Emotion Perception in Borderline Personality Disorder

by

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A thesis submitted in conformity with the requirements for the degree of Master of Arts
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2012

Abstract

Borderline personality disorder (BPD) is a serious mental illness characterized by emotion dysregulation. Symptoms related to emotion are thought to contribute to difficulties in perceiving emotional expressions. Individuals with BPD and demographically matched healthy controls completed a task assessing the recognition of happy, sad, and neutral facial expressions at two intensities. Patients with BPD demonstrated comparable performance on the recognition of very happy and very sad facial expression but were significantly less accurate on neutral expressions. Patients with BPD were also significantly worse in recognizing mildly happy facial expressions, however the severity of current depressive symptoms intervened this relationship. There was evidence that perceptual biases within BPD are unique from mood-congruent biases typically found in major depressive disorder. The findings advance research on the topic of emotion perception in BPD and suggest important new lines of investigation that may be useful for delineating the nature of emotion dysregulation in BPD.
Acknowledgements

I am grateful to many people for their assistance and support on this project. From conception to completion, my graduate advisor and mentor, Dr. Anthony C. Ruocco supported me throughout the long process. Anthony, thank you for keeping me on track, pushing me to think critically, and helping me to become a better writer. My subsidiary advisor, Dr. Konstantine Zakzanis helped shape this project for the better by encouraging me to quantitatively review previous literature on the topic. In doing so, my understanding on the subject matter has increased and new skills in summarizing and analyzing data were acquired. I am also gracious for the helpful comments and support received by Dr. Amanda Uliaszek, my thesis reviewer. This was a thesis committee so well grounded in clinical research that I have gained considerable knowledge throughout the entire process.

This project relied on the teamwork of every single one of the members of the Clinical Neurosciences Laboratory. One person cannot undertake the amount of work that goes into a clinical research study. To the lot of you, I say thank you for your exceptionally hard work and commitment to the projects in the lab. The attitude in the lab was always positive thanks to all of your support and affinity for research.

Friends and family provided an astonishing amount of support and cathartic release throughout the writing of this thesis. I really do appreciate all of the kind words, praise, and constructive feedback that I have received during this year of intense research.
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Chapter 1

1 Introduction

1.1 Borderline Personality Disorder and Emotion Dysregulation

Borderline personality disorder (BPD) is a serious mental illness that affects 1-2% of the general population and is characterized by a pervasive pattern of emotional instability, unstable interpersonal relationships, impulsive aggression, and suicidality (Lenzenweger & Pastore, 2007; Torgersen, Kringlen, & Cramer, 2001). Patients with BPD typically suffer from increased economic hardship and comorbidity with Axis I disorders leading to a disproportionally higher utilization of inpatient psychiatric services (Comtois et al., 2003; Grant et al., 2008). A staggering two-thirds of patients with BPD present with three or more Axis I diagnoses, the most common being major depressive disorder (MDD) and bipolar disorder (BD) (Zimmerman & Mattia, 1999). Prevalence of BPD among psychiatric outpatients is approximately 15% (Torgersen et al., 2001) and this illness is often overlooked and underdiagnosed in many patients (Skodol et al., 2002). Additionally, BPD is associated with a high prevalence of self-injurious behaviour (Clarkin, Widiger, Frances, Hurt, & Gilmore, 1983; McGlashan et al., 2005), suicide attempts (Soloff, Lynch, & Kelly, 2002; Soloff, Lynch, Kelly, Malone, & Mann, 2000; Zisook, Goff, Sledge, & Shuchter, 1994) and completed suicides (Frances, Fyer, & Clarkin, 1986; Paris, Brown, & Nowlis, 1987).

Emotion dysregulation has been hypothesized as the core clinical feature of BPD (Linehan, 1993; Selby & Joiner, 2009). Difficulties with emotion regulation may, at least in part, account for the substantial comorbidity of BPD with mood and other related disorders, as well as their increased risk for suicide. Linehan’s (1993) biosocial developmental model remains a prominent
theoretical framework for describing emotion dysregulation in BPD. Biological predispositions such as a hyperbolic temperament and an emotional vulnerability are hypothesized to lead individuals with BPD to experience a heightened sensitivity to emotional stimuli, experiences of emotions as more intense than other individuals, and slow returns to baseline emotional arousal (Zanarini & Frankenburg, 2007). In conjunction with vulnerabilities, BPD develops in the context of an invalidating environment in which communication of emotional experience is met by erratic, inappropriate, and extreme responses by others. The individual’s emotional behavior is negated, rejected, or dismissed, even though it may be a valid response on the part of the individual (Linehan, 1993). Emotion dysregulation is also theorized to culminate in the development of behavioural dysregulation. In particular, acts that these individuals find difficult to control but are utilized in situations where they seek to shift attention away from unpleasant emotional states (e.g., self-injurious behaviour). Rumination also appears to play a role in BPD and can lead to an amplification of negative affect (Donaldson & Lam, 2004; Lavender & Watkins, 2004) suggesting a second possible link underlying the comorbidity of BPD with MDD. In one study, patients with BPD reported higher levels of rumination compared to individuals diagnosed with MDD (Abela, Payne, & Moussaly, 2003). This result was surprising given the strong and largely specific connection between rumination and depression (Abela et al., 2003; Just & Alloy, 1997).

Research on affective instability and emotional intensity in BPD has provided support for the biosocial developmental model. Individuals with BPD have reported more mood variability throughout the day compared to patients with MDD and healthy individuals (Cowdry, Gardner, O'Leary, Leibenluft, & Rubinow, 1991). Patients with BPD also have shown greater emotional lability with regard to anger, anxiety, and the oscillation between depression and anxiety.
compared to patients with MDD, Bipolar II disorder, and cyclothymia (Koenigsberg et al., 2002). In one experience sampling study that took place over the duration of one month, patients with BPD regularly experienced more extreme changes in hostile, fearful, and sad affect than depressed patients (Trull et al., 2008). Research has also reported a positive correlation between negative emotional intensity in BPD and intense negative emotions following social interactions (Russell, Moskowitz, Zuroff, Sookman, & Paris, 2007). Patients with BPD report greater subjective intensity of negative emotions as compared to healthy controls (Levine, Marziali, & Hood, 1997), and the magnitude of this intensity is strongly associated with severity of BPD symptoms (Cheavens et al., 2005; Rosenthal, Cheavens, Lejuez, & Lynch, 2005; Yen, Zlotnick, & Costello, 2002).

