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Neural Correlates of the Use of Psychological Distancing to Regulate Responses to Negative Social Cues: A Study of Patients with Borderline Personality Disorder

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Abstract

Background—Emotional instability is a defining feature of borderline personality disorder (BPD), yet little is understood about its underlying neural correlates. One possible contributing factor to emotional instability is a failure to adequately employ adaptive cognitive regulatory strategies such as psychological distancing.

Method—To determine whether there are differences in neural dynamics underlying this control strategy, between BPD patients and healthy volunteers (HC's), BOLD fMRI signals were acquired as 18 BPD and 16 HC subjects distanced from or simply looked at negative and neutral pictures depicting social interactions. Contrasts in signal between distance and look condition were compared between groups to identify commonalities and differences in regional activation.

Results—BPD patients show a different pattern of activation compared to HC subjects when looking at negative vs. neutral pictures. When distancing vs. looking at negative pictures, both groups showed decreased negative affect in rating and increased activation of the dorsolateral prefrontal cortex, areas near/along the intraparietal sulcus (IPS), ventrolateral prefrontal cortex and posterior cingulate/precuneus regions. However, the BPD group showed less BOLD signal change in dorsal anterior cingulate cortex and IPS, less deactivation in the amygdala and greater activation in the superior temporal sulcus and superior frontal gyrus.

Conclusion—BPD and HC subjects display different neural dynamics while passively viewing social emotional stimuli. In addition, BPD patients do not engage the cognitive control regions to the extent that HC's do when employing a distancing strategy to regulate emotional reactions, which may be a factor contributing to the affective instability of BPD.

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Keywords

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INTRODUCTION

Emotional instability, one of the most prominent features of borderline personality disorder (BPD) occurs especially in reaction to negative social experiences (1–3) and is linked to many of its most maladaptive symptoms and interpersonal disturbances (4,5), including suicidality, extreme anger, identity disturbance and chronic emptiness (6). Despite its centrality to borderline pathology, the neural mechanisms underlying this instability remain poorly understood (7). Given the difficulty that BPD patients have in modulating their emotional reactions (4), it is plausible that their affective instability derives, in part, from a dysfunction in the neural mechanisms underlying emotion regulation (8–10).

One of the most commonly employed, flexible, and adaptive methods for regulating emotion is cognitive reappraisal, which involves reinterpreting the meaning of an emotional stimulus in ways that alter one's emotional response to it (11–13). Neuroimaging studies have shown that in healthy individuals cognitive reappraisal activates prefrontal and cingulate systems implicated in cognitive control processes and modulates systems involved in emotional responding, such as the amygdala (14–21). To date, no studies have examined the neural correlates of emotion regulation by cognitive reappraisal in BPD. Extant data does, however, suggest that there may be dysfunction in neural systems implicated in passive emotional responding (22–25) and in impulse control (26–30) in BPD, as well as decreased structural volumes in BPD's in the anterior cingulate cortex (ACC), orbital frontal cortex, amygdala and parietal regions (31–35).

Against this backdrop we aimed to better understand sources of emotional dysregulation in BPD by comparing the neural correlates of the passive processing of social emotional cues and of cognitive reappraisal of these cues in BPD and HC subjects. There are two main kinds of cognitive reappraisal strategies, known as reinterpretation and distancing (14,36–38). The former entails reinterpreting stimuli in a less disturbing manner whereas distancing entails viewing stimuli from the perspective of a detached and objective observer. We focused on the distancing strategy because borderline patients have particular difficulty navigating between over-intense involvement and remoteness in interpersonal situations (3,39), and therefore it seemed likely to differentiate between BPD patients and HC's. Our paradigm was adapted from those used previously (14). We asked BPD and healthy control (HC) participants to either look at negative social images and let themselves respond naturally (the Look baseline condition) or to distance themselves from them (the Distance reappraisal condition). Motivated by prior work, we hypothesized that BPD's might exhibit abnormal activation in prefrontal, anterior cingulate, temporal, and parietal regions previously implicated in reappraisal in general and distancing in particular, in combination with a relative failure to decrease amygdala activation.

METHODS AND MATERIALS

Subjects

Subjects were 18 BPD patients (mean age 32.6±10.4, 10 female;) and 16 HC volunteers (mean age 31.8±7.7; 9 female) recruited from outpatient clinics at the Mount Sinai Medical Center and the James J Peters VA Medical Center in New York City and advertisements in local newspapers and local postings. BPD subjects met DSM-IV criteria for BPD and had prominent affective instability as indicated by the presence of 3 of 4 DSM-IV criteria associated with affective instability, i.e. (1) affective instability due to a marked reactivity of mood, (2) chronic feelings of emptiness, (3) unstable and intense interpersonal relationships, and (4) identity disturbance.

Exclusion criteria applied to the BPD group were present or past bipolar I disorder, schizophrenia, schizoaffective disorder, substance dependence, organic mental syndromes or substance abuse disorder within the previous 6 months. HCs were excluded if they met criteria for any current or past DSM-IV axis I or axis II disorder or had first degree relatives with an axis I disorder. Histories of significant head trauma, CNS neurological disease, or significant medical illness were exclusion criteria for all subjects. Subjects were free of psychotropic medication for at least two weeks (6 weeks in the case of fluoxetine) prior to the scan. Subjects with any contraindications to fMRI scanning, pregnant women and those with current active suicidal ideation were excluded. All subjects provided written informed consent.

Diagnostic assessment was obtained using the Structured Clinical Interview for DSM-IV (SCID-I/P) for axis I (40) and the Schedule for Interviewing DSM-IV Personality Disorders-IV (SIDP-IV) for axis II diagnoses (41). In previous studies we have documented an interrater reliability kappa = 0.81 for diagnosing BPD (42).

Affective instability was assessed by means of the Affective Lability Scale (ALS) (43), a self report instrument shown to correlate with clinician-rated affective instability in patients with BPD (42). Depression was rated with the 21-item Hamilton Depression Rating Scale (HAMD) (44), state and trait anxiety with the Speilberger Trait Anxiety Inventory (STAI) (45), impulsivity with the Barrett Impulsivity Scale (BIS-11) (46), anger with the Spielberger State and Trait Anger Inventory (STAXI) (47), and handedness with the Edinburgh Handedness Inventory.

