Event Related Design and Analysis with Example

David C. Zhu

An fMRI Study of Age Effects on Frontal-Striatal Neural Circuit Functions

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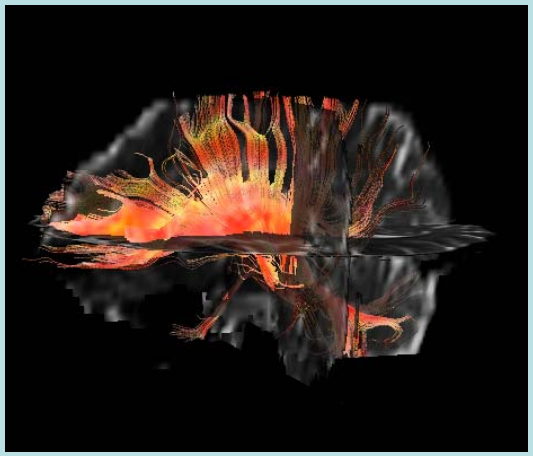
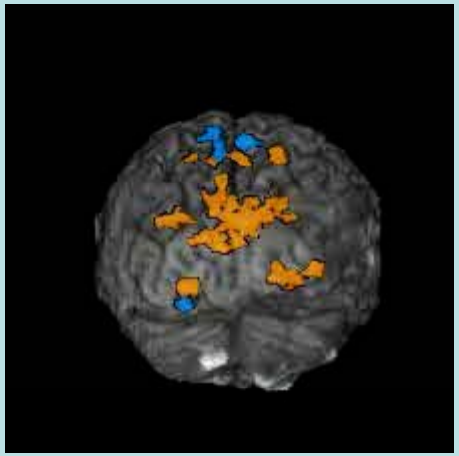
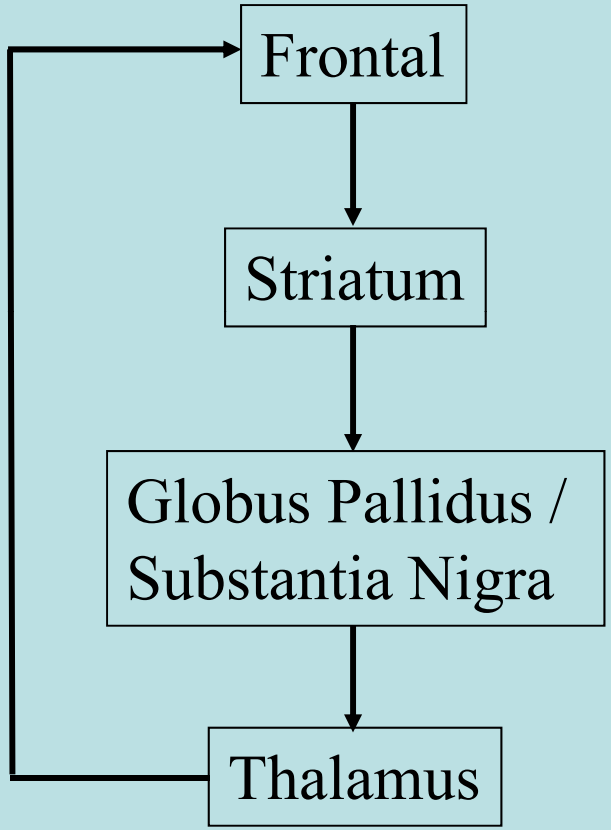




Zhu DC, Zacks RT, Slade JM. Brain activation during interference resolution in young and older adults: an fMRI study. Neuroimage. 2010 Apr 1;50(2):810-7

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



Buckner RL, Head D, Lustig C. Brain changes in aging: a lifespan perspective. In: Bialystok E, Craik FIM, editors. Lifespan Cognition: Mechanisms of Change. Oxford University Press; New York, New York: 2006. pp. 27–42.

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)**

Erickson KI, Ringo Ho MH, Colcombe SJ, Kramer AF. Cogn Brain Res. 2005;22:349-57.

Casey BJ, Thomas KM, Welsh TF, Badgaiyan RD, Eccard CH, Jennings JR, Crone EA. Proc Natl Acad Sci U S A. 2000;97:8728-8733.

