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Short communication

Facial emotion recognition in borderline patients is unaffected by acute psychosocial stress

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ABSTRACT

Borderline Personality Disorder (BPD) is characterized by difficulties in social cognition and social interactions, which exacerbate under stress. A previous study found better facial emotion recognition (FER) in patients with personality disorders and healthy controls (HC) after stress. We recently reported that emotional empathy scores, i.e. the emotional response to another person's emotional state, were significantly lower in BPD patients than in HC after psychosocial stress. Cognitive empathy scores remained unaltered. The present study aims to further investigate the effect of psychosocial stress induced by the Trier Social Stress Test (TSST) on FER as part of social cognition in patients with BPD. We randomized 43 women with BPD and 46 female HC to either the TSST or a placebo condition. Afterwards, participants were asked in an emotion recognition test to identify emotions in faces showing anger or sadness at low and high intensity. Both groups recognized emotions better at high intensity compared with low intensity. There was no effect of stress on FER performance and we found no difference between groups. This is in line with prior research on social cognition in BPD patients demonstrating that the ability to understand another person's perspective might be unaffected by acute stress.

1. Introduction

Difficulties in social interactions are among the core symptoms of Borderline Personality Disorder (BPD; American Psychiatric Association, 2013). A causal factor for those difficulties might be impaired social cognition (Roepke et al., 2013), which primarily occurs under perceived stress (Lazarus et al., 2014). According to Fonagy and Bateman (2008) the capacity to make sense of the self and others, called mentalization, is disrupted in BPD patients due to unstable attachment and early trauma. Semerari et al. (2014) found metacognition, defined as a set of skills that enables people to comprehend their own mental states and those of others, to be impaired in patients with personality disorders. Even further, poor metacognitive functioning was associated with personality disorder symptom severity. Based on these findings, the authors proposed impaired metacognition to be a shared etiological component of personality disorders. Support for such impairments in BPD patients comes from several studies, showing that those patients are more prone to social rejection, social threat cues and negative evaluation (Domes et al., 2009; Renneberg et al., 2012). Von Ceumern-Lindenstjerna et al. (2010) found that BPD patients focused more initial attention toward and had difficulties in disengaging from negative facial expressions. Mancke, Herpertz and Bertsch (2015) proposed that this threat hypersensitivity may be one of the main causes for interpersonal hypersensitivity and aggression in BPD patients. This interpersonal sensitivity seems to intensify under interpersonal stress and might lead to emotional instability and self-harming behaviors (Gunderson, 2007; Stanley and Siever, 2010).

Part of mentalization or metacognition and a prerequisite for adequate social interaction is the ability to correctly identify others' facial emotions (Wagner and Linehan, 1999). Previous research on facial emotion recognition (FER) in BPD patients has yielded heterogeneous results. In some studies, BPD patients detected emotions at lower intensities than healthy controls, indicating enhanced FER ability (Lynch et al., 2006; Domes et al., 2009). In a large meta-analysis, Daros et al. (2013) found no significant differences between BPD patients and HC in FER when considering negative emotions as a group. However, results

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revealed a bias in perception of neutral stimuli and FER deficits for high intense expressions of anger and disgust in BPD patients. As an explanation of diverging results, the authors proposed that BPD patients generally experience higher levels of arousal when presented with facial emotions. This might enhance FER at lower levels of emotion intensity, whereas hyperarousal induced by intense expressions of BPD-specific emotions might reduce performance. Support for their model comes from several studies with BPD patients, showing intense faces of anger to interfere with cognitive resources as indicated by longer reaction times and a hypersensitivity for and deficits in detailed evaluation of angry faces (Schneider et al., 2018; Bertsch et al., 2017; Izurieta Hidalgo et al., 2016). Others found a negative bias in judging positive facial expressions (Kleindienst et al., 2019), deficits in the discrimination of happiness and slow reaction times to happy faces (Izurieta Hidalgo et al., 2016; Schneider et al., 2018).