Research from neuroimaging studies generally supports an underlying pathology for emotion dysregulation in BPD. Decreased amygdala and hippocampal volumes have been reported in structural neuroimaging studies of patients with BPD, regions thought to be involved in the regulation of emotional experiences (Driessen et al., 2000; Ruocco, Amirthavasagam, & Zakzanis, 2012; Schmahl, Vermetten, Elzinga, & Bremner, 2003; Tebartz van Elst et al., 2003). Functional neuroimaging studies have demonstrated an altered baseline metabolism in limbic and paralimbic regions linked to emotion generation in response to stressful challenges (Schmahl et al., 2006). In addition, functional neuroimaging studies have found heightened reactivity to negatively valenced pictures in the cingulate, insula, and dorsolateral prefrontal cortex of patients with BPD when compared to healthy controls (see Ruocco, Amirthavasagam, Choi-Kain, & McMain, 2012). Koenigsberg and colleagues (2009) noted that patients with BPD utilized different brain areas, an action-prone system, while looking at negatively valenced images compared to the less reactive system used by controls. These results led the authors to
hypothesize that emotion dysregulation has downstream influences on emotion perception in BPD, which may have implications for the appropriateness of social behavior and interpersonal interactions in these patients. Perhaps most critical for this process is the role of the prefrontal cortex in differentiating negative expressions of emotion (Adolphs, 2002; Hariri, Bookheimer, & Mazziotta, 2000; Narumoto et al., 2000). Recent neuroimaging studies have provided evidence of a dysfunction of prefrontal systems during negative emotion processing in BPD (Koenigsberg et al., 2009; Ruocco, Medaglia, Ayaz, & Chute, 2010). Understanding how individuals with BPD perceive emotions may provide new avenues of research that can implicate brain areas involved in the neuropathology of BPD. To facilitate regulation of emotional responses to evocative stimuli, the ability to control attention while in contact with these stimuli is necessary (von Ceumern-Lindenstjerna et al., 2010). If emotionally valenced stimuli are perceived in a hyperarousing or hypervigilant manner in BPD, disengaging one’s attention from emotional stimuli becomes more difficult due to emotion dysregulation (Linehan, 1993). Whether the recruitment of additional attentional resources leads to benefits or deficits in the perception of emotionally valenced stimuli within BPD, however, remains to be fully clarified.

1.2 Measuring Emotion Perception Difficulties in BPD

Individuals with BPD have been described as highly vigilant to social stimuli, especially for social cues that might signal social threat or rejection (Linehan, 1995). Patterns in visually recognizing and identifying emotional facial expressions may hold clues as to whether individuals with BPD receive added benefits or consequences from their heightened sensitivity to such stimuli. Recognition of six basic emotional expressions (happiness, sadness, fear, disgust, anger, surprise) has been argued to be universal across cultures because of the highly salient and evolutionary significant information they contain (Ekman, 1992; Ekman, Levenson, & Friesen,
Many psychiatric conditions have been associated with deficits in emotion recognition, including MDD, BD, schizophrenia, panic disorder, generalized anxiety disorder, obsessive-compulsive disorder, and social phobia, among others (Bolte & Poustka, 2003; Corcoran, Woody, & Tolin, 2008; Derntl, Seidel, Kryspin-Exner, Hasmann, & Dobmeier, 2009; Feinberg, Rifkin, Schaffer, & Walker, 1986; Kohler et al., 2003; Rector, Daros, Bradbury, & Richter, 2012). Accurate emotion recognition serves as a cognitive cornerstone for appropriate social functioning and the capacity to recognize internal states from external cues may be important for promoting empathy, trust, and prosocial behavior (Marsh, Kozak, & Ambady, 2007). In turn, enduring misinterpretations due to inaccurate recognition are likely to result in emotional disturbances, inadequate social behavior, and impaired social functioning in a variety of psychiatric disorders.

While the literature on emotion perception research is vast, three main aspects of facial emotion perception have frequently been studied in BPD (see Table 1). The first can be labeled emotion recognition and is usually measured by presenting a series of single photographs of emotional facial expressions and having the respondent ascribe a particular emotion to the stimulus in some fashion. Photographs typically remain static rather than progressively morphed and they primarily employ prototypic expressiveness for each emotion displayed (i.e., 100% expressiveness). A second method used to measure emotion perception has frequently been termed emotion discrimination in which respondents are asked to distinguish between two emotions. One variation of this experimental design presents a single photo containing, for example, 40% anger and 60% happiness, and then asks participants to state which emotion they see (e.g., Domes et al., 2008). A further design presents two stimuli at the same time and asks the participant to determine which face shows more emotion. This second design has more flexibility
in that the participant can be presented with a combination of a neutral face and an emotional face, two faces displaying negative emotions, or one face with a positive expression and the other with a negative expression. Finally, a third test of emotional perception involves the acuity of or threshold for perceiving emotions. These tasks typically present a neutral face first, which is then followed by an incremental blend of a target emotional expression, which represents a successive approximation of the target emotion from mild to more extreme representations of this expression. The respondent is asked to stop the progression of morphs when they are certain that they perceive an emotion in the face and can articulate that emotion. An alternate variant of this task randomly presents individual stimuli at different levels of blending of emotions (e.g., 50% neutral/50% target emotion; 10% neutral/90% target emotion).

A variety of facial emotion stimulus sets have been developed to study emotion recognition in healthy individuals and patients with psychiatric illnesses. Most emotion recognition studies of BPD utilized Ekman and Friesen’s (1976) Pictures of Facial Affect (POFA), which includes 14 actors (eight female and six male) and their portrayal of six basic emotions (happy, sad, angry, fear, disgust, and surprise) and neutral facial expressions. Many researchers favour the POFA because these photographs have been rated by large normative groups and can be reliably identified in a number of cultures with agreement rates often close to 100% in Western societies (Ekman, 1992). There are, however, several drawbacks to using the POFA, including a high ceiling and a lack of ethnic diversity of the actors (all Caucasian), although a more diverse set of faces has been developed (i.e., Japanese and Caucasian Facial Expressions of Emotion, or JACFEE; Ekman and Matsumoto, 1992). The JACFEE collection consists of 56 colour photographs portraying each of the seven emotional categories as in the POFA. These stimuli comprise an equal number of male and female actors as well as Caucasian and Japanese actors.
An abbreviated recognition task is the Fear-Anger-Neutral (FAN) test, which was designed to target the more difficult discrimination of negative and neutral facial expressions (Gur et al., 2002; Schneider et al., 2006). A more recently developed set of standardized facial emotion stimuli is contained within the Penn Emotion Recognition Task (ER40) (Gur et al., 2002; Kohler, Turner, Gur, & Gur, 2004), which consists of 40 stimuli displaying five emotions: happy, sad, anger, fear, and neutral (termed “no emotion”). Advantages of the ER40 are that it contains ethnically diverse actors and exists in a completely standardized and computerized form. The POFA and JACFEE, on the other hand, must be assembled into an experimental paradigm by individual investigators, the specific parameters of which may differ across studies. Importantly, these tests depict emotional stimuli at 100% expressivity (i.e., the prototypic expression) as opposed to blending or morphing two emotions together into more emotionally ambiguous facial expressions.

1.3 Emotion Recognition in BPD

Several studies have demonstrated that patients with BPD may be less accurate than non-psychiatric comparison participants in their recognition of negative facial emotions, including anger, fear, disgust, and sadness (Bland, Williams, Scharer, & Manning, 2004; Dyck et al., 2009; Levine et al., 1997; Unoka, Fogd, Fuzy, & Csukly, 2011). These findings were initially thought to reflect a more generalized deficit in the perception of negative emotions in BPD. Other research, however, indicated that these patients may be less accurate in recognizing faces showing no emotion (i.e., neutral) (Wagner & Linehan, 1999) as well as surprised facial expressions (Lynch et al., 2006). These findings could not be explained by a speed-accuracy tradeoff for patients with BPD (Dyck et al., 2009; Merkl et al., 2010; Minzenberg, Poole, & Vinogradov, 2006). Contrary to these studies were a smaller number of investigations which
suggested that patients with BPD may actually be more accurate in their recognition of fearful (Merkl et al., 2010; Wagner & Linehan, 1999) and surprised facial expressions (Unoka et al., 2011). Perhaps more consistent, however, is the finding of no significant emotion recognition deficits in patients with this illness (Dyck et al., 2009; Lynch et al., 2006; Minzenberg et al., 2006; Robin et al., 2012; von Ceumern-Lindenstjerna et al., 2007). Based on these results, it remains unclear whether patients with BPD indeed show deficits in facial emotion recognition, and if they do, whether these deficits might be limited to specific categories of emotion.

