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HST.583 Functional Magnetic Resonance Imaging: Data Acquisition and Analysis
Fall 2008

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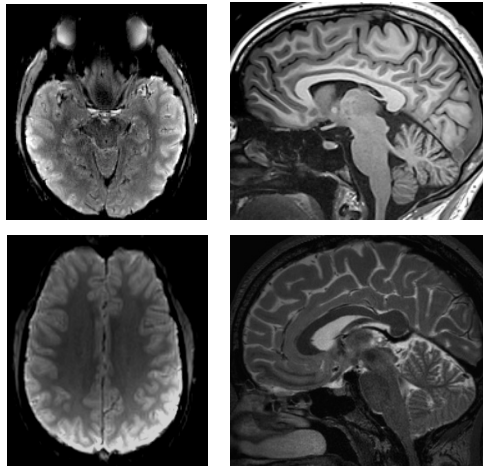


HST.583: Functional Magnetic Resonance Imaging: Data Acquisition and Analysis, Fall 2008
Harvard-MIT Division of Health Sciences and Technology
Course Director: Dr. Randy Gollub.

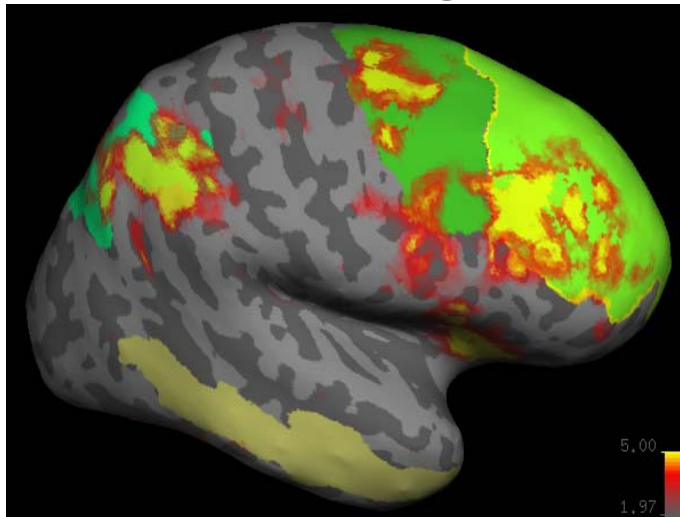
HST:583

fMRI Acquisition Lab

Susan Whitfield-Gabrieli
Christina Triantafyllou
Steven Shannon
Sheeba Arnold



Sternberg (WM)



Courtesy of Randy Gollub. Used with permission.
 Source: Yendiki, A., R. L. Gollub, et al. "Multi-site Characterization of an fMRI Working Memory Paradigm: Reliability of Activation Indices." *Annual Meeting of the Organization for Human Brain Mapping*. Florence, Italy, June 11-15, 2006.

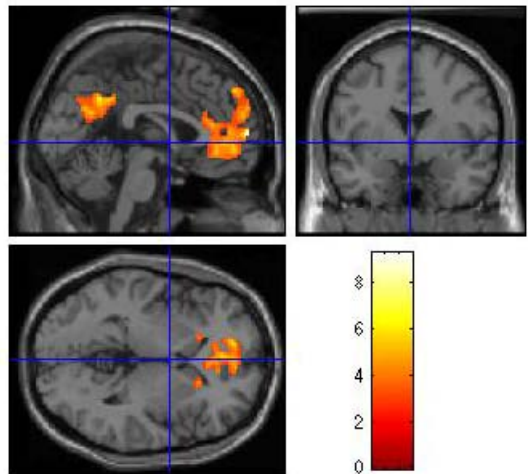
TASKS:

Self Reference

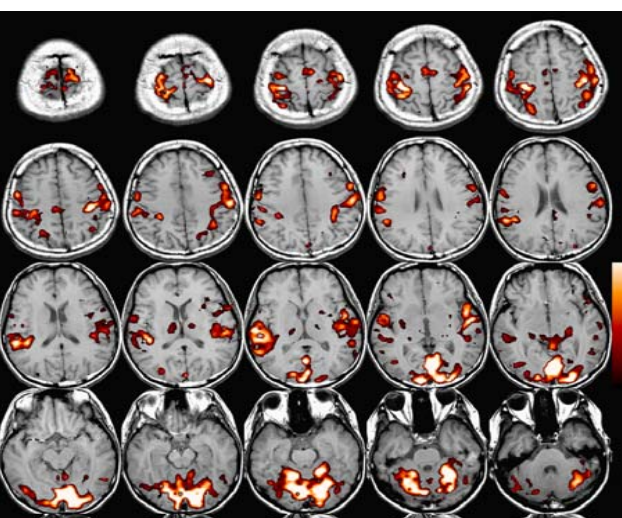
Sternberg (WM)

Sensorimotor with Neuro3D

Self Reference

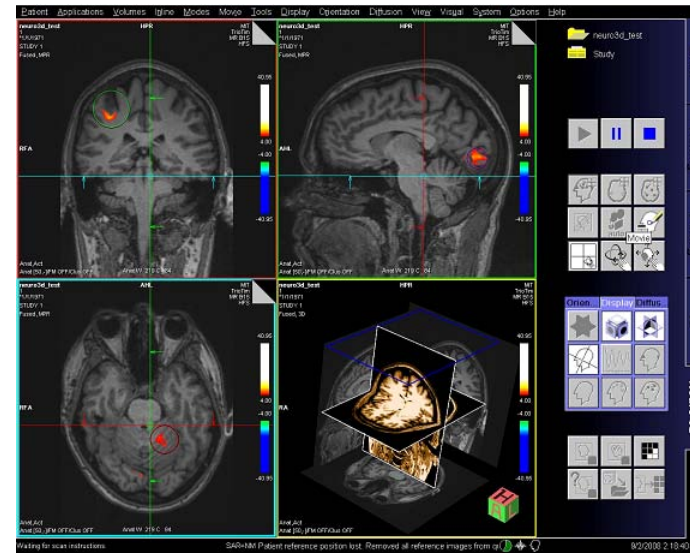


Sensorimotor



Courtesy of Gary Glover. Used with permission.

Neuro3D



Courtesy of Siemens Medical Solutions USA, Inc. Used with permission.

