Exaggerated Affect-Modulated Startle During Unpleasant Stimuli in Borderline Personality Disorder


Background: Excessive emotional responding is considered to be a hallmark of borderline personality disorder (BPD). The affect-modulated startle response is a reliable indicator of emotional processing of stimuli. The aim of this study was to examine emotional processing in BPD patients (n = 27) and healthy control subjects (n = 21).

Methods: Participants viewed an intermixed series of unpleasant, borderline-salient (e.g., “hate”), and neutral (e.g., “view”) words and were instructed to think about the meaning of the word for them personally while eyeblink responses were assessed.

Results: The BPD patients exhibited larger startle eyeblink during unpleasant but not neutral words, indicating exaggerated physiological affect. This finding remained significant when we controlled for comorbid diagnoses, including generalized anxiety disorder and posttraumatic stress disorder. Greater symptom severity was associated with greater affective-startle difference scores (unpleasant-neutral).

Conclusions: Consistent with the symptom of affective dysregulation, these results suggest an abnormality in the processing of unpleasant emotional stimuli by BPD patients.

Key Words: Affective startle, borderline personality disorder, emotion, startle eyeblink

A core feature of borderline personality disorder (BPD) is affective dysregulation (Gunderson and Phillips 1991; Linehan 1993; Siever et al. 2002; Skodol et al. 2002a) (frequently called “emotion dysregulation”), which a recent study indicates is the most prevalent and enduring diagnostic criteria over time (McGlashan et al. 2005). Emotion dysregulation is a combination of an inability to regulate emotional responses (Gunderson and Zanarini 1989; Linehan 1993, 1995) with a high sensitivity to emotional stimuli and unusually strong and long-lasting reactions (Donegan et al. 2003; Linehan 1993). To date, there are only a handful of studies examining emotion dysregulation in BPD, and the majority were exclusively based on the patients’ self-report of affect experience.

The affective startle modulation paradigm is unique in that it requires minimum cooperation from the participant and can yield a nonverbal, objective measure of emotional valence (Lang et al. 1990). The startle reflex consists of a set of involuntary responses to a sudden, strong sensory stimulus, for example, a brief noise burst. The amplitude of the eyeblink component of the human startle reflex is highly modifiable by environmental stimuli that precede the reflex-eliciting stimulus. The startle-evoking stimulus can be presented at any given time during the presentation of a salient emotional stimulus, functioning as a probe of changes in emotions and thus providing an index of ongoing affective information processing. As might be anticipated, phobic subjects show greater than normal startle potentiation when they view pictures of a phobic object (Hamm et al. 1997). In contrast, incarcerated psychopaths—particularly those characterized by the interpersonal-emotional facet of psychopathy (“fearless dominance”)—show diminished startle probe potentiation when viewing unpleasant picture stimuli (Benning et al. 2005; Patrick et al. 1993). Affect-modulated startle has been used to investigate emotional reactivity in patients with anxiety disorders (Grillon 2002) and depression (Kaviani et al. 2004). However, only one study has used the affect-modulated startle paradigm with International Affective Picture System (IAPS) stimuli and reported no differences between healthy control subjects and BPD patients in affective startle and self-report measures of emotion (Herpertz et al. 1999).

The aim of this study was to extend previous work by examining affect-modulated startle in BPD patients and healthy control subjects with a set of unpleasant stimuli that involve themes prevalent in BPD pathology (e.g., abandonment) as well as neutral stimuli. We used word stimuli previously validated in a behavioral study of directed forgetting (Korfine and Hooley 2000). Given that affective dysregulation in BPD is thought to be characterized by enhanced reactions to emotional stimuli (Donegan et al. 2003; Linehan 1993), we thought that the BPD-salient unpleasant words used by Korfine and Hooley (2000) might be particularly well-suited to detect normal-BPD group differences in affective startle. We hypothesized that, consistent with this idea, BPD patients, compared with healthy control subjects, would show exaggerated startle eyeblink (SEB) magnitude during the unpleasant words compared with neutral words. For exploratory purposes, we conducted a correlational analysis to investigate whether greater affective startle is associated with greater BPD symptom severity.

Methods and Materials

Participants

We studied 27 patients who met DSM-IV criteria (American Psychiatric Association 1994) for BPD and 21 healthy control participants. The groups did not differ in age or gender (Table 1). Participants gave written informed consent for this study, which...
was approved by the institutional review board, and were paid for their time.

