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A disposition to reappraise decreases anterior insula reactivity during anxious anticipation

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ABSTRACT

Across individuals there is variability in one's inherent tendency to reappraise emotional events in everyday life, which may be related to how worried one becomes in the presence of an anticipated aversive event. The extent to which this natural tendency to reappraise has neurobiological correlates during anxious anticipation is unknown. Neuroimaging research indicates that responses in the anterior insula precede anticipated aversive events and appear to represent one's affective feeling state of anxious anticipation. Successful cognitive reappraisal should weaken this anticipatory insula response. Here, functional magnetic resonance images were acquired while participants completed an anticipation task. We found increased anterior insula activation during aversive anticipation and a negative association between anxious anticipatory right anterior insula reactivity and dispositional reappraisal. Thus, even without the instruction to reappraise, individuals high in dispositional reappraisal tended to have a reduced anticipatory insula response to aversive stimuli, thereby down-regulating a neural substrate for aversive anticipation.

1. Introduction

Anxiety is typically accompanied by an excessive tendency to worry about aversive events, which may be related to an impaired ability to regulate emotional arousal. *Cognitive reappraisal*, or the reassessment of an event/stimulus in a manner that modifies the affective impact of the event (Gross, 1998), is one method that is often used in cognitive behavioral therapy to reinforce emotion regulation. Neuroimaging research indicates that responses in the anterior insula precede anticipated aversive events (Nitschke et al., 2006; Phelps et al., 2001) and appear to represent ones affective feeling state in general (Craig, 2003) and specifically the feeling of anxious anticipation (Carlson et al., 2010). Cognitive reappraisal of negative emotional stimuli is thought to attenuate insula reactivity to threat and may decrease negative emotional processing (Ochsner and Gross, 2005).

Within the healthy population there is significant variability with respect towards individuals' inherent tendency to reappraise emotional stimuli in everyday life. However, the extent to which these natural tendencies towards dispositional reappraisal have actual neurobiological correlates in anticipation of aversive outcomes is unknown. Here we tested the hypothesis that the anterior insula, a marker for anxious anticipation, would be negatively associated with individual differences in dispositional reappraisal, even in the absence of explicit instructions to use this technique.

2. Methods

2.1. Participants

Twenty (10 female) healthy consenting adults between the ages of 18 and 48 ($M = 23.91$, $SD = 6.64$) participated in the study. Potential participants were screened with the 12-question SCID screener and for the presence of metal implants. Participants completed the Emotion Regulation Questionnaire (reappraisal: $M = 4.86$, $SD = 1.06$, suppression: $M = 3.40$, $SD = 1.15$, on a 1 (low usage) to 7 (high usage) scale, Gross and John, 2003), a measure of individuals' disposition towards using cognitive reappraisal or suppression strategies in everyday life. Trait anxiety was also assessed ($M = 32.55$, $SD = 6.79$; Spielberger et al., 1970).

2.2. Materials and procedure

The experiment was programmed and run with E-prime (Psychology Software Tools, Pittsburg, PA). An MRI-compatible 60 Hz projector with a 1024 × 768 resolution, reflected stimuli onto a mirror attached to the head coil. Each trial began with a white fixation cue presented in the center of a black screen (jittered 4000–8000 ms). The fixation cue was immediately followed by a red "X" or a blue "O" for 1000 ms. The red "X" indicated an aversive image[1], while the blue "O" indicated a neutral image

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[1] We used the following neutral (2190, 2200, 2210, 2250, 2340, 2360, 2500, 2590, 2660, 7550) and aversive (3000, 3010, 3051, 3053, 3060, 3080, 3100, 3102, 3140, 3170) IAPS images (Lang et al., 1999). The normative ratings indicate that aversive images were less pleasant ($M = 1.63$, $SD = 0.29$) and more arousing ($M = 6.79$,

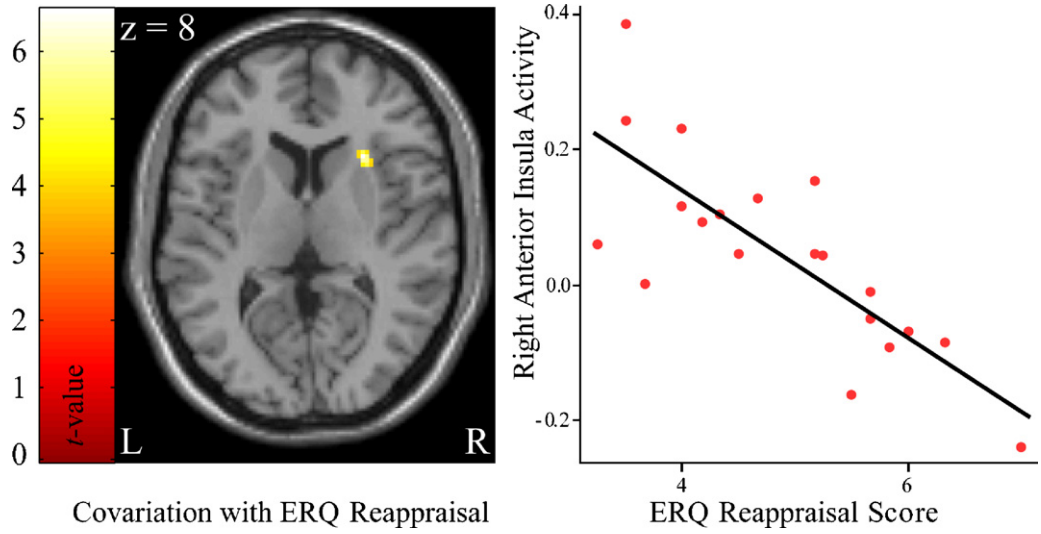

Fig. 1. Right anterior insular activation (*left*) negatively covaried with participants' reappraisal score on the Emotion Regulation Questionnaire (*right*).