Subject Characteristics—The BPD and HC groups did not differ in age, sex, or handedness (Table 1). As expected the BPD patients scored higher (Table 1) in depression (HAMD), affective lability (ALS), impulsiveness (BIS-11), and state and trait anger (STAXI). They scored lower in state anxiety (STAI-State) and did not differ in trait anxiety (STAI-trait). None of the BPD patients met criteria for current major depressive disorder, two had generalized anxiety disorder, and two met criteria for current PTSD. As is typical of clinical samples of BPD patients, a history of depression or anxiety disorders was common, with 12 patients reporting prior major depression. One patient had past panic disorder, two had past generalized anxiety disorder, seven had past PTSD, and two a past eating disorder. Axis II comorbidity was present as is typical in BPD samples (see Table S1).

Materials

Stimuli for the reappraisal task were pictures depicting aversive (negative) and neutral interpersonal situations from the International Affective Picture System (IAPS) (48). Since BPD’s are particularly emotionally responsive to interpersonal cues (2) and social and non-social emotions are processed differently in the brain (49–52) we chose to restrict our stimuli to social cues, specifically excluding non-social IAPS pictures that have been intermixed with social stimuli in prior reappraisal studies. Selected negative interpersonal scenes included pictures of people in situations depicting loss or grief, abuse or physical threat. Neutral images depicted persons engaged in work or hobbies, or attending public events. For the two instructional conditions described below we selected two sets of negative images that were matched for valence (mean valence norm ratings 2.3 and 2.4, respectively, where 1= most negative and 9=most positive; $t(45)=.95$, n.s.) and two sets of neutral images also matched for valence (mean ratings 5.2 in each set; $t(47)=.49$, n.s.). Images were also matched for arousal rating between conditions. Negative images were more arousing than neutral images (mean scores 6.1 and 5.7 respectively for negative images ($t(45)=1.30$, n.s.), and 3.8 and 3.5 for neutral images ($t(47)=1.22$, n.s.) where 1= least arousing and 9 = most arousing).

Experimental Design

Task design—The task consisted of 96 trials divided into 4 blocks of 24 trials each. The trial structure and timings are presented in Figure 1. In each block the order of trials (negative-distance, negative-look, neutral-distance, neutral-look) was pseudorandom and this order was used for all subjects.

Training Procedures—Training of the subjects in the reappraisal by distancing technique included initial instruction followed by practice as the investigator observed and shaped their technique, following the method of Ochsner et al (14). Participants were specifically instructed not to look away from the images or to close their eyes. Once they had mastered the technique to the satisfaction of the investigator, they practiced it on a lap-top computer for 20 trials, using the same protocol and timings that would be used during the scan, but different IAPS pictures. They were instructed to apply the distancing technique in response to the auditory instruction "suppress" and to look while responding naturally and not diminishing their emotional reaction when they heard a "maintain" instruction.

Image Acquisition and Analysis

As subjects performed the reappraisal task (figure 1), BOLD images were obtained using a Siemens 3.0 T Allegra scanner with a gradient echo echoplanar (GE-EPI) sequence using the following protocol: 42 axial slices, 2.5 mm thick, skip= 0.825 mm, TR=3 s, TE=27 ms, Flip angle= 84°, FOV=210 mm, matrix=64×64. For anatomical localization a high resolution T2-weighted anatomical scan was acquired on an axial plane parallel to AC-PC line with a turbo spin-echo pulse sequence.

Preprocessing and statistical analyses were carried out using SPM2 (Wellcome Department of Cognitive Neurology, London) standard workflow: motion correction of EPIs with realignment, co-registration of EPIs onto corresponding subjects' high resolution T2 scan, normalization to a standard template (Montreal Neurological Institute), and spatial smoothing with a Gaussian kernel (FWHM=8mm). General linear modeling (GLM) for each participant used the default SPM basis function convolved with regressors of interest (53). The linear combination of 7 regressors was used to model the hemodynamic response (instruction cue: look or distance, as an event; picture viewing: negative-look, negative-distance, neutral-look, neutral-distance, as epochs; valence rating, as an event). Contrast images for all participants were entered into second-level random-effects group conjunction and contrast analyses as implemented in SPM2. The voxel level significance was set to $p < 0.01$ and the minimum cluster extent threshold was set to $k = 85$ in order to correct for multiple comparisons to reach a corrected $p < 0.05$ as decided by a Monte Carlo simulation. Anatomic regions were identified using the Anatomical Automatic Labeling Algorithm (54). A conjunction analysis was carried out using the method of Friston et al 2005, which tests the global null using the minimum T statistic with a global false-positive rate of 0.01 for the height threshold. This conjunction analysis makes the inference that the consistent effects are significant, but not that the significant effects are consistent (55).

RESULTS

Behavioral Results

In post-scan debriefing subjects reported that they implemented the distancing strategy as instructed and did not close their eyes or look away from the images during either the distancing or look conditions. Self-report affect ratings during the scan (figure 2) demonstrated an overall image type (negative vs. neutral) × instruction (look vs. distance) interaction as well as main effects for image type and instruction. Interactions with diagnosis were not significant (for statistical test results see figure 2). There was no main effect of diagnosis. Planned comparisons revealed that for negative pictures BPD and HC subjects reported less negative affect (i.e. higher scores) following distancing as compared looking (BPD: Look=1.91, Distance=2.52, $t(14)=3.60$, $p<0.01$; HC: Look=1.82, Distance=2.59, $t(14)=5.73$, $p < 0.01$). For neutral pictures, affect ratings were close to the neutral value of 3.0 in both the look and distance conditions, although they were slightly higher in the look condition (BPD: Look=3.39, Distance=3.11, $t(15)=3.86$, $p < 0.01$; HC: Look= 3.20, Distance=3.07, $t(14)=1.99$, $p < 0.01$).

We examined the variance in valence ratings, averaging over groups the within-subject variance for each image type and reappraisal condition, as an index of affective instability. There was a significant main effect of group with the BPD's showing a greater variance in valence rating (BPD: 0.53 ± 0.42 vs. HC: 0.36 ± 0.28) and a main effect of condition in which there was less variance in the distance compared to look conditions (Figure 2). There was no main effect of image type, nor group by condition by image type, group by image type, or group by condition interactions (for statistical tests see Figure 2). Post hoc tests showed that when distancing from negative pictures BPD's had a greater variance in valence ratings than HC's (BPD: 0.40 ± 0.29 vs. HC: 0.23 ± 0.14; $t(31)=2.05$, $p=0.05$).

Imaging Results

We first compared the activation between groups in the look condition when viewing negative compared to neutral pictures. The BPD's showed greater right superior temporal, anterior and posterior cingulate and left cerebellar activation than the HC's, while the HC's showed greater activation in the fusiform gyrus and prefrontal regions (see Table 2).

