Protecting the Self: The Effect of Social-evaluative Threat on Neural Representations of Self

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Abstract

■ One of the most robust ways that people protect themselves from social-evaluative threat is by emphasizing the desirability of their personal characteristics, yet the neural underpinnings of this fundamental process are unknown. The current fMRI study addresses this question by examining self-evaluations of desirability (in comparison with other people) as a response to threat. Participants judged how much personality traits described themselves in comparison with their average peer. These judgments were preceded by threatening or nonthreatening social-evaluative feedback. Self-evaluations made in response to threat significantly increased activation in a number of regions including the OFC, medial pFC, lateral pFC, amygdala, and insula. Individual differences in the extent to which threat increased desirability were significantly correlated with medial OFC activity. This is the first study to examine the neural associations of a fundamental self-protection strategy: responding to threat by emphasizing the self's desirability. Although neural research has separately examined self-evaluation processes from the regulation of social-evaluative threat, little is known about the interplay between the two. The findings build on this previous research by showing that regions, often associated with self-evaluation, are modulated by the degree to which people respond to threat by emphasizing their own desirability. ■

INTRODUCTION

When faced with social-evaluative threat, people compensate by evaluating themselves in especially flattering ways (see vanDellen, Campbell, Hoyle, & Bradfield, 2011, for a review), yet neuroimaging research has not examined this fundamental self-protection strategy. Social-evaluative threat refers to negative feedback about personality, academic competence, social skills, or interpersonal relationships that challenge favorable self-views (vanDellen et al., 2011; Leary, Terry, Allen, & Tate, 2009; Leary, Haupt, Strausser, & Chokel, 1998; Baumeister, Heatherton, & Tice, 1993). Decades of behavioral research have robustly demonstrated that people respond to social-evaluative threat by emphasizing their own desirability across various domains (e.g., vanDellen et al., 2011; Campbell & Sedikides, 1999; Taylor & Brown, 1988). When faced with threat, people emphasize their desirability by evaluating their personalities as more desirable than their peers' personalities (Brown, 2012; Vohs & Heatherton, 2004), downplaying their negative qualities and exaggerating their positive qualities (Sommer & Baumeister, 2002; Brown & Smart, 1991; Greenberg & Pyszczynski, 1985; Baumeister & Jones, 1978; Schneider, 1969), reporting more optimism and self-confidence about their ability to succeed in the future (Josephs, Markus, & Tafarodi, 1992; McFarlin & Blascovich, 1981), and taking personal credit for successes while attributing failures to factors outside the self (Campbell & Sedikides, 1999; Blaine & Crocker, 1993; Shrauger & Lund, 1975). Despite the robust evidence that people respond to threat by emphasizing their own desirability, current neuroimaging research has separately examined self-evaluation processes from the regulation of threat and little is known about the interplay between the two. The present fMRI study explores this unanswered question by examining self-evaluations of desirability (in comparison with other people) made in response to social-evaluative threat.

Most of the current research on the regulation of threat has primarily focused on identifying neural regions involved in processing threat and providing new meaning to threatening stimuli. A wide range of threatening stimuli have been studied such as aversive images, physical pain, social rejection, and negative social evaluations (e.g., Eisenberger, Inagaki, Muscatell, Haltom, & Leary, 2011; Kross, Berman, Mischel, Smith, & Wager, 2011; Onoda et al., 2010; Somerville, Kelley, & Heatherton, 2010; Somerville, Whalen, & Kelley, 2010; Masten et al., 2009; Wager, van Ast, et al., 2009; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008; Kim & Hamann, 2007; Kross, Egner, Ochsner, Hirsch, & Downey, 2007; Kalisch et al., 2006; Bishop, Duncan, Brett, & Lawrence, 2004; Eisenberger, Lieberman, & Williams, 2003; Bantick et al.,

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2002; Ochsner, Bunge, Gross, & Gabrieli, 2002; for a review, see Phelps, 2006; Ochsner & Gross, 2005). This large body of research consistently finds that amygdala and insula are involved in processing threat-related stimuli and relate to self-reported feelings of distress (e.g., Eisenberger et al., 2011; Kross et al., 2011; Somerville, Whalen, et al., 2010; Ochsner et al., 2002). In addition, the association between lateral pFC (LPFC) and the reappraisal of threatening stimuli is reflected in decreased self-reported distress and decreased amygdala activation (e.g., Wager et al., 2008; Kross et al., 2007; Eisenberger et al., 2003; Ochsner et al., 2002). Taken together, previous research provides an important foundation of knowledge about the neural systems involved in processing and reappraising threatening stimuli. However, neural models of emotion regulation remain incomplete. For example, they do not speak to the neural systems involved in a ubiquitous self-protection strategy, namely, using self-evaluations to defend the self from threat.