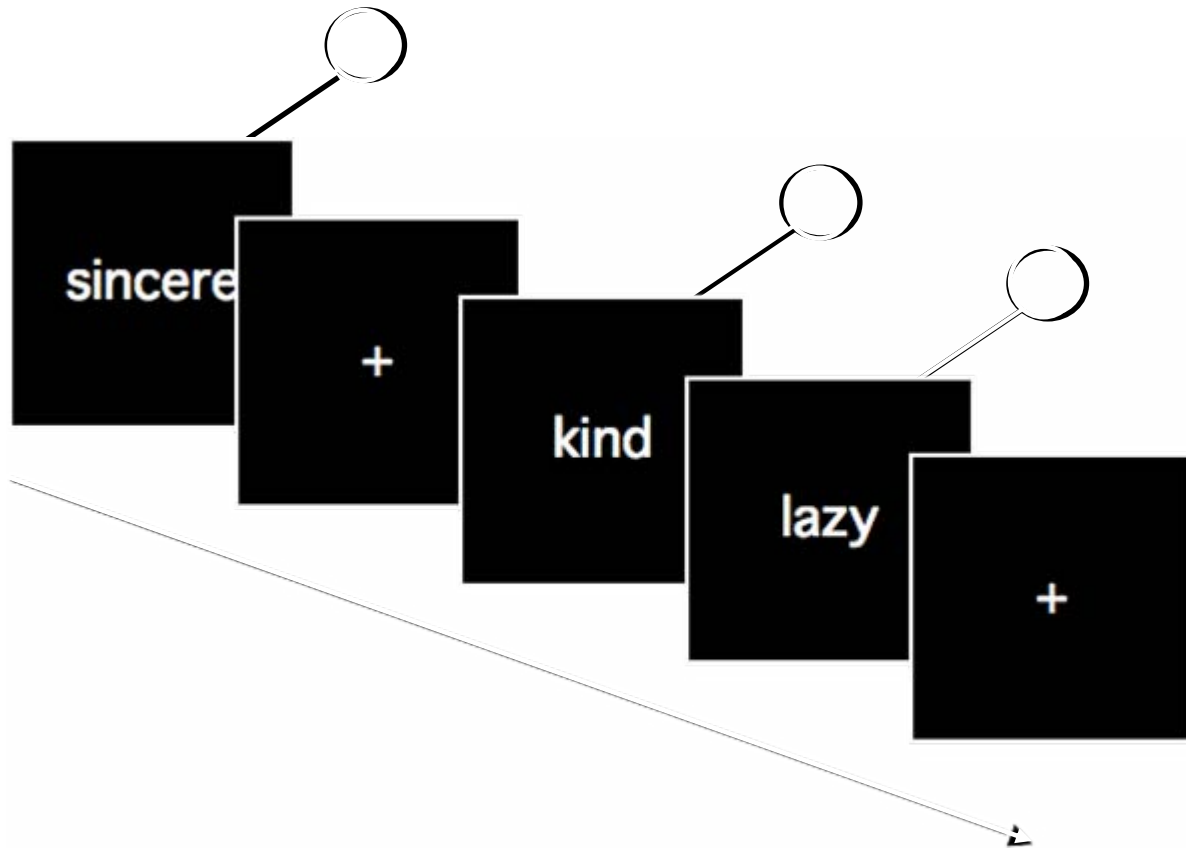
Self

- **representation of knowledge about one's thoughts, feelings**

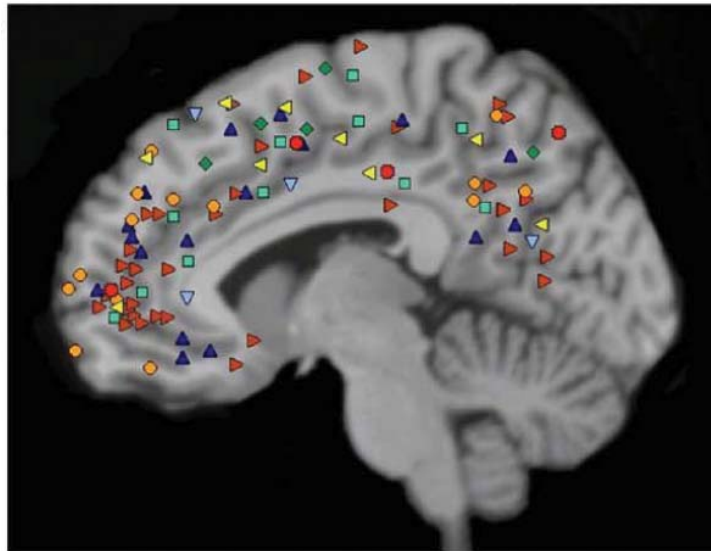
Self-Related Cognition

- **Self-referential processing with trait adjectives**

Cartoon removed due to copyright restrictions. Person thinking "I used to be indecisive...now I'm not sure."



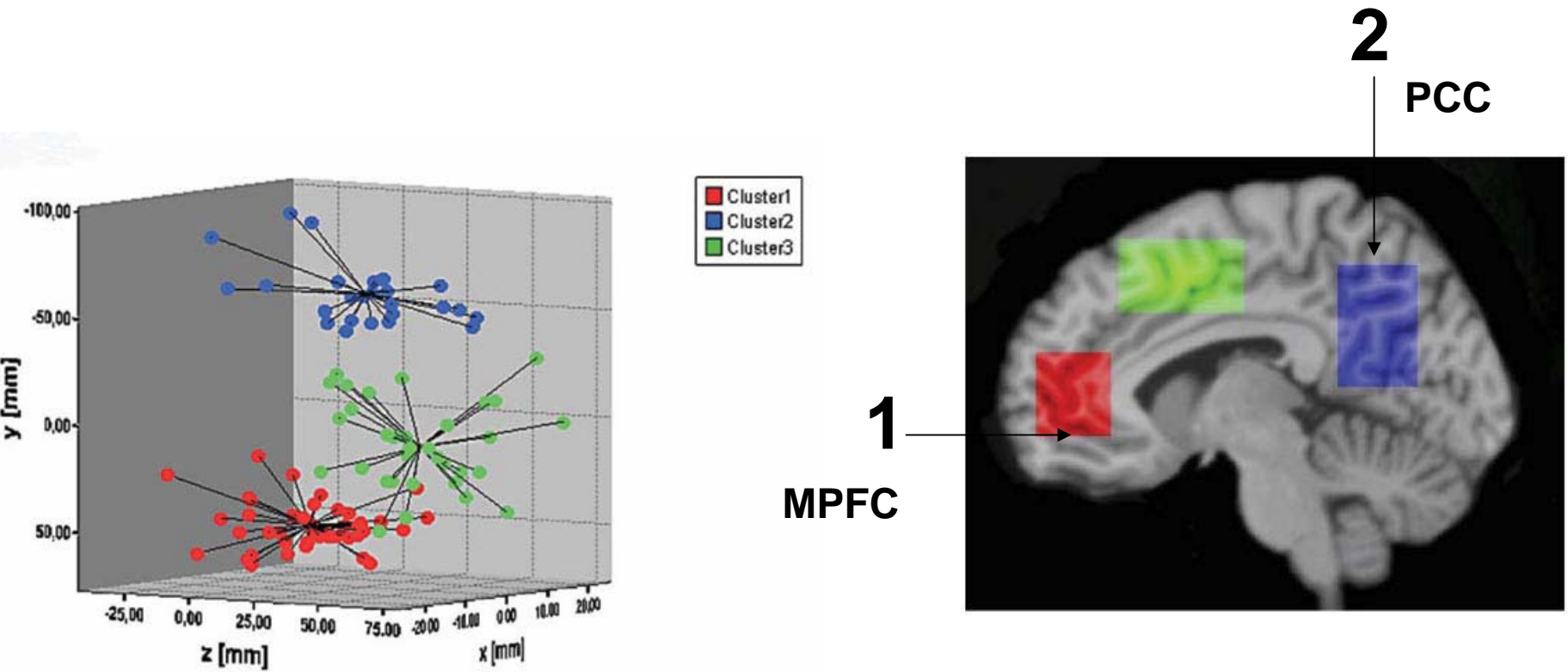
Activation in CMS observed in imaging studies during self related tasks in different domains.