Imaging findings for the negative pictures are the focus of this manuscript because our hypotheses address differences in the neural dynamics of BPD and HC subjects when attempting to down-regulate negative emotion[1]. For each group separately, we identified regions that were activated when viewing negative pictures in the distance > look and look > distance contrasts (Table 3). We then compared and contrasted the two groups to identify regions that were commonly or differentially activated by BPD and HC subjects when distancing versus looking.

Commonly Activated Regions—The conjunction analysis revealed for the distance > look contrast, both BPD patients and HC's together engaged the DLPFC, right and left lateral and ventrolateral prefrontal cortex (right and left middle and superior frontal gyri (BA10, BA8)), extensive regions bordering the intraparietal sulci (IPS) bilaterally, right posterior cingulate cortex (PCC) extending into the precuneus, right parahippocampal gyrus, right insula, and the left superior temporal gyrus. In the look > distance contrast, both groups showed extensive activation in the cuneus, left inferior parietal lobule, and activation of the right postcentral gyrus and left supplementary motor area. (Table 4, Figure 3).

Differentially Activated Regions—To identify differences in patterns of neural activation between BPD patients and HC's when viewing negative pictures in the distancing versus looking contrast, we constructed SPM interaction maps of the double differences in BOLD activation: BPD [distance - look] - HC [distance - look] and the reverse (Table 5 and Figure 4–Figure 6.) The graphs in Figure 4–Figure 6 depict the change in activation from baseline (beta-weights) to the look or distance conditions for the volumes of interest.

[1]For completeness, we have provided in Supplement 1 (Table S2), activation foci contrasting BPD and HC subjects when attempting to distance from neutral pictures, showing greater engagement of the insula and superior/middle frontal gyri bilaterally in BPD compared to HC subjects.

For the distancing minus looking contrast, HC's demonstrated greater activation than BPD patients in the dorsal anterior cingulate (dACC; BA32), bilateral IPS region, right middle occipital gyrus, and right fusiform gyrus. To separate the effects of group and instruction condition upon activation in the dACC and IPS – two regions related to control – we examined the regression weights (betas) quantifying signal change for each group in each condition over all voxels in a 6 mm radius sphere centered on the local maximum for the above contrast in each region. In both dACC and IPS, HC's activated more strongly (relative to baseline) in the distance condition compared to the look condition, while the BPD's showed less activation (Figure 4a–b). For these volumes of interest the Group X Condition interactions were significant and post hoc look vs distance comparisons for each group were significant except for the HC's in the IPS (dACC: Group X Condition: $F(1,32)=10.68$, $p=0.003$; post hoc HC $F(1,15)=5.85$, $p=.03$, BPD $F(1,17)=4.84$, $p=.04$; and for the IPS: Group X condition $F(1,32)=9.34$, $p=.005$; post hoc HC $F(1,15)=1.97$, n.s.; BPD $F(1,17)=8.79$, $p=.009$). In the look condition there was no difference in activation between groups (poct hoc $F(1,32)=0$ 201, n.s. and $F(1,32)=0.091$, n.s., for IPS and dACC respectively).

BPD's showed greater distance versus look activation than the HC's in various regions, including the superior temporal sulcus (STS), right superior frontal gyrus (BA8) and right amygdala (Table 5 and Figure 5). The extracted beta weights for the volume of interest (Figure 5) indicate that relative to baseline HC's showed less activation the amygdala when distancing compared to looking (post hoc $F(1,15)=4.41$, $p=.05$), while the reverse was true for BPD's (post hoc $F(1,17)=6.01$, $p=.03$). In the look condition BPD's show less amygdala activation relative to their baseline than the HC's (post hoc: $F(1,32) = 8.78$, $p=.006$). For both the STS and right superior frontal gyrus (SFG; Figure 6), the extracted beta weights for the volumes of interest showed Group X Condition effects (STS: $F(1,32)=14.59$, $p=.0006$; SFG: $F(1,32)=9.00$, $p=.005$). In both regions, the BPD patients showed greater activation in the distance compared to look condition (post hoc STS: $F(1,32)=22.12$, $p=.00005$; SFG: $F(1,32)=14.73$, $p = .0006$, while there was little difference between conditions for the HC's (STS: $F(1,32)=0.67$, NS; SFG: $F(1,32)=0.25$, n.s.).

We repeated the analysis excluding BPD subjects with histories of PTSD and confirmed that the significant group differences in the distance versus look contrast described above remained for the regions described above: the dACC, IPS, right STS, right superior frontal gyrus, and right amygdala.

DISCUSSION

The purpose of the current study was to further understanding of affective instability in BPD by determining whether the neural bases of one kind of reappraisal – known as distancing – were disturbed in BPD.

Behavioral Observations

As expected, subjects reported less negative affect after distancing as compared to just looking at negative images, but not neutral images. Interestingly, these affect ratings did not differentiate the groups, which runs counter to the expectation that BPD patients would respond more intensely than HC's to negative images and would down-regulate these responses less effectively. It is consistent, however, with prior reports of no differences between BPD patients and HC's in their self-reported affective responses to IAPS pictures despite differences in neural activation (24). One possible explanation is that subjective ratings reflect momentary intensity rather than the chronic instability of affective experience that characterizes BPD (7). This fits with the finding that BPD and non-BPD personality disorder patients differ in ratings of affective instability but not subjective affective intensity (42). In fact, examining the variance in valence ratings as an index of affective instability we found a higher variance in BPD patients than HC's when distancing from negative pictures. Another possibility consistent with our finding and that of Herpertz et al (24) is that in BPD patients there is a disconnect between the subjective experience of emotion and the physiological emotional response.

Neural Dynamics of Passive Looking

When looking at negative social emotional images compared to neutral images borderline patients showed a different pattern of neural activation compared to healthy volunteers, indicating that borderline patients process emotional images differently than controls. The BPD patients showed greater activation in the superior temporal gyrus, posterior cingulate, anterior cingulate and cerebellum than the HC's. We did not find the increased amygdala and fusiform activity reported by Herpertz et al (24). This difference may be due to the fact that that we employed exclusively social emotional pictures in both the negative and neutral conditions, whereas in the Herpertz et al study faces appeared in the negative but not in the neutral pictures, which were all inanimate objects. Since faces are strong activators of the amygdala and fusiform we would expect greater activation when the effect of faces is not subtracted out in the contrast.

Neural Dynamics of Reappraisal-by-Distancing

Common Features in Borderline Patients and Healthy Controls—Borderline patients activated many of the same networks as healthy controls during distancing, including networks implicated in executive function, goal maintenance and the representation of social intensions (the DLPFC; (56)), top-down control of attention allocation (the DLPFC/ IPS network (57–59)) and self-other perspective-taking (the precuneus/PCC (60–62);(63–66)). Notably, DLPFC and IPS (67), but not precuneus/PCC activity, has been reported in prior work on reappraisal (for reviews see (11,15)), possibly because this region is activated only in response to distancing from social cues, which have not been examined specifically until now. The look versus distance contrast identified primary visual regions whose activity diminished during reappraisal. This finding is consistent with prior reports (e.g. Ochsner et. al, 2002) and the idea that distancing involves an inward focus of attention.

