2.706	0.003
other	Intercept	41.200	4.812	0.000	501.601	239.494	0.036	1003.133	96.490	0.000
	Group	-8.474	6.348	0.185	511.525	344.074	0.137	-81.833	141.267	0.563
	Session	-5.994	3.427	0.086	-13.458	156.009	0.931	-231.401	61.598	0.000
	Sample	1.092	0.418	0.009	66.339	34.433	0.054	11.820	18.357	0.521
	negative	-0.035	0.080	0.657	-0.705	5.336	0.895	-5.173	2.277	0.023
	negative*Group	0.128	0.104	0.221	-1.389	6.799	0.838	10.491	2.873	0.000
self	Intercept	36.277	6.803	0.000	771.579	327.092	0.019	638.940	164.971	0.000
	Group	1.463	6.911	0.832	33.401	328.531	0.919	713.431	186.147	0.000
	Session	5.523	2.810	0.049	188.896	125.816	0.134	-141.482	84.208	0.098
	Sample	1.004	0.378	0.008	3.701	30.555	0.904	-5.392	16.864	0.749
	positive	-0.069	0.073	0.344	-6.355	3.974	0.110	1.661	2.004	0.408
	positive*Group	0.029	0.093	0.751	8.820	5.128	0.086	-4.954	2.602	0.057
other	Intercept	41.894	7.775	0.000	1097.332	454.484	0.016	759.051	183.415	0.000
	Group	-3.685	8.227	0.654	-370.597	488.916	0.449	610.644	199.183	0.002
	Session	-6.561	3.825	0.094	17.801	161.792	0.913	-254.415	61.527	0.000
	Sample	1.117	0.407	0.006	71.014	44.879	0.117	13.209	18.706	0.481
	positive	-0.017	0.081	0.836	-8.515	5.524	0.124	1.973	2.264	0.384
	positive*Group	0.013	0.104	0.897	11.606	7.037	0.100	-5.681	2.908	0.051

Supplementary Figure 1:

Figure 3: Level (A) of reported positive and negative mood, as well as (B) fluctuations between probes (squared successive differences) and (C) extremity of ratings (squared deviations from mean ratings). * $p < 0.05$; # $p < 0.10$