Participants were rigorously screened and received a structured interview as described in our other studies (Hazlett et al. 2005; New et al. 2002). All participants received an interview with a psychologist using the Structured Clinical Interview for DSM-IV Axis I disorders (First et al. 1996) and the Structured Interview for DSM-IV Personality Disorders (SIDP-IV) (Pfohl 1996). Healthy control subjects with an Axis I or II diagnosis in either themselves or a first-degree relative were excluded. Exclusion criteria for all participants included: severe medical illness, neurological illness, head injury, history of alcohol/drug dependence, substance abuse in the past 6 months, and use of any psychoactive medications at the time of the study. The patients were free of psychiatric medications for at least 2 weeks before study. Patients with a history of schizophrenia, psychotic disorder, bipolar type I affective disorder, or current (in the last 6 months) major depressive disorder (MDD) were excluded. Thirteen of the patients had a past history of MDD, 5 had PTSD (2 current and 3 past), and 6 had generalized anxiety disorder. The mean total number of DSM-IV BPD criteria met was 6.7 ± 1.2 (of the 9 criteria). All of the patients met DSM-IV criteria of affective instability (item 6), and 22 met criteria of impulsive behavior (item 4 and/or 5). In a finding consistent with reports from other groups (Skodol et al. 2002a), patients who met criteria for BPD also met criteria for other Axis II diagnoses, including schizotypal personality disorder (n = 7; 26%) and antisocial personality disorder (n = 8; 30%). The mean number of non-BPD personality disorder diagnoses the patient group met was 2.2 ± 1.7. One patient did not complete the Barratt Impulsivity Scale, and another did not complete any of the scales.

The BPD patients were primarily a community sample recruited for the study through advertisement in local newspapers (90%). A small percentage of the patients were recruited through referrals from outpatient psychiatric clinics (10%) at the Bronx Veterans Affairs Medical Center (Bronx, New York) and Mount Sinai School of Medicine (New York, New York). Although our BPD patients were recruited from the community, most of them received some previous type of treatment (1 previously received antidepressive drugs, 10 previously received selective serotonin reuptake inhibitors, 9 previously received counseling/psychotherapy, 7 were never previously treated).

Participants completed psychometric self-report measures of aggression (Buss-Durkee Hostility Inventory [BDHI]; Buss and Durkee 1957), impulsivity (Barratt Impulsivity Scale [BIS]; Barratt 1965), affective lability (Affective Lability Scale [ALS]; Harvey et al. 1989), and affective intensity (Affective Intensity Measure [AIM]; Larsen and Diener 1985).

Three patients and two control subjects were eliminated before any statistical analysis, because they were considered to be eyeblink nonresponders. We used a criteria similar to our other work (Hazlett et al. 2001; 2003), in which nonresponders failed to exhibit blinks on over 25% of the baseline startle stimulus presentations.

Table 1. Demographics, Baseline Startle Response, and Self-Report Ratings in Healthy Control Subjects and BPD Patients

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<tr>
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<th>Healthy Control Subjects</th>
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**Significant between-group difference.
activity (10 msec before peak, 10 msec after peak) occurring within a window of 20–120 msec after startle stimulus onset. Startle eyeblink amplitude was the difference between the peak startle activity and the pre-startle EMG activity in microvolts. Startle eyeblink modification scores were then calculated as percent change scores: \([\text{startle during word stimulus } - \text{ startle alone}] / \text{startle alone} \times 100\). Thus, a positive change score indicates startle potentiation relative to baseline eyeblink magnitude. Percent change scores are preferred, because microvolt units are correlated with baseline eyeblink magnitude whereas percent change scores are not, removing any dependence on baseline eyeblink amplitude (Blumenthal et al. 2004, 2005).

### Experimental Design

Statistical analyses were performed with Statistica (StatSoft 2003). We used a mixed model, repeated-measures analysis of variance (ANOVA) to examine the SEB data with a 2 × 2 × 2 design. Diagnostic group (healthy control subjects vs. BPD patients) was the between-subjects variable. Word type (neutral, unpleasant) and startle probe position (4000–msec, 5000–msec) were within-subject variables.

Similar ANOVAs (Group × Word type) were done to examine self-report ratings for the words and word recall. The dependent variables were self-assessment manikin (SAM) ratings for valence and arousal and percent score for unpleasant and neutral words remembered.

Significant interactions involving the group factor were followed by planned comparisons to test our \(a \ priori\) hypotheses. Rom's procedure (Rom 1990) was used for all groups of follow-up \(t\) tests to control for experiment-wise Type I error.