Differences Between Borderline Patients and Healthy Controls—Beyond the above commonalities, BPD's showed a distinctly different pattern of activation compared to HC's in a set of regions related to control and emotional responding. Specifically, during distancing compared to looking BPDs showed less activation relative to baseline in the dACC and IPS and greater activation in the right superior frontal gyrus (BA8) and STS, whereas HC's showed the reverse. Both groups showed comparable activation in the look condition. Unlike HC's, BPD's increased amygdala activation relative to baseline during distancing compared to looking (Figure 5). In addition, during look trials BPD's showed less activation than HC's relative to their respective baselines. A possible explanation for these paradoxical differences in the look condition is that at baseline, BPD's had higher levels of amygdala activation than HC's and their activation decreased as they focused on the task of looking at pictures, while for the HC's activation increased from a low baseline when they looked at the pictures. The decrease in activation in the HC's in the distancing condition is consistent with a downregulation of the amygdala when distancing. What remains unclear is what accounts for the increased amygdala activation in BPD's during distancing.

The regions showing differential activation between BPD and HC subjects have been implicated in various control and affective functions relevant to BPD. Theories of cognitive control postulate the dACC and DLPFC work hand-in-hand to signal the need for control and to implement control processes, respectively (68–70). The IPS has been implicated in top-down attentional control (57–59), and the STS implicated in representing social cues of the intentions of others (52,71–75).

Our finding of differences in neural activation between borderline patients and healthy controls during reappraisal by distancing must be considered in the context of our finding of differences in activation in the passive viewing condition as well. Thus we can not rule out the possibility that the different activation patterns in the reappraisal condition arise from a more general difference in overall emotion processing and not from differences in the mechanism of reappraisal per se. Nevertheless our findings allow us to reject the null hypothesis that in explicit emotion regulation BPD's and HC's do not differ in neural activation. Moreover, with respect to the IPS and dACC, the BPD vs. HC differences during reappraisal do not appear to be a consequence of differences in passive emotion processing, since activation (regression weights) in the look condition did not differ between the groups.

Limitations of the Present Study

Although this study is the first to our knowledge to examine the neural dynamics of cognitive reappraisal in borderline patients, it is important to acknowledge its limitations as well. As in other studies of cognitive reappraisal we relied upon subjects' reports that they carried out the task as directed. The lack of a psycho-physiological measure indexing the reappraisal task is a limitation of this study and future studies should make an effort to monitor reappraisal processes within the scanner Self-reports of affective response. may be influenced by demand. Redirection of eye gaze away from emotionally charged regions in the pictures could play a role in downregulation of the emotional response and is associated with differences in BOLD signal when reappraising vs. looking (76). Eye gaze is regulated by both bottom-up and top-down control networks (77) and may be an intervening mechanism in reappraisal, implemented differently in BPD patients and HC's. While the present study could not determine the extent to which eye gaze redirection was employed to downregulate emotion in each group, it demonstrates clear differences in the neural dynamics of distancing in BPD patients versus healthy volunteers. We cannot eliminate the possibility that contrary to our instructions some subjects closed their eyes or looked away from the pictures.

We cannot exclude the possibility that group differences could be explained by socioeconomic or cognitive differences. The BPD group was heterogeneous in terms of comorbidity and prior psychiatric history and further studies are called for to replicate these findings in more homogenous samples. While group differences in depression as measured by the HAM-D were present, no correlations between HAM-D score and activation were detected.

Implications for Borderline Pathology and Directions for Future Research

The finding that borderline patients do not downregulate amygdala activity as healthy controls do, and do not recruit the networks that healthy subjects employ in cognitive reappraisal by distancing suggests that BPD patients may be impaired in their ability to cognitively regulate their emotions, an impairment which may in turn contribute to the affective instability of borderline patients. To reduce task heterogeneity, the present study examined the single strategy of distancing, selected as one likely to distinguish BPD from HC subjects. Future studies should examine other commonly employed reappraisal strategies such as reinterpretation and response-focused strategies (12,14). Further studies are called for to replicate and to extend the findings of this study to other psychopathological groups, to help determine whether the results reported here are specific to borderline pathology.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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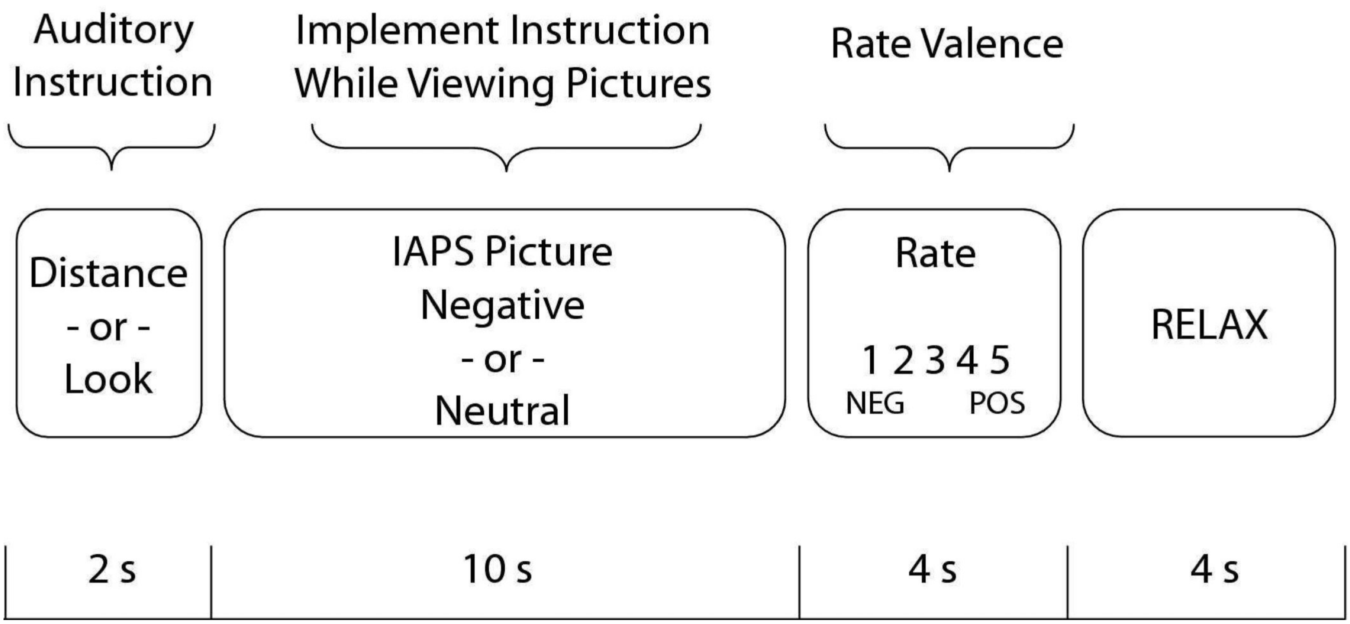

Figure 1.