(see footnote 1) (Lang et al., 1999). An anticipatory countdown from 16 to 1 (16 s; red text for aversive and blue for neutral) preceded the presentation of aversive and neutral images (3000 ms). Following the image a screen prompted participants to rate the level of anxiety they experienced during the countdown on a four-point scale, with one being *not anxious* and four being *very anxious*. The task consisted of 20 trials/blocks of anticipation: 10 aversive and 10 neutral.

2.3. Functional image acquisition and analysis

A 3 Tesla Siemens Trio whole body scanner was used to acquire 248 T2*-weighted whole-brain volumes with an EPI sequence sensitive to bold signal using the following parameters: TR = 2500 ms, TE = 22 ms, flip angle = 83°, matrix dimensions = 96 × 96, FOV = 224 mm × 224 mm, slices = 36, slice thickness = 3.5 mm, gap = 0. Standard preprocessing procedures were performed in SPM5, including image realignment corrections for head movements, slice timing corrections for acquisition order, normalization to standard 2 mm × 2 mm × 2 mm Montreal Neurological Institute space, and spatial smoothing with a Gaussian full-width-at-half-maximum 6 mm filter. First-level single subject SPMs were created from a model, which specified both blocks of anticipation (aversive & neutral; cue + countdown: 17 s) and image events (aversive & neutral; 0 s). A region of interest (ROI) analysis using a false discovery rate search volume corrected $\alpha = 0.05$ with an extent threshold = 10 continuous voxels was performed for the anterior insula (8 mm sphere centered at $x = \pm 34$, $y = 20$, $z = 4$; Critchley et al., 2004).

3. Results

A paired samples *t*-test of participants' mean self-report ratings of their anxiety states during the countdown revealed that participants felt more anxious in anticipation of aversive ($M = 2.19$) than neutral ($M = 1.11$) images ($t(19) = 6.09$, $p < .001$). This behavioral finding confirms that our manipulation had the desired effect of inducing anxious anticipation prior to aversive images. The *aversive vs. neutral anticipation* contrast for our anterior insula ROI revealed bilateral activation during aversive anticipation (*left:* $x = -28$, $y = 16$, $z = 4$, $t = 3.99$, $p_{SVC} < .05$, $k = 33$; *right*: $x = 34$, $y = 28$, $z = 4$, $t = 4.11$, $p_{SVC} < .05$, $k = 21$). Aversive anticipation-related activity in the right anterior insula ROI was found to negatively covary with reappraisal ($x = 28, y = 20, z = 8, t = 6.61, p_{SVC} < .05, k = 39$) (Fig. 1). This effect remained significant in a partial correlation controlling for trait anxiety, trait suppression, and the difference in aversive–neutral ratings ($p < 0.001$). To assess the extent to which this association was unique to the insula an exploratory whole-brain analysis was performed with an uncorrected α of 0.001, which revealed an additional negative association with reappraisal in the posterior cingulate ($x = 18$, $y = -48$, $z = 5$, $t = 5.63$, $k = 55$). Mean anxiety ratings for aversive–neutral anticipation were not correlated with either reappraisal scores or insula activity (p's > 0.10).

4. Discussion

These findings provide supporting evidence that the anterior insula is involved in aversive anticipation and a new finding that variability in anticipatory right anterior insula reactivity is negatively associated with dispositional (i.e., naturalistic) reappraisal. Given that the right anterior insula is thought to form an interoceptive representation of one's affective state (Craig, 2003; Critchley et al., 2004) and anticipatory right anterior insula activity has been found to predict participants' trial-by-trial self-reported feelings of anxious anticipation (Carlson et al., 2010), a disposition to reappraise may decrease negative emotional states of anticipation. Research paradigms explicitly instructing participants to reappraise their emotional response have shown that anticipatory insula reactivity decreases and this decreased insula response is associated with dispositional reappraisal (Herwig et al., 2007). However, it was unclear whether this decreased anticipatory insula response would occur in more natural situations in which cognitive reappraisal was not actively solicited. Our post-trial ratings of anxious anticipation may have limited the accuracy of these self-reports, and future work incorporating physiological measures of anxious anticipation (e.g., heart rate) may help resolve this limitation. Nonetheless, we demonstrate that even without the instruction to reappraise, individuals high in dispositional reappraisal tended to have a reduced anticipatory insula response to aversive stimuli, thereby down-regulating neural areas associated with aversive anticipation.

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$SD = 0.53$) than neutral images ($M = 5.88$, $SD = 1.63$ & $M = 3.78$, $SD = 0.67$, respectively).

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