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Facial trust appraisal negatively biased in borderline personality disorder

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ABSTRACT

Borderline personality disorder (BPD) is characterized by unstable interpersonal relationships and intense concerns regarding abandonment and rejection. Previous studies suggest that these and other symptoms of BPD may have their origin in a greater appraisal of untrustworthiness in others. However, it is not known whether this is a result of a heightened sensitivity to trust related stimuli, an improved ability to discriminate between such stimuli, or a response bias. Furthermore, impairment in facial fear appraisal may influence trust appraisal. Healthy controls and individuals diagnosed with BPD appraised human faces that were parametrically varied along either a trust or fear dimension. The BPD group exhibited a response bias to rate the untrustworthiness of facial stimuli higher compared to controls, but there were no significant differences in the discriminability or sensitivity of trustworthiness between groups. Furthermore, ambiguous trust decisions were associated with longer response times (RTs) in individuals with BPD relative to controls. Individuals with BPD have a facial appraisal bias specific to untrustworthiness that does not co-occur with impairments in the appraisal of fear.

1. Introduction

Borderline personality disorder (BPD) is a serious psychiatric disorder associated with high levels of mortality in the form of suicide (Oldham, 2006) and a pronounced health care burden (Bender et al., 2001). A hallmark symptom of BPD is a profound sensitivity to perceived threats to interpersonal relationships (Blais et al., 1999; Stanley and Siever, 2010). The social cognitive mechanisms by which the appraisal of social cues influence psychopathology in BPD has been the focus of a small but growing literature. Some studies have found that BPD is associated with an overall impairment in emotion recognition (Bland et al., 2004; Levine et al., 1997) particularly when multi-modal, complex processing is required (Minzenberg et al., 2006). Others have reported that overall emotion recognition does not differ between patients and controls; however, individuals with BPD have a bias to interpret negative emotions and traits in neutral or ambiguous social stimuli (Arntz and Veen, 2001; Domes et al., 2008; Meyer et al., 2004; Murphy, 2006). Yet further evidence from both clinical observations(Carter and Rinsley, 1977; Krohn, 1974), and experimental research (Arntz et al., 2009; Fertuck et al., 2009; Lynch et al., 2006) has suggested that BPD may be associated with enhanced accuracy in appraising the mental states and emotions of others. In sum, these studies have suggested that individuals with BPD are worse than, equal to, or better than controls at evaluating social cues. A possible explanation for the disparate findings may be that, in BPD, emotion and personality trait appraisals are subserved by different social and cognitive processes, and, therefore need to be dissociated when investigating social appraisals.

Appraisal of personality traits engages distinct cognitive-affective processes as compared to the appraisal of transient emotional expressions. For example, trait appraisal requires a prediction of future interpersonal behaviors (Freedman et al., 1951; Gilbert and Malone, 1995), whereas emotion appraisal generally requires an assessment of another's transient affective state and the short-term consequences of that state on the appraiser (Bliss-Moreau et al., 2008). Though they are sophisticated social judgments, trust and other trait appraisals (such as of attractiveness, dominance, and likability) can be made in as little as 100 ms (Todorov et al., 2009). Neuroimaging studies have demonstrated that the neural networks that process emotional appraisals are likely to be highly specialized and located in sensory cortex (Haxby et al., 2002). In contrast, predictive judgments regarding traits are likely to require more flexible circuits in frontal cortex (Bechara et al., 2000). Moreover, though these systems are distinct, they must interact during both types of judgments—emotion appraisals are influenced by trait appraisals and vice versa (Gilbert and Malone, 1995; Oosterhof and Todorov, 2009; Todorov, 2008; Winston et al., 2002).

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Individuals with BPD are highly sensitive to social rejection (Ayduk et al., 2008; Butler et al., 2002; Miano et al., 2012; Staebler et al., 2011). Rejection sensitivity is theorized to be an adaptation that minimizes their experience of emotional pain and dysphoria by helping individuals with BPD avoid the experience of rejection (Ayduk et al., 2008), the reaction to which is more intense and prolonged relative to healthy controls (Stanley and Wilson, 2006; Stiglmayr et al., 2005). Trait appraisals regarding the trustworthiness of others—that is, whether others will reject, be dishonest with, negatively judge, or otherwise emotionally hurt—suggests that individuals with BPD have a generalized mistrust of others (Arntz and Veen, 2001; Ayduk et al., 2008; Barnow et al., 2009; Franzen et al., 2011; King-Casas et al., 2008; Meyer et al., 2004; Miano et al., 2012; Nigg et al., 1991; Unoka et al., 2009; Zittel Conklin and Westen, 2005; Zlotnick et al., 2002). Though such appraisal differences are consistently found in BPD, the source of these differences—abnormalities in emotion appraisal, trait appraisal, or both—remains unclear. Furthermore, whether such differences are due to a deficit in the ability to distinguish trustworthy from untrustworthy individuals, an improved sensitivity in the ability to detect "untrustworthy" personality traits, or a response bias in the way individuals with BPD make trust-related decisions is also unknown. In a preliminary study (Miano et al., 2012) we found that BPD features in a non-clinical sample were associated with the appraisal of greater untrustworthiness in neutral faces, and that greater rejection sensitivity mediated the relationship between untrustworthy facial appraisals and increased BPD features. Other personality trait appraisals, such as the degree to which the faces were perceived as extroverted, dull, or attractive, were not associated with BPD symptoms.

