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The influence of emotions on inhibitory functioning in borderline personality disorder

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ABSTRACT

Background. Borderline personality disorder (BPD) is characterized by an emotionally unstable and impulsive cognitive and behavioral style. Inhibitory dysfunction has been hypothesized as playing a crucial role in BPD psychopathology. This study aimed to systematically investigate differential inhibitory functions in patients with BPD as compared to healthy controls, and to investigate their expected impairment in the context of aversive emotions by comparing performances in neuropsychological tasks that present both neutral and emotional material.

Method. Unmedicated female patients with BPD ($n=28$) were compared with age-matched healthy female controls ($n=30$) in the following tasks: the emotional Stroop test (inhibition of interference), directed forgetting (intentional, resource-dependent inhibition), and an emotional variant of the negative priming task (automatic, resource-independent inhibition).

Results. In comparison with the controls, the BPD patients showed reduced inhibition of negative material in the directed forgetting task and in the negative priming task. No effect was found in the emotional Stroop test. Significant correlations with current affect as well as trait anxiety and anger (but not impulsiveness) were found in the BPD group specifically for negative stimuli, while no such correlations were found in the control group. In addition to inhibitory deficiencies, BPD patients had difficulties remembering positive words in the directed forgetting task.

Conclusions. Our data suggest that individuals with BPD have difficulties in actively suppressing irrelevant information when it is of an aversive nature. Inhibitory dysfunction appears to be closely related to state and trait variables of unstable affect, but not to self-reported impulsiveness.

INTRODUCTION

Emotion dysregulation is considered to be a hallmark of borderline personality disorder (BPD). Recently, it has been proposed that emotional hyperarousal is the crucial factor that interferes with organizing and coordinating activities for the benefit of goal-directed behavior (Bohus *et al*. 2004), and thus contributing to behavioral impulsiveness (Herpertz *et al*. 2000). Emotion regulation is conceptualized as referring to the processes by which we influence which emotions we have and when we have them (Gross, 2002). In this view, inhibition is a principal mechanism of emotion regulation. For example, shifting attention away from emotional distractors, as well as voluntary suppression of emotional responses, can be conceptualized as inhibition of predominant reactions. According to Harnishfeger (1995) and Dalgleish *et al*. (1999),

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inhibitory mechanisms and associated neuropsychological tasks can be differentiated as follows: (1) inhibition of interference, that is suppression of a predominant response (e.g. the Stroop task), (2) automatic, rapid, resource-independent inhibition of irrelevant information (e.g. the negative priming task), and (3) intentional, slow, resource-dependent inhibition of irrelevant information (e.g. directed forgetting).

There is a large body of evidence suggesting altered inhibitory functions in a number of psychiatric disorders when processing emotionally significant stimuli. For example, previous data suggest impaired inhibition of attention in anxious individuals, with enhanced interference in the Stroop task (MacLeod & Mathews, 1988) and attenuated negative priming, even when neutral symbols serve as distractors (Fox, 1994). Depression is not reliably associated with the facilitated processing of emotionally negative information, but rather with the selective recall of negative information (Mogg *et al.* 1991; Mathews & MacLeod, 1994), as in the directed forgetting task (Wegner, 1994). Increased recall of aversive information, however, is not a typical phenomenon associated with enhanced anxiety (Power *et al.* 2000).

Similar to individuals with affective disorders, in BPD there might be an attentional bias toward negative rather than positive information. BPD patients may have difficulties disengaging from threatening stimuli, and their ability to focus attention on additional information relevant to safety and relief may be limited (Derryberry & Rothbart, 1997). Previous studies in BPD produced evidence of enhanced emotional sensitivity, that is high emotional responses to everyday life situations (Levine *et al.* 1997) or in experimental situations in which discrete emotional stimuli were presented (Herpertz *et al.* 1997). Using the 'directed forgetting' paradigm, BPD patients showed impaired directed forgetting for BPD-specific negative stimuli, remembering more words that dealt with topics related to BPD symptoms than did healthy controls (Korfine & Hooley, 2000). Another study explored differences in directed forgetting in BPD patients with and without histories of childhood abuse (Cloitre *et al.* 1996). The authors found no differences in directed forgetting but did find enhanced explicit memory in patients reporting childhood abuse compared to healthy controls and BPD patients without a history of childhood abuse. Although stimuli of differing valence were used, no differential effects were reported. Arntz *et al.* (2000) reported attentional bias toward negative emotional stimuli in a Stroop paradigm, although Sprock *et al.* (2000) did not.