Schematic depiction of a single trial in the imaging paradigm. Each 20s trial consisted of a 2s auditory instruction (“maintain” or “suppress”) presented over earphones, a 10s presentation of an IAPS picture (negative or neutral), a 4s rating period and a 4s inter-stimulus-interval (“relax”). During the rating period subjects indicated their emotional reaction to the picture after carrying out the instruction (using a 5-button hand pad; 1= very negative to 5=very positive). Ninety six trials were presented in 4 blocks of 24 trials each. Each block contained 6 trials of each of the 4 conditions in the 2 × 2 design (picture valence X instruction) presented in pseudorandom order.

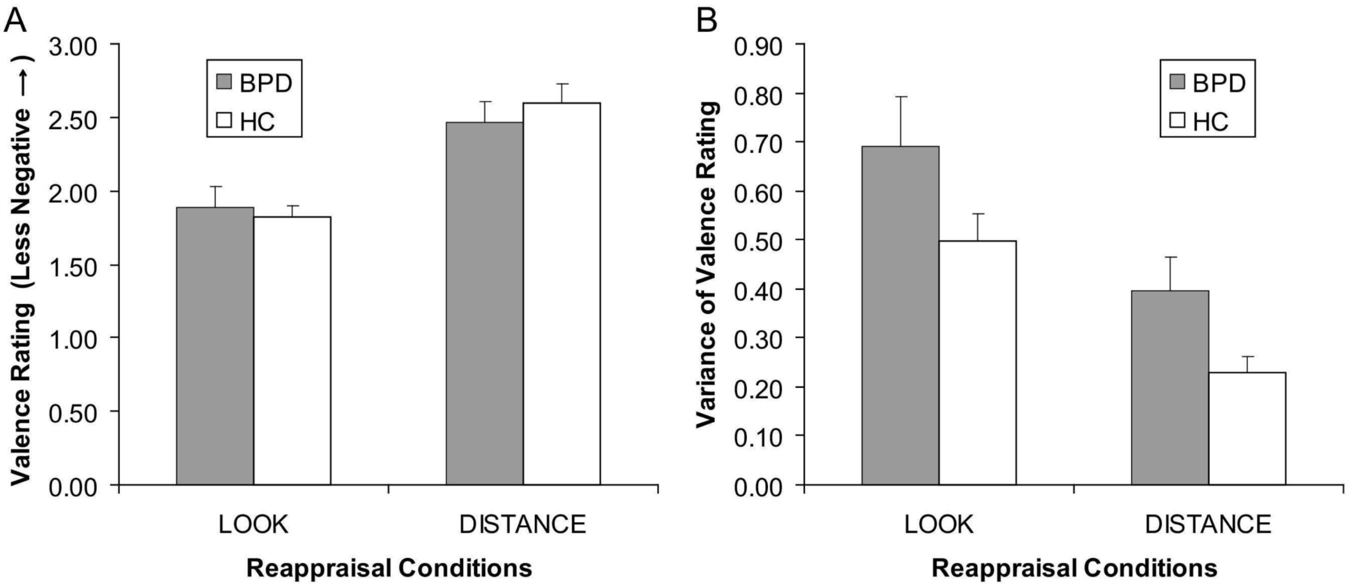

Figure 2.

A.) Subjective ratings of valence of negative IAPS pictures following the look and distance instructions. There is an Image Type (negative vs. neutral) × Instruction (look vs. distance) interaction: $F(1,31)=69.63$, $p<.001$. Main effects for image type and instruction are also significant: $F(1,31)=102.40$, $p <0.01$, and $F(1,31)=15.00$, $p < 0.01$, respectively. Interactions with diagnosis were not significant: image type X diagnosis: $F(1,31)=0.48$, ns; instruction X diagnosis: $F(1,31)=1.83$, ns; image type × instruction × diagnosis: $F(1,31)=0.08$, ns. There was no main effect of diagnosis ($F(1,31)=0.36$,ns). B.) Within-subject varience in valence ratings for negative IAPS pictures. There is a significant main effect of group ($F(1,31) =5.83$, $p=0.02$) and of instruction ($F(1,31)=69.85$, $p<.001$), but not of Image type ($F(1,31)= 0.66$, n.s.). There were no significant group × instruction × image type ($F(1,31)=0.02$, n.s.), group × image type ($F(1,31)=0.04$, n.s.), or group × instruction interactions($F(1,31)=0.20$, n.s.).