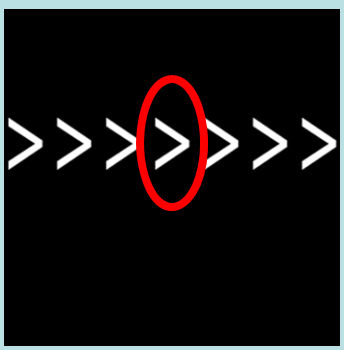
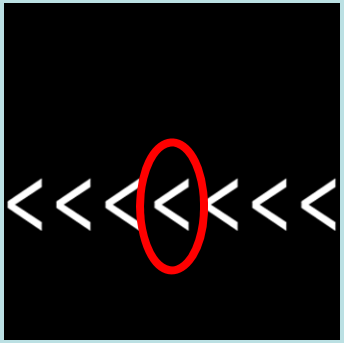
Colcombe SJ, Kramer AF, Erickson KI, Scalf P, McAuley E, Cohen NJ, Webb A, Jerome GJ, Marquez DX, Elavsky S. Proc Natl Acad Sci U S A. 2004;101:3316-3321.

Erickson KI, Milham MP, Colcombe SJ, Kramer AF, Banich MT, Webb A, Cohen NJ. Hum Brain Mapp. 2004;21:98-107.

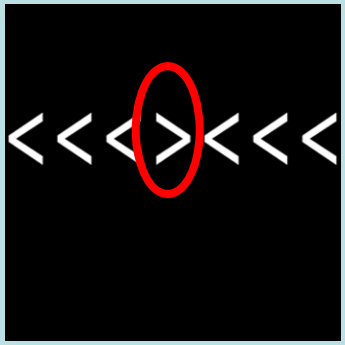
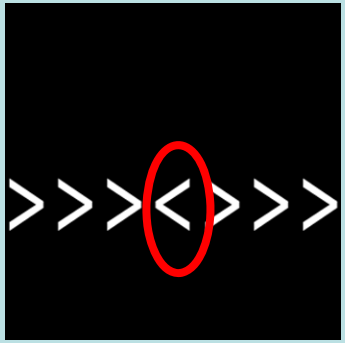
van Veen V, Cohen JD, Botvinick MM, Stenger VA, Carter CS. Neuroimage. 2001;14:1302-1308.

Methods

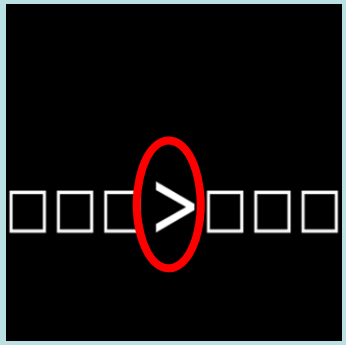
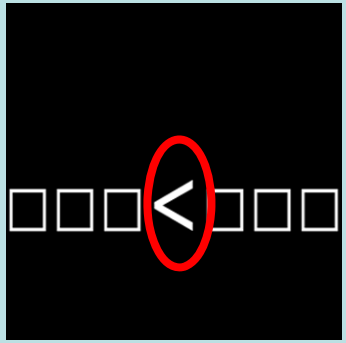
Rapid Event-Related Design

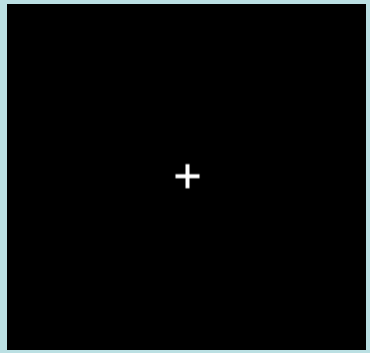
128
Congruent

128
Incongruent

128
Neutral



272
Baseline

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 ⟹ Conflict resolution

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

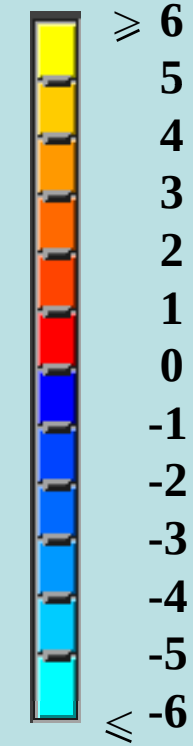
	Congruent Condition		Incongruent Condition		Response Time Comparison
	Number of Correct Response	Mean Correct Response Time (ms)	Number of Correct Response	Mean Correct Response Time (ms)	Incongruent – Congruent (ms)
Young Group	125 ± 8	675 ± 119	124±9	805±188	(~19%) 130±92
Old Group	120±12	787±97	115±18	994±206	(~26%) 207±146