A state of high arousal is psychosocial stress, which is known to worsen many BPD symptoms (Gunderson, 2007; Stanley and Siever, 2010) and to influence social cognition (Lazarus et al., 2014). As one of few studies investigating the relationship between psychosocial stress and social cognition, Wingenfeld et al. (2018) found reduced emotional empathy in BPD patients, i.e. the emotional response to another person's emotional state, in response to the Trier Social Stress Test (TSST). Cognitive empathy, i.e. the ability to understand another person's perspective, was unaltered. Investigating FER before and after psychosocial stress, Deckers et al. (2015) observed increased FER performance in patients with BPD, cluster C personality disorders and healthy women. Studies with healthy adults support the notion of improved FER under psychosocial stress (Barel and Cohen, 2018; Domes and Zimmer, 2019). Our own group, on the other hand, found FER in healthy adults to be unaffected by an increase in stress hormones induced by pharmacological stimulation of cortisol receptors in the brain (Schultebraucks et al., 2016; Duesenberg et al., 2016).

Taken together, the effects of (psychosocial) stress on FER in BPD remain incompletely understood. The aim of the present analysis, which was part of a larger study (Duesenberg et al., 2019), was to further illuminate the association between psychosocial stress and FER in women with BPD. We used the TSST for stress induction, and a placebo version of the TSST as a control condition. Women with BPD and healthy female controls performed the Facial Emotion Recognition Task, in which facial stimuli showing anger and sadness at two different intensities were presented.

Based on previous studies, we expected that BPD patients and HC would not differ in FER in the Placebo condition. Psychosocial stress and high intense expressions of anger have been shown to disrupt social cognitive capacities in BPD patients (Lazarus et al., 2014; Izurieta Hidalgo et al., 2016; Bertsch et al., 2018). With respect to stress, we hypothesized that BPD patients, compared to HC, would detect angry faces under stress with lower accuracy and that this effect would be most pronounced at high emotion intensity.

2. Materials and methods

2.1. Participants

The sample consisted of 43 women with BPD and 46 healthy control (HC) women. For all participants, exclusion criteria were the presence of any of the following medical conditions: CNS disease or severe somatic disease, metabolic or endocrine disease, autoimmune disease, current infection or pregnancy. Exclusion criteria for BPD patients were as follows: current major depressive episode, schizophrenia, schizoaffective disorder, bipolar disorder, anorexia, alcohol or drug abuse and dependence in the last six months. Healthy participants were free of any current or past psychiatric disorders. Inpatients and outpatients were recruited from the Department of Psychiatry, Charité - Universitätsmedizin Berlin, Campus Benjamin Franklin. Additionally, outpatients and the control group were recruited by local and online advertisements, and were reimbursed with 100 €. All participants were diagnosed by trained clinicians using the German version of the Structured Clinical Interview for DSM-IV axis I & II (SCID; Wittchen et al., 1997). Self-reported severity of borderline symptoms was assessed with the short version of the Borderline Symptom List (BSL-23; Bohus et al., 2009). All participants gave written informed consent. The study was approved by the local ethics committee.

2.2. Procedure

The facial emotion recognition task (FER) was part of a larger study, which consisted of two test sessions held with a minimum of one week apart from each other. In a cross-over design, participants were randomly assigned to either a psychological stressor or a control condition on the first test session (T1) and subsequently to the other condition at the second session (T2). The participants completed memory tasks at T1 and T2 (Duesenberg et al., 2019) followed by an empathy task at T1 (Wingenfeld et al., 2018) and the FER at T2. Testing sessions begun at 4 pm in the afternoon. The FER was performed 65 min after the stressor. At T2, 24 patients with BPD and 24 healthy women were in the stress condition, while 19 BPD patients and 22 HC were in the control condition.

As a stressor, the Trier Stress Test (TSST) was used, which reliably induces a stress response as measured by increased cortisol release (Kirschbaum et al., 1993). The TSST starts with a 10-min preparation phase followed by a 5-min speech and a 5-min arithmetic task. Participants are instructed to prepare for a job application and present themselves in front of a camera and two alleged trained behavioral analysts. A "Placebo" version of the TSST (P-TSST) was used as control condition (Het et al., 2009). Participants are instructed to talk aloud about a topic of choice in an empty room, after a preparation phase. Subsequently, they perform an arithmetic task, having to count up in multiples of 15, starting from 0.