We compare trust and fear appraisal in BPD for three reasons. First, since a general deficit in fear appraisal could impact trust appraisal (Oosterhof and Todorov, 2009), we assess whether any trust appraisal impairment could be explained as deficit in fear appraisal. Secondly, facial fear appraisal may be also be impaired in BPD (Dyck et al., 2009; Wagner and Linehan, 1999), so any BPD finding with trust appraisal needs to be differentiated from fear appraisal differences between BPD and controls. Finally, facial fear processing has been extensively studied in basic and clinical research (Whalen et al., 1998), allowing a comparison of our sample with established findings.

To test the hypotheses, participants were assessed on their appraisal of trustworthiness or fearfulness of facial stimuli. Using signal detection theory, we compared three parameters of psychophysical performance—discriminability, sensitivity, and response bias—to show that the perceptual mechanisms used to assess whether emotion, in general, and trust in particular, are impaired in BPD. Signal detection theory (Green and Swets, 1966) is a framework that may aid in resolving the nature of psychophysical differences between groups. By parametrically manipulating the trustworthiness of a stimulus, it is possible to determine whether differences between groups are due to perceptual (sensitivity or discriminability) or response (strategy/bias) properties of the decision (Fig. 1). The aim of the present study is to determine whether the increase in negative trust appraisals associated with BPD is due to (1) improved categorical perception of trust-related facial features, (2) a hypersensitivity to the presence of trust-related facial features, or (3) a behavioral response strategy. In evaluating our hypotheses, we also addressed several potentially confounding variables that have not been adequately addressed in most prior studies, including demographic factors (age, education, and ethnicity/race), severity of depression, state levels of emotional arousal, medication status, aggressivity, and abuse history status (cf. Fertuck et al., 2006; Harkness et al., 2005; Lee et al., 2005).

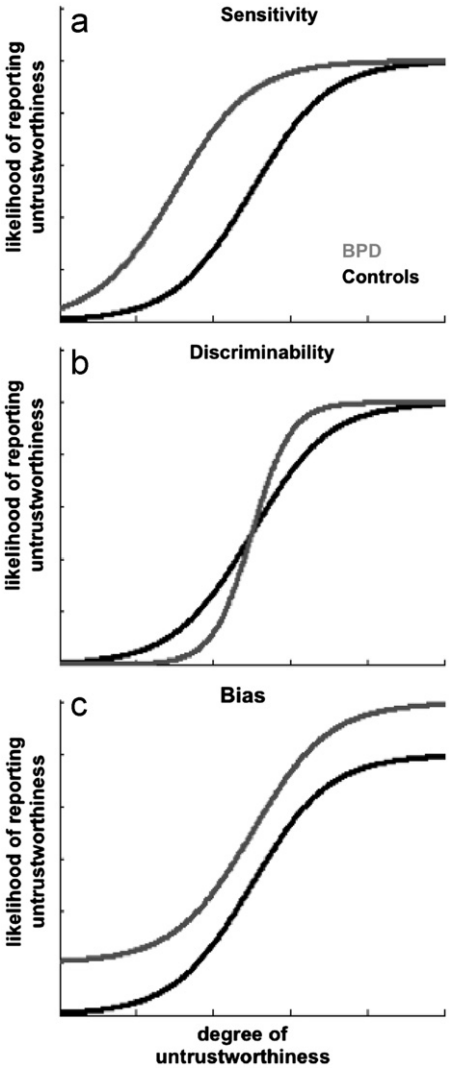

Fig. 1. Signal detection theory. There are three possible ways that appraisals of stimulus valence (e.g. trustworthiness or fearfulness) can differ between groups. (A) Increased sensitivity to untrustworthy features would amplify the likelihood of detection. (B) Greater discriminability would allow finer distinction between trustworthy and untrustworthy appraisals. (C) A response bias increases the likelihood of an untrustworthy appraisal independent of stimulus features. Linear combinations of these three psychophysical differences can also exist.

2. Method

2.1. Participants

BPD participants ($n=17$) were recruited through advertisement, hospital and clinic referrals, and from within active research protocols within a public psychiatric research institution. Exclusion criteria for the BPD group were the diagnoses of schizophrenia and other psychotic disorders, mental retardation, history of severe head trauma, or other cognitive impairment that might interfere with the accuracy assessments or competency to give informed consent. Control participants ($n=19$) were recruited through two sources. First, participants were recruited by advertisement and were assessed with the Structured Clinical Interview for DSM-IV (SCID)-I semi-structured interview and the SCID-II screener questionnaire. They were excluded if there was presence of any lifetime psychiatric or substance use disorder. Second, undergraduate students from a public, racially and ethnically diverse urban college were screened for elevated BPD symptoms with the SCID-II screener. Demographic and clinical characteristics of the samples are summarized in Tables 1 and 2. Institutional Review Boards approved the study, all participants were informed about the risks and benefits of participation, and all provided written consent.