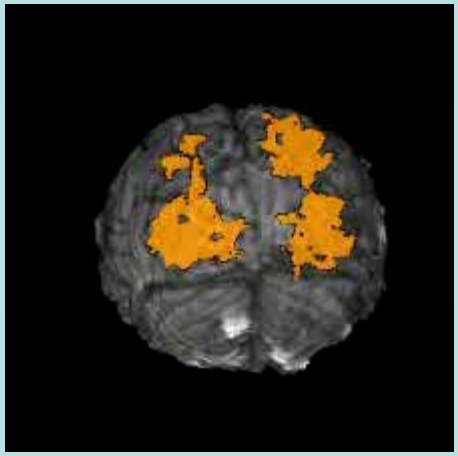
22 younger adults (11 males, age 20 ± 3)
22 older adults (9 males, age 74 ± 6)

Brain Activation Comparison:

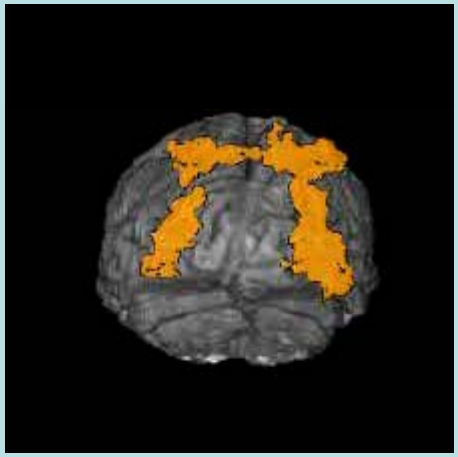
"Incongruent – Congruent" Contrast

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





Younger adults



Older adults

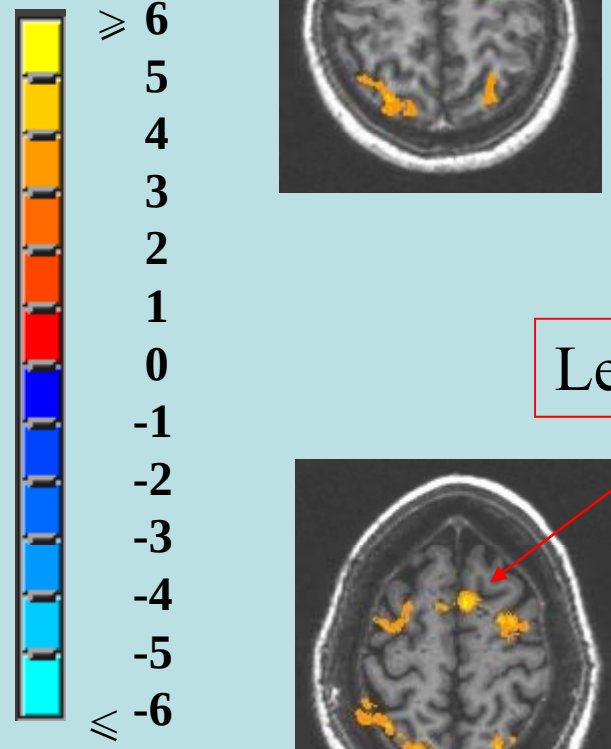
Common for both age groups:

