

Individual differences in neural responses to social rejection: the joint effect of self-esteem and attentional control

Anett Gyurak,^{1,2,3} Christine I. Hooker,⁴ Asako Miyakawa,⁵ Sara Verosky,⁶ Anna Luerssen,⁷ and Özlem N. Ayduk⁷

¹Department of Psychiatry and Behavioral Sciences, Stanford University, Stanford, CA, USA, ²Department of Psychology, Stanford University, Stanford, CA, USA, ³Sierra-Pacific Mental Illness, Research, Education, and Clinical Center (MIRECC) Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, USA, ⁴Department of Psychology, Harvard University, Cambridge, MA, USA, ⁵Helen Wills Neuroscience Institute, University of California, Berkeley, CA, USA, ⁶Department of Psychology, Princeton University, Princeton, NJ, USA, and ⁷Department of Psychology, University of California, Berkeley, CA, USA

Individuals with low self-esteem have been found to react more negatively to signs of interpersonal rejection than those with high self-esteem. However, previous research has found that individual differences in attentional control can attenuate negative reactions to social rejection among vulnerable, low self-esteem individuals. The current fMRI study sought to elucidate the neurobiological substrate of this buffering effect. We hypothesized and found that while looking at scenes of social rejection (vs negative scenes) low self-esteem high attentional control individuals engaged the rostral anterior cingulate cortex (rACC), an area of the brain associated with emotional control, more than their low self-esteem low attentional control peers. Furthermore, we found that low self-esteem high attentional control individuals evaluated social rejection as less arousing and less rejecting in a separate behavioral task. Importantly, activation in the rACC fully mediated the relationship between the interaction of self-esteem and attentional control and emotional evaluations, suggesting that the rACC activation underlies the buffering effects of attentional control. Results are discussed in terms of individual differences in emotional vulnerability and protection and by highlighting the role of rACC in emotion regulation.

Keywords: attentional control; self-esteem; social rejection; rostral anterior cingulate cortex; emotion regulation

INTRODUCTION

Securing interpersonal acceptance is a fundamental human motive (Leary *et al.*, 1995; Hart *et al.*, 2005). Thwarted acceptance strivings, therefore, result in a prototypical sequelae of negative reactions that include heightened negative emotions (Nezlek and Plesko, 2001), elevated cortisol stress responses (Dickerson *et al.*, 2004) and behavioral aggression (Leary *et al.*, 2006). Individual differences in sensitivity to rejection can further exacerbate these response patterns. Low self-esteem—the chronic, enduring sense of low self-worth (Leary and Baumeister, 2000)—appears to make people particularly vulnerable in the face rejection. Specifically, low self-esteem individuals have been shown to experience elevated levels of cortisol stress responses (Pruessner *et al.*, 1999) and negative affect (Nezlek and Plesko, 2001) when faced with rejection.

Owing to the potency of rejection as an interpersonal stressor, people normatively engage regulatory efforts to manage the impact of social threat (Eisenberger *et al.*, 2003; Wager *et al.*, 2009). One potential mechanism through which reactions to threat in general and social rejection specifically might be dampened is attentional control (Derryberry and Reed, 2002)—the ability to direct and maintain attentional focus. Attentional control has been related to faster disengagement from threatening stimuli in anxious individuals (Derryberry and Reed, 2002), and to lower negative affect after a laboratory induction of negative mood (Compton, 2000). Infants with high attentional control tend to be less reactive in threatening, novel situations (Rothbart and Bates, 1998) and show better psycho-social adjustment later in life as adults (Eisenberg *et al.*, 2000; Kochanska and Knaack, 2003). Finally, among adults who are prone to borderline personality disorder, higher attentional control is related to lower likelihood of exhibiting symptomatology (Ayduk *et al.*, 2008).

In our previous work, we hypothesized that attentional control might act as a protective mechanism for vulnerable low self-esteem individuals when faced with social rejection; individuals otherwise prone to display heightened threat reactions (Gyurak and Ayduk, 2007). We assessed physiological threat as the strength of the startle eye-blink

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Correspondence should be addressed to Anett Gyurak, Department of Psychiatry, 401 Quarry Road, MC: 5797, Stanford, CA 94305-5797, USA. E-mail: agyurak@stanford.edu

responses to loud noise bursts paired with rejection stimuli. The startle eye-blink is one component of the biologically based defensive response system, generated by the amygdalae as a reaction to threatening stimuli (Davis *et al.*, 1982). However, startle responses can be modulated by regulatory attempts (Jackson *et al.*, 2000). Thus, we hypothesized that individual differences in attentional control might buffer low self-esteem individuals from heightened reactivity in response to rejection. In line with this, we found that self-esteem and attentional control interacted, and attentional control moderated the effects of low self-esteem, such that low self-esteem was related to smaller eye blink responses to rejection among those high in attentional control.