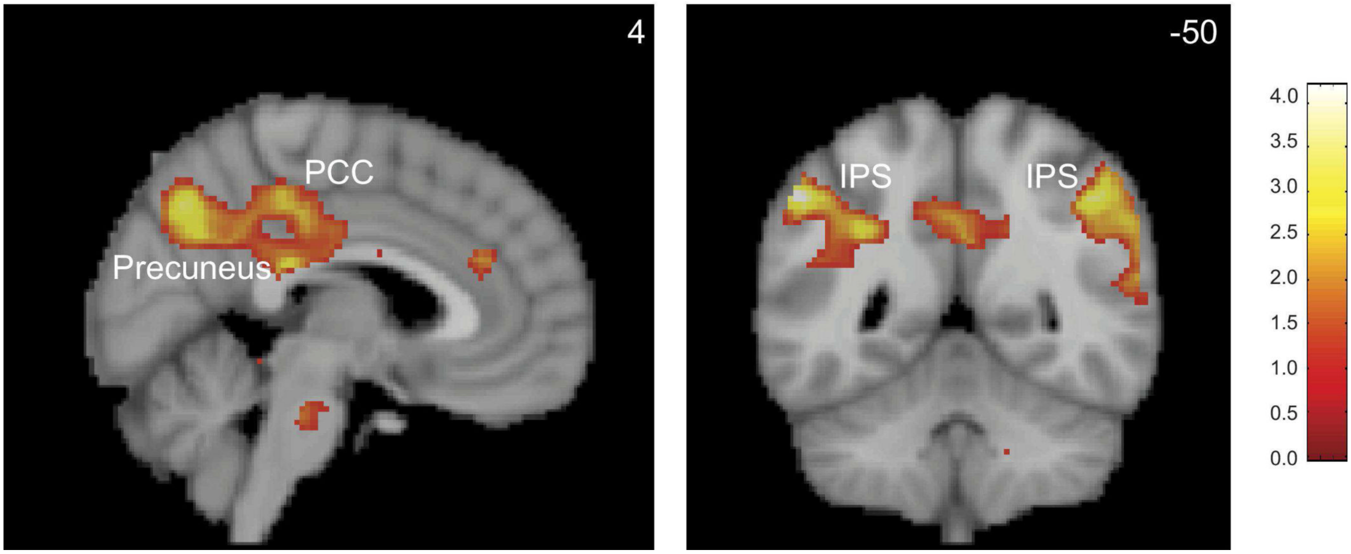

Figure 3.
Regions of common activation in both BPD and HC subjects when distancing versus looking at negative pictures. PCC – Posterior Cingulate Gyrus; IPS – Intraparietal Sulcus. BOLD signals are displayed overlaid on the Montreal Neurological Institute (MNI) SPM canonical anatomic template. The display threshold is $p<.01$. The color bar indicates t-values.

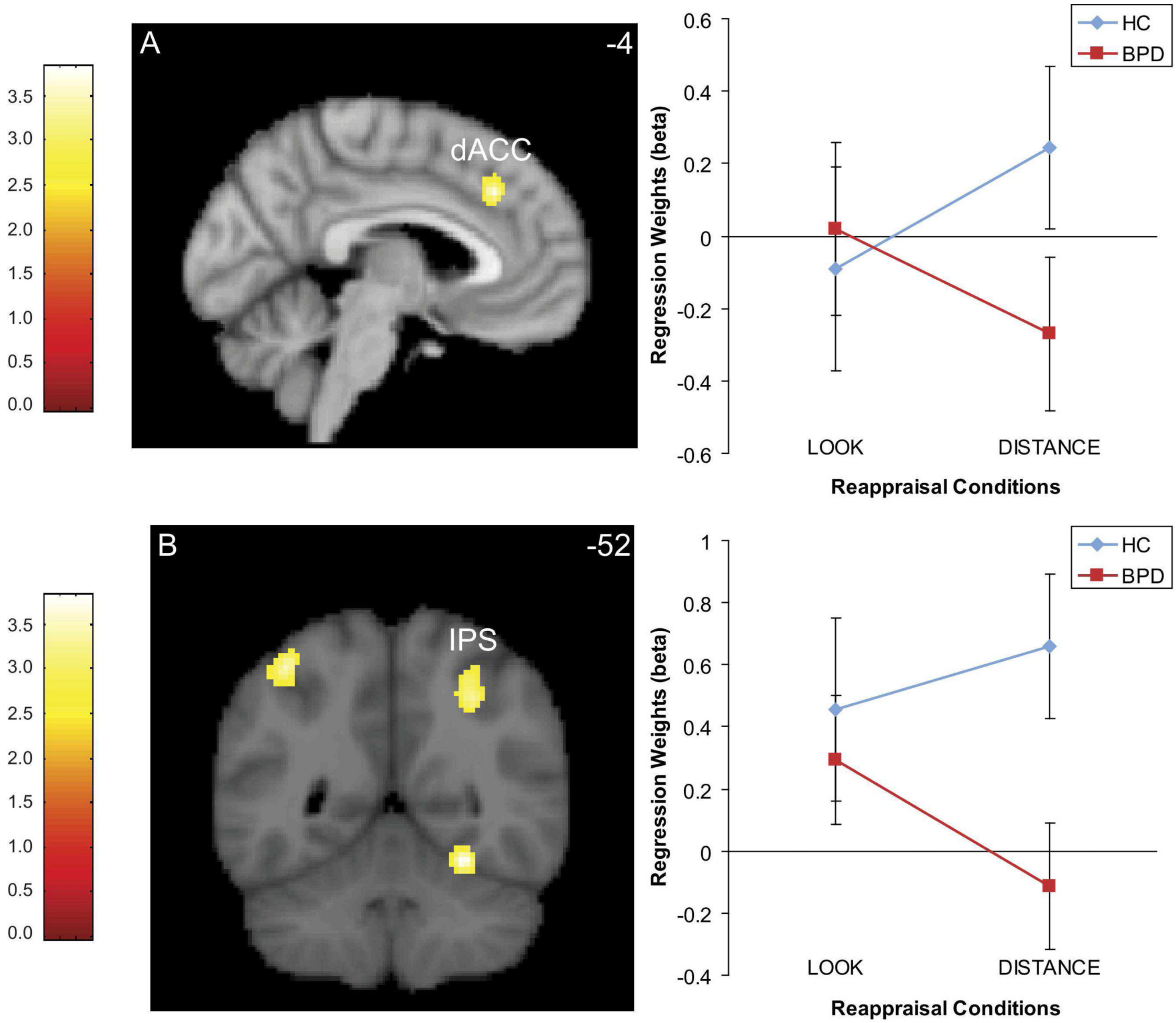

Figure 4.

a) Sagittal section illustrating foci of increased BOLD activation in healthy controls relative to borderline patients when carrying out the distance vs. look instruction to negative IAPS pictures and plot of regression weights in dorsal ACC for healthy controls (HC) and borderline patients (BPD) when carrying out the look and distance instructions. b) Coronal section illustrating regions of increased activation in healthy controls relative to borderline patients and plot of regression weights for each group in right intraparietal sulcus region. BOLD signals are displayed overlaid on the Montreal Neurological Institute (MNI) SPM canonical anatomic template. The display threshold is p<.01. The color bar indicates t-values.