Diagnostic comorbidity with BPD may have a significant impact on facial emotion recognition capacities. Given that mood disorders are prevalent in patients with BPD (Zimmerman & Mattia, 1999), the contribution of mood state to biases in emotion perception is important to consider in this population. For example, patients with MDD show mood-congruent biases in facial emotion recognition as well as in their memory for emotion words (Murphy et al., 1999; Watkins, Vache, Verney, Muller, & Mathews, 1996). Studies of facial emotion recognition have reported no differences in accuracy or reaction time (RT) for patients with BPD in regards to comorbid psychiatric conditions (Bland et al., 2004; Domes et al., 2008; Dyck et al., 2009; Robin et al., 2012; Unoka et al., 2011), while other investigators chose to exclude patients with current depression to avoid this confound altogether (Dyck et al., 2009; Merkl et al., 2010; Minzenberg et al., 2006). Unfortunately, the results of mood rating scales were not reported in most emotion recognition studies of BPD, making it difficult to understand the contributions of patients’ current mood to emotion perception deficits in these studies.

To shed light on this inconsistency, Domes and colleagues (2009) provided a comprehensive narrative review on the topic of facial emotion perception in BPD, concluding that these patients may show subtle impairments in labeling emotional expressions along with a tendency to
perceive emotionally ambiguous faces (i.e., neutral ones) more negatively. A negative perceptual bias is consistent with previous research demonstrating a heightened negative perception of other persons in BPD (Arntz & Veen, 2001; Wagner & Linehan, 1999) and in over-attributing anger to ambiguous facial stimuli (Domes et al., 2008), which could reflect an anticipation of interpersonal rejection or social threat. The results of a recent meta-analysis on emotion recognition in BPD suggests that these individuals may have selective deficits in the recognition of neutral (no emotion), disgust, and angry facial expressions, although there is some evidence to suggest a more generalized difficulty recognizing negatively valenced emotions (Daros, Zakzanis, & Ruocco, 2012).

1.4 Emotional Acuity in BPD

Neuroimaging research on individuals with BPD has found increased metabolic brain reactivity to negatively valenced pictures accompanied by slower returns to baseline, suggesting a hypervigilant response when compared with healthy controls (Herpertz et al., 2001; Koenigsberg et al., 2009). If BPD patients are acutely sensitive (i.e., hypervigilant) to emotional stimuli they should recognize emotions at lower thresholds when compared to healthy individuals. One way of testing this hypothesis incorporates the use of morphing tasks, in which emotional stimuli are morphed from neutral to full expressivity. Three studies used similar methodological designs to test emotional acuity in BPD. Each presented a series of morphed stimuli in order from 0% (neutral) to 100% (emotion) in 5% increments. Participants were instructed to press a stop button when they felt they were aware of the emotion the face was beginning to show. This instruction was intended to reduce false alarms. Stopping the sequence and then giving the correct answer for the emotion provided a detection threshold based on the increment value. The increment value was then averaged for multiple presentations of six basic emotions (happy, sad, anger,
fear, disgust, and surprise) (Domes et al., 2008; Jovev et al., 2011; Lynch et al., 2006). Emotion sensitivity was therefore operationally defined as the ability to recognize emotion at lower levels of intensity and it was expected that individuals with BPD would exhibit this pattern of response.

In two studies of emotion sensitivity, a comparable detection threshold was found in patients with BPD and healthy controls (Domes et al., 2008; Jovev et al., 2011), while a third study demonstrated emotion sensitivity (i.e., lower detection threshold) in patients with BPD that was consistent for each of the six basic emotions, including happiness (Lynch et al., 2006). Furthermore, Lynch and colleagues (2006) found that this hypersensitivity to emotional expressions was not associated with impulsivity and inaccurate responding in the BPD group. Given that the stimuli were not randomly presented but morphed starting from neutral, impulsiveness could still play a role in patients’ response styles on this task. Overall, the results of these studies provide mixed findings for the nature of recognition at milder intensities of emotion in BPD and how this is related to emotional sensitivity.

1.5 Limitations of Previous Research

There are several limitations to previous studies of emotion perception in BPD. First, most patient samples contained high levels of diagnostic comorbidity, particularly with mood and anxiety disorders. Very few of these studies incorporated symptom rating scales at the time of testing to evaluate possible state-related biases in emotion perception. Second, given that many studies used the POFA, it is important to consider ceiling effects associated with these stimuli and the lack of ethnically diverse actors. Third, although patients with BPD have been shown to be less accurate than healthy individuals in recognizing specific facial displays of emotion, most patients were at or above 80% accuracy on these tasks. This suggests a subtle deficit as opposed to a frank impairment in emotion recognition. Fourth, the instructional sets used for facial
emotion recognition tasks are important to consider as they may impact the relative emphasis given to accuracy versus speed, which could lead to systematic biases in test findings. Although most emotion perception studies place an emphasis on both speed and accuracy, patients with BPD might employ a strategy that maximizes the quickness of their responses while sacrificing accuracy. The results of our recent meta-analysis on this topic, however, suggests that this is likely not the case, as patients were found to be both slower to respond to stimuli and less accurate in their performances (Daros et al., 2012). Nevertheless, future work should consider the effects of emphasizing accuracy over speed, or allowing unlimited time to respond, to determine whether patients with BPD show these subtle deficits in facial emotion perception under different task conditions.

1.6 The Present Study
The current study seeks to clarify the manner in which individuals with BPD respond to positive, neutral, and negative facial expressions by taking advantage of a computerized test that assesses the recognition of emotional facial stimuli presented to participants. This test effectively combines two areas of perception research (emotion recognition and acuity) because it determines if participants can recognize and classify varying intensities of three facial expressions (happy, neutral, and sad). Therefore, it will illuminate the ways in which patients with BPD may interpret milder expressions of happiness and sadness, as well as examine full-threshold stimuli. A significant limitation of previous research is that the error patterns on neutral stimuli are not reported, making it difficult to determine whether BPD patients are misattributing a positive or negative emotion to these faces. The current study will provide a detailed assessment of these responses to determine if there are any systematic biases in BPD patients’ responses to these trials. Given that most research on emotion perception in BPD has not
examined the relationship of mood state with performance on emotion tasks, the current study will also examine the potential contribution of current depressive symptomatology on emotional acuity in BPD.

The specific hypotheses for this study are as follows: (1) Patients with BPD will not differ from healthy controls in the recognition of very expressive happy and sad faces, however, accuracy at recognizing neutral expressions is expected to differ significantly, in concordance with earlier meta-analytic findings. (2) Current mood state, particularly in the form of depressive symptoms, is expected to be significantly associated with emotion recognition performance in patients with BPD. This finding was expected to relate only to emotions of positive valence (i.e., very happy and mild happy expressions) given that mood-congruent biases demonstrated by clinically and non-clinically depressed samples typically involve decreased recognition accuracy on positive emotions (Bourke, Douglas, & Porter, 2010; Gray et al., 2006; Surguladze et al., 2004). (3) Finally, it was expected that BPD would report negative emotional expressions for faces displaying no emotion (i.e., neutral faces) consistent with literature reporting a negative bias upon viewing neutral facial stimuli (Dyck et al., 2009; Wagner & Linehan, 1999). In addition to these specific hypotheses, exploration was planned to determine whether emotion sensitivity could be demonstrated using the measures in the study.
Chapter 2

2 Method

2.1 Participants

As part of a larger study of neurocognitive functioning in individuals with BPD, participants were enrolled through the Clinical Neurosciences Laboratory at the University of Toronto Scarborough. They were recruited from the Borderline Personality Disorder outpatient clinic at the Center for Addiction and Mental Health as well as through online and print advertisements in Toronto, Canada. Participants were selected for inclusion in this study if criteria were met for BPD according to the Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 2000). Additional inclusion criteria for BPD patients were as follows: at least 18 years old at the time of recruitment, English-speaking, and able and willing to provide written informed consent to participate in this study. Exclusion criteria included a history of schizophrenia or any psychotic disorder, bipolar I disorder, current alcohol or non-alcohol substance use disorder, lifetime eating disorder requiring hospitalization, mental retardation (IQ < 70), any neurological or severe somatic disorder, and significant head trauma.