A further unexplored question is how the neural regions known to be involved in self-evaluation support the ability to compensate for threat by emphasizing the self's desirability. Self-evaluations are most often associated with activity in medial pFC (MPFC) and the OFC (e.g., Hughes & Beer, 2012a, 2012b; D'Argembeau et al., 2012; Northoff & Hayes, 2011; Beer & Hughes, 2010; Beer, Lombardo, & Bhanji, 2010; Rameson, Satpute, & Lieberman, 2010; Amodio & Frith, 2006; Ochsner et al., 2005). For example, the MPFC is consistently recruited when people evaluate the self-descriptiveness of personality traits (Jenkins & Mitchell, 2011; Rameson et al., 2010; D'Argembeau et al., 2008; Moran et al., 2006; Ochsner et al., 2005; Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Fossati et al., 2003). In addition, the OFC is consistently recruited when people compare themselves to their peers (i.e., medial and lateral OFC: Beer & Hughes, 2010; see Hughes & Beer, 2012b) and consider valued aspects of one's self (i.e., medial OFC: D'Argembeau et al., 2012; Northoff & Hayes, 2011). However, no research has directly examined the neural underpinnings of self-evaluations made in response to threat. This information will be critical for forming complete neural models of self-representation.

The current study used fMRI to examine the neural underpinnings of evaluating the self's desirability (in comparison with other people) in response to threat. Participants made social comparison evaluations that were preceded by threatening or nonthreatening social-evaluative feedback. On the basis of previous research (Brown, 2012; vanDellen et al., 2011; Vohs & Heatherton, 2004), participants should respond to threatening social-evaluative feedback by evaluating their personalities as more desirable. Neural regions associated with this self-protection strategy should (a) be more strongly engaged by social-comparative judgments made after receiving threatening information and (b) predict individual differences in the extent to which self-evaluated desirability increases as a function of threat.

METHODS

Participants

Data analyses focused on 18 participants (12 women; age: mean = 18.7 years, SD = 0.8 years) that were recruited in compliance with the human subject regulations of the University of Texas at Austin and compensated with $15/hr or course credit. Three additional participants were excluded because of excessive head movement (±3.0 mm). The 18 participants included in all analyses had movement parameters that ranged from ±0.3 mm to ±1 mm (mean = 0.72 mm, SD = 0.28 mm). All participants were right-handed, native English speakers, free from medications and psychological and neurological conditions that might influence the measurement of CBF, and within the normal range of self-esteem (>3 on a 1–5 scale for the Rosenberg Self-esteem Scale: Rosenberg, 1979) to avoid confounds from low outlier ranges of self-esteem. Most individuals have positive self-views so the distribution of self-esteem tends to be highly positively skewed (e.g., Twenge & Campbell, 2008; Gray-Little, Williams, & Hancock, 1997); individuals with extremely low self-esteem are rare and react to threat in an idiosyncratic manner (e.g., vanDellen et al., 2011; Vohs & Heatherton, 2004; Swann, Hixon, Stein-Seroussi, & Gilbert, 1990).

As described below, this study utilized deception to provide social-evaluative feedback, and studies utilizing deception methods typically find between 5% and 25% of participants are wise to the deception (Mehta & Josephs, 2006; Baumeister, DeWall, Ciarocco, & Twenge, 2005; Twenge & Campbell, 2003; Gardner, Pickett, & Brewer, 2000; Swann et al., 1990; Stricker, Messick, & Jackson, 1969). Consistent with this previous research, four additional participants were excluded due to expressing suspicion in the veracity of the threat manipulation during the final debriefing procedure (two participants claimed to be suspicious before fMRI portion of the study, two participants became suspicious during the fMRI portion of the study; see below for Debriefing Procedure). It is unlikely that the remaining participants were suspicious but simply did not express it (Stricker et al., 1969). First, all participants were subject to a lengthy debriefing procedure (for more information, see below). Second, norms for behavioral responses have been established by previous research using the same procedure as the current study. Whereas the 21 participants who expressed belief in the manipulation made behavioral responses similar to those reported in previous research (Hughes & Beer, 2012b; Beer & Hughes, 2010; Vohs & Heatherton, 2004), the participants who expressed disbelief confirmed their suspicion by responding in a manner that is inconsistent with established norms (Stricker et al., 1969).