Courtesy Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

- ▲ emotional domain: self > non-self
- ▼ facial domain: self > non-self
- memory domain: self > non-self
- ◆ motor domain: self > non-self
- ◀ social domain: self \cap other
- social domain: self > other
- ⊕ spatial domain: self > non-self
- ▶ verbal domain: self > non-self

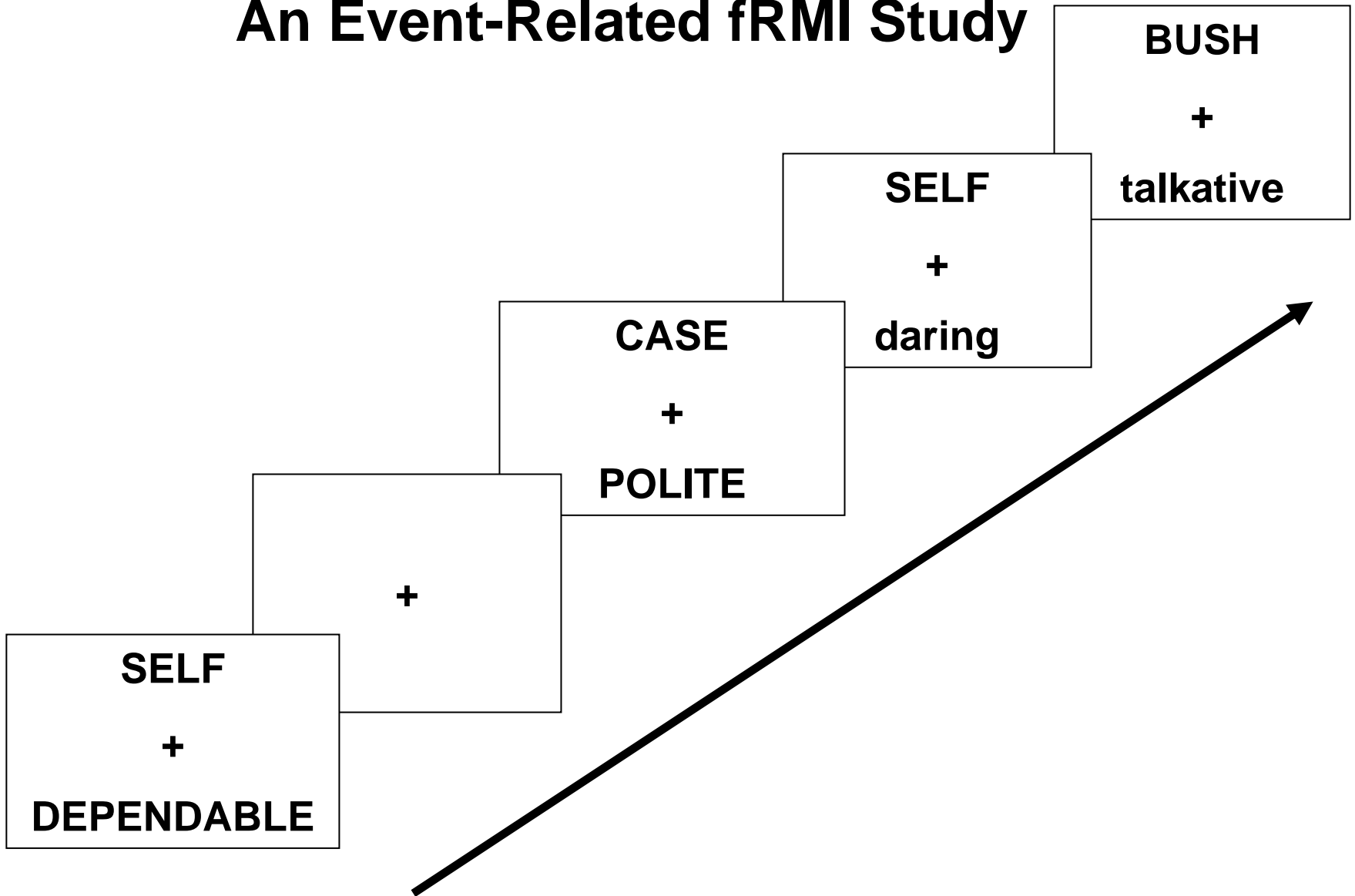
Graphic representation of localizations of clusters



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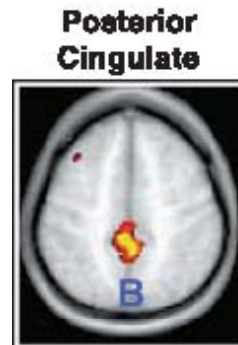
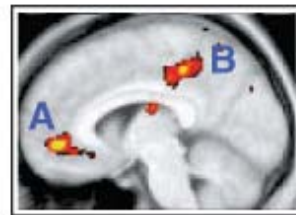
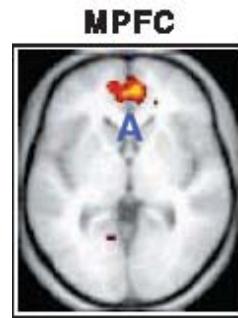
Finding the Self?

An Event-Related fMRI Study

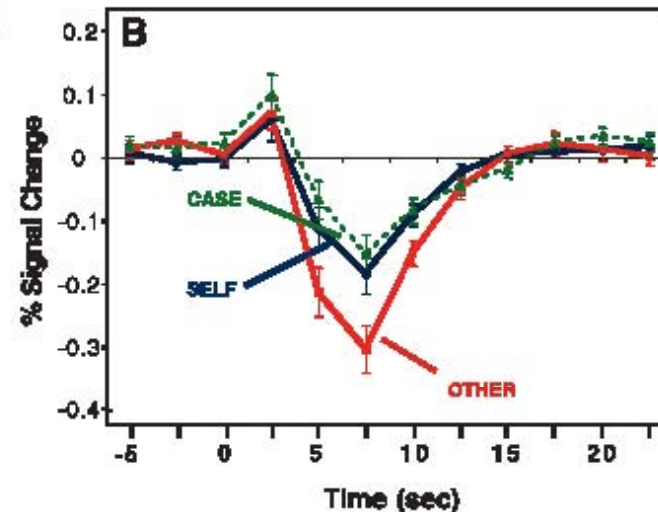
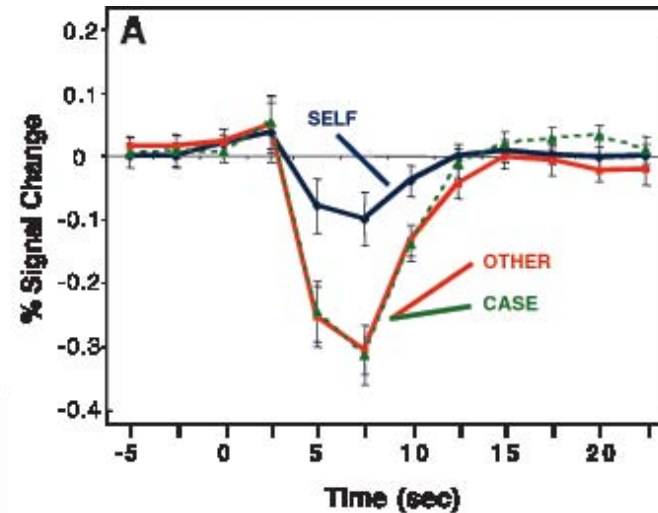