Healthy controls were matched to patients with BPD by age, gender, and education. They were recruited from the community through print and online advertisements. Inclusion criteria for healthy controls were the following: at least 18 years old at the time of recruitment, English-speaking, and able and willing to provide written informed consent. Exclusion criteria included any personal or family history (first- and second-degree relatives) of psychiatric illness, medical and neurologic illness that could affect brain functioning (e.g., hypothyroidism, seizure disorder,
dementia), significant head trauma, and a history of learning or developmental disorders (e.g., attention-deficit disorder, autism).

This study received approval from the Research Ethics Board at the Centre for Addiction and Mental Health and the University of Toronto. Potential participants completed an initial phone screen to assess the inclusion and exclusion criteria. Eligible individuals were invited to visit the University of Toronto Scarborough where all procedures took place. After a complete description of the study, individuals provided written informed consent to participate in the research protocol. Participants were required to provide a negative urine toxicology screen on the day of testing before completing the laboratory procedures. They were compensated up to $100 for their participation.

2.2 Measures

All participants completed semi-structured diagnostic interviews administered by bachelor- and doctoral-level diagnostic interviewers trained to reliably administer these measures and were directly supervised by a licensed clinical psychologist (ACR). Interviews were conducted without knowledge of the status of the recruited individual (i.e., whether they were a patient or healthy control). Narratives for each participant were prepared based on all of the available information obtained during the interviews and discussed in a diagnostic consensus meeting with multiple diagnostic interviewers in attendance.

2.2.1 Diagnostic Interviews

The Structural Clinical Interview for DSM-IV Axis I Disorders, Patient Edition (SCID-I/P; First, Spitzer, Gibbon, & Williams, 2002) is a diagnostic interview to assess major psychiatric disorders in terms of categorical constructs. Multiple studies have found the reliabilities of Axis I
diagnoses to be good, although there are differences based on the psychiatric condition (e.g., Lobbestael, Leurgans, & Arntz, 2011; Skre, Onstad, Torgersen, & Kringlen, 1991). The SCID-I/P has also demonstrated superior validity over other standard interviews at clinical intake sites (e.g., Basco et al., 2000; Fennig, Naisberg-Fennig, Craig, Tanenberg-Karant, & Bromet, 1996).

The Structured Interview for DSM-IV Personality (SIDP-IV; Pfohl, Blum, & Zimmerman, 1997) is a reliable, semi-structured interview designed to assess for DSM-IV Axis II disorders with good interrater reliability and validity (Jane, Pagan, Turkheimer, Fiedler, & Oltmanns, 2006). In accordance with the test manual, a personality disorder diagnosis was made when the diagnostic criteria were met for at least the past five years and did not occur exclusively during the course of an Axis I disorder.

2.2.2 Self-Report Measures

Severity of current depressive symptoms was assessed by the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996), a 21-item scale with ratings from zero to three. Responses are summed to reflect the severity of depression over the past two weeks. The BDI-II has demonstrated good reliability and validity in clinical samples (A. T. Beck, Steer, Ball, & Ranieri, 1996).

2.2.3 Neuropsychological Measures

The Victoria Symptom Validity Test (VSST; Slick, Hopp, Strauss, & Thompson, 1997) is a test used to measure the level of effort participants put forward during the testing session. Unusually poor performance on this task may reflect poor effort, deliberate feigning, exaggeration of real cognitive deficits, or any combination of the above. Participants were included only if their
VSVT scores were within the valid range based on normative data.

To rule out any discrepancies based on intelligence that may arise on emotion perception tasks, all participants completed the Wechsler Test of Adult Reading (WTAR; Wechsler, 2002), designed as a tool for estimating intellectual functioning (IQ) of adults aged 16-89. The WTAR is normed on a nationally representative, stratified American sample, has excellent test-retest reliability, and extensive research supporting its validity.

The Benton Facial Recognition Test, Short Form (BFRT; Benton, Sivan, Hamsher, Varney, & Spreen, 1983) was used to evaluate basic facial recognition capacities. The BFRT requires participants to match a target face with up to three pictures of the same person in a six-stimuli array of faces that vary in terms of angles and lighting. Short form scores were transformed into full-scale age-corrected scores using normative data provided in Benton et al. (1983).

2.2.4 Penn Emotional Acuity Test

The Penn Emotional Acuity Test (PEAT) is a subtest of the University of Pennsylvania Computerized Neurocognitive Test Battery (PennCNP) and is described as a “measurement of emotional recognition and discrimination” (Erwin et al., 1992; Gur et al., 1992; Gur et al., 2002). The PEAT presents 40 faces, one at a time, composed of variably happy, sad, and neutral faces balanced for gender (Sachs, Steger-Wuchse, Kryspin-Exner, Gur, & Katschnig, 2004). The presentation takes place in two randomly presented blocks, the first of which contains sad and neutral faces (sad-neutral block) and the second contains happy and neutral faces (happy-neutral block). The instructions are as follows: “In this test you will see some faces. Look carefully at each face and decide if the face is happy, sad, or neutral. Use the seven-point scale you see below to indicate your rating.” The seven-point Likert scale is forced-choice and consists of the
following options: very happy, moderately happy, slightly happy, neutral, slightly sad, moderately sad, and very sad. There is a brief practice session of five faces that follows the instructions and precedes the forty trials. Outcome measures include the accuracy and RT for overall performance and five collapsed emotion categories: very happy, mildly happy, neutral, mildly sad, and very sad. In addition, responses per item were compiled to determine average deviations from the correct score.

2.3 Statistical Plan

Differences between groups were assessed using Chi-square and independent samples t-tests. A demographic matching process was used and therefore groups were not expected to significantly differ in terms of age, gender, education, intelligence, or accuracy on the BFRT. Accuracies and RTs were considered for six variables on the PEAT, the overall total and subcategories of very happy, mildly happy, neutral, mildly sad, and very sad. An independent samples t-test was used to examine performance differences for the overall PEAT statistics. A 2 X 5 MANOVA (group x emotion categorization) was used along with independent samples t-tests to determine significant differences between groups for subcategories of accuracy. Answers on the PEAT were then arranged into a response matrix to determine whether the response patterns differed between groups. The interpretation of significant group differences was aided by the calculation of Cohen’s $d$, measured as the difference between the two raw means divided by the pooled standard deviation (SD). Cohen (1988) provided guidance for interpreting effect size statistics ($d$) as small (0.2), medium (0.5) and large ($\geq 0.8$).

