



## Neural correlates of using distancing to regulate emotional responses to social situations

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### ABSTRACT

Cognitive reappraisal is a commonly used and highly adaptive strategy for emotion regulation that has been studied in healthy volunteers. Most studies to date have focused on forms of reappraisal that involve reinterpreting the meaning of stimuli and have intermixed social and non-social emotional stimuli. Here we examined the neural correlates of the regulation of negative emotion elicited by social situations using a less studied form of reappraisal known as distancing. Whole brain fMRI data were obtained as participants viewed aversive and neutral social scenes with instructions to either simply look at and respond naturally to the images or to downregulate their emotional responses by distancing. Three key findings were obtained accompanied with the reduced aversive response behaviorally. First, across both instruction types, aversive social images activated the amygdala. Second, across both image types, distancing activated the precuneus and posterior cingulate cortex (PCC), intraparietal sulci (IPS), and middle/superior temporal gyrus (M/STG). Third, when distancing one's self from aversive images, activity increased in dorsal anterior cingulate (dACC), medial prefrontal cortex (mPFC), lateral prefrontal cortex, precuneus and PCC, IPS, and M/STG, meanwhile, and decreased in the amygdala. These findings demonstrate that distancing from aversive social cues modulates amygdala activity via engagement of networks implicated in social perception, perspective-taking, and attentional allocation.

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### 1. Introduction

Many of our most important emotions arise in interpersonal contexts (Adolphs, 2003; Minzenberg, Poole, & Vinogradov, 2006; Olsson & Ochsner, 2008). This suggests that one of the most important self-regulatory challenges is how we voluntarily and adaptively regulate our emotional responses to social cues. Failing to regulate such emotions may have serious consequences for mental and physical health (Gross, 2002), and may underlie psychiatric disorders in which there are serious disturbances in interpersonal functioning, such as borderline personality disorder (BPD) (Gunderson, 2007; Meyer, Pilkonis, & Beevers, 2004), avoidant personality disorder (AvPD) (Leising, Sporberg, & Rehbein, 2006) or schizophrenia spectrum disorders (SSD) (Ballon, Kaur, Marks, & Cadenhead, 2007; Meyer & Shean, 2006), among others.

Individuals with BPD, for example, have particularly intense emotional reactions to social situations of perceived abandonment or abuse (Gunderson & Lyons-Ruth, 2008). Understanding the mechanisms by which we can effectively regulate these socially triggered emotional responses is therefore an important goal of both basic and translational research (Ochsner, 2008; Phillips, Drevets, Rauch, & Lane, 2003; Roffman, Marci, Glick, Dougherty, & Rauch, 2005).

Recently, much progress in understanding these mechanisms has been made using functional imaging to identify the neural bases of cognitive forms of emotion regulation (Ochsner & Gross, 2005). Much of this work has examined the neural dynamics underlying cognitive reappraisal, which involves reinterpreting the meaning of a stimulus or situation in ways that alter one's emotional response. Behavioral studies have shown that reappraisal is one of the most flexible, adaptive and commonly employed strategies for down-regulating negative emotional responses (Gross, 2002). Imaging studies have shown that reappraisal activates prefrontal and cingulate systems implicated in various kinds of cognitive control processes, which in turn appear to modulate activity in neural systems associated with emotional responding, such as the amygdala (Banks, Eddy, Angstadt, Nathan, & Phan, 2007; Beauregard,

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Levesque, & Bourgouin, 2001; Kalisch et al., 2005; Kim & Hamann, 2007; Levesque et al., 2003; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004b; Ochsner & Gross, 2005; Phan et al., 2005; Urry et al., 2006).

For present purposes, two aspects of this work are noteworthy. Examining neural systems implicated in the regulation of response to emotionally evocative social cues is particularly important given the relevance of regulating social-emotional responses in clinical disorders (Ochsner, 2008; Phillips et al., 2003) and the fact that processing socially cued emotion engages different networks than non-socially cued emotion (Britton et al., 2006; Harris, McClure, van den Bos, Cohen, & Fiske, 2007; Lestou, Pollick, & Kourtzi, 2008). Despite the importance of such interpersonal emotional cues, relatively few studies have examined the regulation of emotion in response to emotionally evocative social interactions (Beauregard et al., 2001; Harenski & Hamann, 2006; Levesque et al., 2003). The majority of reappraisal studies have used image-based paradigms that intermix stimuli depicting emotionally charged social cues with non-social stimuli, making it difficult to identify networks that may be involved in regulating socially evoked responses per se (e.g. Kim & Hamann, 2007; Ochsner et al., 2002, 2004b; Phan et al., 2005; Urry et al., 2006). The first goal of the present study was to identify neural correlates of the cognitive reappraisal of social situations that elicit negative emotional responses. Since emotional dysregulation in reaction to interpersonal events is a prominent and disabling feature of a number of emotional disorders, we focus on negative emotions generated from social situations, which can include a variety of emotional responses, rather than limiting our focus to one or more specific emotions that are considered inherently social (Burnett, Bird, Moll, Frith, & Blakemore, 2009).

Second, although it is clear that prefrontal regions are engaged during reappraisal, most research to date has focused on only one of two main types of reappraisal. The most commonly studied variant of reappraisal is the situation-focused or reinterpretation strategy, which involves re-thinking the meaning of the actions and events depicted in an image. Another variant of reappraisal is the self-focused or distancing strategy, which involves viewing an image from the perspective of a detached and distant observer (Ochsner & Gross, *in press*; Ochsner et al., 2004b). In behavioral studies, distancing appears to be adaptive in reducing the intensity of angry and depressive affect and blood pressure responses (Ayduk & Kross, 2008; Kross & Ayduk, 2008; Kross, Ayduk, & Mischel, 2005). Although both strategies have been effective for down-regulating negative emotion (Kalisch et al., 2005; Kross & Ayduk, *in press*; Kross et al., 2005; Kross, Egner, Ochsner, Hirsch, & Downey, 2007; Ochsner et al., 2004b), to date, fewer studies have examined the regulation of responses to aversive images using distancing. The handful of studies examining distancing have used a heterogeneous array of emotionally evocative stimuli, including photos, films, shock, and risky choices (Beauregard et al., 2001; Eippert et al., 2007; Kalisch et al., 2005; Koenigsberg et al., 2009; Ochsner et al., 2004b). By contrast, the reinterpretation strategy has been used in many studies and primarily with image stimuli (e.g. Kim & Hamann, 2007; Ochsner et al., 2002, 2004b; Phan et al., 2005; Urry et al., 2006). The second goal of this study was to further examine the use of distancing to down-regulate negative emotion in a variant of a commonly used image-based reappraisal paradigm. Thus we focus on the use of the distancing reappraisal strategy as applied specifically to emotions evoked by social cues.