Behavioral Procedure

Participants received a standardized social-evaluative threat manipulation used in previous research (Somerville, Kelley, et al., 2010; Horton & Sedikides, 2009; Somerville, Heatherton, & Kelley, 2006; Leary et al., 1998; Swann et al., 1990) and completed the same social comparison task used in previous fMRI research (Hughes & Beer, 2012b; Beer & Hughes, 2010; see Figure 1). An overview of the task sequence is described below followed by a description of the components of the procedure.

Task Sequence

For each trial, participants (a) received threatening or nonthreatening feedback and (b) then answered a block of social comparison questions (see Figure 1). A Threat or No-Threat Cue (4 sec) was followed by a screen with a fixation point that indicated participants should clear their minds. The fixation point screens were randomly jittered (2 sec, 50%; 4 sec, 25%; 6 sec, 25%; Donaldson, Petersen, Ollinger, & Buckner, 2001) to permit independent modeling of neural activation elicited by the cue and subsequent social comparison task. Participants then completed a block of eight social-comparison questions (2 sec each for a total of 16 sec) followed by a screen with a fixation point that indicated they should clear their minds (16 sec).

fMRI data were collected in one 8-min, 48-sec scan (six blocks of social comparison questions: three primed by Threat and three primed by No-Threat). The presentation order of the Threat and No-Threat Cues and trait words in the social comparison blocks was randomly assigned across participants. Stimuli were projected onto a screen mounted on the bed of the scanner, and head motion was limited using foam padding. E-prime on a Windows XP was used to present stimuli and collect responses.

Threat Manipulation

Threat was manipulated by providing participants with unfavorable or favorable social-evaluative feedback (e.g., Brown, 2012; Somerville, Kelley, et al., 2010; Horton & Sedikides, 2009; Somerville et al., 2006; Leary et al., 1998; Swann et al., 1990; see Figure 1). Before scanning, participants were photographed and led to believe that other people would evaluate their likability from the photographs.

During the scanning procedure, threat was manipulated with ostensible feedback about participants' likability. Participants were told that they would see their likability ratings from a randomly selected set of 10 individuals at a time (see Figure 1). Each Feedback Cue consisted of (a) 10 photographs of people (five male, five female) that had ostensibly evaluated the participant's likability and (b) pie charts indicating how many people found the participant unlikable (Threat Cue condition: 6, 7, or 8 of the 10 people; No Threat condition: 0 of the 10 people). The photographs in the Threat manipulation were drawn from 120 photographs of college-aged individuals (60 male, 60 female) used in previous research (Somerville, Kelley, et al., 2010; Somerville et al., 2006). Half of the photographs were used in the fMRI session, and half were used in a postscan task (described below). Each photograph displayed only the head and shoulders of the pictured individual without any additional faces or distracting scenes