Saliva was collected using Salivettes (Sarstedt, Germany) for cortisol and alpha-amylase (sAA) analyses. For more details, see supplementary material. Starting, at 4pm, measurements were conducted at the following time points: baseline measurements (15 min and directly before the (P-)TSST, and after the (P-)TSST at +20 min, +30 min, +45 min and +80 min.

2.3. Facial emotion recognition task

The facial emotion recognition task assesses participants' ability to correctly identify facially expressed emotions. In a total of 120 trials, pictures of human faces taken from the NIMSTIM scale (Tottenham et al., 2009; http://www.macbrain.org/resources.htm) showing anger, sadness or neutral expressions were presented in random order. Anger and sadness were shown at low intensity, i.e. 40 %, and at high intensity, i.e. 80 %, which were created via morphing processes based on the full intensity (100%; task identical to Duesenberg et al., 2016; Fig. 1). Neutral expressions were included as control trials. For each of the two intensities of anger and sadness, as well as for neutral expressions, 24 stimuli were presented. After each stimulus, which was presented for one second, a grey screen appeared for four seconds. By pressing the respective key on the keyboard, participants had to label the emotions giving one of three possible answers: anger, neutral, sadness. A sum score was calculated for all correctly identified emotions at each level of intensity (i.e. sadness reported, when sadness presented at low intensity).

2.4. Statistical analyses

Statistical analyses were performed using SPSS version 26. Demographic and clinical data were analyzed using Pearson's chi-squared test for categorical data and Student's t-test for continuous data. FER data was not normally distributed, hence log-transformations were

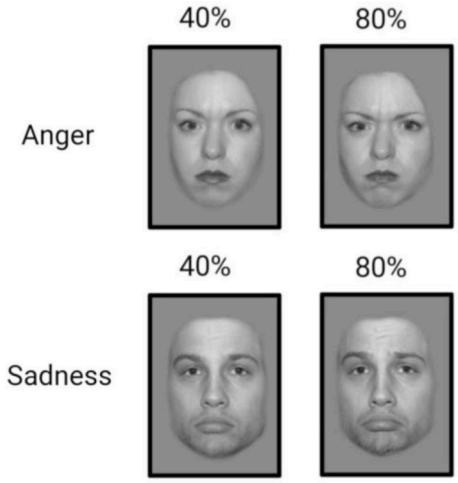

Fig. 1. Examples from the Facial Emotion Recognition (FER) task.

performed and used in subsequent statistical analyses. In a repeated-measures analysis of variance (rmANOVA), effects of stress on facial emotion recognition were analyzed. Stress (TSST vs. P-TSST) and group (BPD vs. HC) served as between-subject factors and emotion (anger, sadness) and intensity (low, high) as within subject factors. For significant interaction effects, post hoc t-tests were performed. We conducted additional 2 (stress) x 2 (group) ANOVAs for each level of intensity for both emotions, as well as for neutral stimuli.

To test whether stress induction was successful, increases of cortisol and alpha-amylase, (delta) (Δ) were calculated by subtracting the mean of the two baseline measurements from the maximum of the four measurements after the TSST or P-TSST. We analyzed the data in 2 (stress) x 2 (group) ANOVAs with Δ-cortisol and Δ-sAA as dependent variables. Additionally, log-transformed data on cortisol and sAA were analyzed using repeated measures ANOVAS with time as within-subjects factor (−15, 0, +20, +30, +45, +80 min) and stress (P-TSST vs. T-SST) and group (BPD vs HC) as between-subjects factors.

3. Results

3.1. Demographic and clinical data

BPD patients did not differ from healthy women in sample characteristics apart from a higher number of smokers. Self-reported severity of BPD symptoms, i.e. BSL-23 scores, were higher in the BPD group compared to controls. Thirty BPD patients were prescribed psychotropic medication at the time of the study, 13 patients and all healthy women were medication free. For details on medication and comorbid diagnoses, see supplementary material. Results are displayed in Table 1.

