Event Related Design and Analysis with Example

David C. Zhu
An fMRI Study of Age Effects on Frontal-Striatal Neural Circuit Functions

David C. Zhu, PhD1,2,3, Rose T. Zacks, PhD1, Jill M. Slade, PhD2

1Department of Psychology, 2Department of Radiology and 3Cognitive Imaging Research Center
Michigan State University, East Lansing, Michigan, USA

Schematic diagram of the frontal-striatal circuit hypothesized to be affected by aging.

Objective

Study aging-associated decline in executive functions related to interference resolution

Hypothesis

The differential activation in Incongruent versus Congruent conditions at IFG, MFG and SFG would be modified with aging

Executive function: directs thoughts and actions according to internal goals and readjusts those goals when necessary.
Specific regions possibly involved in executive functions

- Middle frontal gyrus (MFG)
- Inferior frontal gyrus (IFG)
- Superior frontal gyrus (SFG)
- Superior and inferior parietal lobules (SPL and IPL)
- Anterior cingulate cortex (ACC)

Methods

Rapid Event-Related Design

Each stimulus was presented 2.5 sec.
Four 7-min runs
Rapid Event Related Design

- Time-efficient
- Less predictable

Keeps the subject’s general attentiveness level relatively constant.

Incongruent – Congruent $\Rightarrow$ Conflict resolution $\Rightarrow$ Executive function
**Data Acquisition**

3T GE Signa EXCITE scanner
8-channel head coil
Echo planar images:
  - 34 contiguous 3-mm axial slices,
  - TE = 27.7 ms,
  - TR = 2500 ms,
  - flip angle = 80°,
  - FOV = 22 cm,
  - matrix size = 64 × 64,
  - ramp sampling.

**Data Pre-processing and Analyses**

AFNI: Deconvolution analysis and ANOVA
### Response time and accuracy comparison between the younger and older populations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Young Group</th>
<th>Old Group</th>
<th>Incongruent – Congruent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Correct Response</td>
<td>125 ± 8</td>
<td>120±12</td>
<td>(~19%)</td>
</tr>
<tr>
<td>Mean Correct Response Time (ms)</td>
<td>675 ± 119</td>
<td>787±97</td>
<td>(~26%)</td>
</tr>
<tr>
<td>Mean Correct Response Time (ms)</td>
<td>124±9</td>
<td>115±18</td>
<td></td>
</tr>
</tbody>
</table>

22 younger adults (11 males, age 20 ± 3)
22 older adults (9 males, age 74 ± 6)
Brain Activation Comparison: “Incongruent – Congruent” Contrast

(voxel based $p \leq 0.005$, whole brain corrected $p \leq 0.021$)

Common for both age groups:

- Frontal: Right inferior frontal gyrus (IFG) and both right and left middle frontal gyrus (MFG).
- Visual Processing: Middle occipital gyrus, inferior occipital gyrus, precuneus, superior parietal lobule and surrounding regions.
Brain Activation Comparison:
“Incongruent – Congruent” Contrast
(voxel based $p \leq 0.005$, whole brain corrected $p \leq 0.021$)

$ t $ value

$ \geq 6 $
$ 5 $
$ 4 $
$ 3 $
$ 2 $
$ 1 $
$ 0 $
$ -1 $
$ -2 $
$ -3 $
$ -4 $
$ -5 $
$ -6 $

Younger adults

Left Superior Frontal Gyrus

Older adults
The right IFG/MFG cluster was smaller in the older group and the centroid location was shifted by 19.7 mm.

(a) Young adults (successful trials, “IC-C”)

(b) Older adults (successful trials, “IC-C”)
A 153 mm³ cluster at the left SFG/MeFG (medial frontal gyrus) (centroid coordinate (L6, A9, S51)) was found before whole-brain correction for the older group, but was not found for the younger group.

(c) Older adults (successful and error trials together, “IC-C”)

However, partially driven by errors:

(d) Sub-group of nine older adults (“error IC vs. successful C”)
The within-group whole-brain differential activation during successful flanker trials ("Incongruent – Congruent") (voxel-based $p$ value $\leq 0.005$ and whole-brain corrected $p$ value $\leq 0.021$) revealed a location shift of the IFG/MFG cluster with aging. The mean impulse response functions for older and younger group in conditions IC (Incongruent) and C (Congruent) are plotted at (a) the right IFG/MFG cluster found from the younger group, and (b) the right IFG/MFG/PCG cluster found from the older group.
The within-group whole-brain differential activation during successful flanker trials ("Incongruent – Congruent") (voxel-based $p$ value $\leq 0.005$ but whole-brain uncorrected) revealed a cluster that is more active for the Incongruent condition at the left SFG/MeFG region with older adults but this cluster was not found at the younger adults (a). The mean impulse response functions for older and younger group in conditions IC (Incongruent) and C (Congruent) are plotted at this cluster (b).
**Design:** `give_me_stimuli.s`

- `TS1_analy.1D`, `TS2_analy.1D`, `TS3_analy.1D`, `TS4_analy.1D`, `TSall_analy.1D`, `concat.1D`

**Collect Data**

- `analyze_ts_fwhm4.s`

**E-Prime Programming**

**Register**

- `register_many_image_files_to_AFNI_format`
- `3dTshift`: slice timing adjustment
- `3dvolreg`: motion correction
- `3dTcat`: concatenate all fMRI data together
- `3dmerge`: spatial blurring
- `mask generation`: identify brain region with `3dcalc` or `3dAutomask`

**Link design matrix (TSall_analy.1D, concat.1D)**

**3dDeconvolve (deconv.s):** Compare fMRI image data with design matrix

- `decon_TS (the “bucket”)`

**PerSigCh.s:** calculate % signal change

**FLY_group_ANOVA2_analyze.s:** group analysis from all subjects

**MonteCarlo_moreIterfwhm4.s (AlphaSim)**

**gen_clusterP5103.s (3dclust and 3dmerge):** cluster analysis

**Final results**