In our previous work (Gyurak and Ayduk, 2007), we speculated that this lower physiological reactivity might occur via the engagement of the rostral, pregenual portion (BA24/32) of the anterior cingulate cortex (ACC) given its extensive connections to emotional centers in the brain (Devinsky *et al.*, 1995; Lewis and Todd, 2007). More specifically, a growing body of imaging studies indicates that attentional control is associated with the recruitment of brain areas that enact cognitive control over behavior and emotions (rostral ACC, rACC and dorsal ACC, dACC; Mathews *et al.*, 2004; Etkin, *et al.*, 2006; Carter and van Veen, 2007; Egner *et al.*, 2008). Furthermore, there appears to be some specialization in the ACC, such that the dACC subserves cognitive regulation and expression of negative emotional stimuli (Egner *et al.*, 2008; Etkin, *et al.*, 2011), whereas the rACC is more closely linked to modulation of control and regulatory functions in emotional contexts (Bush *et al.*, 2000; Etkin *et al.*, 2006, 2011). In line with this, better attentional control—measured as an individual difference using a questionnaire measure (Derryberry and Reed, 2002) has been found to relate to activation in the ACC. For example, Bishop and colleagues (Bishop *et al.*, 2007) found stronger blood oxygenation level-dependent (BOLD) signal in the left dACC as a function of attentional control in a task where participants had to disregard threatening negative faces to complete a cognitive digit-recognition task. Importantly, individual difference in attentional control were found to be related to activation in the left rACC in a task where participants were asked to passively view facial expressions of fear *vs* neutral faces (Mathews *et al.*, 2004). These authors concluded that individual differences in the recruitment of the left rACC index engagement of control processes over emotional threat and the ability to maintain attention in the face of threatening stimuli.

Current study

The goal of the current study was twofold. (i) In a functional imaging study, we sought to explore the role of the rACC in individual differences in self-esteem and attentional control when processing social rejection stimuli; and (ii) assess the mediating role of rACC activation on emotional evaluations of social rejection. Similar to our previous work (Gyurak and Ayduk, 2007) we chose to investigate self-esteem and

attentional control as they naturally vary along continuous dimensions in a regression framework to increase generalizability and power.

Drawing on a meta-analysis conducted by Bush and colleagues (Bush *et al.*, 2000) a recent review by Etkin and colleagues (Etkin *et al.*, 2011) and several imaging studies (Mathews *et al.*, 2004; Etkin *et al.*, 2006) who found that activation in the rACC is related to regulatory control over emotional information we defined the rACC as our *a priori* region of interest (ROI). However, given that there is still an ongoing debate about regional specialization of emotional functions in the ACC, statistical analysis was conducted in a bilateral ACC mask (see Etkin *et al.*, 2011).

Participants were presented with previously validated stimuli in the form of evocative paintings proven to elicit feeling of social rejection (Downey *et al.*, 2004; Gyurak and Ayduk, 2007; Kross *et al.*, 2007). We controlled for neural activation associated with processing negative paintings by creating activation contrasts between rejection and negative control trials—and thus isolated rejection related processing. We hypothesized that individuals who are vulnerable to over-react to social rejection (low self-esteem), but able to control these responses (high attentional control) would show spontaneous engagement in rACC when processing social rejection stimuli but low self-esteem individuals low in attentional control would not. We expected high self-esteem individuals to engage rACC in the presence of social rejection cues regardless of their attentional control levels. This expectation is based on previous findings showing that people who are not sensitive to social rejection, such as those high in self-esteem, automatically engage regulation related brain areas when processing social rejection information (Kross *et al.*, 2007).

To assess the mediating role of rACC activation on emotional evaluations of rejection, participants rated the social rejection stimuli (*vs* negative stimuli) outside the scanner on several relevant emotional dimensions. We created an emotional evaluation composite and conducted a mediational analysis between self-esteem and attentional control on emotional evaluation of social rejection with rACC activation as a mediator.

METHODS

Participants and procedures

English-speaking, right-handed undergraduate students were recruited as participants for a larger study on emotional processing in ongoing dating relationships on the UC Berkeley campus (see Ayduk *et al.*, 2009 for details on the larger study). A subset of these participants took part in the imaging study ($n = 23$, 12 males, 11 couples, 1 individual) and the separate behavioral assessment. All participants (in the larger study) completed a laboratory session in which they filled out self-report questionnaires and other tasks unrelated to the present study. At that time, an invitation to participate in the fMRI scan was extended. Interested participants were

then screened for fMRI procedure contraindications (e.g. metal in the body, claustrophobia, etc.) and history or current diagnosis of neurological or psychiatric illness. Eligible participants were scheduled and scanned. The mean age of the participants in the current study was 20.61 years (*s.d.* = 1.77). Thirty-two percent of the sample was Asian, 40% Caucasian, 28% other race. 12% of the sample indicated being Hispanic.

Participants were scheduled for the fMRI session individually. During the fMRI session participants completed the painting task (described below) and other previously reported tasks (Hooker *et al.*, 2010) that are not pertinent to the current study. Following the fMRI scan, participants were scheduled for the separate behavioral session within 1–2 weeks where they completed the rejection perception task (described below). Participants were compensated \$50 for the fMRI scan and \$15/h for the behavioral session.

Questionnaire measures

Self-esteem

Participants completed Rosenberg's (Rosenberg, 1989) 10-item questionnaire to assess subjective feelings of self-esteem. The scale is highly face valid and internally consistent and asks participants to rate their self worth on items like: I feel that I have a number of good qualities. Ratings were made on a scale from 1 (does not describe me at all) to 7 (describes me very well). Items were reverse-scored when appropriate and then averaged ($M = 5.30$, *s.d.* = 0.80).