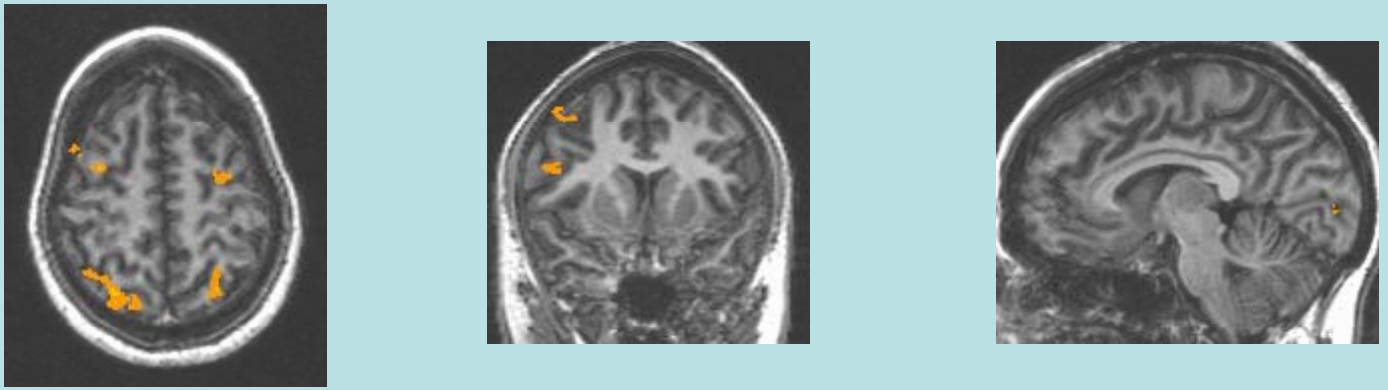
- Frontal: Right inferior frontal gyrus (IFG) and both right and left middle frontal gyrus (MFG).
- Visual Processing: Middle occipital gyrus, inferior occipital gyrus, precuneus, superior parietal lobule and surrounding regions.

Brain Activation Comparison:

"Incongruent – Congruent" Contrast

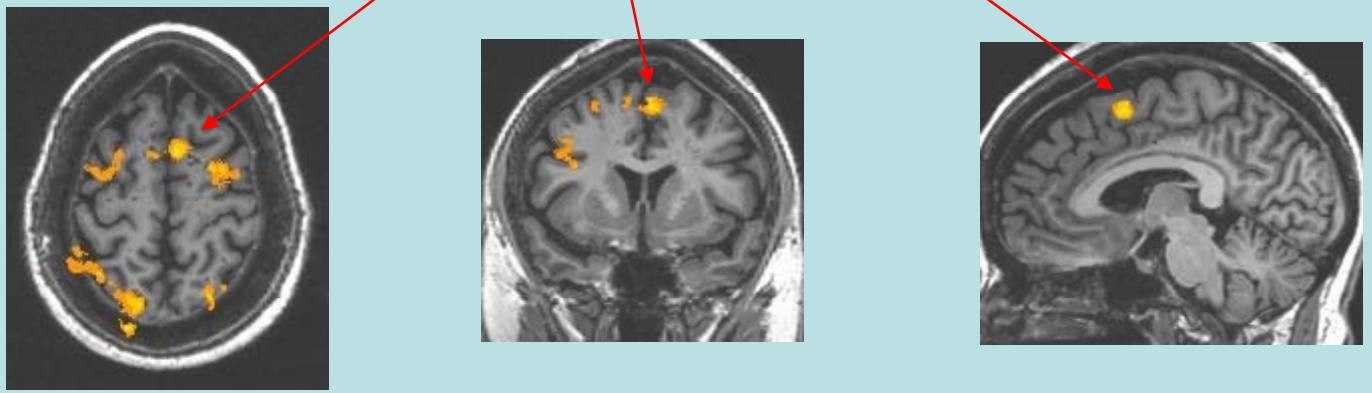
(voxel based $p \leq 0.005$, whole brain corrected $p \leq 0.021$)