2.5 s

ACTIVATION FOR SELF-REFERENCE



min  8
t score



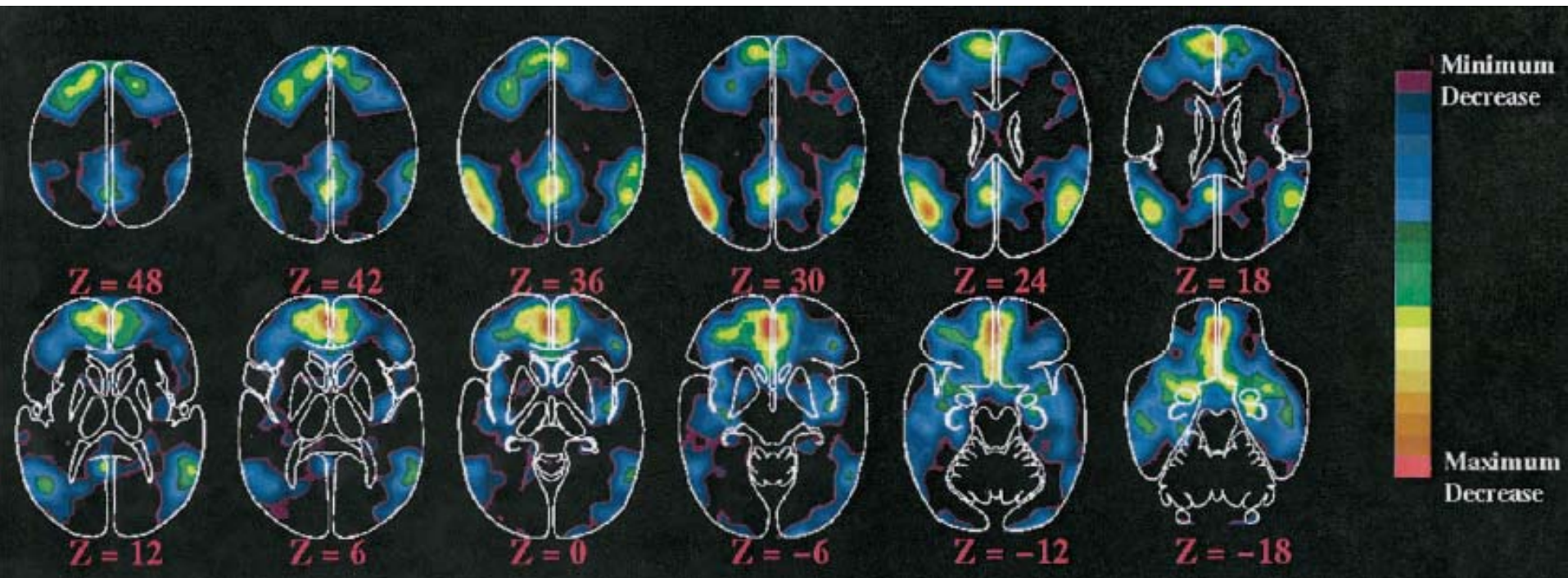
W. M. Kelley, C. N. Macrae, C. L. Wyland, S. Caglar, S. Inati, and T. F. Heatherton, "Finding the Self? An Event-Related fMRI Study." *Journal of Cognitive Neuroscience* 14, no. 5 (July 1, 2002): pp. 785–794. (c) 2002 by the Massachusetts Institute of Technology. Used with permission.

Kelley et al., 2002, *J Cogn Neurosci*

Default Network

- **more active during rest than most attention demanding tasks**
- **stimulus-independent, task-independent**
- **also supported by**
 - medial prefrontal cortex (MPFC)**
 - posterior cingulate/precuneus (PCC)**

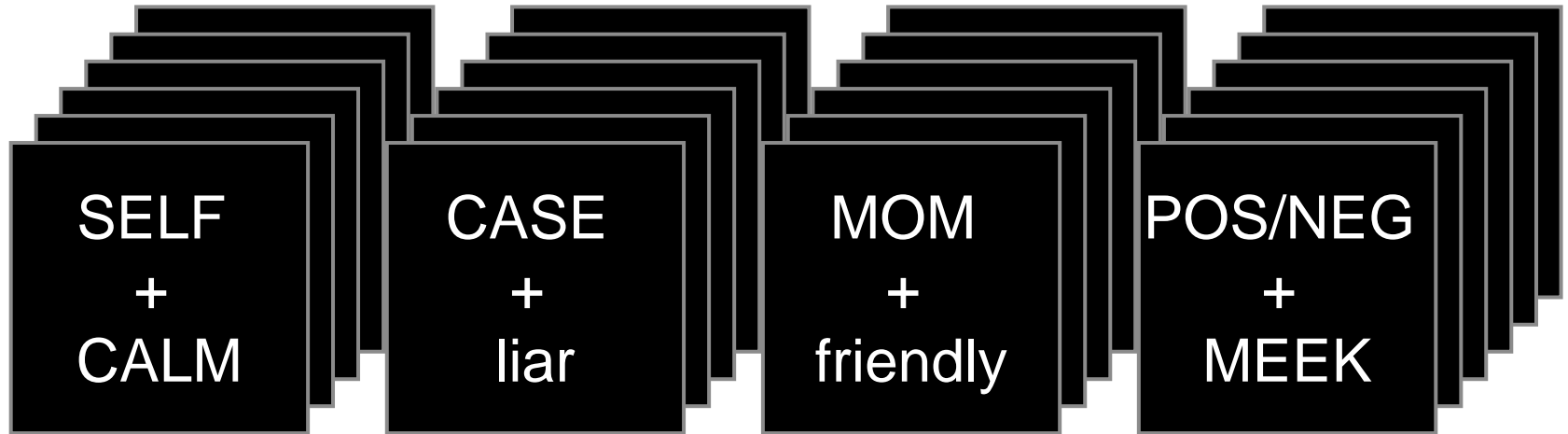
Default Network



Courtesy of National Academy of Sciences, U. S. A. Used with permission. Source: Raichle, M.E., et al, "A Default Mode of Brain Function." *PNAS* 98, no. 2 (January 16, 2001): 676-682.
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Raichle et al, PNAS, 2001