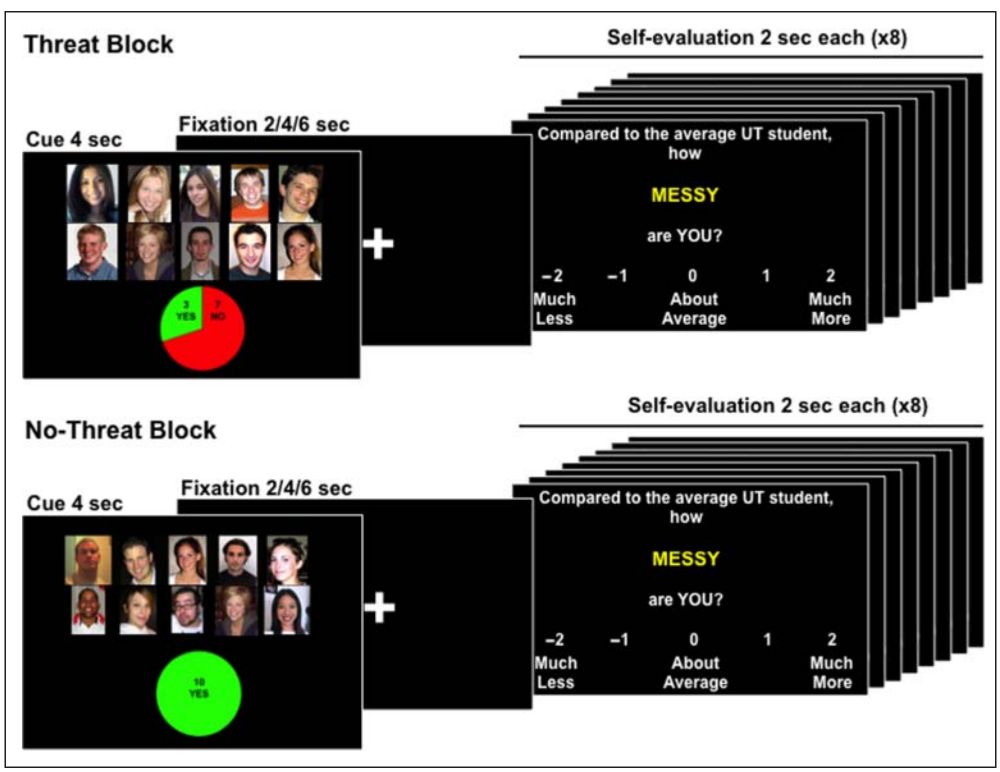

Figure 1. Stimuli and timing for the experimental procedure. Participants were presented with a 4-sec cue that indicated the Threat condition (Threat, No-Threat). A screen with a fixation cross was jittered to separate the Threat Cue from a subsequent block of social comparison judgments. Blocks of social comparison judgments included eight questions presented for 2 sec each (16-sec total for each block). Blocks were followed by a 16-sec screen depicting a fixation cross.

in the background of the photograph. The pie charts in the Threat cues depicted a partially green circle with a large red wedge with the label "6 NO," "7 NO," or "8 NO" to indicate that 6, 7, or 8 of the 10 pictured people did not find the participant likable. Pie charts in the No-Threat Cues depicted a fully green circle with the label "10 YES" within the circle indicating that all 10 of the pictured people found the participant likable.

Social Comparison Task

Participants rated how they compared with their average peer on personality trait words using a 5-point scale (-2 = *much less than the average UT student*; 0 = *about the same as the average UT student*; $+2$ = *much more than the average UT student*). To examine the effect of the threat manipulation on social-comparative desirability, social comparison ratings were averaged across all trials within the Threat blocks and within the No-Threat blocks for each participant and then compared in a paired-samples *t* test.

Trait words were undesirable traits from the narrowly construed trait category in previous fMRI studies (e.g., stingy, jealous, messy, bossy; see Hughes & Beer, 2012b; Beer & Hughes, 2010, for the complete lists of trait words). The personality trait word stimuli have been widely used in behavioral and neuroimaging studies of self-evaluation and social comparison (e.g., Hughes & Beer, 2012b; Beer & Hughes, 2010; Ochsner et al., 2005; Dunning, Meyerowitz, & Holzberg, 1989). The trait stimuli were selected from a standardized stimuli set to avoid potential confounds of valence (i.e., social desirability), range of associated behaviors (i.e., trait breadth), frequency of use, and number of syllables (Kirby & Gardner, 1972; Anderson, 1968).

A comparable "average peer" was ensured by recruiting University of Texas at Austin students who evaluated their personality traits in relation to the average University of Texas student of their same age and gender (Beer & Hughes, 2010; Chambers & Windschitl, 2004). Responses were reverse-scored to indicate increased desirability (i.e., higher scores indicated the self had less of the undesirable traits compared with peers).

Postscan Procedure

A postscan procedure was included to better understand how participants performed the social-comparative task. Research has robustly shown that threat's effect on social-comparative evaluations is most often accounted for by emphasizing one's own desirability rather than derogating others (vanDellen et al., 2011; Dodgson & Wood, 1998; Aronson, Blanton, & Cooper, 1995; Steele, Spencer, & Lynch, 1993; Campbell, 1986). There is some evidence that when people can choose the target of comparison, they may choose someone who is worse off than themselves to make themselves look better (Wood, Giordano-Beech, & Ducharme, 1999; Taylor & Lobel, 1989; Brown, 1986; Wills, 1981). In this study, it was unlikely that participants could selectively derogate the target of comparison in the Threat condition. The target of comparison (i.e., the average peer of same age and gender) was held constant across the Threat manipulation. However, the possibility that the average other was evaluated differently across conditions was tested in a postscan procedure. Participants rated the extent to which personality traits described their average peer ("How well does this trait describe the average University of Texas student": same scale as above) in blocks that were preceded by Threat or No Threat to self.