3.2. Physiological data

Three patients with BPD refused saliva collection. Stress induction was successful as indicated by significantly higher increase, i.e. higher delta values, for cortisol and alpha-amylase in the TSST condition compared to the P-TSST condition. There was no significant group difference between BPD patients and HC in physiological responses. Results are displayed in Table 1. A more detailed description of physiological data is presented in the supplementary material.

3.3. Facial emotion recognition

In a rmANOVA, we tested whether the number of correctly identified facial emotions differed in response to stress in female BPD patients and healthy women. As data were not normally distributed, we used log-transformations for FER data in subsequent analyses.

There was no main effect of stress or group on correctly identified emotions. BPD patients did not differ from healthy women in number of correctly identified emotions. Additionally, there were no main effects of stress and group on correctly identified neutral stimuli. Means (SD) are presented in Table 1.

We found a main effect of intensity (F (1,85) = 314.21, $p < .001$, $\eta^2 = 0.79$). The number of correct answers at high intensity was significantly higher than at low intensity. Correct answers did not differ between the two emotions (F (1,85) = 1.54, $p = .218$). There was a significant interaction between emotion and intensity (F (1,85) = 32.16,

Table 1
Sample characteristics and stress effects (TSST vs. P-TSST) on physiological data and facial emotion recognition.

Sample characteristics			
Variable *M (SD)*	BPD n = 43	HC n = 46	Statistics
Age, years	29.28 (7.46)	31.61 (9.15)	t (87) = −1.31, p = .19
Years of Education	11.51 (1.82)	11.74 (1.36)	t (87) = −0.67, p = .50
BMI (kg/m^2)	23.34 (3.44)	22.51 (2.79)	t (86) = 1.25, p = .21
Smoker y/n	25/18	7/39	χ^2 (1) = 17.78, $p < .001$
Hormonal contraception y/n	13/31	19/27	χ^2 (2) = 1.76, p = .19
BSL-23	2.22 (0.84)	0.12 (0.15)	t (78) = 15.96, $p < .001$
Physiological data			
Variable *M (SD)*	BPD	HC	Statistics[a]
TSST Δ-sAA (U/ml)	36.93 (63.94)	74.80 (74.18)	2 x 2 ANOVA for sAA: main effect stress: F (1,82) = 6.18, p = .02
P-TSST Δ-sAA (U/ml)	20.61 (40.66)	27.92 (46.08)	main effect group: F (1,82) = 3.16, p = .08 stress x group: F (1,82) = 1.45, p = .23
TSST: Δ-Cortisol (nmol/l)	0.78 (2.39)	1.67 (2.12)	2 x 2 ANOVA for Cortisol: main effect stress: F (1,81) = 6.72, p = .01
P-TSST: Δ-Cortisol (nmol/l)	0.02 (1.00)	0.42 (1.0)	main effect group: F (1,81) = 2.80, p = .10 stress x group: F (1,81) = 0.40, p = .53
Facial Emotion Recognition			
Correct answers *M (SD)*	BPD	HC	Statistics[a]
TSST	15.09 (3.29)	15.24 (2.61)	main effect stress: F (1,85) = 0.05, p = .82
P-TSST	15.71 (3.69)	14.98 (3.55)	main effect group: F (1,85) = 0.52, p = .47 stress x group: F (1,85) = 1.39, p = .24
Correctly identified neutral stimuli *M (SD)*	BPD	HC	Statistics
TSST	21.67 (3.46)	21.63 (2.55)	main effect stress: F (1,85) = .08, p = .78
P-TSST	21.53 (3.24)	22.09 (2.64)	main effect group: F (1,85) = .29, p = .59 stress x group: F (1,85) = .08, p = .77

BPD = Borderline Personality Disorder, HC = Healthy Controls, BMI = Body Mass Index, BSL-23 = Borderline Symptom List - short version, TSST = Trier Social Stress Test, P-TSST = Placebo-TSST, sAA = salivary alpha-amylase.
[a] Between-subjects effects of rmANOVA, statistics were perfromed using log-transformed data, for within-subjects effects see text 3.3 and Fig. 2.