Self Reference Task Design



Stimuli: trait adjective words

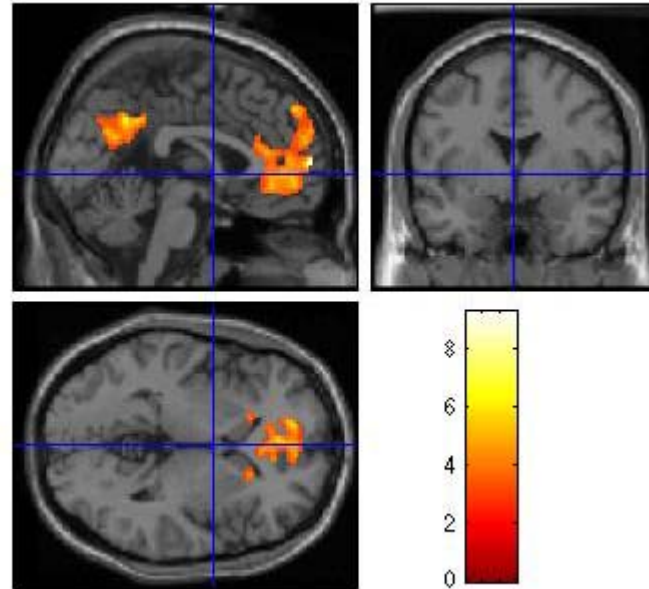
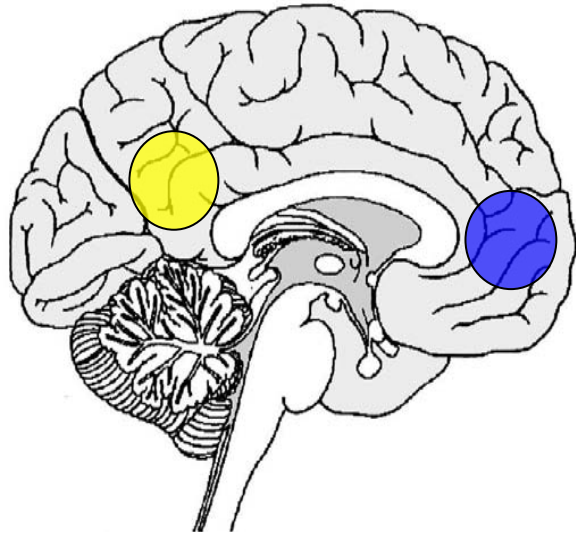
Words were drawn from Anderson's (1968) list of normed trait adjectives. The lists were counterbalanced for word valence, length and number of syllables.

Presentation:

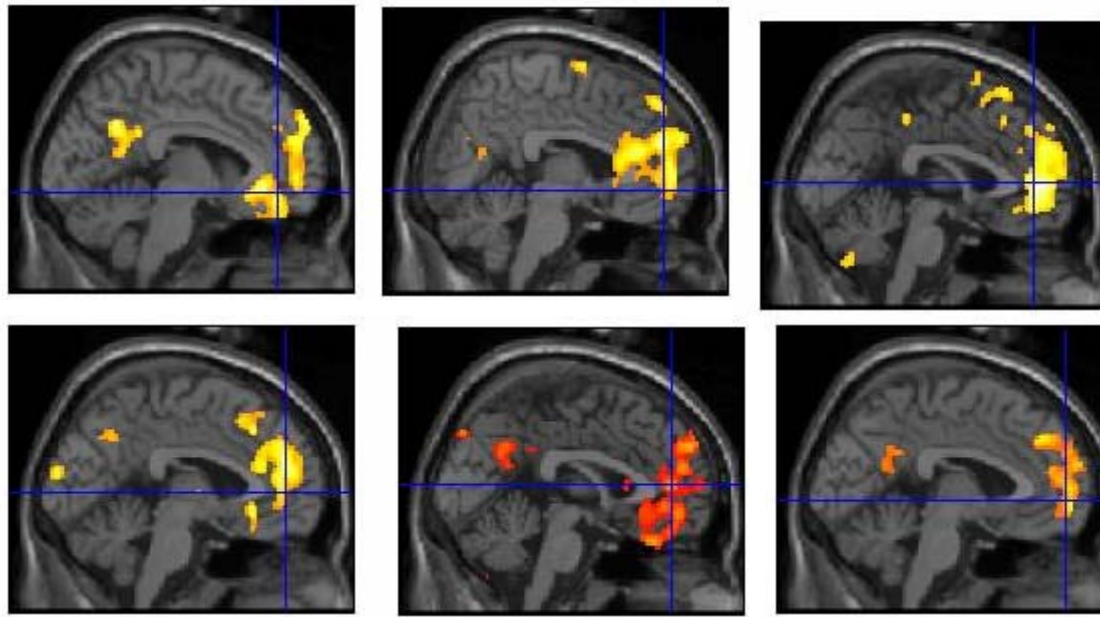
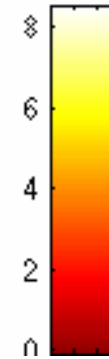
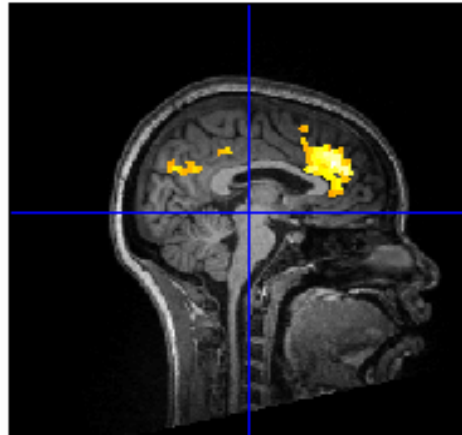
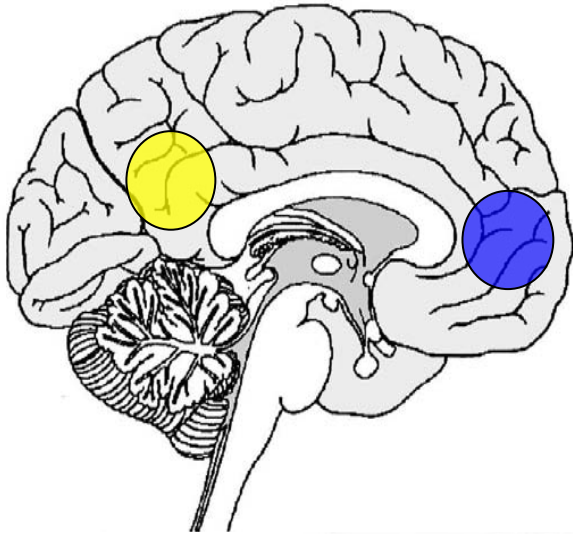
- TR=3s / 6 items per condition / blocked design
- SELF – “Does this word describe you?”
- MOM – “Does this word describe your mother?”
- SEM – “Is this word positive or negative?”
- CASE – “Is this word presented in upper- or lowercase letters?”
- 72 measurements per session