2.2. Measures

2.2.1. Clinical assessment

For individuals with BPD, diagnoses were determined by the Structured Clinical Interview for DSM-IV, Patient Edition (SCID-I; Spitzer et al, 1992) and

Table 1
Demographic and clinical characteristics.

	BPD ($n=17$)		Controls ($n=19$)		t	p
	M	S.D.	*M*	S.D.		
Demographic characteristics						
Age	35.29	12.56	25.89	10.70	2.43	0.02
Education (years)	14.92	2.50	15.42	1.61	−0.70	0.50
	N	%	*N*	%	χ^2	p
Race/Ethnicity						
Asian	2	11.76	1	5.26		
Black or African American	2	11.76	2	10.53		
White	9	52.94	11	57.89		
More than one race	4	23.53	0	0		
Hispanic/Latino	4	23.53	8	42.11		
White	9	52.9	11	57.89	0.09	*n.s.*
Non-White	8	47.1	8	42.11		
Sex						
Female	13	76.5	13	68.4	0.29	*n.s.*
Male	4	23.5	6	31.6		
Married	3	17.65	0	0	3.66	*n.s.*
Not married	14	82.35	19	100		
Clinical characteristics						
Rating scales scores	*M*	S.D.	*M*	S.D.	t	p
Hamilton Depression inventory	20.35	10.52	0.90	2.23	5.73	0.000
Brown–Goodwin aggression history	26.75	10.21	11.50	1.50	4.65	0.000
POMS total at time of assessment	56.85	39.17	8.24	22.87	4.27	0.000
Rejection sensitivity questionnaire—total	13.0	5.02	7.92	3.60	3.4	0.002
GAS score	55.12	7.84				
	N	%				
Past suicide attempter	11	64.71				
Physical or sexual abuse (prior to age 18)	7	41.18				
Sexual Abuse	4	23.53				
Physical abuse	5	29.41				
Lifetime non-suicidal self-injury (NSSI)	9	52.94				
Currently on psychiatric medication	8	47.06				

the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II; First et al., 1997). Recent reliability studies within our research division yielded the following intra-class correlation coefficients (ICCs) (criterion levels are shown in parentheses): Axis I diagnosis/SCID-I, ICC=0.80 (0.70); Axis II diagnosis/SCID-II, ICC=0.70 (0.70); BPD diagnosis, ICC=0.89 (0.70).

Depression: Depression severity was assessed using the Hamilton Depression Inventory (Ham-D; Hamilton, 1960).

State affect: Concurrent negative emotional state was assessed with the Profile of Mood States (POMS; McNair et al., 1981), a 65-item self-report questionnaire that provides a total score of state negative emotion scores based on six transient emotional states: tension–anxiety, depression–dejection, anger–hostility, confusion–bewilderment, vigor–activity, and fatigue.

Traits: Hostility and aggression were assessed using the Buss-Durkee Hostility Inventory (BDHI; Buss and Durkee, 1957) and a modified version of the Brown–Goodwin Aggression History (BGAH; Brown et al., 1979), respectively. Abuse history was assessed as part of the demographic interview, which asks participants whether they have experienced physical and sexual abuse before age 18. We assessed the number of prior suicide attempts from the Columbia Suicide History interview (Posner et al., 2011).

2.2.2. Psychophysical assessment

Trust–fear facial discrimination task: We utilized a face appraisal task that measures the capacity to make subtle discriminations of trustworthiness and fear in facial expressions. The task was programmed using Matlab (www.mathworks.com) and Psychtoolbox (www.psychtoolbox.org), and stimuli were presented and responses (rating and response time [RT]) were collected on a Macintosh Powerbook (OS 9.1). In two separate conditions of the task, individuals were presented with faces that varied in one of the two different dimensions: trustworthy to untrustworthy, or neutral to fearful. We chose fearful facial expressions to contrast with trust because fear is an emotional expression that is well studied in the basic and psychological (Ekman et al., 1978) and clinical neuroscience literature (Rauch et al., 2000; Whalen et al., 1998). Furthermore, unlike anger and disgust, fear processing has been found to mediate trust appraisal (Oosterhof and Todorov, 2009; Todorov, 2008).