A number of earlier studies suggest that inhibitory dysfunction may be common in BPD individuals, even beyond an emotional context. Swirsky-Sacchetti *et al.* (1993) reported increased susceptibility to interference, and Posner *et al.* (2002) were able to show that BPD patients do worse than healthy controls in a typical flanker task that challenges the capacity to suppress distractors. However, the validity of the results was repeatedly questioned and previous studies from our group could not support the theory of general inhibitory attentional failure in BPD, as the performance of BPD patients in a variety of executive functions including inhibitory tasks did not differ from that of healthy controls (Kunert *et al.* 2003; Lampe *et al.* unpublished observations).

To summarize, we propose that emotional hyper-reactivity and deficient emotion regulation in BPD interfere with inhibitory capacity. Therefore, this study aimed to systematically investigate the relationship between emotional processes and a number of inhibitory functions in patients with BPD as well as in healthy controls, using neuropsychological tasks that challenge inhibitory functions presenting emotionally neutral and negative stimuli. We hypothesized that BPD patients would show impaired inhibition in response to negative but not to neutral stimuli.

METHOD

Participants

Participants were 28 female patients with BPD from in-patient units at four psychiatric departments (Universities of Rostock, Aachen and Greifswald, and Rhineland Clinics Cologne). All participants were initially screened for the presence of Axis I psychiatric conditions with the Structured Clinical Interview for DSM-IV (SKID-I). BPD was assessed in accordance with DSM-IV criteria using the International Personality Disorder Examination (IPDE; Loranger, 1996). To secure a homogeneous

group of affectively unstable and impulsive patients, we included only women who met at least five of the DSM-IV classification criteria, including affective instability (item 6) and impulsive behavior (item 4). All but one patient reported self-harm behavior in the IPDE. High impulsivity in BPD patients was further confirmed by high scores on the Barratt Impulsiveness Scale (BIS-10; Patton *et al.* 1995) (BPD: mean = 83·6, S.D. = 12·16; controls: mean = 63·4, S.D. = 8·94, $t = 7{\cdot}244$, df = 56, $p < 0{\cdot}001$). A four-subtest short version of the Hamburg-Wechsler Intelligence Test for Adults (Olbrich, 1976) was used to screen for major cognitive impairments.

Patients with a lifetime diagnosis of schizophrenia, major depression, bipolar affective disorder, panic disorder, agoraphobia, social phobia, generalized anxiety disorder, post-traumatic stress disorder, attention deficit/hyperactivity disorder, or current drug or alcohol abuse in the past 6 months were excluded from the study. Patients with a history of head trauma, neurological disease, or an IQ below 85 were also excluded. Co-morbidity with a number of Axis I disorders was excluded because these disorders are known to influence neurocognitive functioning, with most of them even influencing inhibitory functioning. All patients had been free of medication for at least 4 weeks.

The 30 healthy controls were recruited through a bulletin-board announcement. The group consisted of female university students, non-academic hospital staff, and vocational school students. They had no lifetime history of psychiatric disorders, and, as assessed by the IPDE, did not show any Axis II disorders or dysfunctional impulsive behavior. In addition, we checked that controls did not meet more than one DSM-IV diagnostic criterion of BPD. As the majority of clinical BPD populations are female, and gender may influence affective responses to specific stimuli, only women were included. The study was approved by the ethics committee of Aachen University. All participants gave their written consent after having been informed in full about the study.