Self reference

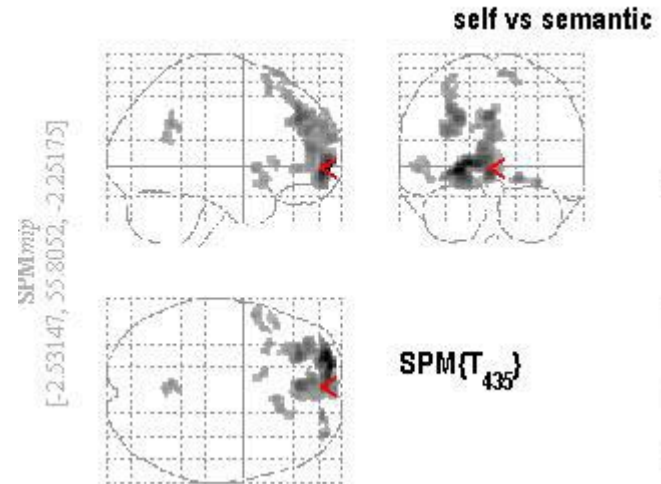
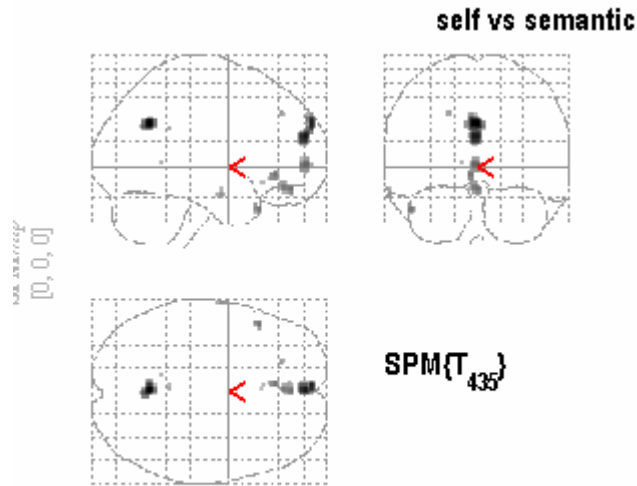
SELF > SEM Group Analysis



Self Reference, Single Subject (self-semantic)



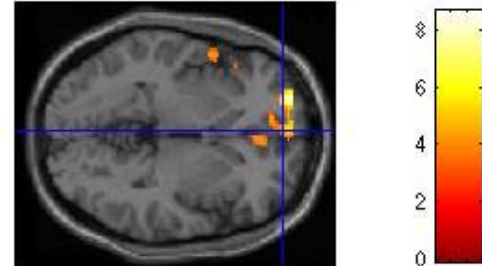
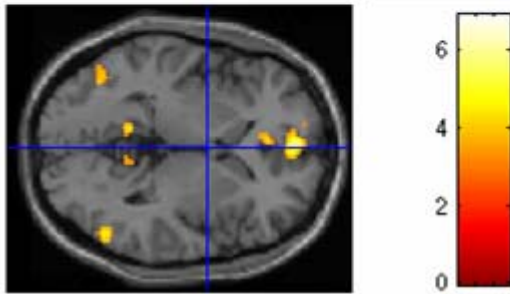
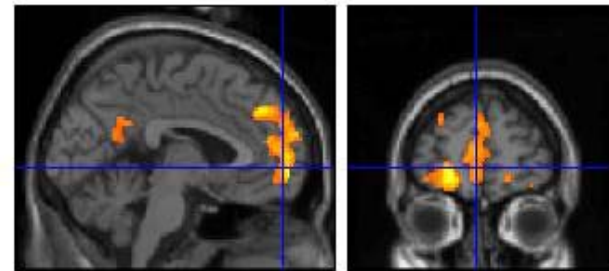
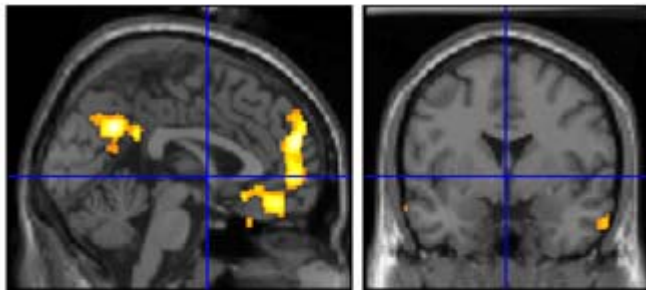
Frontal regions are prone to susceptibility artifact



SPMresults: .normalised\enc_results

Height threshold T = 5.03

Extent threshold k = 0 voxels

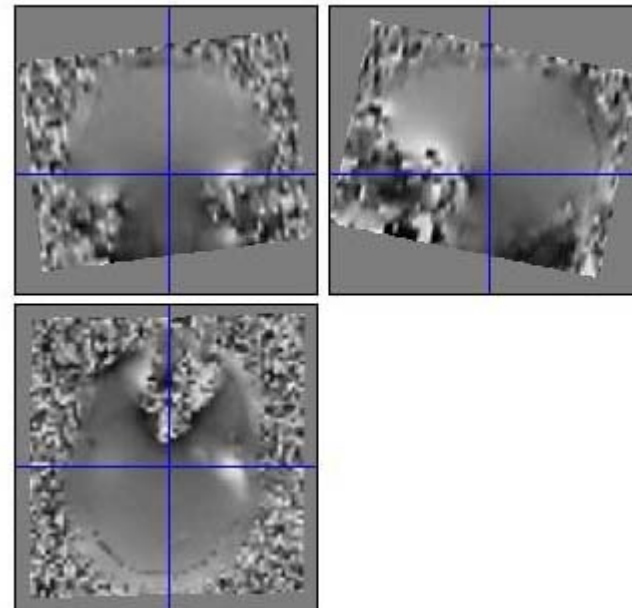


Field Maps:

The field map is a 2D gradient echo sequence which acquires an image at 2 different echo times. This sequence generates 2 types of images, a magnitude image and a phase map.

The phase map represents the phase differences of the spins which ultimately represent the **local field inhomogeneities**. You can display this map to see which regions are prone to **susceptibility artifacts**.