Debriefing Procedure

To ensure that the participants included in all analyses were naive to the deception involved in the threat manipulation, a thorough debriefing interview was conducted at the end of the study (for a discussion of the importance of excluding suspicious participants from analyses, see Stricker et al., 1969). This debriefing procedure was designed to give participants ample opportunity to express whether they knew that the threatening and nonthreatening feedback was false. The debriefing procedure gradually probed for participants' suspicion through open-ended questions about their general impressions of the purpose of the experiment as well as any thoughts and feelings about any aspect of the study (e.g., "What do you think the experiment was about?", "What kind of feedback did you get from other participants in the study?", "Did you have any reactions to the feedback you received?"). Participants were excluded from the final sample if they expressed suspicion or disbelief at any point during the open-ended questions of the debriefing procedure. After the question period, participants were asked not to divulge any information about any aspect of the study to their peers and provided with a full explanation of the study with a special emphasis on the bogus nature of the feedback they received (see Mills, 1976; Aronson & Carlsmith, 1968).

MRI Data Acquisition

All images were collected on a 3.0-T GE Signa EXCITE scanner at the University of Texas at Austin Imaging Research Center. Functional images were acquired with a GRAPPA sequence (repetition time = 2000 msec, echo time = 30 msec, field of view = 240, voxel size = 2.5 × 2.5 × 3.3 mm) with each volume consisting of 35 axial slices oriented to the AC–PC line (e.g., Hughes & Beer, 2012a, 2012b; Beer & Hughes, 2010). These parameters were implemented to optimize coverage of the OFC without sacrificing whole-brain acquisition. A high-resolution fast-spoiled gradient recall T1-weighted image (acquired in the sagittal plane, repetition time = 6 msec, echo time = 1.2 msec, matrix = 256 × 256, slice thickness = 1.3 mm) was also acquired from each participant.

Table 1. Neural Regions Exhibiting Greater Activation during the Social Comparisons Judgment Blocks Primed by Threat > No-threat Cues

Region of Activation (Right/Left)	*Cluster Size*	*BA*	*Coordinates* x	y	z	$t(17)$
MOFC (L)	76	11	−12	54	−14	7.63
LOFC (L)	70	47	−32	42	−20	4.16
			−32	30	−22	3.47
LOFC (R)	158	47	44	42	−4	3.67
			50	48	−8	3.59
MPFC (R)	48	10	6	68	4	4.13
LPFC (R)	1743	45	48	22	16	6.25
		6, 44	56	14	50	5.11
		48	38	18	24	4.55
LPFC (L)	159	44	−62	16	12	4.42
Insula (R)	65		34	16	−8	3.74
Insula (L)	22		−36	22	−6	3.45
Amygdala (R)	182		30	8	−26	5.63
Hippocampus (L)	30		−36	−14	−18	4.04
Hippocampus (L)	162		−26	−28	−4	3.84
Parahippocampal (L)	34	20	−28	−26	−18	3.45
Caudate/Putamen (R)	38		24	−2	18	3.65
Pallidum (R)	62		18	0	−4	5.49
Superior frontal gyrus (R)	73	6	34	2	70	4.42
Precentral gyrus (L)	21	4	−58	12	42	3.48
Postcentral gyrus (R)	64	4	30	−30	60	4.01
Paracentral lobule (R)	36	4	12	−30	68	3.87
			8	−30	76	3.38
Inferior/Middle temporal gyrus (R)	1935	37	36	−56	−16	7.23
			30	−80	0	7.1
		37	36	−42	−16	6.53
Temporal pole (R)	423	20	44	16	−44	5.28
Middle temporal gyrus (R)	84	41	42	−48	14	4.17
Precuneus (R)	21	5	2	−44	58	3.48
Inferior parietal gyrus (R)	478	40	46	−50	50	4.73
			40	−46	34	4.48
			34	−50	42	3.82
Cerebellum (L)	158		−18	−50	−46	6.52
Cerebellum (R)	40		4	−46	−36	3.8

Regions identified by Brodmann's areas (BA) and Montreal Neurological Institute (MNI) coordinates (x,y,z).