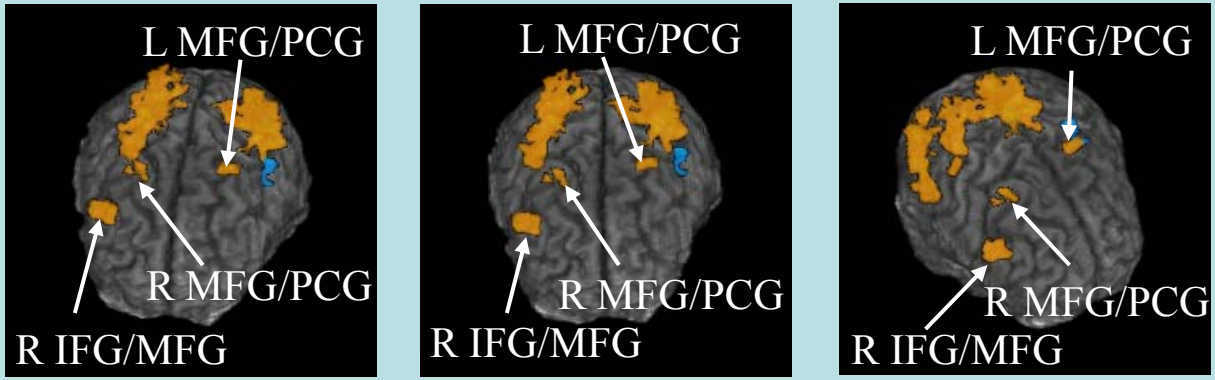
Younger adults

Left Superior Frontal Gyrus

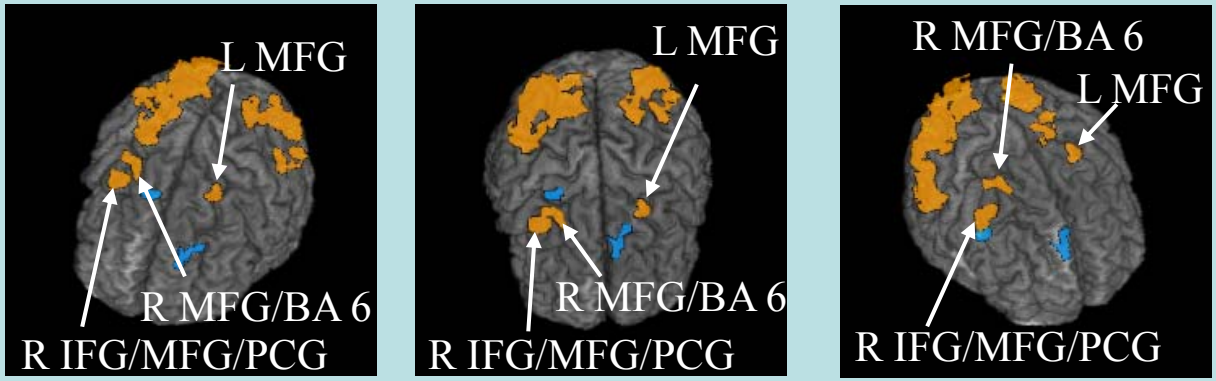


Older adults

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

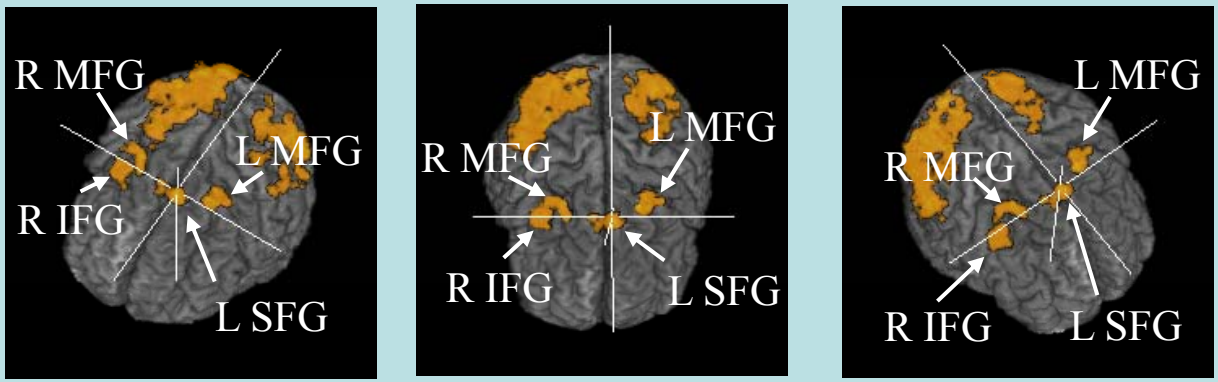


(a) Young adults (successful trials, "IC-C")