Attentional Control

Participants completed the 20-item Attentional Control Scale (Derryberry and Reed, 2002) on a 4-point scale (1 = almost never to 4 = always). The Attentional Control Scale is internally consistent scale and is designed to tap into subjective self-reports of attentional and concentration difficulties that are believed to be biological in their origins. It is unique among self-report measures in that it tries to capture biologically based individual differences in effortful control at the self-report level. The scale taps into two inter-related aspects of effortful control; the ability to focus attention (e.g. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts.) and the ability to shift attention (e.g. It takes me a while to get really involved in a new task.). After appropriate items were reverse scored, we computed each participants overall attentional control score by averaging the 20 items ($M = 2.77$, *s.d.* = 0.29).

fMRI painting task

Participants were asked to appraise how 'negative–positive' they felt while viewing artwork depicting negative, positive, social rejection, social acceptance and neutral themes. The current study focused on the rejection and negative paintings to isolate the neural networks associated with the processing of social rejection specifically while controlling for the effects

of general negativity. Artwork used in this task was identical to the set used in our previous work (Gyurak and Ayduk, 2007) and similar to other imaging studies (e.g. Kross *et al.*, 2007). This set of paintings represents a number of improvements over previously used stimuli sets (e.g. Downey *et al.*, 2004; Kross *et al.*, 2007). Negative paintings used here are representational and paintings are produced by a variety of artists, as opposed to a single source artist used in previous studies. Paintings were pilot tested to be negative, positive or neutral or to elicit social rejection, or acceptance. Results of the pilot were previously reported in Gyurak and Ayduk (2007). The paintings were scanned from high-quality slides and digitally presented on a computer screen using E-prime software (Psychology Software Tools, Pittsburgh, PA, USA). As in our previous work, we controlled for neural activation associated with processing negative paintings by creating activation contrasts between rejection and negative control trials—and thus isolated rejection related processing.

The fMRI task (Figure 1) consisted of two 8-min runs. Presentation of the painting stimuli was blocked by condition type (negative, positive, social rejection, social acceptance and neutral). Four paintings of the same category were presented within a condition block. Each painting was presented for 2750 ms, followed by a 1250 ms blank screen creating 16 s condition blocks. At the beginning of the task, participants were instructed that 'while viewing the paintings, allow yourself to really feel whatever feelings come up for you' to draw attention to internal feelings. After each block of trials, participants rated how 'negative/positive the previous pictures made you feel' on a 1 to 4 scale (1: very negative to 4: very positive). Each condition block was followed by 12 s of 'rest' to ensure that the hemodynamic response returned to baseline.

Across the two runs, each condition block was presented six times. Participants saw each individual painting three times during the task. Within each condition block the paintings were pseudo-randomized so that no two blocks were composed of the same four paintings. The category blocks were presented in a fixed random order. The order of presentation remained the same across participants.

Similar to our previous work, valence rating during the Painting Task (Table 1) indicated that rejection and negative pictures were perceived as equally negative.

fMRI image acquisition

All images were acquired at 4 Tesla using a Varian INOVA MR scanner (Palo Alto, CA, USA) equipped with echo-planar imaging. A standard radiofrequency head coil was used, and a memory foam pillow restricted head motion. E-Prime software controlled the stimulus display and recorded participant responses via a 4-button fiber-optic keypad. An LCD projector (Epson, Long Beach, CA, USA) projected stimuli onto a backlit projection screen (Stewart, Torrance, CA, USA) within the magnet bore, which the participant viewed via a mirror mounted on the head coil.