With these goals in mind, we formulated three predictions. First, in keeping with prior work, we expected that carrying out reappraisal of social-emotional cues by distancing would involve the recruitment of prefrontal and cingulate systems previously implicated in the top-down cognitive control of limbic, attentional and primary sensory regions. In particular, because distancing involves a change in the perceived self-relevance of images as well as with-

drawal of attention from emotional cues, we expected to observe activity in medial frontal and medial parietal regions associated with self-referential processing and perspective-taking, as well as prefrontal and parietal regions implicated in the top-down control of attention (Knight, 2007; Pessoa, Kastner, & Ungerleider, 2002). Second, we expected that the selective presentation of aversive social-emotional cues would activate systems associated with processing aversive stimuli, such as the amygdala, as well as regions implicated in processing the relevance of social cues, such as the superior temporal sulcus (Allison, Puce, & McCarthy, 2000; Kourtzi & Kanwisher, 2000). Third and last, we expected amygdala activity to be modulated by engagement of the distancing strategy, as has been observed in prior work.

To test these predictions we used an experimental design that crossed factors of instruction type (look, a baseline condition vs. distance, the regulation condition) with stimulus type (aversive vs. neutral). Unlike the unbalanced experimental designs of most prior reappraisal studies using images that have not fully crossed instruction and stimulus type (e.g. Ochsner et al., 2002, 2004b; Phan et al., 2005; Urry et al., 2006; van Reekum et al., 2007), this design allowed us to distinguish regions generally engaged by attempts at distancing (the main effect of instruction) or by socially cued negative emotion (the main effect of stimulus type), as opposed to being specifically engaged by attempts to distance one's self from negative events (the instruction  $\times$  stimulus type interaction).

## 2. Methods and materials

### 2.1. Participants

Sixteen (7 male/9 female, mean age:  $31.8 \pm 7.7$ ; range: 18–50) healthy volunteers participated in this study. Potential participants were screened to insure the absence of present or past Axis I or Axis II disorders using the Structured Clinical Interview for DSM-IV (SCID-I/P) to evaluate Axis I diagnoses and the Schedule for Interviewing DSM-IV Personality Disorders-IV (SIDP-IV) for Axis II disorders. Participants who had first degree relatives with an axis I disorder were excluded as were those with significant head trauma, CNS neurological disease, significant medical illness, pregnancy or contraindications to MRI. This study was approved by the Institutional Review Boards of the Mount Sinai School of Medicine and the James J. Peters VA Medical Center and all participants provided written informed consent. A comparison of the responses of these healthy subjects to those of patients with borderline personality disorder is reported elsewhere (Koenigsberg et al., 2009).

### 2.2. Materials

The emotional stimuli for the reappraisal task were selected images from the International Affective Pictures System (IAPS; (Lang and Cuthbert, 2001)), depicting negative and neutral interpersonal situations, specifically excluding non-social IAPS pictures such as images of fearsome animals or insects, human disfigurement, or inanimate objects that have been intermixed with social stimuli in prior reappraisal studies. The negative interpersonal scenes selected included pictures of people in situations of loss or grief, of abuse or of physical threat.<sup>1</sup> Neutral images depicted

<sup>1</sup> The following IAPS pictures were employed: Negative: 2053,2490,9810,6821, 6360,2691,6838,3550,3500,3181,6311,2710,2900,9433,6313,2800,3160,2095, 9910,3530,6312,9800,3350,8485, 3180,6315,6200,6242,6510,2455,3301,6230, 6530,6350,9252,3170,3230,9050,6370,2683,2205,3022,6212,9040,6020,6540,3300. Neutral: 5875,4605,2215,2393,2870,4000,8160,2780,2749,2575,2810,2518,2570, 2441,9210,2210,2385,2487,2516,8232,2394,8311,2410,9070,2495,8060,5455, 2372,2890,2745,1,2580,2635,2702,2880,2514,2850,2493,2440,8010,2485,2499, 2830,2235,2980,2383,5410,2515,7550,2020.

persons engaged at work, participating in hobbies or attending public events. To confirm that the selected IAPS pictures truly reflected interpersonal situations, we carried out a separate validity study in which a different group of healthy volunteers rated the extent to which IAPS pictures were interpersonal (1 = least to 9 = most). We confirmed that for both negative and neutral pictures, the pictures that we used in the study as interpersonal had significantly higher interpersonal scores than similar IAPS pictures of equivalent valence that were not manifestly interpersonal (for negative pictures: mean interpersonal picture score =  $6.5 \pm 1.6$  vs. non-interpersonal =  $3.0 \pm 2.0$ ,  $t(5) = 4.35$ ,  $p = .003$ ; for neutral pictures: mean interpersonal picture score =  $5.0 \pm 2.3$  vs. non-interpersonal =  $1.9 \pm 1.1$ ,  $t(5) = 3.7$ ,  $p = .007$ ).

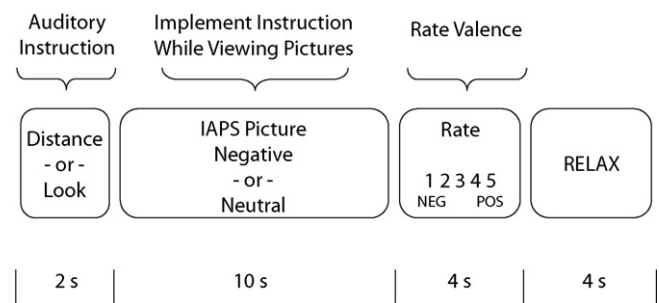
For the two instructional conditions described below we selected two sets of negative images that were matched for valence (mean valence norm ratings 2.3 and 2.4, respectively, where 1 = most negative and 9 = most positive;  $t(45) = .95$ , NS) and two sets of neutral images also matched for valence (mean ratings 5.2 in each set;  $t(47) = .49$ , NS). Within each valence, images were also matched for arousal rating between instructional conditions. Negative images were more arousing than neutral images (mean standard arousal scores 6.1 and 5.7 respectively for look and distance conditions for negative images ( $t(45) = 1.30$ , NS), and 3.8 and 3.5 respectively for look and distance conditions for neutral images ( $t(47) = 1.22$ , NS) where 1 = least arousing and 9 = most arousing).