Extremes of trustworthiness appraisal were selected based on independent ratings from the NimStim Face database (Tottenham et al., 2009), which is a set of photographs representing 646 facial expressions from individuals of different races and genders. For each individual a range of emotional expressions are displayed (http://www.macbrain.org/resources.htm). The goal of the experiment was to assess how subjective ratings and response times varied as a function of two distinct facial appraisals, trust and fear. We designed a facial stimulus set that spanned the high and the low trustworthy/fearful ranges. We chose two faces at each extreme (high trust vs. low trust, and fearful vs. neutral) in each sex, in a total of eight identities (four males and four females) that were used in both the trust and the fear conditions. For the fear condition, faces were morphed within an identity, since a range of emotional expressions can be generated by the same person. For the trust condition, faces were morphed between two identities of high and low trustworthiness, both expressing neutral facial expressions. This was necessary because trust varies as a function of identity. We selected high and low trust identities based on pilot ratings of the neutral faces for these identities. Moreover, for each condition, a single factor varied systematically between stimuli was rated, i.e., either identity remained constant and the degree of expressed fear varied, or the emotional expression (neutral) remained constant and the degree of trustworthiness varied.

All facial stimuli were registered to a standard face image to provide maximal correspondence to eyes, nose, and mouth. The images were gray-scaled and a gradient mask was applied to the periphery of the face in order to occlude non-facial features (e.g. hair, ears, neck, etc.). Finally, all images were intensity normalized by taking the Fourier transform and reapplying the mean of the power spectrum across all images. This produced a stimulus set that differed in phase, while maintaining constant intensity.

Morphing software for Windows (Version 3.1, M. Fujimiya) was used to non-linearly morph the images between two category standards. Morphs were generated in steps of 10% allowing a parametric manipulation of trust (e.g. 40% trustworthy/60% untrustworthy) or fear (e.g. 30% neutral/70% fearful). For each face, participants pressed a button on a laptop and using a 5-point Likert scale to

indicate their perception of intensity of the stimulus along the trust or fear dimension. We instructed all participants to respond as quickly as possible based on their first impression of the face. There were two runs of 144 trials each and all trials within each run were of the same appraisal type, trust or fear. Stimuli were present on screen until a response was made. The inter-stimulus interval was equal to 2 s.

2.3. Data analysis

Analyses of clinical data were performed using PASW/SPSS Version 19 on a Macintosh computer. Graphical analyses of psychophysical data were performed using Matlab. Ratings of trust and fear were fit using a Weibull (Quick, 1974) function of the following form: $\text{rating}=1-2^{(x/\mu)^{\varepsilon}}$, where μ and ε were fit by maximum likelihood estimation. Sensitivity was assessed by computing the point of subjective equivalence (PSE), which corresponds to the morph position at which subjects respond with a rating of (min+max)/2, or, the midpoint of the psychometric function. Discriminability was assessed by computing the slope of the psychometric function at the PSE as $\text{slope}=(\text{rating}_{75}-\text{rating}_{25})/50$ where rating_{25} is the rating at a morph value of 25%. Response bias was assessed by computing the mean rating made by the participant across all trials. All comparisons between groups were performed using 2-tailed *t*-tests with threshold at $p=0.05$.

For each run, the first 11 trials contained the complete range of morph values (0–100%) and were excluded from the analysis to minimize learning effects. For each condition, RTs were concatenated, log transformed, and a mean and standard deviation were computed. Trials that were three standard deviations outside the mean were excluded. This resulted in an average of 4.3 trials excluded from each run, where each run consisted of an average of 124.1 trials. Weibull functions were fit to each group and condition. For some participants, the fits failed to converge. This was due either to (1) too much noise in the data or (2) due to subjects not performing the task properly, i.e., the subjective ratings were unrelated to the stimulus. When the fit failed to converge, the participant was excluded from the analysis. For controls, four out of 25 were excluded for the trust task and none of the 29 for the fear task. For the BPD group, nine out of 41 were excluded for the trust task and one out of 38 for the fear task.

Table 2
Co-occurring diagnoses of the BPD group ($N=17$).

	N	%
Axis I diagnoses: current or lifetime		
Panic disorder	3	17.65
Simple phobia	3	17.65
Generalized anxiety disorder	3	17.65
Obsessive-compulsive disorder	4	23.53
Post traumatic stress disorder	3	17.65
Social phobia	3	17.65
Eating disorder	3	17.65
History of substance abuse/dependence	13	76.47
Current substance abuse/dependence	2	11.76
History of major depression	11	64.71
Current major depression	8	47.06
Bipolar I	1	5.88
Bipolar II	2	11.76
Dysthymia	3	17.65
Axis II diagnoses		
Paranoid	2	12.15
Schizotypal	1	6.25
Obsessive–compulsive	3	18.75
Dependent	1	6.25
Antisocial	0	0
Narcissistic	1	6.25
Avoidant	1	6.25

3. Results

There were no significant differences between the BPD and control groups in sex, race/ethnicity (White vs. non-White), education level, or marital status. Age was significantly different between groups, with the BPD group older than controls (Table 1).