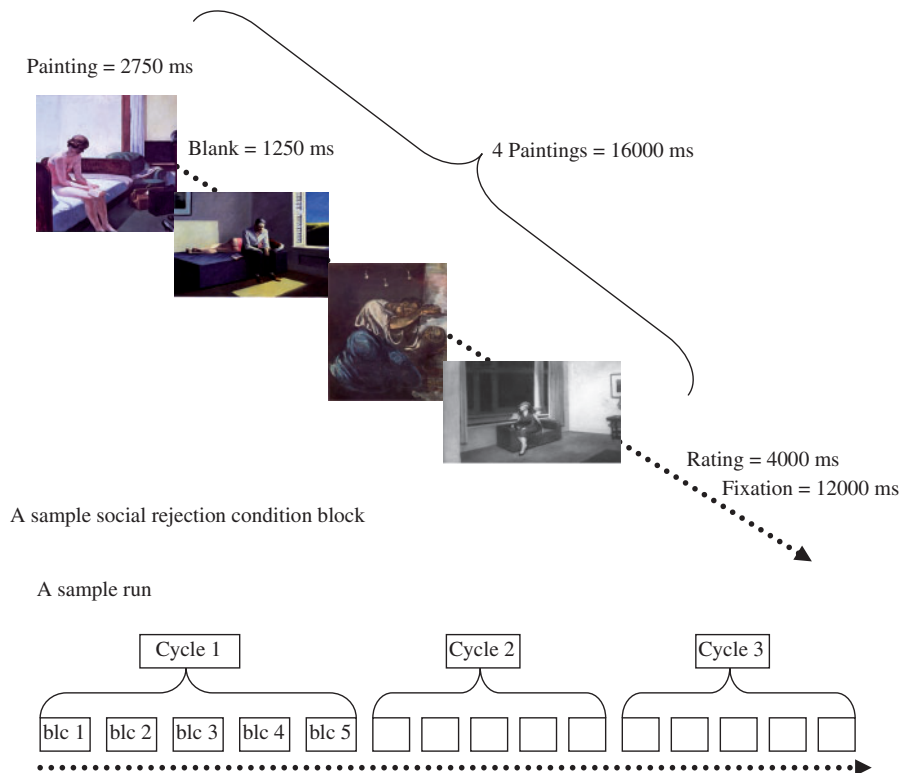


Fig. 1 Schematic depiction of the fMRI task.

Table 1 Valence ratings of different painting category blocks in the fMRI task

Scale	Category				
	Neutral <i>M</i> (s.d.)	Negative <i>M</i> (s.d.)	Positive <i>M</i> (s.d.)	Rejection <i>M</i> (s.d.)	Acceptance <i>M</i> (s.d.)
Valence	2.50 _b (0.45)	1.49 _a (0.42)	3.46 _c (0.42)	1.46 _a (0.50)	3.54 _c (0.40)

Note: Ratings were made on a 4-point scale. Higher ratings on valence indicate greater positivity. Means with different subscripts differ from each other at $P < 0.05$.

Functional images were acquired during two runs. Each run included five dummy scans (with no data acquisition) and four scans at the beginning of the run which were subsequently dropped from analysis to insure steady state magnetization for all analyzed data. This resulted in 242 whole-brain volumes per run (total of 484 volumes). Images were acquired with a set of parameters used to optimize signal in regions susceptible to drop-out due to magnetic field inhomogeneities (i.e. frontal cortices). Each volume acquisition included 40, 3.5 mm thick coronal slices with a 0.5 mm inter-slice gap, with a phase encode direction oriented in the superior-inferior direction. A one-shot T2* weighted echo-planar image (EPI) sequence (TR = 2000 ms, TE = 28 ms, FOV = 22.4 cm², matrix size = 64 × 64) was used to acquire blood-oxygenation dependent (BOLD) signal. EPI voxel

size at acquisition is 3.5 × 3.5 × 4 mm. A high resolution 3D T1-weighted structural scan (MPFLASH sequence) and an in-plane low resolution T2-weighted structural scan (GEMS) were acquired for anatomical localization.

MRI data processing

MRI data was processed and analyzed using SPM2 (Wellcome Department of Cognitive Neurology, London, UK) software. Each EPI volume was realigned in space to the first scan, using a six parameter, rigid body, least-squares transformation algorithm. None of the participants in the sample had >3 mm of movement across the two runs. After realignment, we re-sliced the coronal EPI data to the axial plane, and smoothed the data using 8 mm (FWHM). We then created and estimated a general linear model (GLM), and created contrast images of the difference between neural activity during rejection vs negative paintings. We focused on the rejection vs negative contrast to isolate neural mechanisms associated with processing of social rejection related information for theoretical reasons. Additionally, past research indicated that rejection-related (but not negative) stimuli to be diagnostic of self-esteem (Gyurak and Ayduk, 2007). In the creation of the GLM, the BOLD response for each painting category block was modeled with a boxcar function from the onset of the block. We defined each painting category block as a covariate of interest. We then convolved the canonical hemodynamic

response function (hrf) with brain activity at the onset of the block with duration of 16 s. Brain activity was high-pass filtered at 200 s, scaled by the global mean, and corrected for serial autocorrelation. Finally, contrast images were co-registered to the individual participant's co-planar (GEMS) and high resolution (MPFLASH) anatomical images, re-sliced to $2 \times 2 \times 2$ mm isotropic voxels and then normalized to the Montreal Neurological Institute (MNI) atlas space.

fMRI data analysis

The analysis proceeded in several steps. First, to evaluate task-related activation, in SPM2 (Wellcome Department of Cognitive Neurology, London, UK) we created a whole brain, random-effects analysis across the group of participants to examine significant group level activation in the rejection *vs* negative contrast. This analysis was thresholded at $t(22) = 3.5$, $P < 0.001$ (uncorrected) with an extent threshold of 10 voxels.

Next, in separate regression analyses we entered grand mean centered self-esteem and attentional control scores as predictors using the rejection *vs* negative contrasts. We used an anatomically defined mask of bilateral ACC (WFU PickAtlas; Maldjian *et al.*, 2003) in these analyses.¹ Areas of BOLD activation associated with the main effect of each predictor (i.e. self-esteem and attentional control separately) were modeled in a t-contrast by setting the weight of the predictor at 1 and the other two predictors at 0 (e.g. for modeling self-esteem, we set the weight of self-esteem at 1, and the weight of attentional control and the self-esteem \times attentional control interaction term at 0). Areas of BOLD activation associated with the interaction term (i.e. self-esteem \times attentional control) in the rejection *vs* negative contrast was modeled in a t-contrast by setting the weight of self-esteem and attentional control at 0 and thus holding them constant and setting the weight of the self-esteem \times attentional control interaction at -1 . We used -1 as the weight to isolate areas of significant BOLD activation associated with 'interference' interactions (Cohen *et al.*, 2003) where the value of the outcome variable (i.e. areas of BOLD activation) is significant when the predictors are of opposite signs (e.g. low self-esteem and high attentional control).² Voxel-level family-wise error (FWE $P = 0.05$) correction with extent threshold of 10 was used to correct for multiple comparisons. Where significant effects were found, in order to decompose the pattern of the interaction, we used 'MarsBar' (Brett *et al.*, 2002; [\[marsbar.sourceforge.net/\]\(http://marsbar.sourceforge.net/\)\) to extract the mean contrast values of each participant from the cluster of voxels showing a significant interaction effect. These effects were analyzed in the SAS statistical package \(Version 9.1\) and the pattern of interaction was graphed for visualization purposes.](http://</p>
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Emotional evaluation task