### 2.3. Experimental design

In the  $2 \times 2$  design, BOLD fMRI scans were obtained as subjects viewed negative and neutral images while carrying out instructions either to downregulate their emotional reactions using the reappraisal by distancing strategy (distance condition) or to simply allow themselves to look at the pictures without trying to affect their response (look condition).

#### 2.3.1. Training procedures

Participants were trained in the reappraisal by distancing technique following the method of Ochsner et al. (Ochsner et al., 2004b). For the distance condition, subjects were instructed to relate to the image as though they were not personally connected in any way to the pictured individuals or the context in which they were situated, i.e. as though they were an anthropologist viewing the scene objectively or an emergency room doctor maintaining a detached clinical perspective so that he can function coolly in the situation. For the look condition, they were to simply allow themselves to experience whatever emotion the picture spontaneously evoked in them. Initial instruction in the task was followed by practice as the investigator observed and shaped subjects' technique. In the initial instruction phase, subjects were asked to report their distancing strategy for each picture and were coached and reinforced to assume an appropriate detached perspective. They rated their emotional reactions to each picture after carrying out the distance or look instruction, as they would do during the scanning sessions. Participants were specifically instructed not to close their eyes or look away from the images. Once they had mastered the technique as demonstrated to the satisfaction of the investigator by their ability to consistently downregulate their negative emotional reactions to the aversive images by assuming an emotionally detached stance, they practiced it on a lap-top computer for 20 trials, using the same protocol and timings but different pictures than would be used in the scanner. They were trained to apply the distancing technique in response to the auditory instruction "suppress" and to look without diminishing their initial emotional reaction to the IAPS image when they heard a "maintain" instruction.



**Fig. 1.** Schematic diagram of a single trial in the imaging paradigm. Each 20 s trial consisted of a 2 s auditory instruction, a 10 s picture display, a 4 s rating period and a 4 s interstimulus ("relax") interval. Participants were presented with 24 trials in each of the four conditions in the  $2 \times 2$  design. Trials were presented in four blocks of 24 trials each, with the four conditions intermixed in pseudorandom order within each of the blocks.

#### 2.3.2. Event-related design

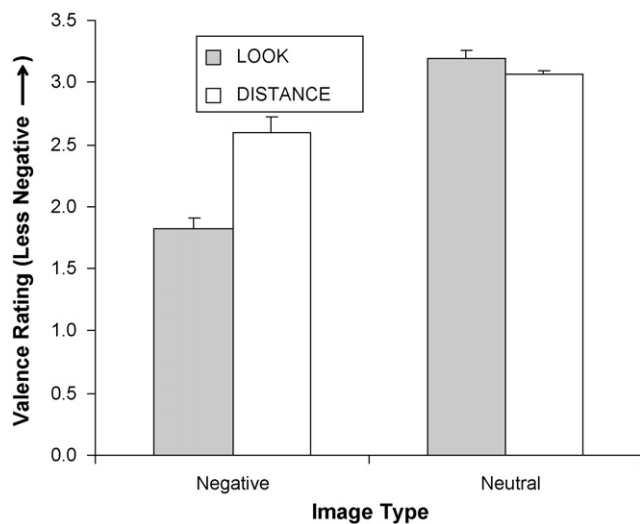
The task (Fig. 1) consisted of four blocks of 24 trials each. Each trial began with an auditory instruction ("maintain" or "suppress") presented to the subject over earphones while a blank screen appeared for 2 s. This was followed by a negative or neutral valence IAPS picture presented for 10 s, followed by a rating screen for 4 s, during which time the subject rated his/her emotional reaction to the picture after carrying out the instruction (using a MRI compatible 5-button hand pad; 1 = very negative to 5 = very positive), followed by a 4 s "Relax" screen. In each block the order of trials (negative-distance, negative-look, neutral-distance, and neutral-look) was pseudorandom and this order was used for all participants.

### 2.4. Image acquisition and analysis

MRI scanning was performed using a Siemens 3.0 T Allegra scanner. BOLD images were obtained with a gradient echoplanar (GE-EPI) sequence with the following protocol: 42 axial slices, 2.5 mm thick, skip = 0.825 mm, TR = 3 s, TE = 27 ms, Flip angle =  $84^\circ$ , FOV = 21 cm, matrix =  $64 \times 64$ . 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). Slice timing correction, realignment, normalization (to a standard template of Montreal Neurological Institute), and spatially smoothing (with an 8 mm full-width-at-half-maximum Gaussian kernel) were conducted followed established protocols. General linear modeling for each participant used the default SPM basis function convolved with the regressor of interest (Friston et al., 1998). The linear combination of seven 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 10 s epochs; rating valence, as an event). Contrast images for all participants were entered into a second-level random effects group analysis. The per-voxel significance level was set to  $p < 0.01$  and the minimum cluster extent threshold was set to  $k = 85$  in order to correct for multiple voxel comparisons at  $p < 0.05$ , as decided by a Monte Carlo simulation.

Based on the a priori hypothesis of amygdala involvement in emotional regulation, we expected to observe differential activation patterns in the amygdala across conditions and image type. However, because of the relative small volume of the amygdala and weak signal due to field inhomogeneity, it is usually unrealistic for amygdala activation to survive strict multiple comparison correction for the whole brain. We therefore use the anatomical mask of the amygdala to perform a small volume correction, as



**Fig. 2.** Mean valence ratings after carrying out look/distance instruction during the scan.

implemented in SPM2. The resampled voxel size was  $2 \times 2 \times 2 \text{ mm}^3$ . Regression weights (betas) were used to quantify signal change for each instructional condition and picture type in regions of interest.