MRI Data Analysis

Statistical analyses were conducted using SPM2 (Wellcome Department of Cognitive Neurology). Functional images were reconstructed from *k*-space using a linear time interpolation algorithm to double the effective sampling rate. Image volumes were corrected for slice-timing skew using temporal sinc interpolation and for movement using rigid body transformation parameters. Functional data and structural data were coregistered and normalized into a standard anatomical space (2 mm isotropic voxels) based on the EPI and T1 templates (Montreal Neurological Institute), respectively. Images were smoothed with an 8-mm FWHM Gaussian kernel. A high-pass filter with a cutoff period of 128-sec was applied to remove within-session drifts.

A fixed-effects analysis modeled (a) the Threat and No-Threat Social Comparison blocks using a canonical block hemodynamic response function and (b) the Threat cues and the jittered fixation screens as regressors of no interest using canonical hemodynamic response function with a temporal derivative. The 16-sec fixation blocks estimated baseline for the 16-sec Social Comparison blocks. A general linear model analysis created contrast images for each participant to examine neural activation in the Social Comparison blocks as a function of Threat (blocks primed by Threat vs. No-Threat, No-Threat vs. Threat). Contrasts from each participant were used in a second-level analysis treating participants as a random effect. The group average SPM{t} maps were corrected for multiple comparison at the whole-brain level ($p < .05$ false discovery rate, $k > 10$). Additionally, correlation analyses tested whether individual differences in behavior modulated neural activation clusters identified from the main contrasts. Parameter estimates from clusters identified in the main contrast were extracted (Brett, Anton, Valabregue, & Poline, 2002) and tested for significant correlation with individual differences in Threat's effect on increased desirability (i.e., average Social Comparison rating primed by Threat minus average Social Comparison rating primed by No Threat; Kriegeskorte, Simmans, Bellgawan, & Baker, 2009; Poldrack & Mumford, 2009).

RESULTS

Behavioral Results

In the Threat condition, participants rated themselves as having significantly more desirable personalities in comparison with their average peer (Threat: $M = .67$, $SD = .38$; No-Threat: $M = .55$, $SD = .36$; $t(17) = 4.07$, $p < .05$). Threat did not significantly affect RTs for social comparison ratings in the scanner (Threat: $M = 1.29$ sec, $SD = .76$; No-Threat: $M = 1.29$, $SD = 1.07$ sec; $t < 1$, *ns*). Threat did not significantly affect postscan ratings of the average peer (Threat: $M = .09$, $SD = .34$; No-Threat: $M = .18$, $SD = .35$; $t < 1$, *ns*).

Imaging Results

Neural Systems Associated with Social Comparisons as a Function of Threat

Table 1 includes the neural regions that exhibited greater activation during social comparison judgment blocks primed by Threat cues compared with the No Threat cues. Results include medial OFC (MOFC; BA 11), MPFC (BA 10), bilateral lateral OFC (LOFC; BA 47), bilateral LPFC (BA 44 and BA 45), bilateral insula, and an activation cluster that includes amygdala, which have been