Secondary analyses explored the relationship of current moods and performance on the PEAT. Pearson’s and Spearman’s correlations were utilized to determine the relationships between variables (e.g., the relationship between overall score on the PEAT and BDI scores). The
contribution of Axis I comorbid diagnoses were examined using t-tests for within-group patient comparisons. Multiple regressions were used to test whether mediation was occurring in the relationship between BPD and emotion perception performance. Consideration to the assumptions of normality and heterogeneity were undertaken using a variety of statistical tests. Variables were analyzed for normality using the Shapiro-Wilk test. Differences between groups were tested under the assumption of non-normality using non-parametric tests such as the Mann-Whitney U and Kruskal-Wallis in order to determine if the direction of significance would be affected. Finally, Spearman’s correlations were used to determine if ranking the data would significantly alter its association with other variables under an assumption of non-normality.
Chapter 3

3 Results

3.1 Demographic and Clinical Characteristics

Demographic information for the BPD patient sample and IQ- and demographically-matched healthy controls is presented in Table 2. There were no differences between the groups in age, gender, education or IQ. Patients with BPD and healthy controls performed within the average range with regard to single-word reading (WTAR) and facial recognition (BFRT). With regard to clinical characteristics, patients with BPD were more depressed than controls, reporting moderate levels of depression on average ($M = 27.03$, $SD = 9.76$) on the BDI (Beck et al., 1996).

At the time of the study, 89.3% of the patient sample had a history of inpatient hospitalization. Most patients (89.3%) had completed one or more outpatient treatment programs. Current rates of psychotropic medication use among patients were as follows: sedatives (34.5%), stimulants (13.8%), minor tranquilizers (6.9%), antidepressants (62.1%), neuroleptics (10.3%), and mood stabilizers (20.7%). Table 3 lists the frequencies of Axis I comorbidities for individuals with BPD. The most common comorbid condition was MDD, with a substantial proportion of patients in a current episode (40.0%). Other remarkable diagnostic comorbidities included a history of past substance dependence (33.3%), PTSD (30.0%), eating disorders (26.3%), and anxiety disorders (23.3%).

3.2 PEAT Accuracy

The total correct (TC) score on the PEAT was calculated using individual answers collapsed into five categories of response: very happy (VHC), mild happy (MHC), neutral (NC), mild sad (MSC), and very sad (VSC). Following the scoring guidelines for this task, the two most extreme
categories of emotion stimuli comprised two levels of intensity (“very” and “moderately”) that were combined into one category (“very”). Responses to all stimuli corresponding to these two intensities were scored as correct if either response was selected.

Overall, patients with BPD were less accurate than controls on the PEAT, \( t(55) = -2.92, p = .005, d = .77 \). A MANOVA examining differences for patients and controls by emotional intensity category (VHC, MHC, NC, MSC, VSC) was statistically significant, \( F(5,51) = 3.19, p = .01 \). Post-hoc t-tests revealed comparable accuracy between patients and controls for the categories VHC, MSC, and VSC (all \( p’s > .55 \); see Table 4). Patients did, however, score significantly worse on NC \( (t(55) = -2.26, p = .03, d = .60) \), and MHC \( (t(55) = -2.38, p = .02, d = .63) \) when compared to controls.

To explore the patterns of errors that patients with BPD made for each of the emotional intensity categories, a classification matrix was generated that presents the frequency with which each response was selected for each respective category of stimuli (see Table 5 and Figure 1). BPD patients were more than three times more likely to perceive MHC stimuli as more extreme (i.e., selecting VHC) than healthy controls. For the NC category, patients appeared to perceive any emotion (i.e., this finding was not valence-specific) by selecting either MHC or MSC for these trials.

### 3.3 Analysis of Current Mood

BDI scores were moderately and significantly correlated with lower overall accuracy on the PEAT \( (r = -0.43, p = .001) \), suggesting that more severe current depression is associated with poorer recognition of emotional intensities, at least with regard to happy, neutral and sad facial expressions. Given that BPD is also associated with increased depressive symptomatology,
mediation analyses were explored to understand the role of current depression in possibly mediating the relationship between group status (i.e., patients versus control) and overall performance accuracy on the PEAT. Following the guidelines presented in Baron and Kenny (1986), multiple regression analyses were performed using TC on the PEAT as the dependent variable in relationship to group status and BDI score. The variables TC, group status, and BDI total were significantly correlated with each other (Figure 2A). In Step 1 of the mediation model, the regression of TC on BPD status, without including the possible mediator of current depression, was significant, $\beta = -2.67$, $t(55) = -2.92$, $p = .005$. Step 2 demonstrated that the regression of TC on current depression also was significant, $\beta = -0.10$, $t(55) = -3.34$, $p = .002$. Step 3 of the mediation analysis demonstrated that current depression, controlling for BPD status, was no longer statistically significant, $\beta = -0.11$, $t(55) = -1.75$, $p = .09$. The results of this analysis did not satisfy the requirements of mediation and therefore the association between BPD diagnosis and poorer overall recognition accuracy on the PEAT did not appear to be mediated by current depression severity.

When the same process was followed above for NC as the dependent variable, mediation status was not achieved (Figure 2B). On the other hand, depression was found to be a significant mediator of the relationship between group status and poorer accuracy on MHC (see Figure 2C). In Step 1 of the mediation model, the regression of BPD status on MHC status, without including the possible mediator of current depression, was significant, $\beta = -0.67$, $t(55) = -2.38$, $p = .02$. Step 2 demonstrated that the regression of current depression on MHC was also significant, $\beta = -5.07$, $t(55) = -3.06$, $p = .003$. Step 3 of the mediation analysis demonstrated that current depression, controlling for BPD status, was significant, $\beta = -0.04$, $t(55) = -2.00$, $p = .05$ and that the effect of the original variable, BPD group status, was no longer significant ($\beta = 0.34$, $t(55) =$
Sobel’s test statistic confirmed the finding of mediation for MHC, $t = 2.47$ ($p < .01$).

### 3.4 Secondary Analyses

#### 3.4.1 Reaction Time

To achieve normality, RT data were transformed using a square root function of the raw data. Additionally, three outliers were removed from the patient sample because their scores were more than three standard deviations above the mean. Although there were no significant differences with respect to RT, $F(1,55) = 0.14$, $p = .71$, analysis of standardized effect sizes revealed that patients with BPD were faster, on average, across correct trials for all emotional intensities and valences, $t(52) = -0.46$, $p = .67$, $d = .12$ (Table 6). The largest differences were seen on VSC trials ($d = .38$) and MHC ($d = .28$).

#### 3.4.2 Comorbidity and Psychotropic Medications

There were no differences in overall PEAT accuracy between patients with current MDD and those without, $t(28) = -0.07$, $p = .94$. Similarly, neither a history of PTSD nor substance dependence was associated with overall performance differences on the PEAT (all $p$’s $> .16$). Patients currently using antidepressant medication were significantly less accurate in recognizing VHC, $t(27) = -2.43$, $p = .02$, and VSC facial expressions, $t(27) = -2.06$, $p = .05$, as compared to those not currently taking these medications.
Chapter 4

4 Discussion

The present study utilized an established test to determine how patients with BPD and healthy individuals perceive emotions corresponding to three valences (happy, neutral, and sad) in both mild and more extreme intensities. This study advanced previous research by accounting for current mood state and comparing error patterns made by both BPD patients and healthy controls. Groups were tightly matched on age, education, gender, and IQ. The patient sample was clinically stable but reported more symptoms of depression than controls, which fell within the moderate range of severity (Beck et al., 1996).