### 3. Results

#### 3.1. Behavioral results

In post-scan debriefing, participants reported that they carried out the reappraisal by distancing strategy as instructed during the scan. Participants confirmed that they did not close their eyes or avert their gaze during the viewing periods in either the look or distance conditions.

The self-report ratings of emotional valence obtained during the scan demonstrated an image type (negative vs. neutral)  $\times$  instruction (look vs. distance) interaction ( $F(1,14) = 50.35, p = .000005$ ) as well as main effects for image type and instruction ( $F(1,14) = 66.78, p = .000001$ , and  $F(1,14) = 14.52, p = .002$ , respectively). Planned comparisons showed that negative affect was greater (lower score) when simply looking at (mean score:  $1.82 \pm 0.33$ ) as compared to distancing from (mean:  $2.59 \pm 0.51$ ;  $t(14) = 5.73, p = .00005$ ) negative images (Fig. 2). Responses to neutral images were not significantly different in the look (mean score:  $3.07 \pm .07$ ) and distance (mean score  $3.07 \pm .11$ ) conditions ( $t(14) = 1.99, p = .07$ ).

**Table 1**

Main effect of picture valence  $k$  is cluster size in  $2 \times 2 \times 2 \text{ mm}$  voxels, ( $x, y, z$ ) are MNI coordinates of peak voxel in cluster. Individual voxel  $p < .01$ , with  $k > 85$  voxels to obtain corrected  $p < .05$ .

Region	$k$	MNI coordinates			Z-score
		$x$	$y$	$z$	
<b>Negative <math>\geq</math> neutral</b>					
R fusiform G. (BA19)	10969	36	-70	-12	5.59
R amygdala	571	20	-2	-10	3.98
R inferior parietal (BA7)	150	32	-48	56	3.42
L posterior cingulate (BA30)	89	0	-50	26	3.44
R superior medial frontal G. (BA10)	783	4	54	28	4.78
R inferior frontal G., pars triangularis (BA45)	925	50	32	12	4.17
L inferior frontal G., pars triangularis (BA45)	206	-50	26	18	3.12
L thalamus	1159	-4	-16	2	3.64
<b>Neutral <math>\geq</math> negative</b>					
R middle frontal G. (BA11)	225	26	48	4	3.69
R superior frontal G. (BA6)	86	22	4	56	2.88
R cerebellum	134	34	-60	-34	3.87
Cerebellum vermis	161	-2	-68	-20	3.18
R caudate	106	12	22	-4	3.37

#### 3.2. Imaging results

##### 3.2.1. Main effect of picture valence

We first examined the effect of picture valence independent of instruction, computing the (negative > neutral) and (neutral > negative) contrasts (Table 1). As expected, there was greater amygdala activation to negative as compared to neutral pictures.

##### 3.2.2. Main effect of instruction type

To examine the main effect of distancing, we computed the (distance > look) and (look > distance) contrasts, collapsing across image type (Fig. 3 and Table 2). Regions with significantly greater activation in the distance compared to look condition included the middle and superior temporal gyri bilaterally (BA21/22; the region bordering the superior temporal sulcus; STS), the posterior cingulate cortex (PCC; BA31)/precuneus (BA7), and inferior parietal lobules (IPL: BA40) bilaterally. During the look compared to distance condition there was greater activation in visual areas (cuneus, middle occipital gyrus; BA17), in the left fusiform gyrus (BA37), the left middle temporal gyrus extending to the occipital gyrus (BA37/39/19), the right superior parietal lobule (BA7), and medial prefrontal regions (BA8/9/10).

##### 3.2.3. Interaction between instructional condition and image type

To explore the interaction between instructional condition and picture valence we constructed SPM maps of the double differences of BOLD activation: (1) distancing (negative pictures – neutral pictures) – look (negative pictures – neutral pictures), and (2) look (negative pictures – neutral pictures) – distancing (negative pictures – neutral pictures) (Table 3 and Fig. 4).

Contrast (1) identified regions where the effects of distancing were greater for negative as compared to neutral images, and included the dorsal anterior cingulate gyrus (dACC; BA32), the middle cingulate gyrus (BA23), medial prefrontal cortex (mPFC, BA10), right middle and superior frontal gyrus (BA10), left, inferior frontal gyrus/insula (BA45/47/13), the middle occipital (BA19) and middle and superior temporal regions (BA39/19) bilaterally. Inspection of the regression weights (betas) for condition and picture type (see Fig. 5) show condition effects for both picture types. We carried out post hoc repeated measures ANOVAs to determine whether the effects of condition were significant for the negative pictures alone. For negative pictures there was significantly greater activation in the Distance vs. Look condition in the dorsal ACC (BA32/9) ( $F(1,15) = 6.71, p = .02$ ), the right medial prefrontal cortex (mPFC, BA10) ( $F(1,15) = 4.93, p = .04$ ), the middle cingulate (BA23) ( $F(1,15) = 19.40, p = .0005$ ), and the left superior occipital



**Table 2**

Group activations for distancing > looking and looking > distancing for all pictures collapsed across valence (negative/neutral)  $k$  is cluster size in  $2 \times 2 \times 2 \text{ mm}^3$  voxels,  $(x, y, z)$  are MNI coordinates of peak voxel in cluster. Individual voxel  $p < .01$ , with  $k > 85$  voxels to obtain corrected  $p < .05$ .

Region	$k$	MNI coordinates			Z-score
		$x$	$y$	$z$	
<b>Distancing <math>\geq</math> looking</b>					
Posterior cingulate (BA31)/precuneus (BA7)	3035	4	-24	34	4.19
L inferior parietal lobule/supramarginal G (BA40/7)	1560	-40	-52	36	6.00
R inferior parietal lobule (BA40)	416	50	-54	42	3.84
R middle/superior temporal G (BA21/22)	330	56	-18	-2	3.61
L middle temporal gyrus (BA21)	193	-62	-42	-4	3.57
<b>Looking <math>\geq</math> distancing</b>					
L & R cuneus/middle occipital G (BA17)	4632	-6	-88	4	4.43
L middle temporal/occipital G. (BA37/39/19)	1446	-54	-60	10	4.90
L postcentral G (BA2)	282	-50	-32	56	3.62
L superior/medial frontal G (BA8/9/10)	298	-6	56	26	3.46
R superior parietal lobule (BA7)	151	24	-70	44	3.85
L fusiform G. (BA37)	127	-42	-46	-14	3.03
R thalamus	164	16	-6	10	3.65