Questionnaires

A number of questionnaires were used to assess clinical characteristics, and trait and state variables of the participants. The severity of clinical symptoms was measured with the Global Severity Score of the Symptom Checklist (SCL-90-R; Franke, 1995), the Beck Depression Inventory (BDI; Beck *et al.* 1995), and a German version of the BIS-10 (Patton *et al.* 1995). The affective state at the time of testing was assessed by means of the state subscales of the State-Trait Anxiety Inventory (STAI; Laux *et al.* 1981) and the State-Trait Anger Expression Inventory (STAXI; Schwenkmezger *et al.* 1992). To measure affective trait characteristics, participants completed the trait version of the Positive and Negative Affect Schedule (PANAS; Watson *et al.* 1988) and the STAI and STAXI trait subscales.

Inhibitory tasks

To explicitly test for interference of emotional processes with differential inhibitory functions, emotional versions of various standard neuropsychological tests were used. Lists of emotional and neutral words were compiled to control for word length, number of syllables, concreteness and frequency of occurrence in everyday life (Hager & Hasselhorn, 1994). All tests, except for the directed forgetting task, were conducted with a standard personal computer. The first two trials were presented for practice and therefore were not entered in the statistical analyses.

Emotional Stroop

An 'emotional version' of the Stroop test was used (for a review, see Williams *et al.* 1996). In the present version of the test, the participant was sequentially shown two words on the monitor: an adjective printed in a specific color, and below or above this a color word printed in black. The adjectives consisted of 12 neutral and 12 negative words and they were shown three times each. In total, 72 trials were presented in random order. The participant had to decide as quickly as possible whether the color of the adjective corresponded to the color word by pressing one of two buttons. There were two classes of trials: trials with the adjectives written in the same color as the color word, and trials written in a color different to the color word. Interference of the meaning of the adjectives with the process of color evaluation can be inferred when reaction times (RTs)

to emotional words are longer than RTs to neutral words.

Negative priming (*Tipper*, *1985*)

In this paradigm, each trial consisted of two presentations: a prime and a probe. The prime and the probe consisted of two words each, presented simultaneously on top of each other. One word was printed in red, and the task was to press a button that corresponded with the position of the red word (target) and to ignore the second word (distractor). In addition, there were two different classes of trials: ignored repetition (IR) and control (C) trials. In IR trials, the distractor to be ignored in one trial becomes the target in the next, while in the C trials, targets and distractors differ from each other in sequential trials. RTs to the probes were recorded on a trial-by-trial basis. In total, 480 trials (five blocks with 96 trials each) were presented. The negative priming effect is thought to prolong the RTs of the IR trials as compared to the C trials. In the present experiment, we again used negative and neutral words to test for effects of emotional processes. For statistical analyses, the mean C trial RT was subtracted from the IR trial RT for neutral and negative words.

Directed forgetting (*Bjork*, *1989*)

This test involved a first list of 21 words being read to the participants at a rate of one word every three seconds, with the instruction to learn them for later recall. After finishing the first list, participants were instructed to forget the words (the to-be-forgotten items), as they were for practice purposes, and instead to learn a second comparable list of a further 21 words (the to-be-remembered items) that were then read to them. After the second list was finished, each participant was provided with a blank sheet and was asked to write down all the words from both lists. To explicitly assess the modulatory role of emotional processes, the valence of the listed words was varied, with the two lists containing an equal number of positive, neutral, and negative nouns. Positive words were additionally introduced into this task to test the ability of the BPD patients to process positive information. Emotionally influenced inhibitory function was assessed by calculating separate coefficients between the number of remembered words from the first list within a specific valence and the total number of recalled words.

For motivational reasons, we divided the assessment into three sessions. In the first session, we conducted the clinical interviews and the tests of general cognitive performance. In the second session, the emotional Stroop test and the negative priming test were taken, together with part of the clinical questionnaires. In the final session, the participants worked on the directed forgetting task and filled out further questionnaires.

Data analysis and statistics

Demographic and clinical data were analyzed using Student's t tests. If data were not normally distributed, non-parametric Mann–Whitney U tests were applied instead.