Several important findings were revealed with the PEAT, a measure of emotion recognition for happy, neutral, and sad facial expressions at varying levels of emotional intensity. Overall accuracy on the task differed significantly between the groups, with healthy controls performing more accurately than patients with BPD. Further inspection of the emotional intensities revealed that patients were less accurate in recognizing mildly happy and neutral stimuli. On the other hand, patients with BPD showed comparable levels of recognition accuracy for the emotions at 100% intensity (i.e., very sad and very happy). These results are consistent with a recent meta-analysis in which patients with BPD were not found to significantly differ from controls in the recognition of happy and sad expressions (at 100% intensity), but a large effect size difference for reduced accuracy in recognizing neutral faces (Daros et al., 2012). This difficulty in recognizing neutral expressions in patients with BPD has now been replicated across multiple studies using a variety of methodologies. Several studies on emotion recognition have found decreased accuracy on neutral facial expressions specifically (Bland et al., 2004; Dyck et al.,
In addition, previous research suggests that patients with BPD have more trouble understanding mixed valence feelings and have an inability to synthesize both positive and negative feelings about themselves and others (Levine et al., 1997). Individuals with BPD are also known to misinterpret ambiguous social cues more negatively (Wagner & Linehan, 1999) and process neutral information in a negatively biased way (Meyer, Pilkonis, & Beevers, 2004). Collectively, the findings of the present study support the notion that patients with BPD misinterpret neutral stimuli and are more likely to ascribe a particular valence to them.

This study is among the first to characterize the pattern of errors patients with BPD made on the PEAT. For mildly happy stimuli, patients with BPD were more likely to select a response in the direction of a higher intensity of happiness. Patients were more likely than controls to select mildly happy or mildly sad responses to neutral faces as compared to healthy controls. This latter finding was not specific to a particular valence, which was unexpected given that individuals with BPD are thought to process neutral stimuli in a more negatively biased manner (Dyck et al., 2009; Korfine & Hooley, 2000; Levine et al., 1997; Meyer et al., 2004; Wagner & Linehan, 1999). Specifically, two previous studies of emotion recognition in BPD found evidence for a negative perceptual bias for neutral stimuli, although the response options did not include milder intensities of emotions (Dyck et al., 2009; Levine et al., 1997). The misperception of neutral stimuli as being more positive or negative suggests that patients with BPD may not necessarily have a bias towards a specific emotional valence (i.e., they may show an affectively non-specific perceptual aberration for neutral faces). This non-specificity with regards to selection of emotional valence may reflect the increased tendency that individuals with BPD experience emotional extremes of both valences (Buie & Adler, 1982). Moreover, the emotional sensitivity
that underlies many behaviors in BPD may cause individuals with this illness to overreact to even minor emotional events, and the task of being confronted with salient emotional (or non-emotional) faces could lead them to become emotionally unstable and perceive emotions in faces that healthy individuals do not (Lynch et al., 2006).

Prior research on the topic of emotion recognition in BPD is limited to the extent that current mood state was not reported and could account for emotion perception in biases associated with this disorder. As previously mentioned, analyses were carried out to explore whether current depressive symptomatology might mediate the relationship between group status (i.e., BPD versus healthy control) and performance indices on the PEAT. The results of these analyses indicated that current depressive symptomatology mediated this relationship for mildly happy facial expressions but not neutral faces or total accuracy on this task. The finding that depression may account for BPD patients’ reduced accuracy in recognizing mild happy faces is in some ways consistent with documented emotion recognition biases in patient with depression (Gray et al., 2006; Surguladze et al., 2004). These results, however, also depart significantly from research on depressed samples in two ways. First, research on depressed patients (with no personality disorder) suggests that happy faces at 100% intensity would be recognized with less accuracy; however, the moderately depressed BPD patients in this sample recognized these faces with near perfect accuracy, and there was no difference in performance in this respect when we compared currently depressed versus euthymic patients with BPD. Second, reviews on emotion recognition in MDD have generally found a negative bias in depressed individuals where they tend to rate all expressions as less positive or sadder (Bourke et al., 2010). Individuals with BPD did not display the negative perceptual bias that would be expected based on research of depressed individuals. Unexpectedly, these patients were more likely to perceive mild happy
faces as more intensely happy (rather than less neutral or sad). Furthermore, they were equally likely to select positive or negative responses for neutral faces. Consistent with these findings, a previous study found that while patients with BPD showed moderate levels of depression, they were actually more adept at recognizing happy facial expressions than healthy controls (Lynch et al., 2006).

Also contrary to what would be expected in depression, patients with BPD in a previous study were quicker at recognizing facial expressions more generally (across all valences), which could suggest that emotional sensitivity in BPD may be independent of current depressive symptoms (Lynch et al., 2006). In the present study, patients with BPD recorded faster RTs (albeit not significantly) on correct trials regardless of emotional valence. Patients were also particularly fast in recognizing very happy and very sad faces, the latter of which could be associated with a mood-congruent bias for sad faces given that the sample of patients with BPD was moderately depressed at the time of testing. Post-hoc comparison between individuals who were currently depressed versus non-depressed, however, found that there was no significant difference between groups on the RT for very sad stimuli. As further evidence that emotion sensitivity may be uniquely contributing to the pattern of results obtained in the present study, Lynch and colleagues (2006) argue that quick and accurate responding to emotional stimuli in patients with BPD is unlikely to be due to higher depressive symptoms. Previous research has demonstrated that clinically depressed individuals display longer reaction times compared with non-depressed individuals on attention-dependent tasks (Farrin, Hull, Unwin, Wykes, & David, 2003; Thomas, Goudemand, & Rousseaux, 1999). While RTs were not significantly different between groups in the present study, it appears that there is some evidence for emotional sensitivity. Non-significantly faster RTs were present for the BPD group, despite moderate levels of depression in
the BPD group, which suggests the possible influence of emotion sensitivity on the results obtained in the present study (i.e., patients with BPD are able to recognize and/or categorize emotions faster on average).

Diagnostic comorbidity with respect to current MDD, PTSD, or past substance dependence did not appear to account for the performance differences revealed in primary analyses for the PEAT. Current antidepressant medication use, however, was associated with lower accuracy in recognizing very happy and very sad facial expressions. Importantly, there was no difference in severity of current depression for patients taking antidepressants versus those who were not. Nevertheless, it should be noted that patients with BPD were commonly taking more than one psychotropic medication; however, this was difficult to control in order to ensure stability in the patient group during the testing procedures. Research on the effects of antidepressants on emotion recognition is sparse; however, one study has suggested that early reversals in the decreased recognition of happiness after two weeks of antidepressant treatment predicted symptomatic improvement at six weeks in patients with MDD (Tranter et al., 2009). One further study suggests that antidepressant use in patients with MDD may normalize emotion recognition independently of mood state (Anderson et al., 2011). Therefore, patients with MDD may subjectively report depressive symptoms while antidepressants manipulate affective processing systems on a biological basis for improved recognition of emotional expressions (particularly happiness). In the present study, approximately 60% of the patients with BPD were currently taking antidepressants and performed well on the recognition of very happy stimuli. Nevertheless, more research is required in order to understand the effects of antidepressant medications on state-dependent emotion recognition in patients with MDD and BPD.
4.1 Strengths and Limitations

