Role of the Ventrolateral Prefrontal Cortex in Coping with Distracting Emotions: Event-Related fMRI Evidence
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1. INTRODUCTION

Lesion and functional neuroimaging evidence has associated ventrolateral prefrontal cortex (vlPFC) with general inhibitory processes [1, 2]. It is not clear, however, whether this brain region is also associated with inhibitory processes that are specifically engaged in the inhibition of distracting emotions. Investigation of the neural mechanisms of coping with emotional distraction has relevance for understanding clinical conditions associated with increased susceptibility to emotional distraction, such as depression and PTSD. Here, we used event-related fMRI to investigate the role of the vlPFC in coping with emotional distraction in healthy participants. A recent study from our group investigating the neural systems mediating cognitive interference by emotional distraction, provided evidence supporting a role of the vlPFC in the inhibition of distracting emotions [3].

Specifically, subjects that showed greater vlPFC activity in the presence of emotional distractors also tended to rate them as both less distracting and less emotional. However, because activity in this region did not correlate with the actual performance in the main cognitive task it is not clear whether this right vlPFC region is involved in controlling the subjective feeling of being distracted as opposed to controlling the actual impact of emotional distraction on cognitive performance. Therefore, clarification of this issue was the focus of the present approach.

2. METHODS

Subjects
- Participants were 15 healthy young female adults (18-31 yrs.).

Experimental task
- Subjects performed a delayed-response working memory (WM) task with distractors presented during the delay interval between the memoranda and probes (see diagram). Following the delay, subjects made Old/New responses to probes (50% old/50% new).

- Three types of distractors were presented in pairs: Emotional Scene, Neutral Scene, Scrambled Scene. Distractor scenes were negative and neutral pictures selected from IAPS [4] based on their scores for arousal and valence, and divided into two categories: high arousing and negative and low arousing and neutral. Subjects were instructed to look at the distractors but maintain focus on the WM task, and to make fast and accurate responses to the probes. There were 40 trials per condition, randomly presented in 10 runs.

- Following scanning, subjects performed two consecutive rating tasks, in which they assessed the emotional and neutral pictures for distractibility and emotional intensity (1 = lowest, 4 = highest). These measures were obtained in order to confirm that perceived distractibility and emotional intensity co-vary with each other, and to separate emotional and neutral distractors according to subjects’ own responses to each picture.

Data Acquisition and Preprocessing
Thirty axial slices (4 mm voxels) images sensitive to BOLD contrast (i.e., T2*-weighted) were acquired, using a T2 scanner (spiral-in pulse sequence; TR = 2000ms; TE: 31ms). Preprocessing steps included motion correction, slice timing correction, normalization, and spatial smoothing (8mm), and were performed with Duke’s BIAC tools.

Data Analysis
Voxel-based analyses were conducted using custom MATLAB scripts. For each trial of interest, an epoch time-locked to stimulus onset was selected and trials were averaged for each TR. Individual and group r-statistics were calculated on a time point-by-time point basis for the contrasts of interest. Correlation analyses involving brain activity and behavioral measures were also performed both within and across subjects.

3. BEHAVIORAL RESULTS

Working Memory Performance
Impaired WM performance in the presence of meaningful distracters. Emotional distracters produced the most detrimental effect on performance.

4. fMRI RESULTS

3. Amygdala-vlPFC Interactions during Processing of Emotional Distractors
Greater Amygdala-vlPFC correlations during processing of emotional distracters. The figure illustrates regions of the vlPFC that showed greater within-subject correlations with the amygdala during processing of Emotional vs. Neutral distracters. The active voxels were identified by a paired t test directly comparing amygdala-vlPFC correlation maps for the emotional and neutral distracters, which were calculated in each subject on a trial-by-trial basis.

II. vlPFC Hemispheric Asymmetry during Coping with Emotional Distraction
Delay activity in the right vlPFC did not distinguish between trials associated with successful vs. unsuccessful WM maintenance in the presence of emotional distracters. However, delay activity in the left vlPFC was greater for trials associated with correct vs. incorrect responses in the presence of emotional distracters, and this difference was greater than in the presence of neutral distracters.

5. CONCLUSIONS

I. Increased amygdala-vlPFC correlations in the presence of emotional distracters suggest that these two regions are part of a functional network in which the amygdala may play the role of an ‘emotional detector’ that signals the vlPFC about the presence of transient emotional distraction.

II. The hemispheric asymmetry observed in the vlPFC suggests that left and right vlPFC regions have differential involvement in coping with emotional distraction. The fact that the right vlPFC delay activity did not differ for correct vs. incorrect trials along with our previous finding that enhanced activity in this region was associated with lower distractibility ratings suggest that the right vlPFC is involved in controlling the subjective feeling of being distracted. The left vlPFC activity, however, dissociated correct vs. incorrect trials in the presence of emotional distractors, thus suggesting that this region is involved in controlling the actual impact of emotional distraction on WM performance.

Collectively, these results provide novel evidence concerning the neural mechanisms of coping with emotional distraction, and identify a specific role of the vlPFC in the inhibition of distracting emotions.

References

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