$p < .001$, $\eta^2 = 0.27$). To decode the interaction, two paired t-tests using Bonferroni corrections for multiple testing with $\alpha = 0.025$ were carried out. At low intensity, sad faces were identified correctly more often than angry faces (t (88) $= -3.57$, $p = .001$). At high intensity, there was no significant difference in correct answers between the two emotions (t (88) $= 1.90$, $p = .060$).

In Fig. 2, number of correct answers for each emotion at both intensities are shown separately for BPD patients in the TSST and P-TSST group and for HC in the TSST and P-TSST group. A more detailed analysis of results is presented in the supplementary material.

There was no significant correlation between Borderline Symptom severity as measured by the BSL and FER variables, all $p > .1$.

4. Discussion

We investigated the effects of psychosocial stress on facial emotion recognition (FER) in female BPD patients and healthy women. As expected, BPD and HC did not differ in FER at baseline, i.e. in the placebo condition. We expected BPD patients to show lower accuracy in detecting angry faces under stress than healthy controls and that this effect would be most pronounced at high emotion intensity. Our predictions were not met, as FER did not significantly differ between groups after the TSST or P-TSST. Both groups recognized emotions better at high intensity. At low intensity, sadness was better recognized than anger. Stress resulted in a significant increase in cortisol and salivary alpha-amylase. BPD patients and HC did not significantly differ in endocrinological responses.

There is evidence that BPD patients do not experience general deficits in FER, but rather subtle impairments or a hypersensitivity to potentially threatening stimuli, such as angry faces (Bertsch et al., 2017). It is possible, that our paradigm might not have been sensitive enough to detect these deficits. Even though, overall power was sufficient, conclusions can only be drawn cautiously, as sample sizes were too small to detect small or medium effects.

Modest cortisol responses in the stress condition raise the question, whether the TSST was stressful enough to reduce FER abilities in BPD patients. One of the most unpleasant components of the TSST is the lack of feedback from the judges, which can be perceived as social rejection and might induce a feeling of failure. Patients with BPD are known to be especially sensitive to rejection (Chapman et al., 2014). According to Colle et al. (2020), the ability to describe mental states of the self and others is compromised in people experiencing a sense of failure. Subjective stress measures before and after TSST also suggest that the TSST

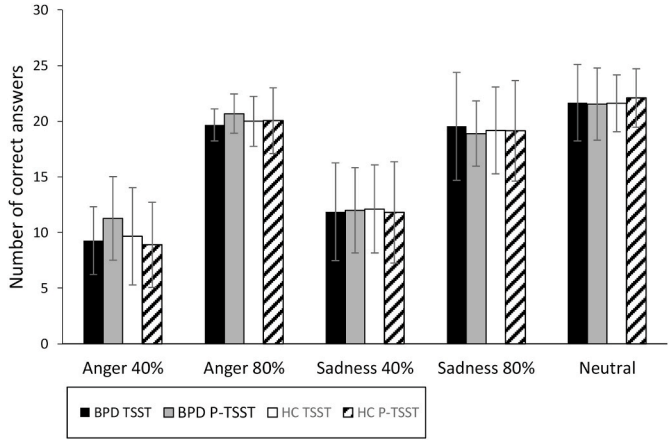

Fig. 2. Number of correct answers (mean ± 1SD) of the facial emotion recognition task. There was a significant main effect for intensity, with emotions at high intensity being detected correctly more often, and an intensity*emotion interaction. At 40% difficulty, sad faces were detected more accurately than angry faces.

was indeed stressful (see supplement p. 4 and 5). There was a significant worsening of mood, and an increase in nervousness after the TSST as measured by the Multidimensional Mood State Questionnaire (MDMQ; Steyer et al., 1997).