The emotional evaluation task was designed to assess emotional-evaluative processing of the same pictures used in the 'fMRI Painting Task' section. Participants completed the task in a separate session scheduled at the earliest available opportunity, usually 1–2 weeks after the MRI scan in a sound-attenuated behavioral testing room. Paintings were presented using E-prime, and were displayed for 6 s. The order of the paintings was randomized across participants. After picture offset, participants were asked to evaluate how the painting made them feel on three scales. Valence: unhappy/bad-happy/good (1: very bad–5: very good), arousal: calm-aroused (1: very calm–5: very alert), and rejection: rejecting-accepting (1: highly rejected–5: highly accepted). Ratings were self-paced, each question and corresponding scale appeared on the screen until the participant submitted their response via key press on the key board. To parallel the method used in the fMRI task, we focused on the rejection and negative paintings (by creating a difference score on all three scales separately).

RESULTS

Main effects of task

Areas of BOLD activation in the rejection *vs* negative contrast appear in Table 2 ($P < 0.001$ uncorrected, extent threshold 10). Areas that survived whole brain FWE correction included a cluster in the right middle temporal gyrus/extending to the precuneus.

Brain areas associated with the main effects of self-esteem and attentional control

There were no areas of significant activation associated with the main effects of self-esteem or attentional control. Next, we examined the effect of the interaction term.

Table 2 Significant activations at the group level in the rejection *vs* negative contrast

Brain region	Voxels	BA	x, y, z	t -value
Right parahippocampal gyrus	2249	27	16, -40 , -4	5.95
Right middle temporal gyrus/extending to precuneus	1320	21	58, -50 , 14	7.61 ^a
Left middle temporal gyrus	472	21	-54 , -56 , 18	4.20
Left lateral occipital cortex	139	19	-18 , -52 , 0	4.02

Note: BA = Brodmann Area; x, y, z = center of mass according to MNI coordinates, $P < 0.001$ uncorrected, extent threshold 10.

^aThe only area that survives whole brain FWE correction is the Right middle temporal gyrus/extending to precuneus, $P = 0.016$.

¹We also conducted an unmasked, whole brain $P = 0.001$ uncorrected regression analyses to explore any additional areas of activation outside of the ACC. In addition to the rACC activation reported in the main text, these analyses revealed a significant locus of activation in left superior frontal gyrus (SFG) in BA 10 ($x, y, z = -14, 62, 20$) that survived small volume correction in an anatomically defined BA10 mask, $t(21) = 5.13$, $P < 0.05$. We explored this area in similar analyses reported for the rACC and found very similar pattern of results for self-esteem and attentional control though less consistent. For example, we failed to find a significant mediation effect, because there was no relationship between brain activation in the SFG and emotional evaluations of rejection stimuli. The SFG is considered to be an important emotion regulatory region, thus it is theoretically consistent that low self-esteem high attentional control would have an effect there, but because in previous work we predicted the involvement of the rACC, and the results in the SFG did not relate to emotional evaluations of rejection we do not present detailed results for this cluster.

²We investigated areas of significant BOLD activation associated with the positive interaction term (contrast weight +1), but this analysis did not result in any significant areas of activation, even at lenient threshold.

Brain areas associated with the self-esteem \times attentional control interaction

Consistent with our predictions, a cluster in the rACC on the left side was associated with the interaction term of self-esteem \times attentional control, $x, y, z = -4, 46, 2, t(21) = 4.72, FWE P = 0.03$, (see Figure 2A). Mean contrast values were extracted using 'MarsBaR'. Analyses of distribution conducted in SAS indicated that one participant's contrast value was more extreme than the rest, though it did not qualify as an outlier (over 2.5 s.d. away from the group's mean), thus we kept this person in the analyses. Re-analyses of the data without this observation revealed the same pattern of results, and the main interaction findings remained significant but some of the simple slope tests did not reach conventional level of significance. Figure 2B depicts the pattern of interaction where contrast values from the rACC region were entered as dependent variables, centered self-esteem, attentional control and their interaction term as predictors in a multiple regression analysis. Results show that rACC activation was significantly predicted by the self-esteem \times attentional control interaction term, $F(1, 19) = 20.51, P = 0.0004$, while none of the main effects were significant. Follow-up simple slopes analyses 1 s.d. above and below the respective means of the centered predictors were conducted to examine the pattern of interaction (Aiken and West, 1991).