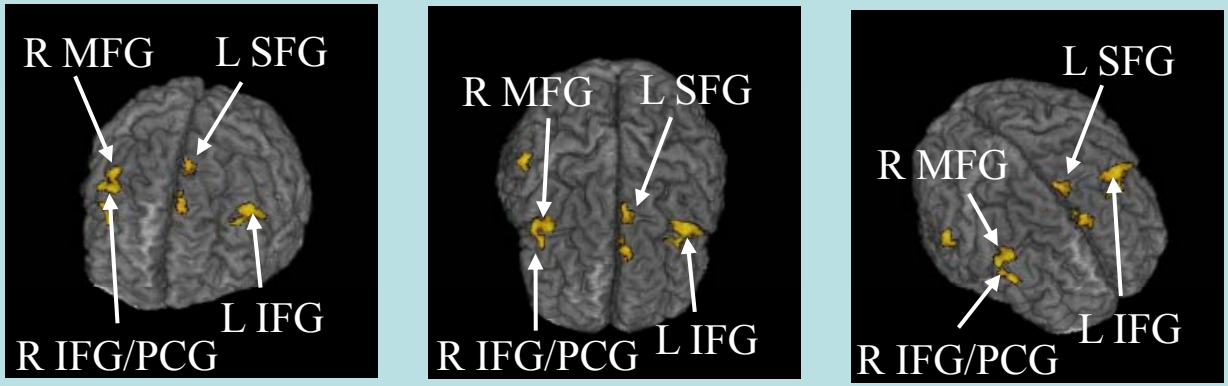
(b) Older adults (successful trials, "IC-C")

A 153 mm^3 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

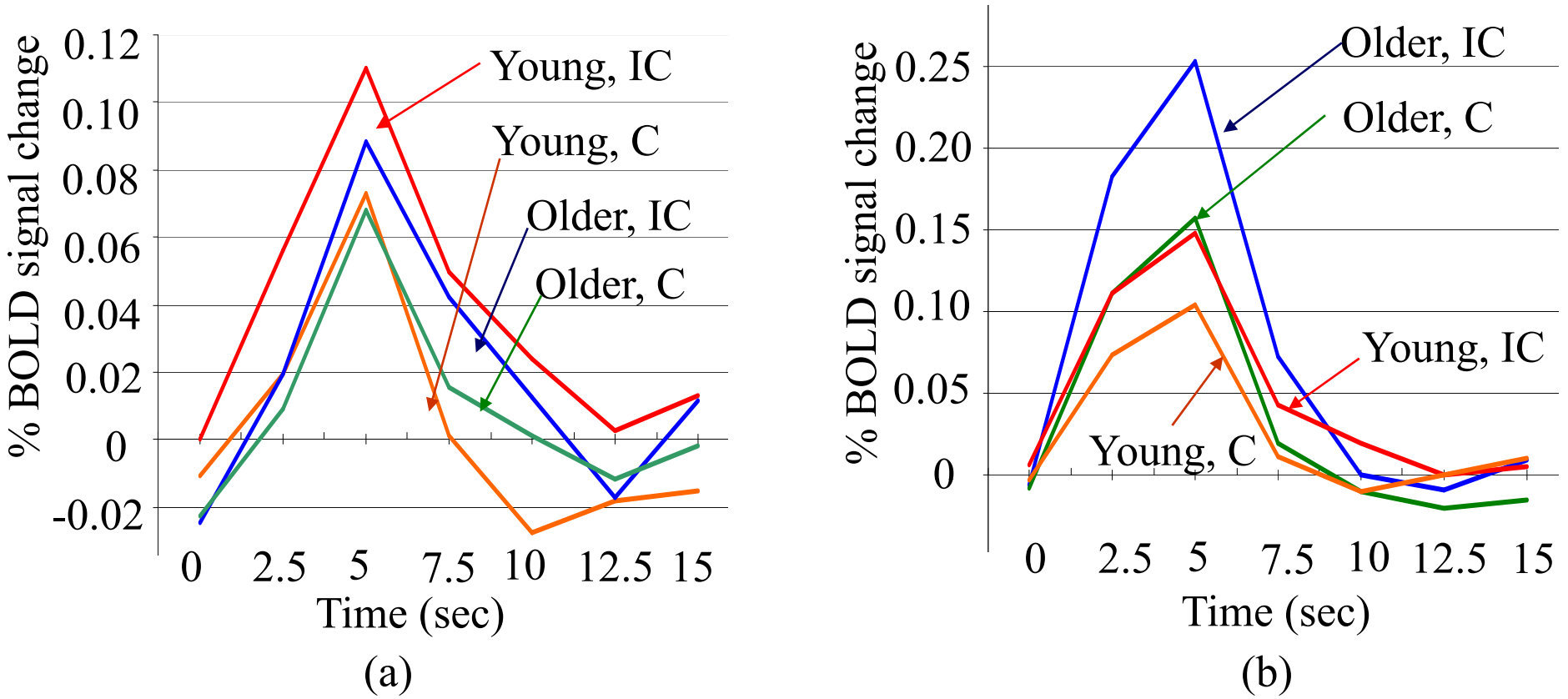


(c) Older adults (successful and error trials together, "IC-C")