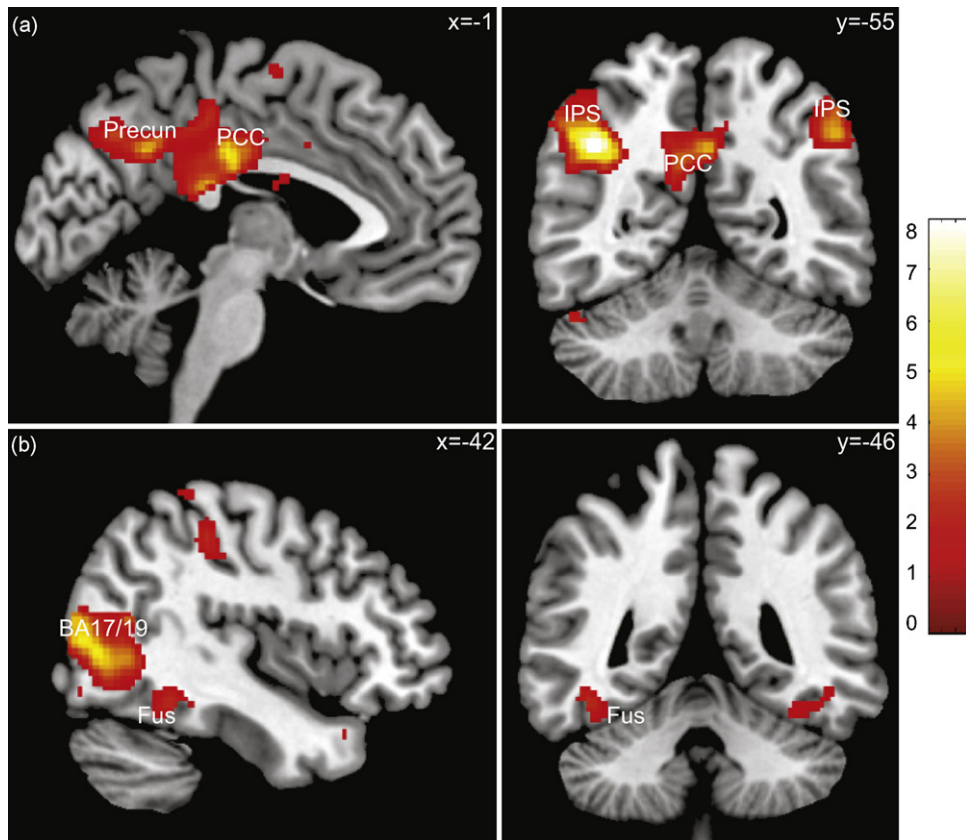
gyrus (BA7) ( $F(1,15) = 10.22$ ,  $p = .006$ ). Although we had no specific a priori hypotheses about regions involved in distancing from neutral pictures, for completeness we report the post hoc finding for these pictures as well. In the left and right middle temporal/occipital regions (BA39/19) there is a significant decrease in activation to neutral pictures when distancing compared to looking (post hoc  $F(1,15) = 42.35$ ,  $p = .00001$ , left;  $F(1,15) = 23.99$ ,  $p = .00002$ , right) and no change for negative pictures ( $F(1,15) = 0.04$ , NS and  $F(1,15) = 0.34$ , NS, respectively).

Contrast (2) identified regions where the modulatory effects of distancing were greater for negative as compared to neutral images, and included the right lingual gyrus (Fig. 4d) and cuneus

(BA17/18), the right and left precentral gyri (BA43/BA6), as well as the left superior temporal gyrus (BA38). In addition these modulatory effects were also observed in the amygdala (Fig. 4c) at  $p < .05$  (two-tailed) threshold, applying a small volume correction as described above. This interaction effect is accounted for by the response to negative pictures (Fig. 5b) as demonstrated in the post hoc analysis of the region of interest ( $F(1,15) = 4.94$ ,  $p = .04$ ).

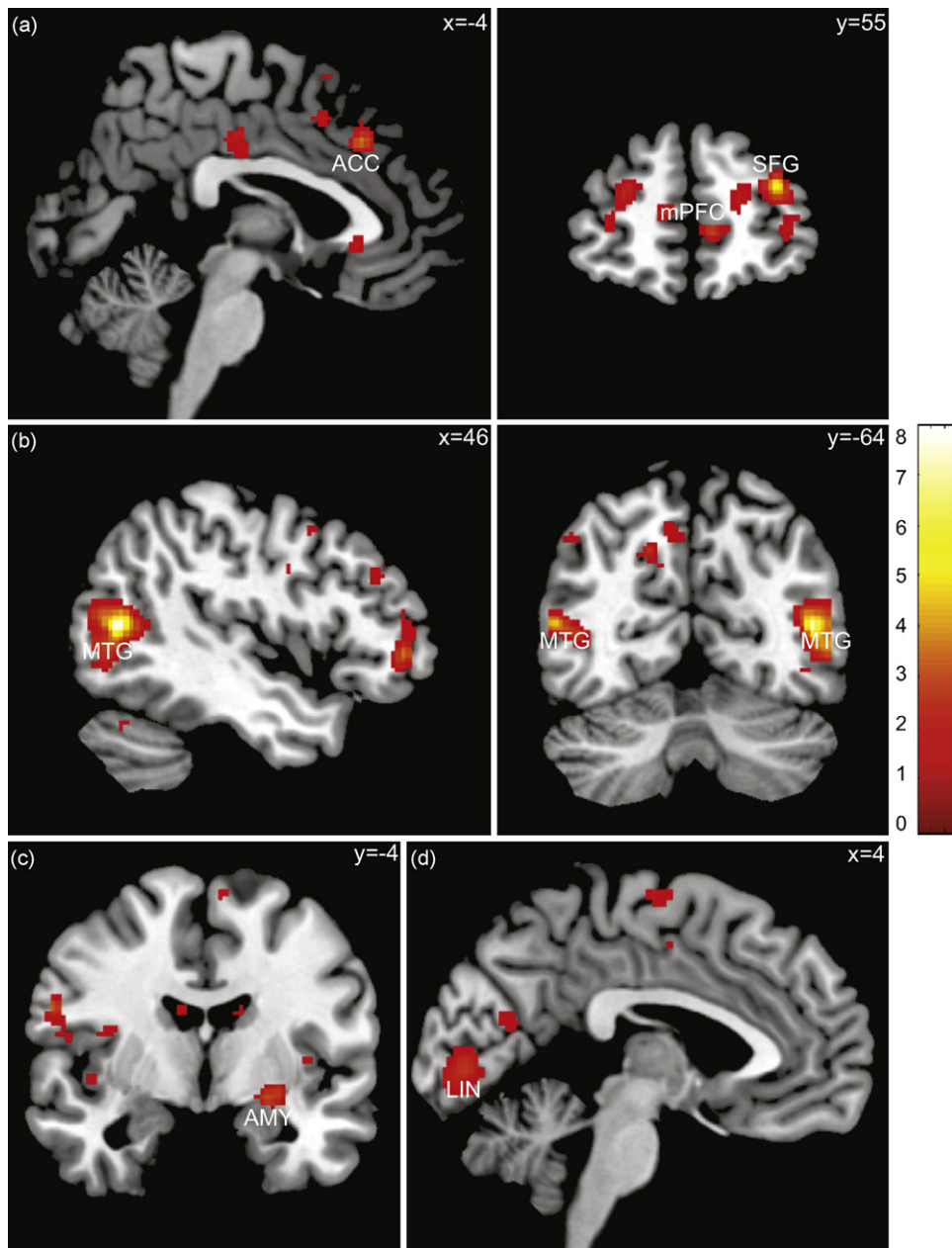
### 3.2.4. Simple effect of instruction type for negative images only