To characterize behavioral performance, trust and fear ratings were plotted against morph percentage and psychometric functions were fit to the data (Fig. 2).The point of subjective equality, a rating of perceptual sensitivity for rating trustworthiness of the stimulus, was not significantly different between groups (control: $M=50.68$, S.D.$=20.26$; BPD: $M=58.26$, S.D.$=18.32$; $t(34)=1.17$, $p=0.25$). The groups also showed no differences in the slope of the function, a measure of discriminability, for the trust ratings (control: $M=14.00$, S.D.$=12.72$; BPD: $M=17.27$, S.D.$=16.82$; $t(34)=0.65$, $p=0.52$). However, a response bias was present for BPD relative to controls (control: $M=1.85$, S.D.$=0.59$; BPD: $M=2.28$, S.D.$=0.61$; $t(34)=2.20$, $p=0.03$, Cohen's $d=0.72$), indicating a propensity to judge all the stimuli as less trustworthy. To assess whether this response bias was a non-specific effect characteristic of all valence judgments, a psychophysical comparison was made for ratings of fear stimuli. No

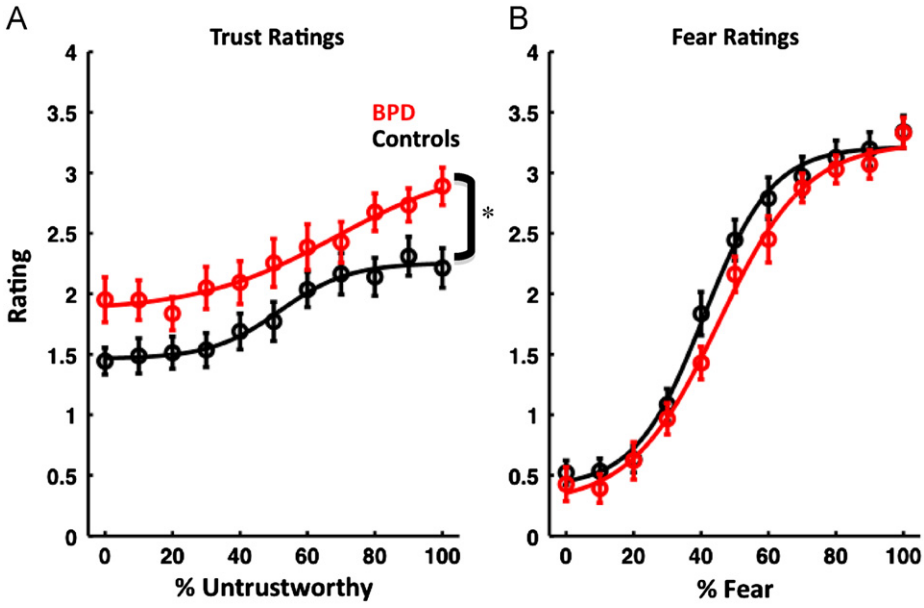

Fig. 2. Trust and fear ratings in BPD and control groups. (A) BPD was associated with higher ratings (higher untrustworthiness) across all stimuli indicating the presence of a response bias. No significant difference in sensitivity (PSE) or discriminability (slope) was present. (B) There were no significant differences in sensitivity, discriminability or bias for appraisals of fear. $^{*}p<0.05$.

significant differences between groups were found in fear judgments for sensitivity ($p=0.26$), discriminability ($p=0.45$), or bias ($p=0.31$).

BPD and control participants also showed differences in RTs (Fig. 3). The BPD group had longer RTs for the most ambiguous trust appraisals, i.e., ratings of 2 and 3 (Rating 2: control: $M=$ 1.35s, S.D.$=0.47$; BPD: $M=2.00$s, S.D.$=0.76$; $t(34)=3.07$, $p=0.004$; Cohen's $d=1.02$; Rating 3: control: $M=1.29$; S.D.$=0.47$; BPD: $M=1.86$; S.D.$=0.81$, $t(32)=2.51$, $p=0.02$, Cohen's $d=0.86$).There were no differences for other trust ratings (1, 4, and 5). RTs were not significantly different between conditions for controls. For controls, paired sample t-tests (two-tailed) comparing trust and fear RTs were not significant between conditions (Rating 1: $t=0.72$, $p=0.48$; Rating 2: $t=-1.44$, $p=0.17$; Rating 3: $t=-0.95$; $p=0.36$; Rating 4: $t=0.27$, $p=0.79$; Rating 5: $t=0.60$; $p=0.56$). For the BPD group, there was a significant different at the one rating between trust and fear conditions, with higher RTs in the trust condition relative to the fear condition (Rating 1: $t=2.8$, $p=.25$; Rating 2: $t=1.1$, $p=0.02$; Rating 3: $t=0.17$; $p=0.28$; Rating 4: $t=-0.25$, $p=0.87$; Rating 5: $t=-0.09$; $p=0.93$).

In post-hoc analyses, we evaluated the impact of age, depression severity, state negative effect, the sex of the face, medication status, and abuse history on ratings of trust and fear:

Age: Controlling for age in an ANCOVA did not alter the trust bias difference between BPD and control groups ($F=7.34$, $p=0.01$). Age did not impact any of the other psychophysical findings between groups, including trust sensitivity ($F=0.67$, $p=0.5$), trust discriminability ($F=0.61$, $p=0.6$), fear sensitivity ($F=0.97$, $p=0.4$), fear discriminability ($F=0.34$, $p=0.7$), and fear bias ($F=0.50$, $p=0.12$). Additionally, there were no significant differences in fear RTs between groups after controlling for age: rating 1 ($F=0.20$, $p=0.66$), rating 2 ($F=0.02$, $p=0.90$), rating 3 ($F=0.09$, $p=0.8$), rating 4 ($F=0.08$, $p=0.78$), and rating 5 ($F=0.26$, $p=0.18$).