### Results

#### Affective Modulation of Startle

Compared with the healthy control subjects, the BPD patients showed greater startle potentiation during the unpleasant words but not during the neutral words [Group × Word type interaction, \(F(1,46) = 6.91, p = .01, \) Figure 2A]. Follow-up \(t\) tests confirmed that the patients showed significantly greater mean startle potentiation during unpleasant words (averaged across the two probe positions) than the control subjects \([t(46) = 2.57, p = .01]\) but did not differ from normal during neutral words \((p = .47)\).

The Group × Word × Startle probe position interaction was not significant \((p = .52)\). There was a nonsignificant trend for a group main effect, which indicated that the BPD patients showed greater overall startle potentiation (averaged across word type and probe position) than the healthy control subjects \([F(1,46) = 3.94, p = .053]\). However, as can be seen in Figure 2A, this difference was due to a group difference in startle potentiation during unpleasant words. The groups did not differ in baseline startle amplitude during the inter-trial interval (Table 1).

It should be noted that a Kolmogorov-Smirnov test for normality indicated that the percent change SEB modification scores showed a normal distribution (all \(p > .20\)). In contrast, the absolute microvolt SEB values were significantly skewed (all \(p < .01\)). The ANOVAs on the absolute value data (square root transformed microvolt values) produced results that were nearly identical to the percent change data.

#### Diagnostic Comorbidity in BPD

We conducted parallel analyses in order to assess whether our main finding of exaggerated affective startle during unpleasant words could be explained by a comorbid diagnosis of antisocial

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**Figure 1.** Schematic of a portion of the experimental session. A startle eyeblink (SEB) eliciting probe (104 dB, 50-msec white noise burst) was presented either 4 or 5 sec after the onset of pre-selected unpleasant and neutral words. Occasionally the startle probe was presented alone during the inter-trial interval to measure baseline startle magnitude. The unpleasant words were selected by generating a list of words presumably salient to individuals with borderline personality disorder (BPD) and included themes of abandonment, rejection, anger and rage, self-harm, and others being uncaring or unempathic (see Korfine and Hooley 2000 for details). Unpleasant and neutral words were matched on frequency of usage in the English language and on string length (word list taken from Korfine and Hooley: 2000).

**Word Stimuli**

Our word list was taken from a published behavioral study and consisted of 32 words (16 unpleasant, 16 neutral; see Korfine and Hooley 2000 and Figure 1 for details). Each word was presented for 6 sec on a computer screen in a mixed, fixed pseudorandom order. The inter-trial interval between words was 21–31 sec (mean = 26 sec). Of the 32 word trials, 24 included a presentation of the acoustic startle stimulus at one of two long-lead intervals: 4000 or 5000 msec. There were 12 presentations (6 during neutral and 6 during unpleasant words) for each lead interval. The remaining eight words were presented without a startle stimulus. There were also 12 presentations of the startle stimulus during the inter-trial interval that serve as our baseline measure of startle magnitude.

**Psychophysiological Recording and Scoring of SEB**

The startle-eliciting stimulus was a 104-dB sound pressure level (SPL) (A) white noise burst of 50 msec in duration with a near-instantaneous (< 1 msec) rise/fall time. Startle eyeblink was measured by recording electromyographic (EMG) activity with a pair of miniature silver-silver chloride electrodes (3 mm in diameter) filled with standard electrolyte gel and positioned over the orbicularis oculi muscle just below and slightly lateral to the participant’s lower right eyelid. Eyelid responses were recorded as EMG activity with a Contact Precision Instruments system (London, England) that interfaces with a Pentium 4 computer. The EMG activity was filtered with a 30-Hz high-pass filter and a 500-Hz low-pass filter, along with a 60-Hz notch filter. The data were collected as raw EMG at 1000 Hz, beginning 500 msec before startle stimulus onset to 300 msec after startle stimulus onset. Integrated EMG was used to score eyeblink amplitude with a time constant of 20 msec.

Startle eyeblink amplitude was scored off line with our standard methods described elsewhere (Hazlett et al. 2003) with the raw, rectified EMG signal. Pre-startle EMG activity was defined as occurring 100 msec before startle stimulus onset. Peak startle activity was defined as a 20-msec average of the peak
confirmed that the patients rated the unpleasant words as less unpleasant ($t(46) = 2.85, p = .01$) but did not differ from normal on neutral word ratings ($p = .81$).