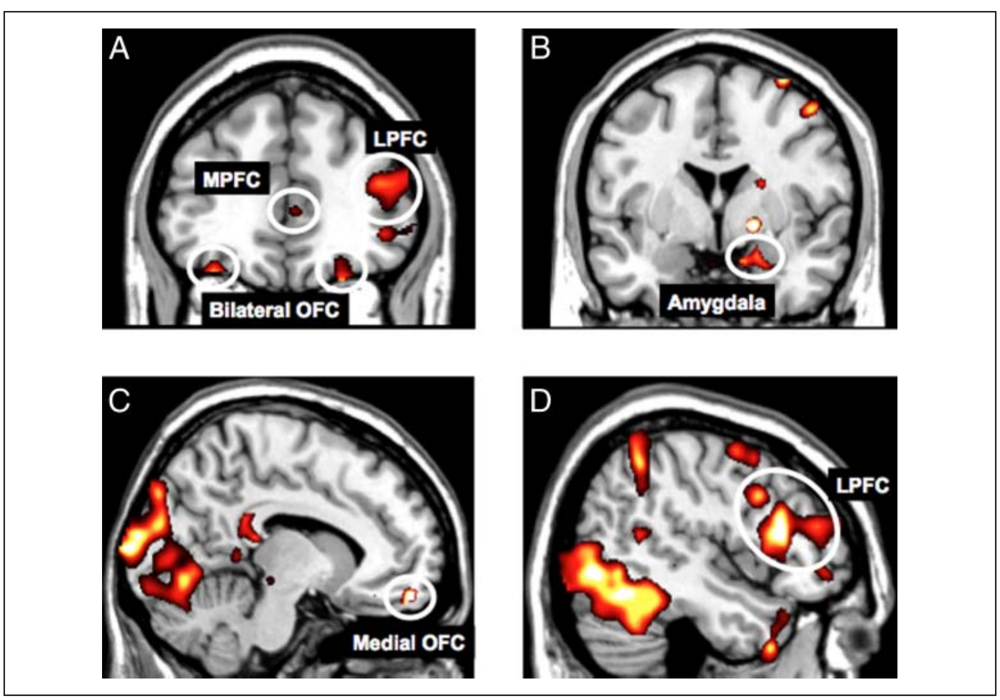

Figure 2. Illustration of a subset of neural regions listed in Table 1 exhibiting greater activation during the Social Comparisons judgment blocks primed by Threat > No-Threat cues (Social Comparisons primed by Threat > No-Threat contrast). Panel A ($y = 42$) includes medial prefrontal cortex (MPFC), lateral prefrontal cortex (LPFC) and bilateral orbitofrontal cortex (OFC), Panel B ($y = 0$) includes amygdala, Panel C ($x = 10$) includes medial orbitofrontal cortex (MOFC), Panel D ($x = 48$) includes lateral prefrontal cortex (LPFC).

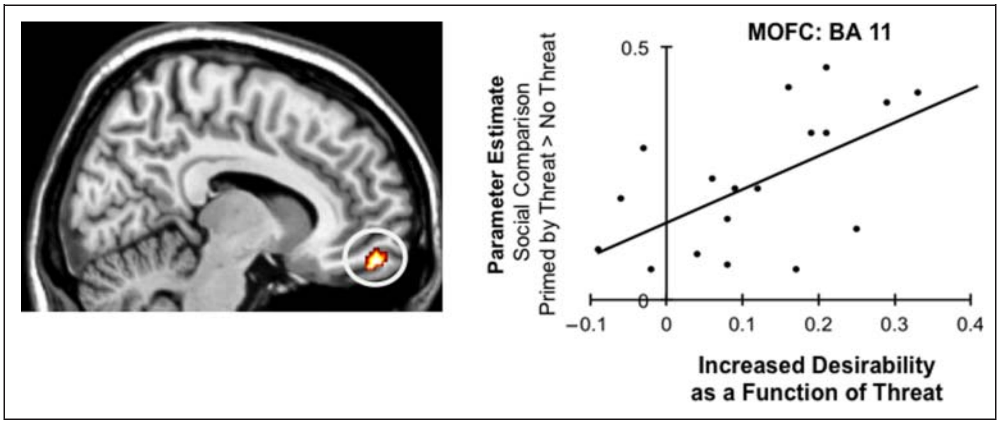

Figure 3. Individual differences in social-comparative ratings modulate MOFC activation identified in the Social Comparisons primed by Threat > No-Threat contrast. Scatterplot depicts individual differences in increased desirability as a function of Threat (Social Comparison ratings primed by Threat minus Social Comparison ratings primed by No-Threat) in relation to parameter estimates of the MOFC activation identified in the Social Comparison primed by Threat > No-Threat contrast.

associated with self-evaluation, social comparison, and threat regulation (see Figure 2). No significant activation was found for the reverse contrast (Social Comparison block primed by No Threat > Threat).

Individual Differences in Increased Desirability as a Function of Threat Modulate MOFC Activation

The more participants evaluated themselves as "above average" in the Threat condition, the more they recruited the MOFC region identified in the main contrast. Individual differences in increased desirability as a function of Threat significantly correlated with parameter estimates extracted from the MOFC ($r = .56$, $p < .05$) activation found in the Social Comparison block primed by Threat > No Threat contrast (see Figure 3). No other significant correlations were found for other regions identified in the main contrast (all *r*s between −.04 and .31, $p > .05$) although left LOFC showed a marginal correlation ($r = .45$, $p = .06$).