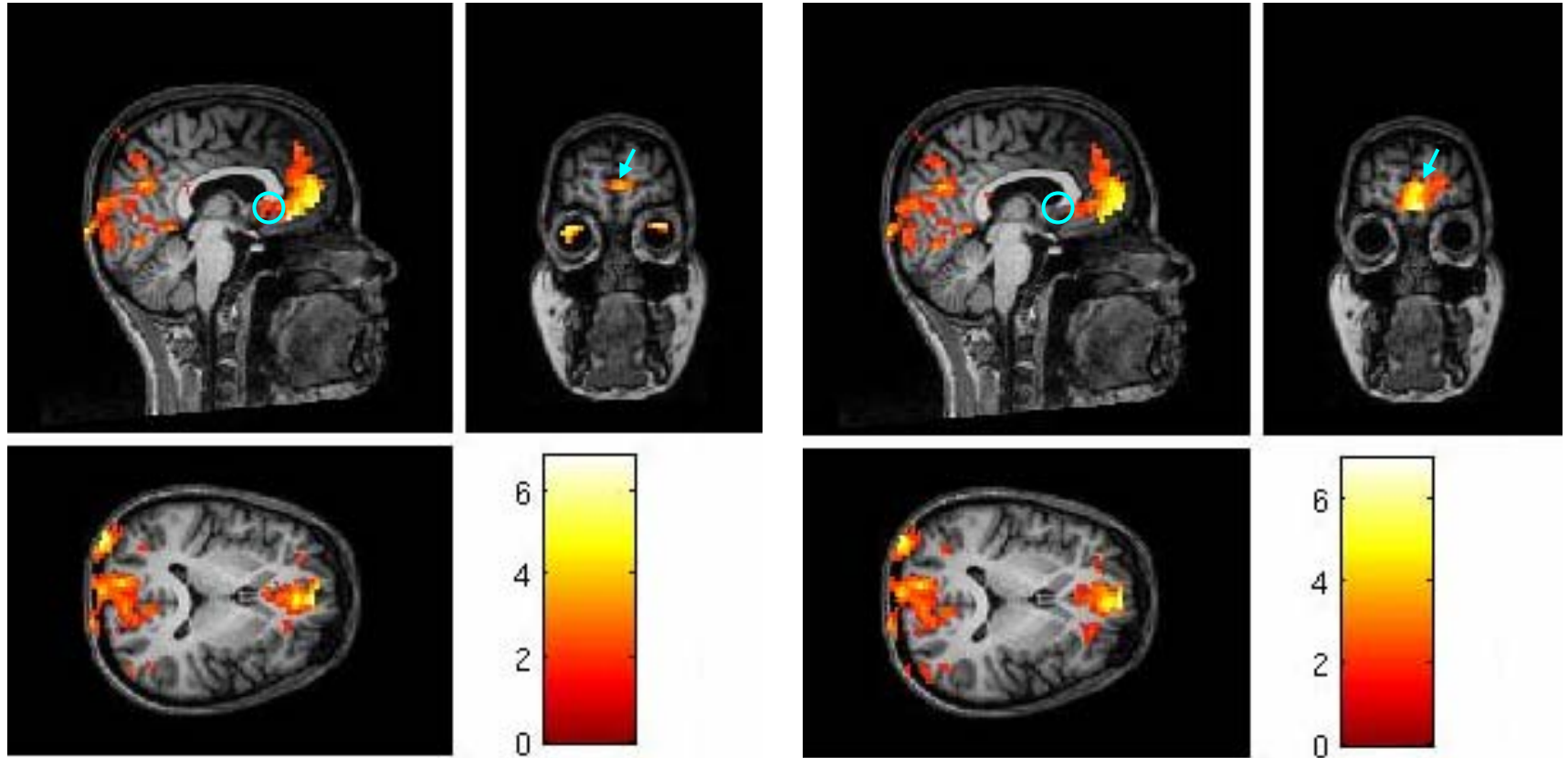
PHASE MAP



Field Map Correction

Base>Sem
(Before Correction)

Base>Sem
(After Correction)



p-value = 0.05 (unc)
Extend threshold=5

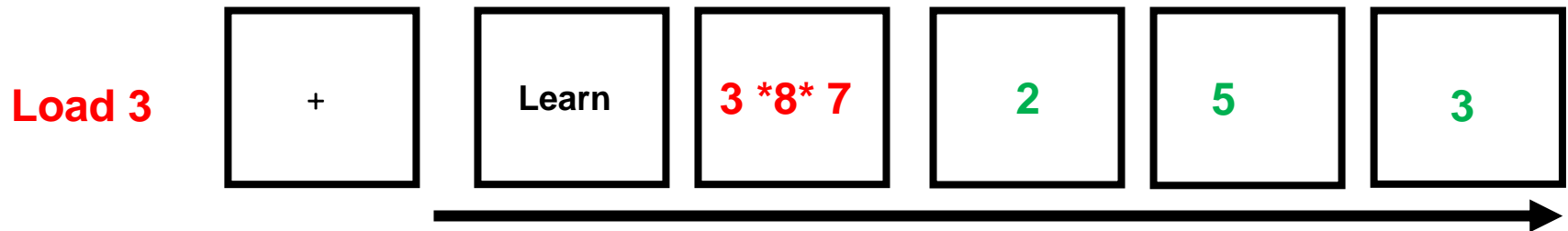
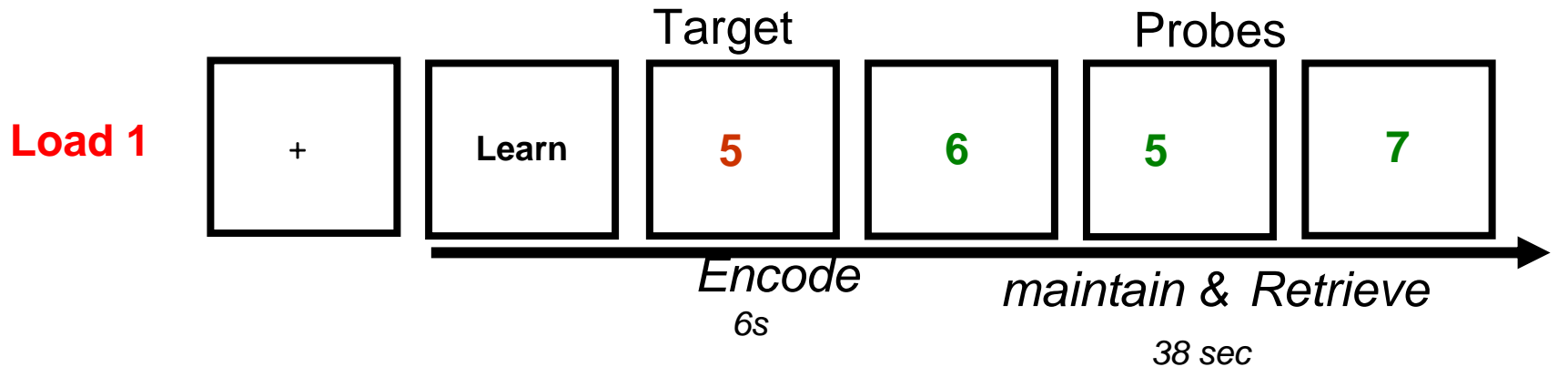
WORKING MEMORY WM

- **a system for temporarily storing and manipulating information required to carry out complex cognitive tasks.**
- **supported by prefrontal cortex, parietal cortex, anterior cingulate, and basal ganglia**

Sternberg WM Task

- **encoding, maintenance, retrieval components of WM (event-related design)**
- **parametric design: influence of load (the amount of information) on brain functions (blocked & event-related designs)**