Depression and negative affect: We evaluated the impact of depression (HAM-D scores) and state negative effect (POMS total scores) on facial appraisal performance using Pearson correlations on ratings and RTs. These correlations were conducted within the BPD group due to low mean levels and low variability of HAM-D and POMS in the control group. There was no significant association between depression severity on the HAM-D and trust bias ($p=0.82$) or the trust RTs (Rating 2: $p=0.43$; Rating 3: $p=0.72$). Similarly, state negative affect (POMS total) in the BPD group was not associated with trust bias ($p=0.40$) or trust RTs (Rating 2: $p=0.96$; Rating 3: $p=0.82$).

Abuse: A history of abuse (physical or sexual) before age 18 may have accounted for the trust bias in BPD. Those with BPD and no abuse ($N=10$) had a higher negative trust bias compared to individuals with BPD and abuse ($N=7$; BPD with abuse: $M=1.9$, S.D.$=0.42$; BPD without abuse: $M=2.5$, S.D.$=0.60$, $t(15)=2.5$, $p=0.02$). Controlling for abuse in an ANCOVA comparing BPD and controls strengthened the trust bias difference between BPD and control groups in trust bias ($F=10.02$, $p=0.003$). Abuse did not impact any of the other psychophysical findings between groups, including trust sensitivity ($F=0.75$, $p=0.4$), trust discriminability ($F=0.10$, $p=0.75$), fear sensitivity ($F=0.49$, $p=0.5$), fear discriminability ($F=0.32$, $p=0.6$), or fear bias ($F=1.54$, $p=0.22$). For trust RTs, rating 2 remained significantly longer in the BPD group after controlling for abuse in an ANCOVA ($F=4.35$, $p<0.05$), however using abuse as a covariate did reduce the significance of trust RT for rating 3 ($F=1.10$, $p=0.30$). Controlling for abuse did not alter the non-significance of the other trust RTs for rating 1 ($F=0.62$, $p=0.44$), 4 ($F=0.01$, $p=0.44$), and 5 ($F=0.09$, $p=0.77$) between groups. There were no significant differences in fear RTs

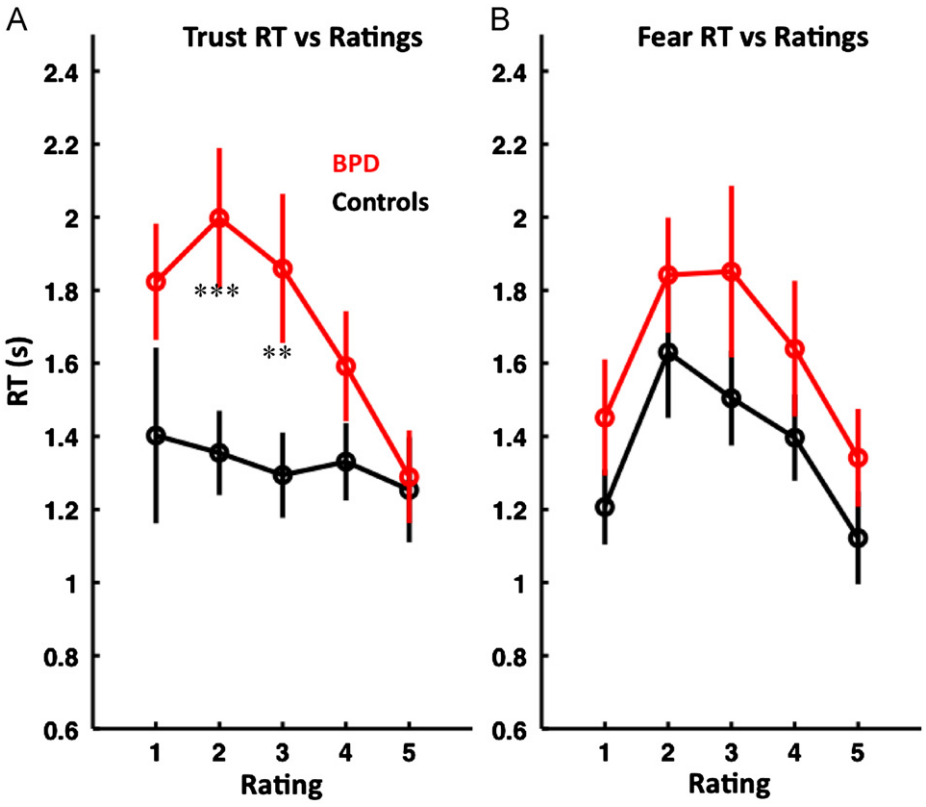

Fig. 3. Response time in BPD and control groups. (A) The BPD group showed significantly longer RTs for trust appraisals on Ratings 2 and 3. The longer processing time was not associated with improvements of perceptual performance (i.e. sensitivity or discriminability). (B) In contrast, no significant RT differences were detected for fear appraisals. ***$p<0.005$, **$p<0.025$.

after controlling for abuse: rating 1 ($F=0.62$, $p=0.44$), rating 2 ($F=0.00$, $p=0.99$), rating 3 ($F=0.01$, $p=0.9$), rating 4 ($F=0.07$, $p=0.80$), and rating 5 ($F=0.13$, $p=0.73$).