DISCUSSION

Despite robust evidence that people routinely emphasize their desirability when faced with social-evaluative threat (vanDellen et al., 2011), neuroscience research has yet to examine this fundamental self-protection strategy. The current study is the first to explore this unanswered question by identifying neural regions associated with evaluations of one's own desirability (in comparison with other people) in response to social-evaluative threat. Consistent with previous behavioral research (Brown, 2012; Vohs & Heatherton, 2004), participants responded to threatening social-evaluative feedback by significantly increasing the extent to which they evaluated their personalities as more desirable than their peers' personalities. Self-evaluations made in response to threatening social-evaluative feedback significantly increased activation in a number of neural regions, some of which have previously been associated with threat regulation or self-evaluation (e.g., MOFC, MPFC, LOFC, LPFC, amygdala, and insula). Of the activation identified in the main contrast, MOFC activation was significantly correlated with individual differences in threat's effect on self-evaluated desirability (and a marginal association was found with LOFC activation). The current study represents a first step toward addressing the interplay of two processes that are intricately linked but which have previously been studied separately in the neuroimaging literature: self-evaluation and threat regulation. Findings point to new avenues for research on emotion regulation and new conceptualizations of the role of frontal cortex in self-evaluation.

These findings illustrate the importance of expanding neural models of threat regulation to processes beyond inhibition and reappraisal. The current study found that using social comparisons to cope with threat does not draw on the neural systems associated with previously studied forms of emotion regulation. Whereas neural regions associated with threat and its reappraisal (e.g., amygdala, insula, LPFC: Somerville, Whalen, et al., 2010; Wager et al., 2008; Kross et al., 2007; Ochsner & Gross, 2005; Eisenberger et al., 2003) were activated more for social comparisons preceded by threat, they did not significantly predict individual differences in increased desirability as a function of threat. To develop more complete neural models of emotion regulation, future research should continue to investigate processes other than inhibition and reappraisal. For example, people cope with threat by modifying their social-comparative judgments and making flattering attributions for their own failures (see vanDellen et al., 2011, for a review). What neural systems support these common strategies and how do they compare to the neural systems associated with inhibition and reappraisal?

The present research also raises new questions about the role of OFC in self-evaluation such as those involved in social-comparative judgments. The MOFC was the only region that was (a) more strongly engaged by social comparisons made in response to threat and (b) significantly modulated by individual differences in behavior. The OFC has been generally associated with self-evaluation and more specifically associated with social comparative judgments (D'Argembeau et al., 2012; Hughes & Beer, 2012b; Rameson et al., 2010; Beer & Hughes, 2010; Kelley et al., 2002). However, the current research is the first to examine threat's effect on social-comparative judgment and it identifies a new association with MOFC activation. Whereas previous research finds a negative relation between MOFC function and flattering self-evaluations (Beer & Hughes, 2010; Somerville, Kelley, et al., 2010; Beer, John, Scabini, & Knight, 2006), the current study finds a positive relation. A point of current debate is whether the cognitive mechanism underlying social-comparative judgments differ depending on whether people intend to use them as a means of coping with self-esteem threat or not (Chambers & Windschitl, 2004). This debate would benefit from understanding whether the different associations between MOFC and the flattering nature of social-comparative judgment are driven by MOFC activation in the contexts of different networks or a common process that reverses depending on the presence of threat (e.g., shifts away from the "starting point" used to make a self-judgment: Hughes & Beer, 2012a). A deeper understanding of the role of OFC in social-comparative judgments is an important avenue for fleshing out both neural and psychological models of self.

More research is needed to understand the myriad self-processes that are routinely used to protect the self from threat. This study provides an initial step toward extending neural models of self-evaluation and threat regulation by identifying neural systems that underlie a fundamental self-protection strategy: emphasizing the self's desirability in response to social-evaluative threat. Questions, both big and small, remain unanswered. For example, do the current findings extend to situations in which people evaluate how they compare to others on positive traits? Are they modulated in relation to the magnitude of threat? Individuals with low self-esteem or depression often do not respond to threat by evaluating themselves as more desirable (vanDellen et al., 2011; Vohs & Heatherton, 2004). What explains their failure to fight back against threats to self? Are there vulnerabilities in MOFC function or is an altogether different network engaged? Future research will benefit from manipulating contextual, motivational, and individual difference factors known to influence self-evaluation to deepen our understanding of the neural systems that support the interplay between self-evaluation and threat regulation.

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