Inhibition test data were initially subjected to separate univariate analyses of variance (ANOVAs). *Post hoc* single comparisons of group differences were performed with Student's t test for independent samples. Linear associations between state and trait characteristics of emotion and inhibitory performance were tested using Pearson's correlations. Equality of variances was tested using Levene's F test. Where unequal variances were found, degrees of freedom were corrected using the Greenhouse–Geisser correction. Finally, significant group differences were controlled for possible modulation by means of psychometric state and trait variables using analyses of covariance (ANCOVAs).

The significance level for all tests was $p < 0{\cdot}05$. Data were analyzed using SPSS version 12 (SPSS Inc., Chicago, IL, USA).

RESULTS

Demographic and clinical group characteristics

The groups were comparable with regard to age as well as general and verbal intellectual abilities, although the BPD group reported a significantly lower educational level than the controls ($p < 0{\cdot}046$).

Comparison of the groups with regard to clinical variables (Table 1) showed that the BPD group had significantly more severe symptoms of depression (BDI; $p < 0{\cdot}001$), general psychopathology (SCL-90-R; $p < 0{\cdot}001$), and

Table 1. *Demographic and clinical characteristics of the study groups*

	Borderline group ($n=28$)		Healthy controls ($n=30$)		t test		
	Mean	(S.D.)	Mean	(S.D.)	t	df	p
Age	24·93	(5·85)	23·90	(5·88)	0·67	56	0·507
Years in school	10·92	(1·69)	11·82	(1·49)	−2·05	50	0·046
HAWIE total	110·14	(14·79)	110·17	(15·69)	−0·01	56	0·995
HAWIE verbal	106·89	(14·65)	111·37	(14·89)	−1·02	46	0·316
SCL-90 total	1·43	(0·68)	0·20	(0·15)	9·34	29·31	<0·001
BDI sum	23·29	(9·95)	1·83	(2·21)	11·15	29·56	<0·001
BIS total	83·57	(12·16)	63·37	(8·94)	7·24	56	<0·001
PANAS Positive Affect	25·27	(6·92)	32·03	(5·29)	−4·14	54	<0·001
PANAS Negative Affect	28·23	(8·47)	15·97	(4·29)	6·68	35·81	<0·001
Trait anxiety – STAI	59·29	(8·92)	34·13	(7·65)	11·56	56	<0·001
Trait anger – STAXI	23·57	(5·92)	16·07	(4·18)	3·65	56	<0·001
State anxiety – STAI	51·46	(8·69)	34·90	(5·67)	8·58	45·45	<0·001
State anger – STAXI	14·43	(5·35)	10·63	(1·90)	3·55	33·32	0·001

HAWIE, Hamburg-Wechsler Intelligence Test for Adults; SCL-90, Symptom Checklist; BDI, Beck Depression Inventory; BIS, Barratt Impulsiveness Scale; PANAS, Positive and Negative Affect Schedule, trait version; STAI, State-Trait Anxiety Inventory; STAXI, State-Trait Anger Expression Inventory.

impulsiveness (total score on the BIS; $p<0·001$) than controls.

With regard to personality traits of affectivity, BPD was associated with lower positive affect ($p<0·001$) and enhanced negative affect (PANAS; $p<0·001$), and the BPD patients showed significantly higher scores of habitual anxiety (trait subscore of the STAI; $p<0·001$) and anger (trait-anger subscore of the STAXI; $p=0·001$) than controls.

When we checked for differences in state anger and state anxiety, we also found significant group differences; BPD patients reported stronger feelings of anger ($p<0·001$) and anxiety ($p<0·001$) immediately before inhibitory testing than healthy controls. Furthermore, the BPD group showed a remarkably higher within-group variance of state anger ($F=17·52$, df = 27, 29, $p<0·001$) and state anxiety ($F=5·09$, df = 27, 29, $p<0·05$) than controls. The PANAS negative affect ($F=9·24$, df = 27, 29, $p<0·005$), the global severity index of the SCL-90 ($F=45·66$, df = 27, 29, $p<0·001$), and BDI ($F=29·05$, df = 27, 29, $p<0·001$) variability were also significantly higher in the BPD group.