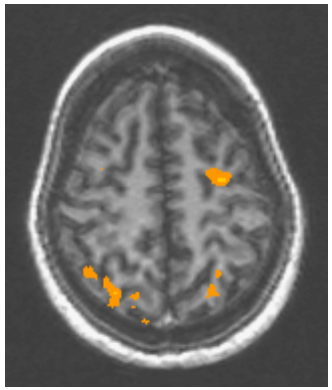
However, partially driven by errors:



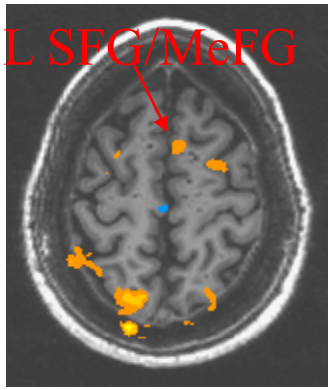
(d) Sub-group of nine older adults ("error IC vs. successful C")



The within-group whole-brain differential activation during successful flanker trials ("Incongruent – Congruent") (voxel-based p value ≤ 0.005 and whole-brain corrected p value ≤ 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.

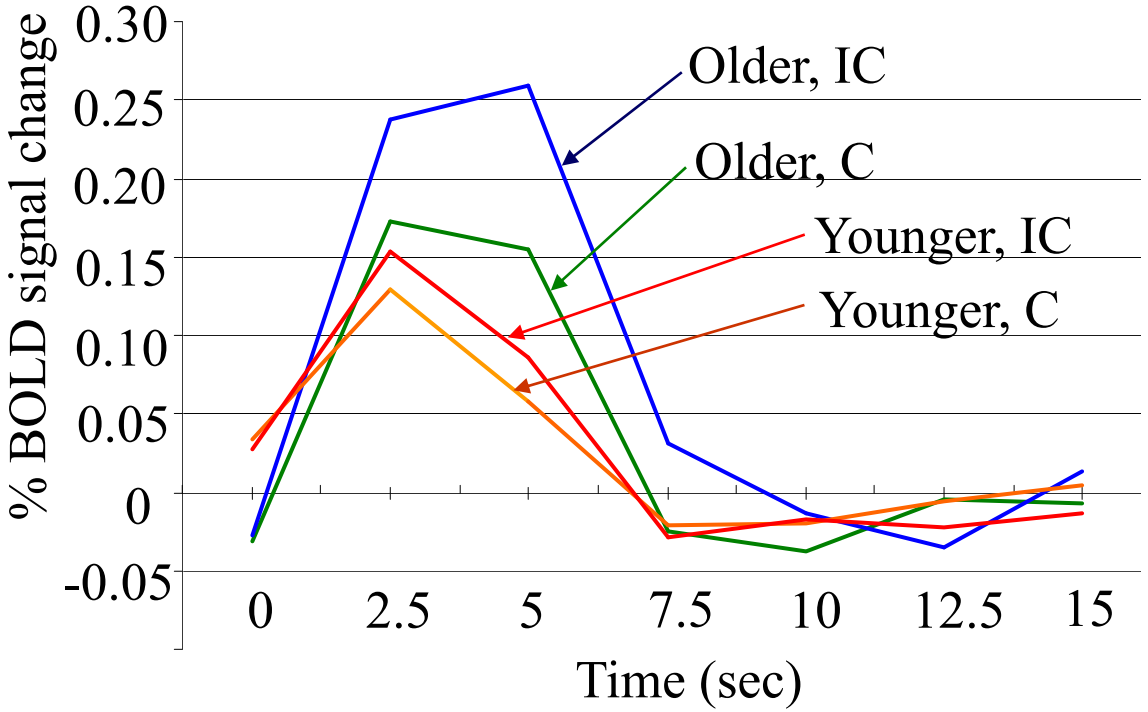


Younger Adults