Our results replicate and extend findings by Schultebraucks et al. (2016) and Duesenberg et al. (2016), who used similar versions of our FER task. By administering fludrocortisone (Schultebraucks et al., 2016) and hydrocortisone (Duesenberg et al., 2016), they investigated whether an increase in stress hormones, i.e. cortisol, would influence FER in young healthy individuals. In the brain, cortisol binds at two receptors, the mineralocorticoid receptors (MR) and the glucocorticoid receptors (GR). Stimulation of neither of the two types of receptors altered FER performance. In conclusion, it seems that increased cortisol does not influence FER in healthy individuals. The present results extend these findings, as psychosocial stress induction differs in important aspects from the pharmacological approach. In addition to inducing cortisol release via the hypothalamic-pituitary-adrenal axis (HPA-axis), psychosocial stress also activates the sympathetic nervous system, and comprises an interactional and affective component. However, this endogenous stress response did not affect FER in HC or BPD patients. Additionally, BPD patients and HC did not differ in FER at baseline, which is in line with recent studies (Deckers et al., 2015; Niedtfeld, 2017). As reported by Wingenfeld et al. (2018), it seems that cognitive skills, such as emotion recognition, are not impaired in BPD patients. Emotional processes, on the other hand, might be altered by stress.

In contrast to our study, Deckers et al. (2015) used ecologically more valid video stimuli and found enhanced FER after the TSST in BPD patients and HC. However, there is reason to believe that their results might be influenced by practice effects, not the actual ability to recognize emotions. The FER task was taken before and during stress induction, while in front of the judges who told participants “to do better this time”. A no-stress control group was missing. In contrast to Deckers et al.‘s study, participants in our study performed the FER task 65 min after the stressor. By this time point, the rapid stress effects - which are mediated through noradrenergic activation, as well as fast cortisol effects via membrane-bound glucocorticoid receptor activation - might have already worn off (de Kloet et al., 2005). These rapid stress effects are associated with heightened vigilance, alertness, arousal and attention (de Kloet et al., 2005). Instead, the slower cortisol effects might have started, which are responsible for normalizing the HPA-axis and restoration of cognitive control (Joëls et al., 2012). In our former study with the same participants, however, we found significant stress effects on the Multifaceted Empathy Test (MET) that was also performed 65 min after the stressor. Interestingly, these effects were only seen in the emotional part of the MET. Cognitive empathy, which shares some similarities with FER, was unchanged (Wingenfeld et al., 2018; Wolf et al., 2015).

There are some limitations to the study. We only investigated negative emotions, i.e. anger and sadness, and results cannot be generalized to positive emotions. Future research should investigate positive emotions, such as happiness or surprise as well as other BPD-relevant negative emotions, such as disgust. Comorbid psychiatric illnesses are known to affect HPA-axis functioning and subsequent cortisol release in BPD patients (Wingenfeld and Wolf, 2015). For that reason, patients with current major depressive episode were not included. However, many patients had other psychiatric comorbidities, such as PTSD or other anxiety disorders. Additionally, two thirds of the sample was prescribed psychotropic medication at the time of the study. Subgroup sample sizes were too small to conduct subgroup analyses, such as effects of comorbidities or medication on FER, with sufficient power. Explorative analyses, however, revealed that intake of medication or comorbid diagnoses were not associated with stress effects on FER. Additionally, as the study only included female participants, results cannot be generalized to men.

Our results do not support the hypothesis that BPD patients show deficits in FER under psychosocial stress. Future research should use

paradigms that are ecologically more valid, e.g. videoclips using BPD-specific emotions, such as anger and disgust. Additionally, it might be interesting to investigate FER early after a psychosocial stressor.

CRediT authorship contribution statement

Livia Graumann: Writing - original draft, Writing - review & editing, Formal analysis. **Moritz Duesenberg:** Investigation, Data curation, Writing - review & editing. **Sophie Metz:** Investigation, Data curation, Writing - review & editing. **Lars Schulze:** Software, Writing - review & editing. **Oliver T. Wolf:** Conceptualization, Funding acquisition, Writing - review & editing. **Stefan Roepke:** Resources, Writing - review & editing. **Christian Otte:** Conceptualization, Funding acquisition, Writing - review & editing. **Katja Wingenfeld:** Conceptualization, Methodology, Supervision, Project administration, Funding acquisition, Writing - review & editing.

Declaration of competing interest

There are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2020.10.007.

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