A number of strengths and limitations should be noted as they pertain to the current study. First, the PEAT is limited in that it provides only three emotional valences: happy, sad, and neutral. It would be important to examine other emotions in mild and extreme intensities in a fashion similar to the PEAT, especially given findings of reduced accuracy for facial displays of anger and disgust in patients with BPD (Daros et al., 2012). Importantly, the paradigm employed by the PEAT to measure acuity of emotion recognition provides important information that differs from information obtained from emotion threshold paradigms. The latter puts patients in control of when they subjectively perceive an emotion. This can create problems when recognition rates for each emotion are compared across participants because some patients may have stopped the progression through emotional intensities earlier while others may have stopped the sequence at a higher intensity. The PEAT avoids this by using preset levels of intensity coupled with a forced-choice selection approach rather than stopping a morphing sequence. Also, by virtue of examining emotions at varying levels of intensity (and hence difficulty), the PEAT avoids the ceiling effect common to POFA tasks; no one completed the task in the present study perfectly. A further strength of the PEAT in comparison to emotion threshold paradigms is the use of randomized presentations, which more stringently control for impulsivity. A second limitation of PEAT is the limited number of stimuli in some emotional categories and the large number of neutral stimuli included in this task. An improved design might incorporate more stimuli for the mild and extreme expressions, which could improve the reliability of these more extreme ratings as well as provide a more adequate measure of these emotional intensities for patients with BPD. Third, a larger sample size might have allowed us to examine specific indices of the PEAT with greater statistical power (i.e., RT indices). Fourth, these results do not speak to the specificity of
our findings to BPD as compared to other related diagnostic entities, such as MDD. Comparisons of these findings with individuals diagnosed with MDD may help to strengthen the specificity of our findings regarding mood-state contributions for patients with BPD. Finally, psychotropic medication use was not controlled in the present study and the patients were shown to have been taking a wide variety of medications at the time of testing. It is therefore difficult to know how pharmacologic treatments might impact the present findings.

4.2 Implications and Conclusions

Notwithstanding these limitations, this study provides novel information about emotion perception abilities in patients with BPD. There are both diagnostic and treatment implications based on the findings of this study. Diagnostically, tasks such as the PEAT may be better able to discriminate between patients with BPD, MDD, and comorbid MDD-BPD. Patients with BPD are specifically less accurate in recognizing neutral and patients with MDD appear to be less accurate in recognizing happiness in addition to presenting with a negative bias. Taken together, clinicians and researchers could differentiate between these conditions, in addition to the comorbid diagnosis of MDD-BPD, with an experimentally constructed task rather than self-report or interview measures. With regards to treatment implications, an important aspect of treatment may include understanding and correcting misinterpretations of neutral stimuli. Similar to Aaron T. Beck’s cognitive-behavioural therapy for depression (Beck, Rush, Shaw, & Emery, 1987), individuals with BPD should explore with their therapist their cognitive appraisals regarding neutral and negative information. The patient may also greatly benefit from group discussion involving cognitive restructuring revolving around the interpretation of neutral stimuli. Learning to understand and appropriately respond to neutral facial stimuli may help patients with BPD better regulate their social behavior when in the presence of others.
In summary, the findings of the present study indicated that individuals with BPD show comparable performance with regard to accuracy in recognizing very happy and very sad facial expressions (i.e., 100% intensity) but significantly lower accuracy on neutral expressions as compared to healthy controls. Patients with BPD were also significantly worse in recognizing mildly happy facial expressions and the severity of current depressive symptoms appeared to mediate this relationship. There was no evidence, however, of a negative perceptual bias on the PEAT. That is, BPD patients rated mildly happy stimuli as more intensely happy and neutral stimuli as either mildly happy or sad, suggesting that their perceptual bias is unique from the mood-congruent biases typical in depressed individuals. Finally, there was some evidence BPD patients were faster in recognizing emotions across nearly all emotion categories of emotion and intensity, perhaps providing preliminary evidence for increased emotional sensitivity in BPD. Taken together, these findings advance prior research on the topic of emotion perception in BPD and suggest important new lines of investigation that may be useful for delineating the nature of emotion dysregulation in BPD.
References


### Table 1

**Description of Emotion Perception Tasks**

<table>
<thead>
<tr>
<th>Goal of Task</th>
<th>Emotion Recognition</th>
<th>Emotion Discrimination</th>
<th>Emotional Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Frequent Presentations</td>
<td>Identification of an emotion known from previous experience.</td>
<td>Understanding the difference between one emotion and another.</td>
<td>Determine the sharpness of recognition for emotional intensity.</td>
</tr>
<tr>
<td></td>
<td>(1) Participants are shown series of single photographs of emotional facial expressions and the participant is asked to label the emotion in some fashion. It is important to note that photographs in the typical emotion recognition task are not morphed but remain static.</td>
<td>(1) Presentations with singular photos that blend two emotions (e.g., containing 40% anger and 60% happiness) and asks participants to state which emotion they see. (2) Presentation of two stimuli at the same time probing discrimination between the two facial displays of emotion in various ways. This design is more flexible.</td>
<td>(1) Neutral faces are incrementally blended towards a fully expressive target emotion. The respondent is asked to stop the progression of morphs when they can articulate what emotion is being displayed. (2) An alternate variant of this task randomly presents morphed stimuli at different levels of saturation, the saliency of the emotional expression (e.g., 50% neutral, 50% emotion; 10% neutral, 90% emotion).</td>
</tr>
<tr>
<td>Typical Instructions</td>
<td>“What emotion do you see? How does the person feel?”</td>
<td>“What emotion do you see? Which face displays an emotion? Which face is angrier? Which face displays fear (vs. disgust)?”</td>
<td>“When can you tell me the specific emotion that is forming? When can you start to see an emotion and tell me what emotion that is?”</td>
</tr>
<tr>
<td>Response Styles</td>
<td>Open-ended or forced-choice; paper-and-pencil or computerized</td>
<td>Forced-choice</td>
<td>Forced-choice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Computerized</td>
<td>Computerized</td>
</tr>
</tbody>
</table>
Table 2

Demographic and clinical characteristics of patients with borderline personality disorder and healthy controls

<table>
<thead>
<tr>
<th>Variable</th>
<th>BPD Group (n = 30)</th>
<th>Healthy Controls (n = 27)</th>
<th>Statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Female</td>
<td>93.33 (96.30)</td>
<td></td>
<td>$X^2 = 0.25$</td>
<td>.62</td>
</tr>
<tr>
<td>Age</td>
<td>29.00 (9.34)</td>
<td>27.19 (10.86)</td>
<td>t = 0.67</td>
<td>.50</td>
</tr>
<tr>
<td>Mean yrs. education</td>
<td>13.83 (2.65)</td>
<td>14.93 (1.96)</td>
<td>t = 1.75</td>
<td>.09</td>
</tr>
<tr>
<td>FSIQ (WTAR)$^1$</td>
<td>108.55 (7.91)</td>
<td>110.19 (6.16)</td>
<td>t = 0.86</td>
<td>.40</td>
</tr>
<tr>
<td>BFRT$^2$</td>
<td>47.44 (4.10)</td>
<td>47.37 (5.10)</td>
<td>t = 0.05</td>
<td>.96</td>
</tr>
<tr>
<td>BDI total</td>
<td>27.03 (9.76)</td>
<td>1.63 (2.12)</td>
<td>t = 13.23</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Notes: $M$ = mean; $SD$ = standard deviation.

$^1$ FSIQ = Full Scale IQ, based on the WTAR = Wechsler Test of Adult Reading. Standard scores with $M = 100$, $SD = 15$.