Sex of the facial stimuli: For fear, the sex of the face did not impact the ratings in either group. Male fear faces: sensitivity $t(34)=0.73$, $p=0.47$, discriminability $t(34)=1.61$, $p=0.12$, and bias $t(34)=-0.96$, $p=0.34$. Female fear faces: sensitivity $t(29)=0.72$, $p=0.20$, discriminability $t(29)=-0.54$, $p=0.60$, and bias $t(29)=1.29$, $p=0.21$. However, trust bias findings were significant comparing BPD and controls in the male faces (BPD: $M=2.6$, S.D.$=0.51$; control: $M=2.1$, S.D.$=0.68$, $t(28)$, $p=0.03$). Male trust sensitivity ($t(29)=1.65$, $p=0.11$) and discriminability ($t(29)=0.61$, $p=0.55$) findings were not different between groups. Trust bias differences in female faces were not significant (BPD: $M=2.1$, S.D.$=0.61$; control: $M=1.8$, S.D.$=0.73$, $t(29)$, $p=0.20$). Additionally, RT findings were not different for male and female trust faces for any rating.

Medication status: Individuals with BPD on ($N=8$) and off ($N=9$) medication did not differ on any ratings for trust or fear: trust sensitivity ($t(15)=-0.41$, $p=0.69$), trust discriminability ($t(15)=-1.04$, $p=0.31$), trust bias ($t(15)=0.08$, $p=0.94$). Fear sensitivity ($t(15)=0.94$, $p=0.36$), fear discriminability ($t(15)=-0.41$, $p=0.69$), fear bias ($t(15)=0.57$, $p=0.58$). RTs also did not differ for trust or fear at any rating.

4. Discussion

This study found that, compared to controls, individuals with BPD exhibited a response bias to appraise less trustworthiness in non-emotional facial stimuli. However, there were no differences between BPD and controls in measures of sensitivity or discriminability, suggesting that BPD is not associated with any perceptual enhancements during trust appraisal. This conclusion is underscored by longer RTs during trust appraisals for BPD relative to controls; that is, contrary to expectations based on speed-accuracy trade-offs (Laming, 1968; Ratcliff and McKoon, 2008; Stone, 1960; Vickers and Smith, 1988), longer RTs for the BPD group did not lead to improvements in discriminability or sensitivity. The response bias in BPD was specific to trust appraisals and does not appear driven by an impairment in fear recognition, as suggested by some studies (Dyck et al., 2009; Oosterhof and Todorov, 2009; Todorov, 2008; Wagner and Linehan, 1999). Furthermore, neither fear ratings nor RTs differed between groups. Finally, the findings were not confounded by age, depression severity, negative affect state, abuse history, or medication status.

Prior studies of facial appraisal in BPD have exhibited mixed results, with some studies indicating enhanced (Wagner and Linehan, 1999; Lynch et al., 2006; Fertuck et al., 2009), and others impaired (cf. Bland et al., 2004; Minzenberg et al., 2006) facial emotion recognition. This study was designed to address whether these apparently conflicting results primarily reflect a fear appraisal deficit or a bias in a trust appraisal in BPD. With concurrent assessment of trustworthiness and expression of fear, the present study suggests that individuals with BPD are characterized by a trust response bias, but not a generalized deficit of fear appraisal. However, since we only assessed fear, a deficit in the recognition of other emotions cannot be excluded. Moreover, the inconsistent findings in the emotion recognition of BPD literature may be partly accounted for by the lack of differentiation between these two distinct appraisal processes (Gilbert and Malone, 1995). We speculate that for controls, trust appraisal may be more automated, whereas in BPD trust requires a greater level of effort, particularly for more ambiguous trust decisions. Thus, individuals with BPD may prefer to utilize a binary decision-making processes to make a "categorization" (Grinband et al., 2006) rather a dimensional discrimination association between facial features and particular personality traits when appraising trust. Recent experimental research has supported the theory that individuals with BPD are characterized by dichotomous thinking and "splitting" of interpersonal and emotional experiences into polarized "good" and "bad" dichotomies (cf. Coifman et al., 2012). We speculate dichotomous thinking may include trust appraisal processes in BPD, in that those with BPD may have preference to polarize others into trustworthy and untrustworthy categories.

