ADULT AGE DIFFERENCES IN THE HEMODYNAMIC RESPONSE DURING VISUAL TARGET DETECTION MEASURED BY FUNCTIONAL MRI

David J. Madden, Scott A. Huettel, Wythe L. Whiting, Niko J. Harlan, Linda K. Langley, James M. Provenzale and Gregory McCarthy

Departments of Psychiatry and Behavioral Sciences, Radiology, and Brain Imaging and Analysis Center, Duke University Medical Center, Durham, NC

author contact: djm@geri.duke.edu

INTRODUCTION

Previous fMRI research with visual oddball detection tasks suggests that, in younger adults, prefrontal cortical regions (especially the middle frontal gyrus) are activated by infrequent events that require a differential response, either overt or covert (Kirino et al., 2000; McCarthy et al., 1997). One goal of this experiment was to determine whether an age-related change in prefrontal activation would be evident in the visual oddball task. We extend previous fMRI studies of the oddball task, which have focused primarily on prefrontal regions, by imaging midbrain and visual cortical areas as well.

A second goal was to obtain additional information regarding age-related changes in the form of the hemodynamic response. Previous research comparing younger and older adults’ hemodynamic response, during fMRI, indicates that the form of the hemodynamic response is similar for the two age groups, although activation is more extensive spatially and less variable for younger adults than for older adults (Huettel et al., 2001). These previous findings reflect the response of visual cortical regions during a sensory task (checkerboard viewing), and we sought to extend these analyses to the response of additional cortical regions during a more cognitive task.

METHOD

Visual Target Detection (Oddball) Task

![Visual Target Detection (Oddball) Task](image1)

METHOD

Participants

Healthy, right-handed, community-dwelling individuals; 16 younger adults (19-25 years; 8 females); 16 older adults (60-70 years; 8 females). The two groups were comparable in education and WAIS Vocabulary, but the older adults were worse in corrected visual acuity and on psychometric tests of memory, psychomotor speed, and executive functioning.

Imaging Parameters

Structural:

- Sagittal localizer images (T1-weighted).
- High-resolution spin-echo (T1-weighted) images acquired at locations selected to encompass majority of prefrontal, basal ganglia, and visual cortical regions. There were 14 contiguous near-axial oblique slices (5 mm thick) selected parallel to the AC-PC plane.
- Functional:
  - Spirial gradient-echo functional images at 1.5T. TR = 1 sec, TE = 40 ms, NEX = 1, Flip Angle = 81°, FOV = 24 cm, voxel size = 3.75 mm (64x64).
  - Functional images acquired at same slice location as structural images.
- While in the magnet, participants viewed the displays through custom lenses ground to correct for optical astigmatism.

- Preprocessing:
  - Using custom MATLAB scripts, epochs were created that were time-locked to event types. The data were temporally aligned to correct for slice acquisition order within a TR. 19 time points (1 per sec) were extracted, including 1 at display onset, plus 5 time points before display onset and 15 time points following.

Regions of Interest (ROIs):

- ROIs were drawn on a slice-by-slice basis for each participant, using high-resolution structural images.
- The ROIs included prefrontal regions (superior, middle, inferior prefrontal gyri, motor cortex, anterior cingulate), midbrain (caudate, putamen, thalamus, insula), and visual regions (cuneus, lateral occipital gyrus, fusiform gyrus).

RESULTS: Task Performance

![RESULTS: Task Performance](image2)

RESULTS: Functional Imaging

<table>
<thead>
<tr>
<th>Z-Score</th>
<th>Targets Novel</th>
<th>Older Adults</th>
<th>Targets Novel</th>
<th>Older Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>FG</td>
<td>1.5</td>
<td>p &lt; .01</td>
<td>2.66</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>MFG</td>
<td>3.07</td>
<td>p &lt; .05</td>
<td>2.49</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>SFG</td>
<td>2.28</td>
<td>p &lt; .05</td>
<td>2.21</td>
<td>p &lt; .05</td>
</tr>
<tr>
<td>MOT</td>
<td>2.82</td>
<td>n.s.</td>
<td>2.7</td>
<td>n.s.</td>
</tr>
<tr>
<td>AOS</td>
<td>2.28</td>
<td>p &lt; .05</td>
<td>2.7</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>CAU</td>
<td>1.13</td>
<td>n.s.</td>
<td>2.1</td>
<td>n.s.</td>
</tr>
<tr>
<td>INS</td>
<td>1.08</td>
<td>p &lt; .01</td>
<td>2.1</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>PUL</td>
<td>1.58</td>
<td>n.s.</td>
<td>2.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>THA</td>
<td>0.88</td>
<td>p &lt; .01</td>
<td>1.9</td>
<td>p &lt; .05</td>
</tr>
<tr>
<td>LOG</td>
<td>0.55</td>
<td>p &lt; .01</td>
<td>1.9</td>
<td>p &lt; .05</td>
</tr>
</tbody>
</table>

- Activation of prefrontal cortex (MFG) to targets is similar for younger and older adults.
- Task-related activation is not limited to prefrontal cortex and occurs throughout midbrain and visual regions.

CONCLUSIONS

- Activation to novels occurs in visual processing regions and is greater for younger adults than for older adults, representing an age-related decline in visual sensory processing for these task conditions.
- Anterior cingulate activation to targets is relatively greater for younger adults, which may represent more efficient attentional focus.