$^2$ BFRT = Benton Facial Recognition Test. Short-form scores converted to age-corrected long-form raw scores.
Table 3

*Clinical characteristics for patients diagnosed with BPD for the present study*

<table>
<thead>
<tr>
<th></th>
<th>BPD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Medicated</td>
<td>75.86</td>
<td>29</td>
</tr>
<tr>
<td>% Antidepressants</td>
<td>62.10</td>
<td>29</td>
</tr>
<tr>
<td>% Mood Stabilizers</td>
<td>20.70</td>
<td>29</td>
</tr>
<tr>
<td>% Sedatives</td>
<td>34.48</td>
<td>29</td>
</tr>
<tr>
<td>% Stimulants</td>
<td>13.79</td>
<td>29</td>
</tr>
<tr>
<td>% Neuroleptics</td>
<td>10.34</td>
<td>29</td>
</tr>
<tr>
<td>% Minor Tranquilizers</td>
<td>6.90</td>
<td>29</td>
</tr>
<tr>
<td>% Major Depression, Past</td>
<td>40.00</td>
<td>30</td>
</tr>
<tr>
<td>% Major Depression, Current</td>
<td>40.00</td>
<td>30</td>
</tr>
<tr>
<td>% PTSD, Past</td>
<td>20.00</td>
<td>30</td>
</tr>
<tr>
<td>% PTSD, Current</td>
<td>10.00</td>
<td>30</td>
</tr>
<tr>
<td>% Substance Dependence, Past</td>
<td>33.33</td>
<td>30</td>
</tr>
<tr>
<td>% Dysthymia</td>
<td>13.33</td>
<td>30</td>
</tr>
<tr>
<td>% Any Anxiety Disorder, Current</td>
<td>23.33</td>
<td>30</td>
</tr>
<tr>
<td>% Eating Disorder, Past</td>
<td>26.33</td>
<td>30</td>
</tr>
</tbody>
</table>

Note: One patient’s data was incomplete regarding medication use.
### Table 4

*Accuracy results from the PEAT for BPD and HC*

<table>
<thead>
<tr>
<th>Variable</th>
<th>BPD (n = 30)</th>
<th>HC (n = 27)</th>
<th>t(55)</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Happy (VHC)</td>
<td>4.17</td>
<td>1.32</td>
<td>4.15</td>
<td>1.17</td>
<td>0.06</td>
</tr>
<tr>
<td>Mild Happy (MHC)</td>
<td>2.37</td>
<td>1.22</td>
<td>3.04</td>
<td>0.85</td>
<td>-2.38</td>
</tr>
<tr>
<td>Neutral (NC)</td>
<td>15.03</td>
<td>3.53</td>
<td>16.85</td>
<td>2.36</td>
<td>-2.26</td>
</tr>
<tr>
<td>Mild Sad (MSC)</td>
<td>2.77</td>
<td>1.14</td>
<td>2.81</td>
<td>1.33</td>
<td>0.15</td>
</tr>
<tr>
<td>Very Sad (VSC)</td>
<td>4.93</td>
<td>1.20</td>
<td>5.11</td>
<td>0.97</td>
<td>0.61</td>
</tr>
<tr>
<td>Total Correct¹</td>
<td>29.27</td>
<td>3.94</td>
<td>31.96</td>
<td>2.90</td>
<td>-2.92</td>
</tr>
</tbody>
</table>

Notes: *M* = mean; *SD* = standard deviation. *d* = Cohen’s standardized effect size.

¹The subcategories contained the following number of stimuli: VHC = 6, MHC = 4, NC = 20, MSC = 4, VSC = 6. The total score was out of 40.
### Table 5

*Response patterns based on PEAT stimulus classification*

<table>
<thead>
<tr>
<th>% Respondents</th>
<th>Answer</th>
<th>VHC</th>
<th>MHC</th>
<th>NC</th>
<th>MSC</th>
<th>VSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHC</td>
<td>BPD</td>
<td>69.44</td>
<td>26.67</td>
<td>3.89</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>HC</td>
<td>69.14</td>
<td>29.01</td>
<td>1.85</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>MHC</td>
<td>BPD</td>
<td>29.17</td>
<td>56.67</td>
<td>14.17</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>HC</td>
<td>9.26</td>
<td>75.93</td>
<td>13.89</td>
<td>0.93</td>
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</tr>
<tr>
<td>NC</td>
<td>BPD</td>
<td>0.33</td>
<td>10.67</td>
<td>75.83</td>
<td>12.83</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>HC</td>
<td>--</td>
<td>6.67</td>
<td><strong>84.26</strong></td>
<td>8.89</td>
<td>0.19</td>
</tr>
<tr>
<td>MSC</td>
<td>BPD</td>
<td>--</td>
<td>0.83</td>
<td>7.50</td>
<td>70.00</td>
<td>21.67</td>
</tr>
<tr>
<td></td>
<td>HC</td>
<td>--</td>
<td>0.93</td>
<td>4.63</td>
<td>70.37</td>
<td>24.07</td>
</tr>
<tr>
<td>VSC</td>
<td>BPD</td>
<td>0.56</td>
<td>1.11</td>
<td>0.56</td>
<td>15.56</td>
<td>82.22</td>
</tr>
<tr>
<td></td>
<td>HC</td>
<td>0.62</td>
<td>--</td>
<td>--</td>
<td>14.81</td>
<td>84.57</td>
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</table>
Table 6

*Reaction Time (RT) results from the PEAT for BPD and HC*

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<thead>
<tr>
<th></th>
<th>BPD (n = 27)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>t(52)</td>
<td>p</td>
<td>d</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Median RT Correct</td>
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<td></td>
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<tr>
<td>Very Happy (VHC)</td>
<td>1761.46</td>
<td>450.13</td>
<td>1819.80</td>
<td>393.37</td>
<td>-0.59²</td>
<td>.58</td>
<td>-.16</td>
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<tr>
<td>Mild Happy (MHC)</td>
<td>1676.91</td>
<td>463.10</td>
<td>1809.52</td>
<td>495.52</td>
<td>-1.03</td>
<td>.31</td>
<td>-.28</td>
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<tr>
<td>Neutral (NC)</td>
<td>1765.31</td>
<td>530.27</td>
<td>1809.67</td>
<td>638.87</td>
<td>-.022</td>
<td>.83</td>
<td>-.06</td>
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<tr>
<td>Mild Sad (MSC)</td>
<td>1881.50</td>
<td>560.08</td>
<td>1840.48</td>
<td>647.14</td>
<td>0.33</td>
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<td>.09</td>
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<tr>
<td>Very Sad (VSC)</td>
<td>2160.69</td>
<td>796.19</td>
<td>2450.33</td>
<td>794.81</td>
<td>1.38²</td>
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<td>-.38</td>
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<tr>
<td>Median RT Correct Total</td>
<td>1786.31</td>
<td>469.51</td>
<td>1830.57</td>
<td>414.47</td>
<td>-0.44</td>
<td>.67</td>
<td>-.12</td>
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</tr>
</tbody>
</table>

Notes: $M =$ mean; $SD =$ standard deviation. $d =$ Cohen’s standardized effect size.

1 Square root transformation applied before using independent samples t-test.

2 In these cases, one patient in each of these instances got all VHC or VSC incorrect and there was no correct RT values to be included, df = 51.
Figure 1. Response patterns on (A) mildly happy stimuli and (B) neutral stimuli of the PEAT for BPD (n = 30) and HC (n = 27) participants.
Figure 2. Mediation analyses with BDI score as a mediator and (A) TC score, (B) NC score, (C) MHC score as dependent variables. The simple correlation (and beta coefficient) for the association between two variables is represented by $r$. $\beta_1$ represents the association for the mediator, controlling for group status. $\beta_2$ represents the magnitude of the association between group status and the dependent variable after the MR with the mediator has been run (* indicates $p < .05$).