Group differences in inhibitory functions

Table 2 presents descriptive data on the inhibitory tasks. With regard to the emotional Stroop test, both groups showed the well-known effect of word valence, reflected by a significant main effect of valence ($p=0·018$), with negative words eliciting longer RTs. Although BPD patients showed an overall increase in RTs compared to healthy controls ($p=0·026$), this effect was independent of word valence (group *versus* valence interaction: N.S.).

In the directed forgetting task, negative words were inhibited more easily than neutral words regardless of group membership (valence effect: $p<0·001$). There was no overall difference between the groups with regard to inhibition of list 1 ('to forget') words (group effect: N.S.). The valence effect appeared to be less pronounced in BPD patients, due to a significant effect towards a higher proportion of wrongly remembered negative words ($t=1·79$, df = 56, $p=0·04$, single-sided). To explore explicit emotional memory, we also analyzed retrieval of list 2 ('to remember'). BPD patients appeared to remember significantly fewer positive words than controls (BPD: mean = 1·46, S.D. = 1·14; controls: mean = 2·47, S.D. = 1·14; $t=-3·35$, df = 56, $p<0·002$, two-tailed). As the groups differed significantly in terms of depression, affect, anger and anxiety (see above), we controlled for these variables, including them as covariates in an ANCOVA on the significant group difference for negative stimuli (see Fig. 1). Of all of the variables included, only positive and negative affect proved to be significant covariates ($F=5·04$, df = 1, 46, $p<0·05$ and

Table 2. *Group differences in inhibitory functions*

	Borderline patients ($n=28$)		Healthy controls ($n=30$)		Statistical test (ANOVA/t test)		
	Mean	(S.D.)	Mean	(S.D.)	Group (df = 1, 56)	Valence (df = 1, 56)	Group by valence (df = 1, 56)
Emotional Stroop[a]					$F=5{\cdot}21$, $p=0{\cdot}026$	$F=5{\cdot}98$, $p=0{\cdot}018$	$F=0{\cdot}29$, $p=0{\cdot}595$
I: RT neutral words	640·62	(131·43)	566·92	(105·67)	$t=2{\cdot}90$, $p=0{\cdot}003$		
II: RT negative words	652·99	(133·91)	586·21	(102·61)	$t=2{\cdot}25$, $p=0{\cdot}014$		
II – I	12·37	(52·88)	19·29	(44·84)	$t=-0{\cdot}54$, $p=0{\cdot}280$		
Directed forgetting[b]					$F=2{\cdot}17$, $p=0{\cdot}146$	$F=10{\cdot}29$, $p<0{\cdot}001$	$F=1{\cdot}03$, $p=0{\cdot}360$
Positive words	12·93	(9·71)	10·30	(7·96)	$t=1{\cdot}13$, $p=0{\cdot}263$		
Neutral words	11·86	(10·00)	12·62	(7·82)	$t=-0{\cdot}32$, $p=0{\cdot}375$		
Negative words	7·45	(9·85)	3·77	(5·35)	$t=1{\cdot}79$, $p=0{\cdot}040$		
Negative priming[c]					$F=2{\cdot}34$, $p=0{\cdot}132$	$F=2{\cdot}47$, $p=0{\cdot}115$	$F=0{\cdot}50$, $p=0{\cdot}485$
I: Neutral IR – C	−6·15	(22·02)	−3·36	(12·78)	$t=-0{\cdot}60$, $p=0{\cdot}276$		
II: Negative IR – C	−3·32	(17·55)	3·91	(16·02)	$t=-1{\cdot}64$, $p=0{\cdot}054$		
II – I	2·83	(25·03)	7·28	(23·06)	$t=-0{\cdot}70$, $p=0{\cdot}243$		

Student's t tests p are single-sided.

[a] Mean reaction time (RT) in milliseconds to neutral (I) compared to negative (II) words. A positive difference (II – I) indicates an effect of word valence.

[b] Mean percentage of recalled words from list 1 ('to forget') relative to all remembered words.

