Executive Function and Emotional Processing in Major Depression

Lihong Wang1, Kevin S. LaBar 2, Mark Z Rosenthal3, Moria Smoski3, Thomas Lynch3, Gregory McCarthy1,4

INTRODUCTION

Neuropsychiatric studies of major depressive disorder (MDD) have identified deficits in executive function and emotional processing.

The dorsal system includes the dorsolateral prefrontal cortex and anterior cingulate gyrus and subserves executive functions. The ventral system includes the amygdala, anterior insula and orbital frontal cortex and subserves emotional processing [1].

Neuromaging studies of MDD have shown abnormally elevated resting cerebral blood flow (CBF) in the ventral system and decreased CBF in the dorsal system [2]. However there is less knowledge on how the ventral and dorsal systems functionally interact in MDD during processing an executive function and emotional task

In our previous study in healthy population [3], we used an emotional oddball distractor task which successfully evoked activation in dorsal system by attentional targets and in ventral system by emotional distractors

In current study, the same task was applied in MDD patients to evaluate executive function and emotional processing.

METHODS

Summary of subjects

<table>
<thead>
<tr>
<th></th>
<th>MDD patients</th>
<th>Healthy controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Subjects</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>No of Female/male</td>
<td>12/7</td>
<td>10/6</td>
</tr>
<tr>
<td>Age (mean±SD) yrs</td>
<td>39.3±9.1</td>
<td>35.6±10.9</td>
</tr>
<tr>
<td>HAMD score (mean±SD)</td>
<td>19.9±5.5</td>
<td>0.6±0.9</td>
</tr>
</tbody>
</table>

* Note, HAMD refers to Hamilton Rating Score for depression

Experimental design

There were 10 runs of 150 images each (3.3% sad, 3.3% neutral, 3.3% targets, 90% standards).

Sad and neutral pictures were matched for visual complexity and presence of human figures.

Subjects pushed a button whenever a circle (target) appeared.

Functional Imaging Acquisition (4T GE Scanner)

- high-resolution 3-D SPGR structural series (256 × 256 × 68 matrix; 24 cm FOV)
- 34 slices of functional data covering the whole brain acquired along AC-PC line
- BOLD contrast-sensitive images acquired using an inward spiral imaging sequence
- TR = 2 s, TE = 31 ms, flip angle = 60°, 64×64 matrix, 24 cm FOV, 3.75-mm3 isotropic voxels

Reaction time (RT) recording

- During the scan: Subjects pushed a button upon target detection. RT to targets was recorded.
- After the scan: Subject rated the distracter pictures on a 5-point rating scale indicating intensity of sadness. RT to sad and neutral pictures were recorded.

fMRI Data Analysis

- Voxel-based analysis using random-effects model (p<0.005, FDR corrected threshold).
- Anatomic Region-of-Interest (ROI) Analysis of amygdala (AMY):
  - Time-activation waveforms were computed for each hemisphere using mean value of all voxels in each ROI to visualize the HDR time course and compute ANOVAs on peak signal change.
  - Voxel-based Pearson’s correlation analysis on signal percentage change and HAMD score

RESULTS

1. MDD patients were slow in reaction time (RT), tended to rate more pictures as very sad than controls

   During the scan

   Image rating

   Activation evoked by attentional targets

   RT to targets (ms)

   control MDD

   Image rating

   Activation evoked by attentional targets

   During the scan

   Image rating

   Activation evoked by attentional targets

   RT to targets (ms)

   control MDD

   Number of images

   Mild happy neutral mild sad sad very sad

   0 5 10 15 20 25 30

   * MDD

   * Control

   Activation evoked by attentional targets

   Time course (sec)

   signal percentage change (%)

   control MDD

   Number of images

   Mild happy neutral mild sad sad very sad

   0 5 10 15 20 25 30

   * MDD

   * Control

   Activation evoked by attentional targets

   Time course (sec)

   signal percentage change (%)

2. MDD patients showed extensive activation to sad distracters compared with controls

   FFG

   MDD vs Control

   Signal percentage change (%)

   Time course (sec)

   signal percentage change (%)

   Time course (sec)

   signal percentage change (%)

3. MDD patients showed relatively reduced activation to attentional targets compared with controls

   FFG

   MDD vs Control

   Signal percentage change (%)

   Time course (sec)

   signal percentage change (%)

   Time course (sec)

   signal percentage change (%)

4. Voxels significantly correlated with the HAMD score in MDD patients (r>0.5,p<0.05)

   VMpFC

   Activation evoked by sad distracters

   Time course (sec)

   signal percentage change (%)

   HAMD score

   signal percentage change (%)

   Time course (sec)

   signal percentage change (%)

CONCLUSIONS

MDD patients showed slowed reaction time to attentional targets during the scan. They tended to rate more pictures as very sad, suggesting a possible emotional processing bias. Consistent with our previous work using this task [3,4], the present study showed that attentional targets activated the dorsal system (the dorsal prefrontal cortex, the cingulate gyrus and supramarginal gyrus) and the sad distracters activated the ventral system (the amygdala, orbital frontal cortex and the inferior frontal gyrus and fusiform gyrus). In comparison with the controls, the ventral system in MDD patients was more extensively activated by sad distractors. The activation in ventral medial prefrontal cortex is positively associated with their clinical depression intensity measured by HAMD. The MDD patients also showed lower activation in the dorsal system middle frontal gyrus and anterior cingulate gyrus in response to the attentional targets, confirming alteration of function within the ventral and dorsal systems in MDD.

REFERENCES


ACKNOWLEDGEMENTS

This research was supported by NIH grants MH60451 and DA14094.

Author contact: wang@biac.duke.edu

Visit the BIAC website for more information concerning this and other research: www.biac.duke.edu