First, we examined the association between attentional control and BOLD activation separately for participants low and high in self-esteem. These analyses showed that consistent with our prediction, among vulnerable low self-esteem participants, those higher in attentional control showed significantly more BOLD activation in the rACC in response to the rejection than to the negative paintings, $\beta = 0.85, t(21) = 4.94, P < 0.0001$, whereas among high self-esteem participants, the slope of attentional control did not reach significance, $\beta = -0.23, t(21) = -1.10, P = 0.30$. Next, we examined the slope of self-esteem separately for low and high attentional control. Among low attentional control participants, the slope of self-esteem was significant such that higher self-esteem was related to more rACC activation, $\beta = .63, t(21) = 3.56, P = 0.002$, whereas among high attentional control participants, the slopes of self-esteem was significantly related to less rACC activation, $\beta = -0.46, t(21) = -2.19, P = 0.04$. These results demonstrate that in the face of rejection threat low self-esteem-high attentional control individuals and high self-esteem individuals as a group (regardless of their level of attentional control) engage the rACC to a greater degree than low self-esteem-low attentional control individuals (Figure 2 panel B).

Emotional evaluation task

We examined the relationship between mean contrast values from the rACC and valence, arousal and rejection appraisals

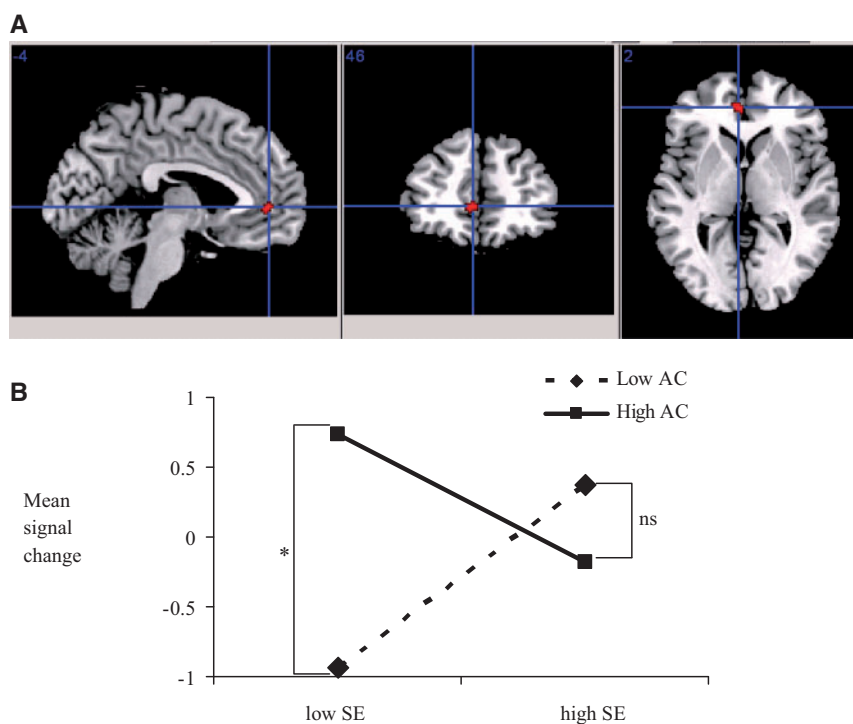


Fig. 2 (A) BOLD activation significantly related to the interaction term of self-esteem and attentional control in the left rACC area [$x, y, z = -4, 46, 2, t(20) = 4.73, FWE P = 0.03$] in the fMRI painting task in the rejection vs negative contrast. Crosshairs are aligned at center of mass. (B) Contrast values were derived from the left rACC area and predicted values were graphed at 1 s.d. above and below the respective means of the centered predictors. Images for display were thresholded at $t(21) = 3.78, P < 0.001$, extent threshold 10 voxels. Self-esteem (SE), attentional control (AC). * $P < 0.05$.

of rejection stimuli (*vs* negative stimuli) using the SAS package. Ratings of valence were in the expected direction (indicating more positive perceptions) but did not reach significance, $r(21) = 0.28$, $P = 0.19$. Importantly, correlations indicated that higher rACC recruitment was related to lower arousal, $r(21) = -0.45$, $P = 0.03$, and more acceptance appraisals, $r(21) = 0.48$, $P = 0.01$. We thus created a composite emotion evaluation score of arousal (reverse scored) and acceptance ratings for subsequent mediational analyses, Cronbach's α 0.64. Correlation between emotional evaluation of rejection (*vs* negative) stimuli and activation in the rACC was significant, $r(21) = 0.73$, $P < 0.001$, indicating that more rACC activation was related to more favorable (less arousal and more acceptance) evaluations of rejection stimuli.³

Does activation in the rACC mediate the relationship between self-esteem and attentional control on emotional evaluation of rejection?