[c] Mean difference between ignored repetition (IR) and control (C) trials in milliseconds for neutral (I) and negative (II) words. A positive difference (II – I) indicates a priming effect that is more pronounced for negative words.

FIG. 1. Group differences in the directed forgetting task for positive, neutral and negative words. Borderline personality disorder (BPD) patients selectively remembered more negative words from the 'to forget' list relative to all remembered words. ■, BPD patients ($n=28$); □, healthy controls ($n=30$).

$F=5{\cdot}40$, df = 1, 46, $p<0{\cdot}05$, respectively). Controlling for these variables, the group difference regarding inhibition of negative memories disappeared ($F=0{\cdot}48$, df = 1, 46, $p=0{\cdot}49$).

In the negative priming paradigm, the ANOVA did not reveal significant differences between the groups, either in overall performance or differentially for negative and neutral words (group *versus* valence interaction). Checking the data for group differences in respect of negative and neutral stimuli separately, we found a trend towards impaired negative priming in BPD patients compared to controls for negative stimuli only ($t=-1{\cdot}64$, $p=0{\cdot}054$). No main stimulus valence effect was recorded. Again, we controlled for psychometric group differences using an ANCOVA. Of all of the variables included, depression showed a trend towards covariation with negative priming for negative stimuli ($F=3{\cdot}88$, df = 1, 46, $p<0{\cdot}056$). Once again, the group effect disappeared after controlling for depression ($F=1{\cdot}34$, df = 1, 46, $p=0{\cdot}25$).

Correlations between inhibitory functions and trait/state variables of affect

To explore the possibility that impulsivity in the BPD group might be associated with inhibition performance, Pearson's correlations were

Table 3. *Linear correlations of inhibitory functions in the borderline personality disorder (BPD) group with anxiety, anger, positive and negative affect, and depression*

	Trait characteristics				State characteristics		
	Trait anxiety	Trait anger	Positive affect	Negative affect	Depressive symptoms	State anxiety	State anger
Emotional Stroop[a]							
I: RT neutral words	−0·04	0·02	−0·18	0·14	0·09	0·28	0·32
II: RT negative words	0·05	−0·01	0·08	0·22	0·15	0·43*	0·46*
II−I	0·23	−0·07	−0·25	0·19	0·17	0·39*	0·36
Directed forgetting[b]							
Positive words	−0·05	0·10	0·14	−0·01	−0·11	0·16	0·30
Neutral words	0·24	0·31	0·20	0·14	0·07	0·03	−0·19
Negative words	−0·15	0·05	−0·14	0·22	−0·06	0·15	0·23
Negative priming[c]							
I: Neutral IR−C	−0·24	−0·18	−0·07	−0·13	−0·37	0·01	0·17
II: Negative IR−C	−0·57**	−0·01	0·05	−0·41*	−0·50**	−0·54**	0·15
II−I	−0·18	0·16	0·10	−0·17	−0·03	−0·39*	−0·05

[a] Mean reaction time (RT) in milliseconds to neutral (I) compared to negative (II) words. A positive difference (II−I) indicates an effect of word valence.

[b] Mean percentage of recalled words from list 2 ('to forget') relative to all remembered words.

[c] Mean difference between ignored repetition (IR) and control (C) trials in milliseconds for neutral (I) and negative (II) words. A positive difference (II−I) indicates a priming effect that is more pronounced for negative words.

* $p<0{\cdot}05$, ** $p<0{\cdot}01$ (two-tailed).

calculated between the BIS and inhibitory task scores. No significant correlation was found between inhibition performance and impulsivity, for both the BPD group and the healthy control group.

We further tested for linear associations between traits of anger, anxiety, depression, positive and negative affect and inhibitory functioning within the BPD group (Table 3). The only correlations that reached levels of significance were found for the negative stimuli in the negative priming paradigm: disinhibition of negative stimuli was associated with higher trait anxiety ($r=-0{\cdot}57$, $p<0{\cdot}002$), depression ($r=-0{\cdot}50$, $p<0{\cdot}007$) and enhanced negative affect ($r=-0{\cdot}41$, $p<0{\cdot}04$).