While the importance of suspiciousness of others, or, untrust, in the psychopathology BPD has been apparent for decades (Kernberg, 1967; Stone, 1986), the experimental assessment of trust appraisal is a novel avenue for experimental research in BPD. In the social psychology and cognition research literature, trust appraisals have been conceptualized as an individual's attempt to infer another's intentions, and, thus decide whether to initiate approach or avoidance behaviors toward that individual (Todorov, 2008; Winston et al., 2002). In fact, exaggerating trustworthy facial features leads to cues associated with the expression of happiness in the faces of others. Conversely, intensifying the facial features associated with low trust leads to the facial features of anger (Todorov, 2008). Future studies will be needed to incorporate these emotions into the study of social appraisals in BPD to identify if individuals with BPD have a conflict between approach and avoidance of others based in a trust appraisal bias.

Current diagnostic criteria and clinical description indicate that trust, abandonment concerns, and stress related suspiciousness are central symptoms of BPD. The tendency to fear rejection and abandonment from emotionally significant others represents the most sensitive and specific clinical descriptors of BPD (Blais et al., 1999; Zittel et al., 2005). High levels of rejection sensitivity also differentiate the BPD groups from controls and other clinical groups, including social anxiety disorders (Staebler et al., 2011).The negative response bias in BPD suggests that the threshold for trusting someone is raised in those with BPD. We speculated that this higher threshold may serve a protective function by preventing "false positives" in trusting others, which may be particularly important given the emotional stress associated with being rejected and ignored for those with BPD (Miano et al., 2012). However, the negative consequence of this high threshold may be premature foreclosure of potentially enriching relationships through avoidance of people who may actually be trustworthy. Moreover, such bias may contribute to frequent crises in existing relationships. Further studies in the relationship between rejection sensitivity and trust appraisal in BPD are needed to further clarify these issues.

The finding that those with BPD and a history of abuse exhibited less of a bias in trust appraisal is noteworthy. One of the few studies that has addressed the role of early abuse and facial processing in children with PTSD symptoms found an attentional bias to direct attention away from threatening faces (Pine et al., 2005). Relatedly, a bias to attend to happy faces mediated the association between childhood abuse and trauma related symptoms in adult survivors of maltreatment with and without PTSD (Fani et al., 2011). Though these finding involve a different diagnosis, PTSD, they are consistent with our finding that BPD patients with abuse did not exhibit the same untrustworthy bias toward neutral faces as those without abuse. Focusing on positive cues may be an attentional strategy that allows those with childhood abuse to endure early interpersonal adversity in a way that overrides the effect of BPD and PTSD diagnoses.

Strengths and limitations: The strengths of this studying include the parametric nature of our facial stimuli, the well characterized clinical and control groups, and the concurrent measurement of rating and response time. This study also has several limitations. Because these are subjective ratings of the stimuli, there was no

way to evaluate accuracy of the trust appraisals (i.e., we did not collect information on trust related behaviors of the identities associated with the faces in real world settings). Instead of objective accuracy, we used subjective ratings elicited from healthy control subjects as the comparison. Future studies are needed to clarify the role of actual trust related interpersonal behaviors on facial trust appraisal in BPD. Further, while there is a trust bias in BPD relative to controls, the finding in this sample was largely accounted for by the ratings of male faces. This study may have been underpowered to detect trust differences in female faces. Or, this sample of predominantly female participants with BPD may focus their mistrust bias on men, with whom they may have had more troubled relationships. Future research with larger samples and a greater number of men with BPD will be needed to investigate whether the trust bias we identify is specific to male faces for all individuals with BPD. Further, the dynamic range (difference between the highest and lowest rating) of the trust stimuli was small relative to fear. It is possible that with a larger dynamic range in trust, sensitivity or discriminability differences between BPD and controls could emerge. In future studies we will employ a larger dynamic range for trust stimuli to investigate this possibility. Additionally, it is important for future studies to compare trust to other personality appraisals and to evaluate trust in relation to other facial emotions such as anger and disgust. Finally, while education level was not different between our groups, it would have been optimal to have a measure of IQ.

Social appraisals are central to social neuroscience, and we can draw upon this growing literature in attempting to contextualize the findings in the present study. Facial fear appraisal is strongly associated with amygdala activity (Rauch et al., 2000; Whalen et al., 1998). In BPD, fearful faces and negative emotional stimuli are also associated with greater amygdala activation relative to controls (Donegan et al., 2003; Herpertz et al., 2001; Koenigsberg et al., 2009). Fear, in particular, has been shown to produce increased activation of the right amygdala and less activation in the bilateral rostral/subgenual anterior cingulated cortex (ACC) in BPD relative to controls (Minzenberg et al., 2006). Lower trust appraisal in non-clinical groups also involves greater amygdala reactivity (Todorov, 2008; Winston et al., 2002), however, trust related social exchanges suggest that other regions are involved in these types of social appraisals in BPD. The psychophysical findings from the present study suggest that for BPD, trust and fear appraisal are distinctive processes. However, future studies focusing on the interaction of these regions in trust and fear appraisal at the neural level are necessary to compare these findings to social neuroscience results.

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