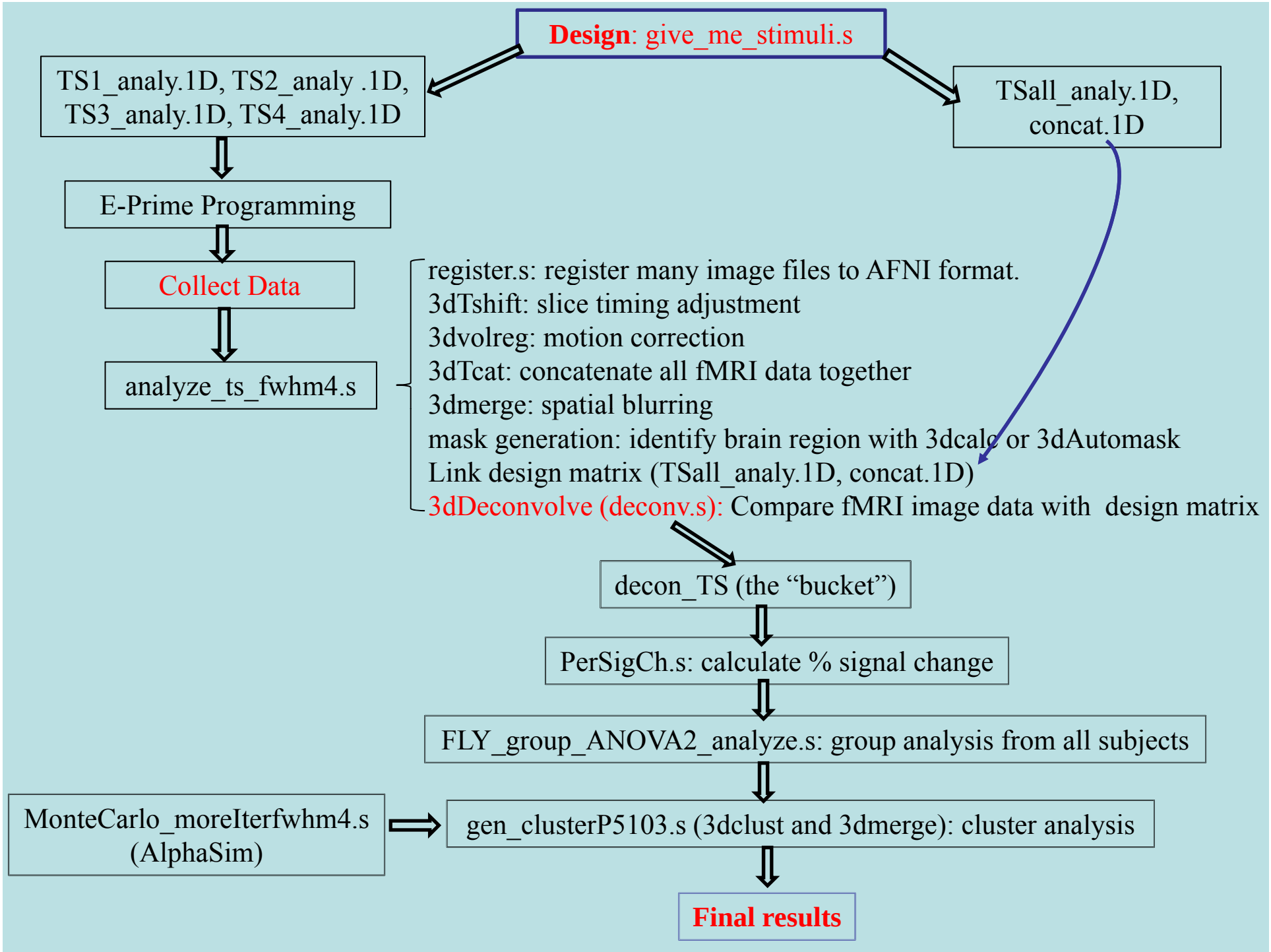
Older Adults

(a)



(b)

The within-group whole-brain differential activation during successful flanker trials ("Incongruent – Congruent") (voxel-based *p* value ≤ 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).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TS1_analy.1D, TS2_analy .1D, TS3_analy.1D, TS4_analy.1D
TSall_analy.1D, concat.1D
E-Prime Programming
Collect Data
analyze_ts_fwhm4.s
register.s: 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