Correlational analyses of inhibitory task scores and state variables revealed significant associations between Stroop RT and aversive stimuli and state anger ($r=0{\cdot}46$, $p<0{\cdot}018$) as well as state anxiety ($r=0{\cdot}43$, $p<0{\cdot}027$). Finally, again for negative stimuli, a negative correlation was found between state anxiety and the negative priming effect ($r=-0{\cdot}54$, $p<0{\cdot}004$), indicating that a relatively high state of anxiety was associated with decreased inhibition of aversive stimuli (Table 3).

Regarding healthy controls, inhibitory function was not significantly correlated with depression, anxiety, anger or positive/negative affect, for both trait and state variables.

DISCUSSION

In the present study, patients with BPD differed from healthy women in two facets of inhibitory function: they showed a significant impairment in their intentional inhibition of aversive words in the directed forgetting task, and a tendency towards a decreased capacity for automatic inhibition of irrelevant negative stimuli in the negative priming task. Our finding of impaired directed forgetting is in accordance with results reported previously (Korfine & Hooley, 2000). Our data extend the previous study as the present results suggest that the enhanced recall of negative information, despite the instruction to forget it, is not limited to borderline-specific stimuli. It should be mentioned that there are alternative concepts to explain directed forgetting effects that rely on differential processing and encoding rather than intentional inhibition (MacLeod, 1998). In particular, the hypothesis of differences in selective rehearsal for 'to remember' items has gained attention in recent years (MacLeod *et al.* 2003). Following this explanation, it is possible that the present finding reflects impaired suppression of involuntary

rehearsal of negative material rather than impaired inhibition of negative memories at retrieval. However, it has been argued that differences in the list version of the directed forgetting (which was used in the present study) are more likely to reflect processes of effects of inhibition rather than encoding or processing (Johnson, 1994). Whichever processes are involved, BPD patients showed enhanced recall for negative items, despite the instruction to actively forget them. A selective deficit to inhibit aversive memories at retrieval or (less likely) the inability to suppress rehearsal for negative stimuli might contribute significantly to emotional hyperarousal, not only in the context of traumatic life events, which are frequently reported by BPD patients (Yen *et al.* 2002). In addition, the reduced recall of positive information from the 'to remember' list may aggravate the problem because BPD individuals may not only have difficulties disengaging from aversive information but also be limited in their ability to process positive information that could compensate for the negative contents (Derryberry & Rothbart, 1997). A limitation of the presented paradigm might be that the words were read to the participants by the experimenter. Thus we cannot rule out the possibility that subtle variations in prosody or facial expression might have influenced emotional processing.

In the negative priming paradigm, we also found less inhibitory capacity in BPD patients than in controls. The present results suggest that BPD patients show a tendency towards a reduced negative priming effect for the aversive stimuli, which means a reduced automatic involuntary cognitive inhibition (Tipper, 1985). Compared to controls, who showed a negative priming effect of about 4 ms when processing negative words, the negative score for BPD patients indicated the absence of negative priming (inhibition) in BPD. This result, however, should be interpreted with caution as the effect was quite small and neither group showed negative priming for neutral stimuli.

No differential group differences were found in the emotional Stroop test, a task that challenges the ability to inhibit interference. Other researchers were also unable to detect effects of stimulus valence on interference in the Stroop test (Sprock *et al.* 2000), but there are results that confirm the hypothesis of interference susceptibility in BPD individuals using the emotional Stroop task (Arntz *et al.* 2000). Differences in co-morbidity between the studies may account for these inconsistencies; previous studies included patients with co-morbid Axis I disorders, while in the present group these patients were explicitly excluded. However, the BPD patients in the present study were significantly slower in their response, regardless of stimulus valence. Thus, another explanation for the lack of emotional Stroop effect could be that overall low performance might have masked subtle differential effects of stimulus valence. This is in line with Arntz *et al.* (2000) and Sprock *et al.* (2000), who also reported that the BPD group showed slower response times for non-emotional stimuli than healthy controls. Thus, a general psychomotor deficit or a general vulnerability to interference could also be discussed as a significant factor in the Stroop paradigm. Unfortunately, we did not incorporate a non-interference condition to exclude the possibility of a general vulnerability to interference in BPD. However, we did not find evidence for this possibility in previous studies using the non-emotional Stroop task in several samples of female BPD patients (Kunert *et al.* 2003; Lampe *et al.* unpublished observations). Finally, deficits in the processing of aversive words in the negative priming but not in the Stroop task might correspond to the observation reported by Hamm & Hasher (1992) that only the latter can be successfully performed by increasing voluntary effort to selectively attend to the target in the presence of a competitive response set.