There was a significant group main effect, which indicated that the BPD patients had a lower overall self-report rating (averaged across neutral and unpleasant words) compared with the healthy control subjects ($F(1,46) = 5.20, p = .03$). This difference was primarily due to a group difference in the valence rating of the unpleasant words (Figure 2B).

**Arousal.** Both groups rated the unpleasant words as more arousing than the neutral words (main effect of word type, $F(1,46) = 22.70, p = .0002$), and there were no group differences (Group $\times$ Word type interaction, $p = .68$). Control subjects: unpleasant mean $= 6.55 \pm 1.32$, neutral mean $= 5.10 \pm 0.93$; Patients: unpleasant mean $= 6.16 \pm 1.39$, neutral mean $= 4.94 \pm 1.29$.

**Self-Report Measures of Affective Lability, Impulsivity, and Aggression**

The BPD group had higher self-report scores compared with the healthy control subjects for affective intensity, affective lability, and aggression (Table 1). The two groups did not differ on the self-report rating of impulsivity.

**Recall of Words**

The two groups did not differ on word recall for unpleasant or neutral words (Group $\times$ Word type interaction, $p = .43$). Both groups recalled more unpleasant than neutral words (Control subjects: unpleasant mean $= 65.9 \pm 13.2\%$, neutral mean $= 34.1 \pm 13.1\%$; Patients: unpleasant mean $= 67.4 \pm 19.5\%$, neutral mean $= 28.8 \pm 16.9\%$), and the main effect of word type was significant ($F(1,46) = 66.77, p = .0000$; overall mean unpleasant $= 66.6 \pm 17.0\%$; neutral words $= 31.5 \pm 15.2\%$).

**Symptomatic Correlates of Affective Startle**

We conducted Pearson correlations for the patient group between three affective startle variables (SEB magnitude during unpleasant and neutral words, SEB difference score [unpleasant-neutral word condition] averaged across the two probe positions), and total number of DSM-IV BPD symptoms, ALS, and AIM scores. Among the BPD patients, those with higher total number of DSM-IV diagnostic criteria (each criterion was rated either 0 = absent or 1 = present) showed larger SEB modification difference scores (unpleasant-neutral condition), $r = .38, p = .049$. This pattern indicates that greater symptom severity is associated with larger SEB magnitude during the unpleasant word condition relative to the neutral condition. None of the other correlations reached significance.

**Discussion**

To our knowledge, this is the first study to show affective startle abnormalities in BPD patients. Our main findings are: 1) compared with healthy control subjects, the BPD patients showed enhanced startle potentiation during the unpleasant word condition but not during the neutral word condition or baseline startle amplitude; this pattern of results remained statistically significant when we controlled for comorbid diagnoses of PTSD, generalized anxiety disorder, and antisocial personality disorder; and 2) greater symptom severity, defined by total number of DSM-IV BPD symptoms, was associated with greater affective-startle difference (unpleasant-neutral) scores in patients.

The BPD-related affective startle abnormality suggests that the patients showed excessive emotional responsivity specifically...
during the unpleasant words. This provides objectively measured physiological evidence of the emotion dysregulation that is observed clinically to be a core feature characterizing BPD (Skodol et al. 2002a, 2002b). In further support of emotion dysregulation and consistent with exaggerated startle during an unpleasant stimulus: the patients in our study as well as other studies (Levine et al. 1997) had higher-than-normal AIM scores, which is a self-report measure thought to assess the intensity with which feelings are experienced. Intensity on this scale is defined as the strength of response, and items include manifestations of reaction such as bodily responses and subjective experiences.

Our affective-startle findings are inconsistent with the only other BPD study published to date, which showed a normal pattern of startle modulation in response to unpleasant (IAPS) pictures (Herpertz et al. 1999). Possible reasons for this discrepancy include our use of different unpleasant stimuli. We chose words shown to be particularly salient to BPD patients, whereas Herpertz et al. (1999) employed more generally unpleasant pictures. Perhaps during passive viewing of generally unpleasant stimuli (e.g., picture of disfigured baby), BPD patients exhibit normal startle potentiation. In contrast, stimuli related to BPD-salient themes combined with the instruction to actively “think about the meaning of the word for them personally” might be more powerful triggers of affective dysfunction in BPD. In a finding consistent with this concept, a study that included BPD-specific words (negative self-descriptors) in the context of an emotional Stroop task showed that BPD patients exhibited interference caused by supraliminally (consciously processed) presented emotional words (Arntz et al. 2000). Our sample characteristics also differed from Herpertz et al. (e.g., we had a community sample that included both genders, whereas Herpertz et al. examined female inpatients).