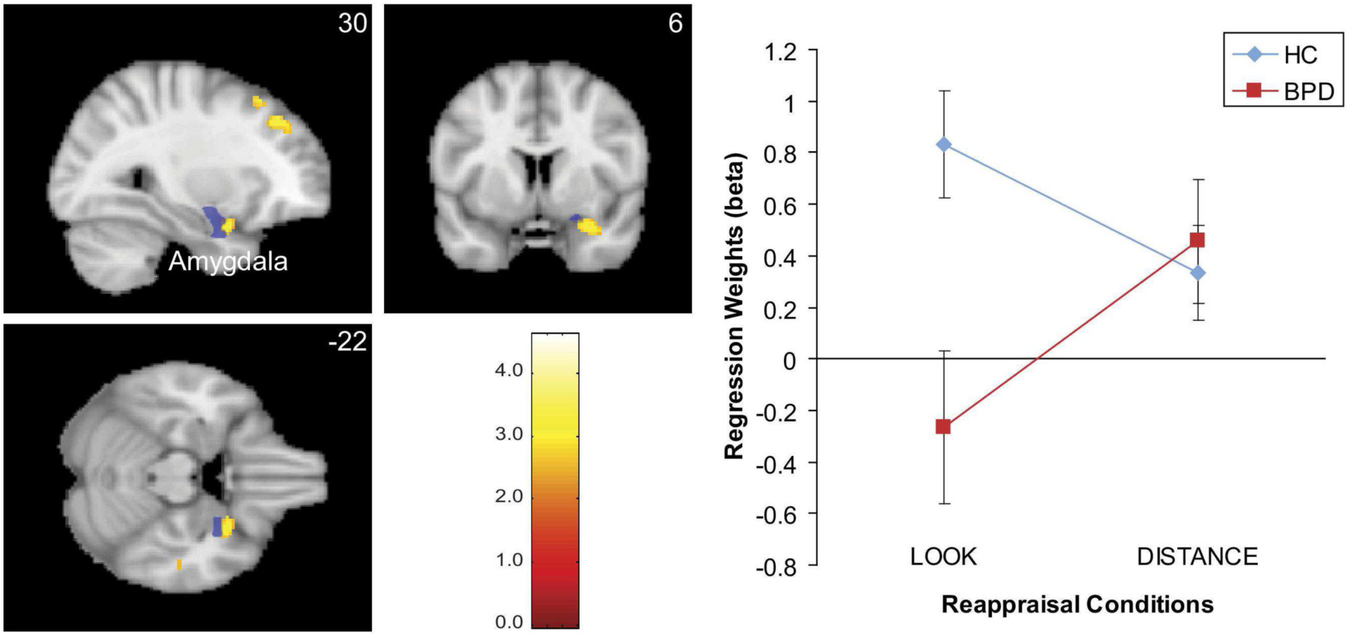

Figure 5.

Coronal, sagittal, and horizontal sections illustrating greater activation in the amygdala of BPD patients compared to healthy controls when distancing and plot of regression weights for each group in right amygdala. The BOLD signal appears in yellow and the anatomic locus of the amygdala is show in blue. BOLD signals are displayed overlaid on the Montreal Neurological Institute (MNI) SPM canonical anatomic template. The display threshold is p<.01. The color bar indicates t-values.

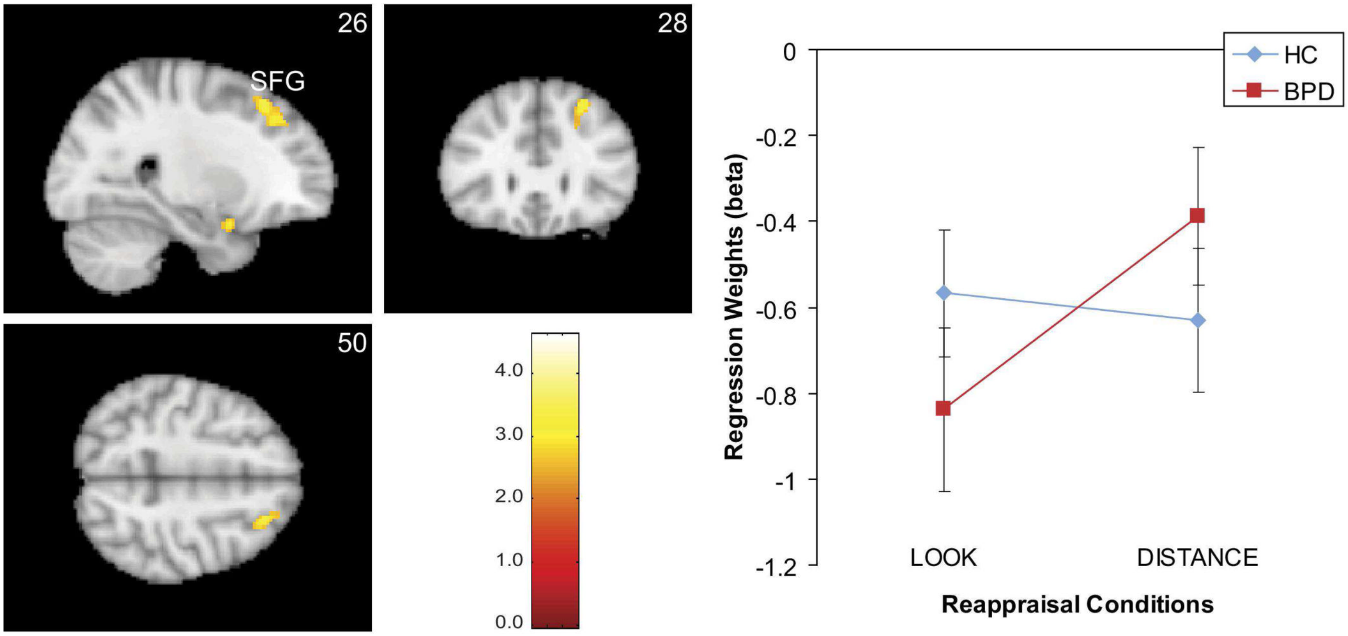

Figure 6.
Coronal, sagittal, and horizontal sections illustrating greater activation in the superior frontal gyrus (SFG) of BPD patients compared to healthy controls when distancing and plot of regression weights for each group in right SFG. BOLD signals are displayed overlaid on the Montreal Neurological Institute (MNI) SPM canonical anatomic template. The display threshold is $p<.01$. The color bar indicates t-values.

Table 1

Sample characteristics

	BPD N = 18	HC N = 16	Statistic
Age (SD)	32.6 ± 10.4	31.8 ± 7.7	t(32) = 0.27 (NS)
Sex	10 Female	9 Female	χ^2 = 0.002 (NS)
Handedness	17 R; 1 L	14 R; 1L; 1M	χ^2 = 1.177 (NS)
ALS Total	94.9 ± 23.7	20.3 ± 16.0	t(31) =10.4*
HAM-D	11.6 ± 4.3	1.9 ± 1.7	t(28) = 7.4*
BIS-11	77.9 ± 8.7	51.1 ± 9.7	t(30) = 8.2*
STAI – Trait	47.9 ± 1.6	45.3 ± 2.9	t(30) =1.4
STAI – State	42.8 ± 6.7	47.6 ± 3.5	t(30) = 2.4*
STAXI – Trait	24.8 ± 5.9	14.8 ± 4.5	t(30) = 5.3*
STAXI – State	12.8 ± 4.3	10.1 ± 0.4	t(30) = 2.3*