Given that the behavioral data demonstrated that distancing reduced the negative emotion experienced when viewing negative pictures, but had little effect for neutral pictures, we examined



**Fig. 3.** Statistical parametric maps of the main effects of reappraisal (distancing vs. looking).

a.) Distancing > looking showing greater activity in the posterior cingulate cortex (PCC), precuneus and intraparietal sulcus (IPS) when distancing compared to looking. b.) Looking > distancing showing greater activity in the occipital visual regions (BA17/19) and left fusiform gyrus (Fus) when looking compared to distancing.



**Fig. 4.** Statistical parametric maps of the effects of distancing as a function of image type.

a.) and b.) Effects of distancing (negative – neutral) – looking (negative – neutral). a.) Sagittal and coronal views showing greater activation when distancing compared to looking in the dorsal anterior cingulate cortex (dACC), medial PFC (mPFC) and middle/superior frontal gyrus (SFG). b.) Sagittal and coronal views showing greater activation in the region of the superior temporal sulcus (MTG/STG) when distancing compared to looking. c.) and d.) Looking (negative – neutral) – distancing (negative – neutral). c.) Coronal view showing increased right amygdala (AMY) activity when looking compared to distancing. d.) Sagittal view showing increased visual cortex (lingual gyrus; LIN) activity under the same conditions.

the (distance > look) contrast and the reversed contrast (look > distance) for the negative pictures alone. The results (Table 4 and Fig. 6) were similar to those for the main effect of instruction across valence, suggesting the distancing finding arose primarily from the aversive pictures, as would be expected. In addition, the distance > look contrast for negative pictures also identified a locus in the right middle frontal gyrus (BA10) and the reverse contrast of look > distance identified loci in the right inferior temporal gyrus (BA19) and left precentral gyri (BA6).

#### 4. Discussion

To our knowledge, this study is the first to focus specifically on the use of distancing to regulate responses to aversive social

cues employing an event-related fMRI design. As detailed below, this study extends previous work by identifying regions that may play a special role in regulating emotional responses to social cues using distancing, and replicates the findings of prefrontal and cingulate participation in distancing that have been demonstrated by other studies using reappraisal of emotional cues that have mixed content.

##### 4.1. Behavioral and brain correlates of distancing from aversive social cues

###### 4.1.1. Behavioral performance

Participants reported less negative emotion when distancing themselves from, as compared to looking at, negative images,

**Table 3**

Group activations for interaction between instruction (distancing vs. looking) and image type (negative vs. neutral)  $k$  is cluster size in  $2 \times 2 \times 2 \text{ mm}^3$  voxels,  $(x, y, z)$  are MNI coordinates of peak voxel in cluster. Individual voxel  $p < .01$ , with  $k > 85$  voxels to obtain corrected  $p < .05$   $^* p < .05$  (two-tailed) with small volume correction.

Region	$k$	MNI coordinates			Z-score
		$x$	$y$	$z$	
Distancing (neg – neu) $\geq$ looking (neg – neu)					
R middle & superior temporal G/middle occipital G (BA19)	963	46	–64	12	4.94
L middle & superior temporal G/middle occipital G (BA39/19)	539	–50	–60	12	4.10
L superior occipital G. (BA7)	126	–16	–66	40	3.07
Anterior cingulate G./L medial frontal G. (BA32/9)	162	–2	28	38	3.57
Middle cingulate G. (BA23)	103	0	–20	40	3.00
L inferior frontal G./insula (BA45/47/13)	102	–38	18	2	3.88
R middle/superior frontal G. (BA10)	341	32	54	20	4.20
R medial frontal G. (BA10)	132	8	54	2	3.24
L medial/superior frontal G. (BA10)	200	–10	56	10	3.45
Looking (neg – neu) $\geq$ distancing (neg – neu)					
R lingual G/cuneus (BA17/18)	505	4	–84	2	3.19
L superior temporal G. (BA38)	120	–44	0	–16	3.68
R precentral G (BA43)	93	–58	–4	24	3.41
L precentral G (BA6)	239	–40	–14	58	3.12
R amygdala <sup>*</sup>	37	28	–6	–10	3.34

<sup>\*</sup>  $p(\text{FDR}) < .05$  (two-tailed) using small volume correction with anatomical mask of right amygdala.