In contrast to the nonverbal, objective affective startle measure of emotional response, the SAM self-report scores indicated that the BPD patients rated the unpleasant words as less emotional or unpleasant than healthy control subjects. Thus, the psychophysiological measure of valence indicated that the BPD patients exhibited emotional hyper-responsivity, whereas the self-report indicated emotional hypo-responsivity. Herpertz et al. (1999) reported a dissociation between psychophysiological and self-report measures of arousal in BPD patients—lower-than-normal physiological arousal (skin conductance) during neutral pictures yet higher-than-normal self-report of their arousal experiences. Some investigators have suggested that psychopaths learn over time to edit or tailor their verbal responses to conform to social expectations (Herpertz et al. 2001; Patrick et al. 1993). Borderline personality disorder patients might also learn over time to tone down their verbal expressions of emotion in order to “fit in better.” This idea is consistent with clinical research (Rosenthal et al. 2005) that suggests increased psychopathology in BPD is associated with the tendency to chronically and deliberately attempt to reduce the frequency or intensity of unpleasant cognitions.

One of the important issues our study and previous work (Herpertz et al. 1999) reflects is the inadequacy of self-report measures of emotional responsiveness. Our findings suggest startle might be an important nonverbal adjunct to self-reports for assessment of emotion regulation and treatment outcome in BPD. As discussed by others (Grillon and Baas 2003), verbal reports are frequently inaccurate and influenced by demand characteristics, erroneous interpretations, and misperceptions. In contrast, startle is a physiological response impervious to voluntary control yet sensitive to emotional processing.

One might expect that because the BPD patients showed exaggerated startle during the unpleasant words, they might also recall more unpleasant words than normal, but this was not the case. Both the healthy control subjects and BPD patients recalled unpleasant words significantly more than they recalled neutral words. The lack of a Group × Word type interaction for recall is consistent with the findings of Korfine and Hooley (2000) for the “remember” condition and suggests that despite showing greater-than-normal affective processing, the BPD patients did not display a memory bias for the unpleasant words.

Our results suggest that greater symptom severity in the patient group, defined here by greater total number of DSM-IV BPD criteria, is associated with greater affective startle (unpleasant-neutral condition). Thus, affective instability and impulsivity traits as defined by DSM-IV criteria seem to be related to the BPD patients’ unusual pattern of exaggerated affective startle. This coupling of biological measures of emotional responsiveness and personality disorder traits is consistent with other work by our group showing greater BPD traits related to affective instability are associated with greater mood responsiveness as indexed by phystostigmine response (Steinberg et al. 1997).

An important caveat is that our sample of BPD patients included more men than women and therefore might be considered unrepresentative. Although DSM-IV reports that BPD is diagnosed predominately in women (3:1 ratio of women to men), recent studies suggest that the differential gender prevalence of BPD in clinical settings might largely be a function of sampling and diagnostic biases of various types (Skodol and Bender 2003). Studies employing semi-structured interviews have yielded a more balanced gender distribution, and data from the Collaborative Longitudinal Personality Disorders Study (CLIPS) suggests that symptoms of BPD are largely similar in men and women (Johnson et al. 2003).

In conclusion, these findings are consistent with the concept that BPD patients exhibit emotion dysregulation, which includes an inability to regulate emotional responses (Gunderson and Zanarini 1989; Linehan 1993, 1995) with a high sensitivity to emotional stimuli and unusually strong reactions (Donegan et al. 2003; Linehan 1993). However, replication efforts will need to address important issues like employing positively valenced words matched on arousal level to the negatively valenced words to determine whether the effects found here were due to the negative valence of the stimuli or to a more general arousal during any emotional stimuli. Yet, there were no group differences on reported arousal in the current study. Examining whether BPD patients exhibit exaggerated affective startle during generally unpleasant words versus BPD-salient words would also be useful. A recent behavioral study found that BPD patients showed enhanced recall of both generally unpleasant as well as borderline-specific stimuli, despite the instruction to forget it, suggesting enhanced processing of negative information (Domes et al. 2006). Future studies should examine gender differences and include non-BPD psychiatric control subjects (e.g., schizotypal personality disorder) to determine specificity of these findings. Lastly, research integrating psychophysiology and functional neuroimaging is needed to examine brain circuitry underlying these BPD-related affective startle abnormalities.

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