In order to address this question, we conducted a mediational analysis using bootstrapping (Preacher and Hayes, 2008) implemented in SAS. Emotional evaluation of rejection stimuli was entered as the outcome variable, rACC activation served as the mediator and the interaction term between self-esteem and attentional control was the predictor while the main effects of self-esteem and attentional control were entered as control variables. In order for a mediation to work, first we had to establish three links between our respective predictors (Figure 3). The first critical link between self-esteem and attentional control and emotional evaluation of rejection was significant, $b = -0.57$, $t(21) = -2.58$, $P = 0.02$. Because the predictor in this case is the interaction between self-esteem and attentional control, we ran follow-up simple slopes analysis to visualize these effects (Figure 4). As expected, among low self-esteem participants, attention control was related to more accepting/low arousal evaluations of rejection stimuli, $b = 0.92$, $t(21) = 3.81$, $P = 0.001$. Among high self-esteem participants attentional control had no effect, $b = 0.01$, $t < 1$, ns. Furthermore, among low attentional control, self-esteem was related to more accepting/low arousal evaluations, $b = 0.20$, $t(21) = 2.29$, $P = 0.03$. Finally, among high attentional control, the slope of self-esteem was not significant, $b = -0.12$, $t(21) = -1.17$, $P = 0.26$. These results closely parallel the effects of self-esteem and attentional control on rACC activation and reveal a more positive evaluation of rejection stimuli among low self-esteem individuals who are high on attentional control relative to those with low self-esteem and low attentional control.

The second critical link was between self-esteem and attentional control and rACC activation. Results for this link have been reported above, but were confirmed again using

bootstrapping, $b = -2.8$, $t(21) = -5.40$, $P < 0.001$. This relationship is visualized in Figure 2B.

The third critical link was between rACC activation and emotional evaluations of rejection, also reported above and confirmed by bootstrapping, $b = 0.21$, $t(21) = 2.5$, $P = 0.02$. In the final step of the mediation the predictors (self-esteem \times attentional control) were entered simultaneously with the mediator (rACC). These results indicated that rACC remained a significant predictor, but the relationship between self-esteem and attentional control on emotional evaluation was no longer significant, $b = 0.03$, $t < 1$, ns and a significant mediation was confirmed at 95% CI (-1.2460 to -0.1713).⁴

DISCUSSION

Social rejection, a ubiquitous source of threat in human life poses an emotion regulatory challenge to most people. Managing social rejection effectively is likely to depend on top-down control processes that enable regulation of immediate responses and better anticipation of future outcomes (Wager *et al.*, 2009). Results of the current study demonstrate that individual differences in self-esteem and regulatory abilities can alter the nature of these top-down neurobiological responses to social rejection. Our results show that those low self-esteem individuals who are also low in attentional control capacity show a less advantageous pattern of neural responses to rejection than their low self-esteem high regulatory capacity counterparts. Specifically, we find that low self-esteem individuals who are also low in attentional control show less activity in emotion control related regions in the rACC while appraising their personal feelings in response to rejection-themed images.

On the flip side, our results show that high attentional control alters the neural signature among low self-esteem individuals resulting in higher engagement of the rACC—a neural response indicative of more adaptive responding to threat (Mathews *et al.*, 2004). Similar to rACC activation, we also found that self-esteem and attentional control modified emotional evaluations of rejection stimuli. Low self-esteem but high attentional control participants perceived rejection-themed images as more arousing and accepting than their low attentional control counterparts. Since these evaluations were assessed in a separate behavioral session, we have convincing evidence that the constellation self-esteem and attentional control reliably shapes recruitment of emotion control-related brain areas and perceptions of rejection. Most importantly, activation in the rACC mediated the relationship between personality and emotional evaluation of rejection, indicating that more favorable perceptions of

³Similar to the non-significant relationship between valence ratings during the emotional evaluation task, correlations between valence ratings during the fMRI painting task and rACC activation were not significant, $r(21) = -0.11$, $P = 0.60$.

⁴We also evaluated the reverse mediation effect where self-esteem and attentional control served as a predictor, rACC activation as the dependent variable and emotional evaluations of rejection as the mediator. Results of bootstrapping indicated that there was 'no evidence' for mediation, 95% CI (-2.67 to 0.01). Thus it appears that rACC activation is responsible for the link between self-esteem and attentional control and emotional evaluations.

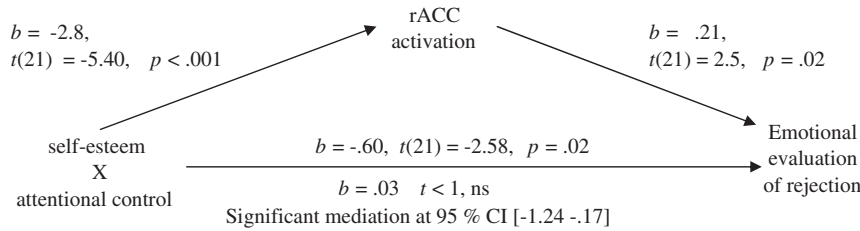


Fig. 3 Mediation analysis showing that rACC activation fully mediates the relationship between self-esteem \times attentional control and emotional evaluations of rejection stimuli.

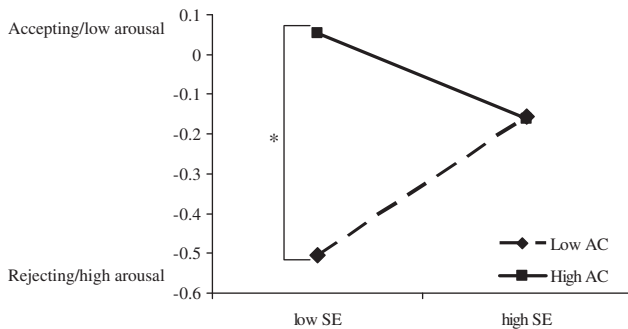


Fig. 4 Emotional evaluation of rejection (vs negative) stimuli as a function of self-esteem and attentional control.

rejection come about via the engagement of critical regulatory regions.