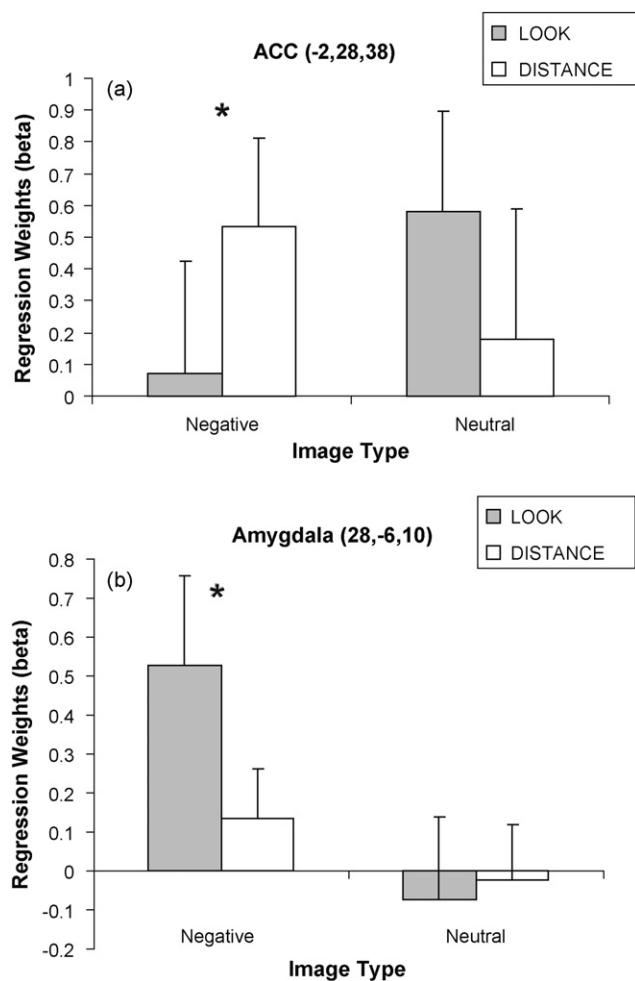
but reported similarly low levels of negative emotion in response to neutral images in both the distance and look conditions. This suggests that participants were able to reduce their subjective negative reactions to aversive social scenes by employing the dis-

tancing strategy, but that this strategy had little effect, as would be expected, upon neutral scenes that evoked little emotion to begin with. While we can not rule out the possibility that subject responses were influenced by the demand characteristics of the task or the possibility that subjects closed their eyes or looked at non-emotional parts of the pictures, during debriefing participants indicated that they followed instructions. Furthermore, as noted below, we observed decreased amygdala activation in the distancing condition, which suggests that participants were in fact decreasing their emotional reactions as they reported (Kim & Hamann, 2007; Ochsner et al., 2002, 2004b; Phan et al., 2005).

#### 4.1.2. Imaging findings

The main effect of distancing the self from interpersonal scenes was to activate a network of regions important for perspective-taking, attentional control, and assessment of social cues. With regard to perspective-taking, we found activation of posterior cingulate and precuneus regions implicated in processes important for assuming a distanced perspective, including being unengaged in (i.e. remote from) witnessed social interactions (Schilbach et al., 2006), turning away from external sources of information to a more inward focused state of consciousness (Binder et al., 1999; Kjaer, Nowak, & Lou, 2002), and with assessing the self-relevance of stimuli (Kelley et al., 2002; Ochsner et al., 2005; Vogt, 2005). The IPL engagement we found is consistent with its role in top-down control of the allocation of attention to visual cues (Corbetta, Kincade, Ollinger, McAvoy, & Shulman, 2000; Hopfinger, Buonocore, & Mangun, 2000; Pessoa et al., 2002). The activation we observed in the region of the superior and middle temporal gyri is consistent with the purported role of this region in social perception (Allison et al., 2000; Kourtzi & Kanwisher, 2000) as well as in attributing intention and mental states to others (theory of mind) (Allison et al., 2000; Frith & Frith, 2003; Gallagher et al., 2000; Kourtzi & Kanwisher, 2000).

The interaction of instruction type by image type highlights those regions that are more engaged when distancing from negative as compared to neutral social cues. Our findings suggest that regulatory demands when distancing from negative social cues recruits a network of regions, some active for distancing in general, as well as additional regions that appear to support distancing from aversive stimuli per se. The latter regions are of greatest interest because they are critical to the emotion regulatory and not just the perspective-taking aspects of distancing.



**Fig. 5.** Comparison of regression weights in the look and distance conditions for negative and neutral pictures. a.) Anterior cingulate cortex (ACC), b.) Right amygdala.

<sup>\*</sup>Significant difference between look and distance condition ( $p < .02$  ACC;  $p < .05$  amygdala, see text).

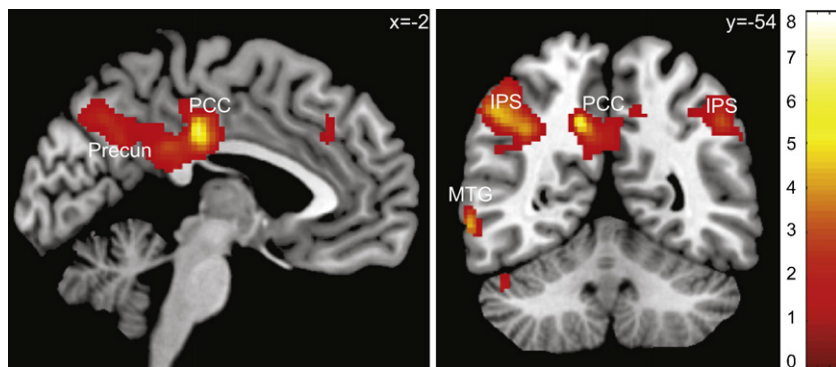
**Table 4**  
Group activations for distancing vs. looking when viewing negative valence pictures  $k$  is cluster size in  $2 \times 2 \times 2 \text{ mm}^3$  voxels,  $(x, y, z)$  are MNI coordinates of peak voxel in cluster. Individual voxel  $p < .01$ , with  $k > 85$  voxels to obtain corrected  $p < .05$ .