Notes: R –Right; L- Left; M- Mixed Handedness; ALS- Affective Lability Scale; HAM-D – Hamilton Depression Scale (21 Item); BIS-11 – Barratt Impulsiveness Scale, version 11; STAI – Spielberger State and Trait Anxiety Inventory; STAXI – Spielberger State and Trait Anger Inventory

*p<.05

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Table 2

Activation foci that differed between the groups when looking at negative versus neutral IAPS pictures

Region	k	MNI coordinates			Z-score
		x	y	z	
Healthy Controls > Borderline Patients					
R Fusiform (BA18)	96	26	−80	−2	3.10
L Lingual G. (BA19)	105	−26	−64	−8	3.06
L Inferior Temporal G. (BA20)	114	−58	−24	−16	2.88
R Fusiform (BA20)	121	40	−16	−22	3.48
L Frontal Inf G. (BA45)	159	−50	28	16	3.72
R Superior Medial Frontal G. (BA9)	281	10	44	36	3.47
L Superior Frontal G (BA9)	92	−18	54	28	3.17
Borderline Patients > Healthy Controls					
L Cerebellum	106	−4	−68	−18	3.68
R Superior Temporal G (BA48)	208	56	−34	22	3.18
Posterior Cingulate (BA23)	1679	4	−20	46	3.83
Anterior Cingulate (BA32)	439	0	8	46	3.76

Notes: k – cluster size in 2×2×2mm voxels. $p<.01$, minimum cluster size, k=85.

Table 3

Activation foci for healthy controls and borderline personality disorder patients when distancing versus looking at negative IAPS pictures.

Region	BA	k	MNI coordinates			Z-score
Healthy Controls			x	y	z	
Distance > Look						
L Inferior Parietal Lobule	40	1450	−40	−56	38	4.04
R Inferior Parietal Lobule	40	470	50	−56	40	3.66
L Middle Temporal G.	21	210	−58	−52	−6	3.94
R Superior & Middle Temporal G	22/21	225	62	−36	2	3.64
L & R Precuneus/Posterior Cingulate G	7/31	3154	4	−24	36	4.60
R Middle Frontal G	10	89	36	56	4	2.85
Look > Distance						
L & R Cuneus/Lingual G.	18/17	3173	2	−86	0	4.53
L Middle Occipital G/Middle & Inf Temporal G	37/19	486	−40	−78	14	4.79
R Middle & Inf Occipital G/Middle & Inf Temporal G	37/19	219	44	−72	−6	3.20
L Postcentral G/Inf Parietal Lobule	2/40	95	−50	−32	56	2.93
L Precentral/Postcentral G	3/4	304	−40	−12	62	3.31
Borderline Patients						
Distance > Look						
L & R Precuneus	7	406	−6	−56	42	3.19
L Inferior Parietal Lobule	40	132	−54	−50	46	3.44
L Superior Temporal G/Insula	22/29/13	524	−38	−36	22	3.87
R Middle & Sup Temporal G/Inf Parietal Lobule	40/21/22	4173	52	−28	−6	4.44
L Superior & Middle Temporal G	22/21	187	−50	−12	2	3.43
L Parahippocampal G/Hippocampus/Amygdala	34/28	102	−24	−12	−22	3.09
R Parahippocampal G/Amygdala	34	100	8	−8	−22	3.71
L Caudate		162	−8	6	−4	3.79
L Sup, Middle, Inf Temporal G	38/21	347	−36	12	−38	3.82
L Middle Frontal G	9	158	−36	30	30	3.48
R Inferior Frontal G	47	93	44	30	2	3.05
R Middle & Superior Frontal G	10/9/8	1988	14	64	20	4.52

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Region	BA	k	MNI coordinates			Z-score
Healthy Controls			x	y	z	
Look > Distance						
L & R Cuneus/Lingual G	18/19	10413	−8	−98	16	4.91
L Postcentral G/Inferior Parietal Lobule	2/40	982	−56	−22	44	3.69
R Precentral G/Postcentral G	4/6	122	62	−12	34	3.68
R Inferior Frontal G	9	113	42	8	26	3.56
L Inferior Frontal G/Precentral G	9/6	366	−56	4	34	4.29

Notes: k – cluster size in 2×2×2mm voxels. p<.01, minimum k=85.

Table 4

Conjunctive activation by both groups when distancing versus looking at negative IAPS pictures.

Region	BA	k	MNI coordinates			Z-score
			x	y	z	
Distance > Look						
L Inferior Parietal Lobule	40	1538	−54	−50	46	5.61
R Inferior Parietal Lobule	40	3131	46	−52	46	5.30
R Precuneus	7	3254	6	−66	44	4.89
L Superior Temporal G.	42	275	−62	−38	14	3.69
R Parahippocampal G.	28	122	18	−6	−24	3.42
R Middle Frontal G.	10	1314	38	56	4	4.72
R Superior Frontal G.	8	93	26	20	60	3.87
L Superior Frontal G.	10	283	−18	58	10	3.51
R Middle Frontal G.	9	100	44	12	50	3.44
L Middle Frontal G.	8	241	−30	28	52	3.38
R Insula	48	87	34	−16	18	3.32
Look > Distance						
R Cuneus	17	8081	14	−96	14	6.53
L Inferior Parietal Lobule	7	2056	−28	−48	54	4.52
L Supplementary Motor Area	6	159	−4	−6	54	3.53
R Post Central G.	3	285	58	−10	32	3.51

Notes: k – cluster size in 2mm×2mm×2mm voxels. $p<.01$, minimum cluster size, k=85.

Table 5

Activation foci that differed between the groups when distancing versus looking at negative IAPS pictures.

Region	BA	k	MNI coordinates			Z-score
			x	y	z	
Healthy Controls > Borderline Patients						
R Middle Occipital G	19	107	40	−76	4	3.06
R Middle Occipital G	19	266	30	−70	20	3.20
R Fusiform G	37	149	28	−54	−16	3.44
R Inf/Sup Parietal Lobule	7	175	30	−52	44	3.01
L Inferior Parietal Lobule	40	173	−40	−50	54	3.29
L Anterior Cingulate G	32	128	−4	30	36	3.34
Borderline Patients > Healthy Controls						
R Superior Temporal G	41	113	42	−20	6	4.01
R Middle/Superior Temporal G	21/22	427	50	−18	−14	3.64
R Amygdala		89	30	6	−22	2.96
R Superior Frontal G	8	307	26	28	50	3.14

Notes: k – cluster size in 2mm×2mm×2mm voxels. $p<.01$, minimum cluster size, k=85.