In anxiety disorders or individuals with high trait anxiety, an attentional bias towards threatening information is thought to result from both the amplification of threat representations by means of enhanced attentional focusing and an inhibitory defect (Dalgleish *et al.* 1999). This assumption is supported by our correlational data in BPD individuals, which show an association between anxiety and abnormal performance in the processing of negative information in the Stroop and the negative priming task. While only state anxiety correlated with interference in the Stroop task, state and trait anxiety were accompanied by low negative priming.

BPD patients have been characterized as experiencing intense negative emotions (Herpertz *et al*. 1997; Levine *et al*. 1997). Results from correlation analyses clearly illustrate that deficient inhibition is closely related to emotional characteristics of BPD subjects. We found significant negative correlations between habitual negative (but not positive) affectivity and negative priming. A negative correlation was also found between depression and negative priming for aversive words. High interference in the Stroop task was associated not only with state anxiety but also with state anger, although it was not associated with any trait characteristics of affectivity. In accordance with the assumption that group-specific state and trait characteristics contribute to the observed group differences in inhibitory functioning, the small group effect in the negative priming task disappeared when controlling for depression. This was also true for the directed forgetting task when controlling for affective style. As impulsivity is a major problem in BPD, inhibitory dysfunction could also be related to impulsivity. However, there was no substantial association between self-reported impulsivity assessed with the BIS and inhibitory neuropsychological function.

In general, all observed group differences were fairly small (less than 5% explained variance). There are several possible reasons why group differences were small and why the effect of stimulus valence was not always observed (e.g. in the negative priming paradigm). In the present study, we observed a remarkably high variance, particularly of state variables such as anger, anxiety and depression, in the BPD patients as compared to healthy controls, a finding consistent with the typical BPD characteristic of affect instability. Correlational analyses showed that emotional state has a strong influence on inhibitory function only in the case of aversive material and only in the BPD group. More general explanations rely on stimulus features and group characteristics. Compared to pictures or movies, verbal stimuli might be less potent triggers of emotional responses. Having excluded a number of significant Axis I disorders as co-morbid conditions and – as is necessary in studies on cognitive functioning – all patients on psychotropic medication, the possibility might be discussed that the present sample of BPD patients was not representative of the population of BPD subjects. However, data from self-report questionnaires on general and borderline-specific symptomatology suggest that the present sample was comparable to those previously reported in literature. In addition, the disorder was severe enough to demand inpatient treatment in a supra-regional therapy unit specializing in a cognitive-behavioral psychotherapeutic approach to BPD. Therefore, it is most unlikely that the present sample represents a subsample of 'high-functioning' patients. However, we cannot rule out the possibility that inhibitory function might be worse in patients with particularly severe forms of BPD.

To summarize, consistent with our hypothesis, the present results suggest that female BPD patients without prominent Axis I co-morbidity tend to differ from healthy controls with respect to inhibitory processes in working memory and automatic inhibition in the context of implicit priming when processing negative material. As a consequence, deficient inhibition of aversive emotional stimuli might contribute to affective instability in BPD. In addition to trait characteristics of affective processing, we found that state anxiety, anger and mood are associated with deficient inhibitory function. Finally, impaired memory for positive information may aggravate the sequels of the deficient inhibition of negative stimuli.

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DECLARATION OF INTEREST

None.

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