Region	$k$	MNI coordinates			Z-score
		$x$	$y$	$z$	
<b>Distancing <math>\geq</math> looking</b>					
Posterior cingulate G/precuneus (BA23/31)	3154	4	-24	36	4.60
L inf parietal lobule/angular G/supramarginal G (BA40)	1450	-40	-56	38	4.04
R inf parietal lobule/supramarginal G/Angular G (BA40)	470	50	-56	40	3.66
L middle temporal G. (BA21)	210	-58	-52	-6	3.94
R middle temporal G. (BA21/22)	225	62	-36	2	3.64
R middle frontal G. (BA10)	89	36	56	4	2.85
<b>Looking <math>\geq</math> distancing</b>					
L middle temporal/middle occipital G (BA19)	486	-40	-78	14	4.79
R inferior temporal G. (BA19)	219	44	-72	-6	3.20
L & R cuneus/lingual G. (BA17)	3173	2	-86	0	4.53
L postcentral G. (BA1)	95	-50	-32	56	2.93
L precentral G. (BA6)	304	-40	-12	62	3.31

Three regions were selectively engaged during distancing to aversive social cues. The first was the dACC, which is typically engaged in monitoring conflict between opposing tasks and it recruits cognitive control processes to resolve such conflict (Botvinick, Cohen, & Carter, 2004; Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Liu, Banich, Jacobson, & Tanabe, 2004; Mohanty et al., 2007; Ochsner et al., 2002). In keeping with prior work showing dACC activity during reappraisal (Kim & Hamann, 2007; Ochsner et al., 2002, 2004b; Phan et al., 2005), we would expect this region to be activated in the distancing task because there would be a conflict between a prepotent tendency to attend to emotionally salient images and the conscious effort to distance oneself from them. In fact, as observed here, there should be greater recruitment of the dACC in the reappraisal of negative compared to neutral images since the viewing of aversive images should heighten look vs. distance conflict because of the tendency to attend more strongly to potentially threatening aversive situations, with the dACC being called into play to resolve the conflict by enlisting top-down control. The second was the mPFC, which is recruited in monitoring how emotional cues affect the self (Fossati et al., 2003; Gusnard, Akbudak, Shulman, & Raichle, 2001; Lane & McRae, 2004; Ochsner et al., 2004a), information that would be important for keeping matters emotionally distant from the self. The third was the right middle frontal gyrus, which was expected since this region is implicated in the selection and control of behavioral strategies and actions, keeping these strategies in mind throughout performance of a task, inhibiting prepotent responses, and regulating selective attention (Garavan, Ross, Murphy, Roche, & Stein, 2002; Miller & Cohen, 2001).

Taken together these findings fit with prior studies implicating the lateral PFC in reappraisal (Kim & Hamann, 2007; Ochsner et al., 2002, 2004a; Phan et al., 2005) and the mPFC in distancing in particular (Kalisch et al., 2005; Ochsner et al., 2004b). We cannot rule out the possibility that activation of these regions during distancing may reflect the engagement of cognitive effort in general rather than processes specific to distancing (Urry, van Reekum, Johnstone, & Davidson, 2009). Our two-by-two factorial design, however, makes this interpretation less likely because distancing from neutral pictures (a somewhat counter-intuitive task) could be expected to impose an equal or even greater general cognitive demand compared to distancing from negative pictures. In addition, our observations extend previous work by demonstrating that regions generally implicated in perspective-taking, such as the precuneus, are involved in distancing in general, whereas other regions implicated in emotion regulation and social perception, such as the STS, are engaged in distancing from aversive social cues in particular. These findings have not been reported in prior work on distancing which involved shock (Kalisch et al., 2005) or mixed aversive images (Kim & Hamann, 2007; Ochsner et al., 2002, 2004b; Phan et al., 2005; Urry et al., 2006). This difference also suggests that activation of these regions is not simply a reflection of general cognitive demand during reappraisal.

The instruction type by image type interaction also identified regions that are modulated more strongly when distancing from negative as compared to neutral images, presumably because these are the regions supporting the generation of the negative emotional response from which one must distance one's self. These regions include the amygdala and visual areas. This is consistent with prior work showing modulation of amygdala (Kim & Hamann, 2007;



**Fig. 6.** Statistical parametric maps for distancing > looking when viewing negative pictures only. Note increased activation when distancing compared to looking in the posterior cingulate cortex (PCC), the precuneus (Precun), the intraparietal sulcus (IPS) and the left middle temporal gyrus (MTG).



Ochsner et al., 2002, 2004b; Urry et al., 2006) and visual cortex activity (Ochsner et al., 2002) by various forms of reappraisal.

#### 4.2. Limitations and future directions

Although this study sheds new light on the neural bases of distancing, it is important to acknowledge its limitations as well. As in other studies of cognitive reappraisal, we relied upon participants' reports that they carried out the task as directed. We selected IAPS images that exclusively depicted persons in socially evocative situations and excluded images of bodily mutilation, disfigurement, threatening animals that have been included as aversive emotional stimuli in other studies. Further studies are called for to replicate these findings and to directly contrast distancing from social and non-social images.

Future work might also further clarify the specific processes engaged during the two conditions in this experiment – looking and distancing. Looking at pictures with facial emotional content is itself a complex task that likely involves a number of psychological operations that encode the perceptual characteristics of stimuli as well as their valence and intensity, and support recognition of them. These processes may call upon distributed neural networks including the ventromedial and dorsolateral prefrontal cortex, the ventrolateral and dorsomedial prefrontal cortex and the ACC (Grimm et al., 2006). As noted in the introduction, distancing, too, involves a number mental operations in addition to those implicated in looking at emotional stimuli, including the maintenance of a regulatory goal, attentional allocation, self-monitoring and attributions about one's emotional state. In future work, it will be important to further clarify which regions specifically are engaged by distancing, as opposed to looking, other variants of reappraisal, and other types of emotion judgments and regulatory strategies. This is important, given that even seemingly simple cognitive operations such as making a judgment about one's emotional response as opposed to passively looking at a stimulus can modulate responses in the amygdala (Taylor, Phan, Decker, & Liberzon, 2003).

As this research progresses and normative patterns of neural activation in distancing from aversive social cues are firmly established, this work could be extended to contrast the patterns of activation in healthy volunteers to those of individuals with disorders characterized by disturbances in interpersonal relatedness such as BPD, AvPD and SSD (Koenigsberg et al., 2009). This can help us to better understand the neural correlates of these disorders and suggest psychotherapeutic and pharmacologic approaches to address interpersonal disturbances.

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