These results are consistent with our earlier findings and hypotheses on the buffering role of attentional control among low self-esteem individuals (Gyurak and Ayduk, 2007). In the current study we found that those who showed the strongest physiological reactivity to rejection (i.e. low self-esteem low attentional control individuals) in our prior work (Gyurak and Ayduk, 2007), demonstrated the lowest levels of rACC activation and the least favorable emotional evaluation of rejection. Lack of activation in the rACC thus appears to result in rating rejection as more arousing and more rejecting. These perceptions, in turn might pave the way for heightened physiological reactions and negative behavioral responses down the road.

The results of this study are also consistent with findings that implicate the rACC in situations when the organism needs to meet the demands of a heightened emotion regulatory challenge (Bush *et al.*, 2000; Mathews *et al.*, 2004; Etkin *et al.*, 2006; Bishop *et al.*, 2007; Wager *et al.*, 2009). Furthermore, these results underscore findings by animal and neuroimaging studies that show that the rACC is located at a critical regulatory juncture (for a review see, Etkin *et al.*, 2011) and is optimally positioned to modulate emotional responses. Collectively, the results argue that the activation of the rACC during social threat serves an important regulatory role and enables a more beneficial profile of responding. Adding further to this argument, there is support from a

recent PET study that more rACC activation during the Trier Social Stress Task, a potent elicitor of rejected feelings, can buffer prototypical stress responses, such as elevated cortisol level, that typically ensue after social rejection (Kern *et al.*, 2008).

Although previous studies have looked at how self-esteem relates to neural activity (Onoda *et al.*, 2010; Somerville *et al.*, 2010), none has examined the effect of self-esteem in the context of attentional control. Nonetheless, these studies suggest that the rACC and medial prefrontal cortex (MPFC) in general show heightened activation among low self-esteem individuals—an effect that was not found in our study. There are a number of differences that might account for these findings. First, unlike these previous studies, we did not subject our participants to direct social exclusion or negative feedback; rather, we showed them evocative stimuli that are shown to elicit feelings of rejection and encouraged them to freely process these while monitoring their own feelings. Viewed this way, our task may index spontaneous processing and modulation of self-generated feelings, rather than emotional reactivity and self-referential processing to receiving social rejection. Second, our analyses focused on social rejection while controlling for general negative valence. We think this is a critical distinction, given that self-esteem is typically correlated with high neuroticism, a marker of general negative affect (Judge *et al.*, 2002). Lastly, these studies did not report correlations between perceptions of social rejection and rACC activation, thus it is not clear how activation in this area might be related to emotional evaluations of rejection.

Our results support recent advances in clinical science that characterize psychological disorders, especially anxiety disorders as an interaction of underlying dispositional vulnerability exacerbated by poor effortful control (Beavers, 2005; Carver *et al.*, 2008; MacDonald, 2008). Even though our sample was recruited to be psychologically healthy, we found that not all low self-esteem individuals are equally reactive in the face of rejection. Those characterized with high attentional control recruit regulatory resources whereas those low in effortful control do not. The Attentional Control Scale is designed to tap into biological differences in the efficiency of effortful control that provide the foundation for personality and other more complex skills related

to self and emotion regulation (Derryberry and Rothbart, 1997). In a separate study (Gyurak, 2010, Study 4), we explored the correlates of the Attentional Control Scale on the domain of executive functioning and found that the scale was related to performance on complex executive function tasks such as verbal fluency, but not to more simple executive functions such as working-memory, inhibition or task switching. Better verbal fluency performance in turn has been shown to relate to better emotion regulation in several laboratory-based emotion regulation tests (Gyurak *et al.*, 2009, in press). Thus, scores on the Attentional Control Scale are likely to index one's ability to direct, alter and maintain attentional focus in the service of goal attainment—a central feature of emotion regulation. We speculate that low attentional control indexes low regulatory abilities and in combination with a vulnerability (low self-esteem) it might be a precursor of later mental health problems.

Several limitations of this research are worth mentioning. fMRI methodology, especially with the blocked task design used here does not allow us to speak to the timing and orchestration of the regulatory sequence implemented by the rACC; this requires future research. Furthermore, our results do not reveal the precise mechanism of regulation that the rACC supports. The rACC might aid several modes of emotion regulation, for example, cardiovascular regulation (Gianaros *et al.*, 2005) or simple control operations (Bush *et al.*, 2000) or implicit emotion regulation (Etkin *et al.*, 2011) or perhaps all simultaneously. Further research is needed to elaborate on these mechanisms.

In conclusion, the present study contributes to our understanding of the vulnerability and protection pattern exhibited by low self-esteem but high attentional control individuals in the face or rejection. Additionally, these findings offer a more nuanced view of these personality dispositions by elucidating the brain correlates that play an important role in lower reactivity in response to rejection.

Conflict of Interest

None declared.

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