Working Memory



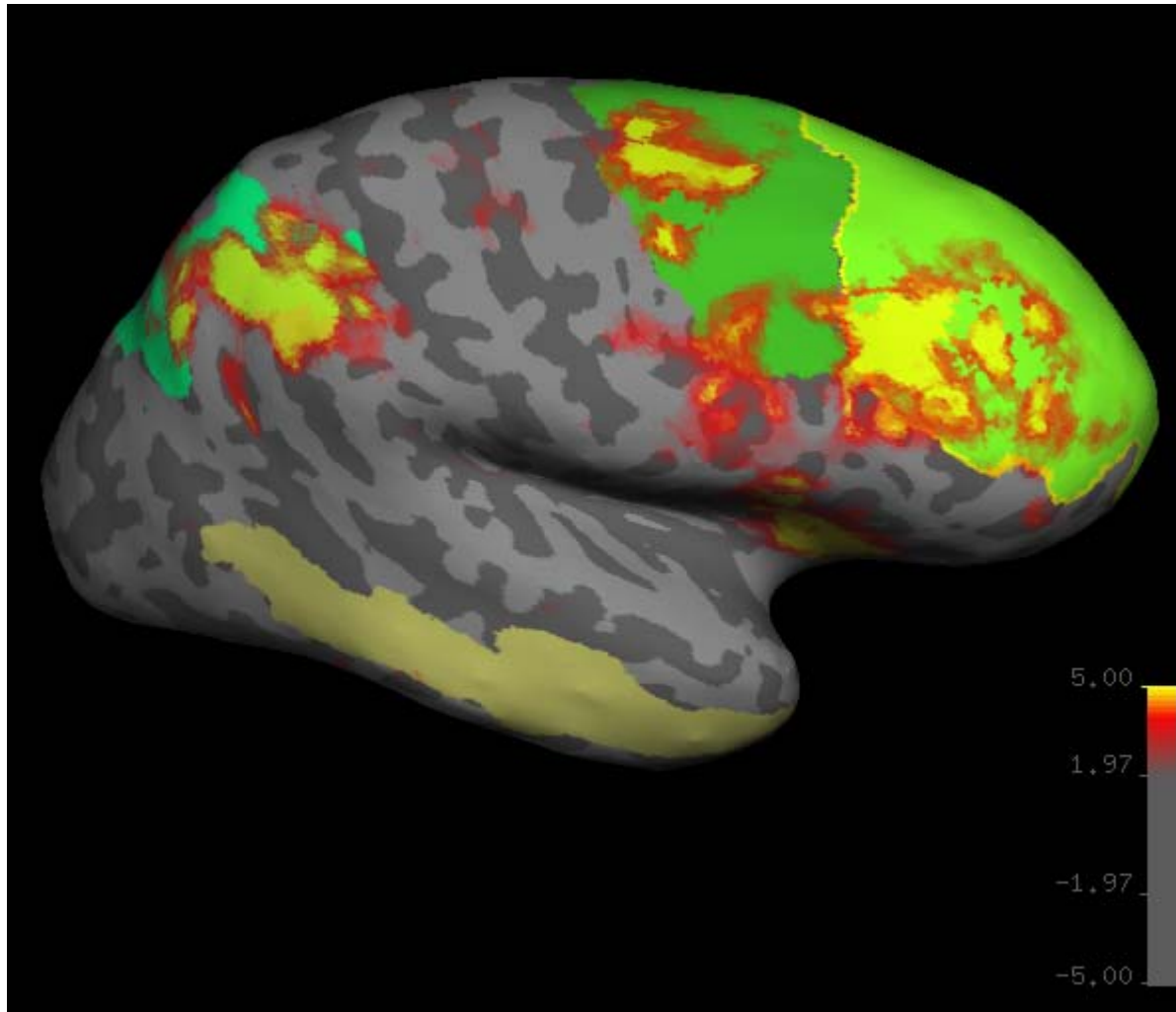
**Sternberg Item Recognition Paradigm
(SIRP)**

Sternberg Task: Group analysis (n=10)

HIGH (5) – LOW(1) Working Memory Load:

Green regions: ROIs of 3 working memory related areas (DLPFC, DLPMC, IPS) and 1 control region (MTG)

IPS
(intraparietal sulcus)



DLPMC
(dorsal lateral premotor cortex)

DLPFC
(dorsal lateral prefrontal cortex)

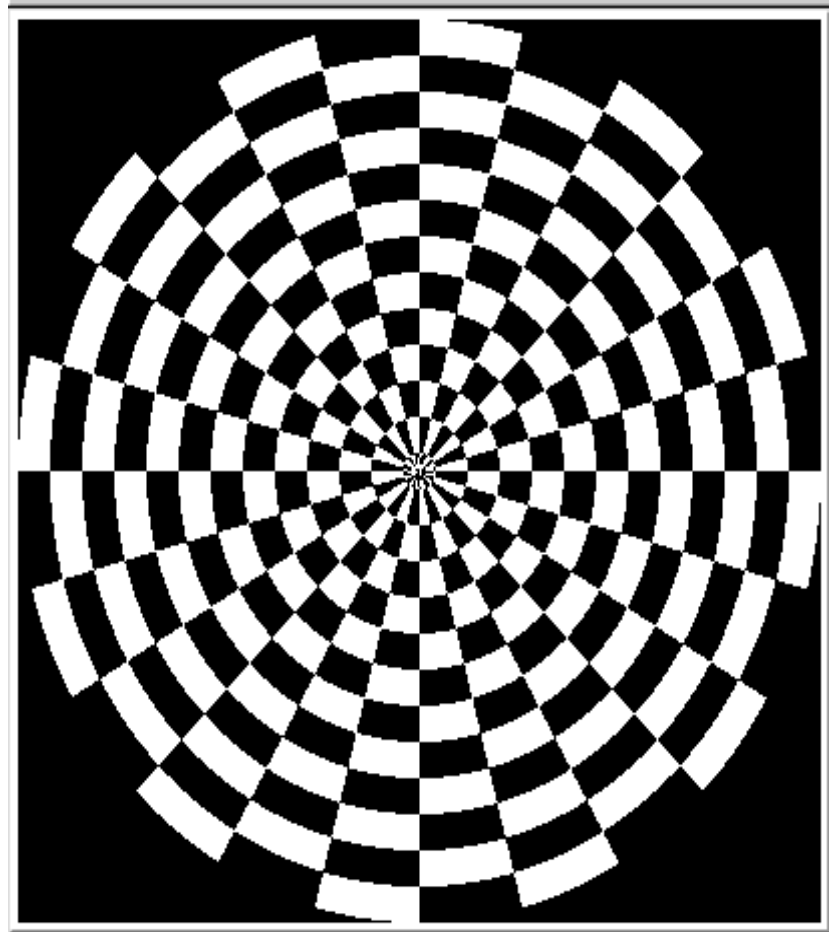
MTG
(middle temp gyrus)



Randy Gollub

Sensorimotor Task

The task consists of a block design with block durations of 16s on/off. When checkerboard appears, subject taps fingers with their dominant hand and the off-block is fixation/no tapping. There are 15 total, 16s blocks. (4 min)



On block parameters: ISI ranges from 500-1000ms, average ISI = 762ms, std. dev = 156ms.

21 checkerboard flashes per on block, each checkerboard flash duration = 200ms.

The sequence begins with an off block. Scanner triggers the paradigm

*(after the dummy scans). **fBIRN** (**functional biomedical informatics research network**)*

Motor and Visual Cortex

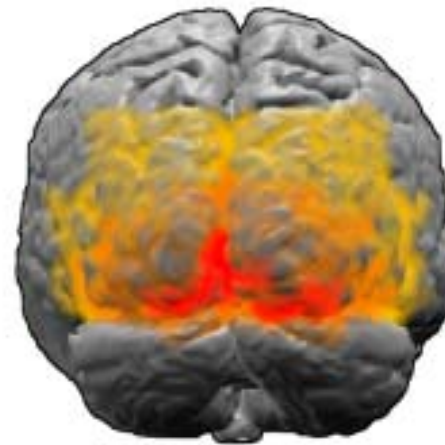
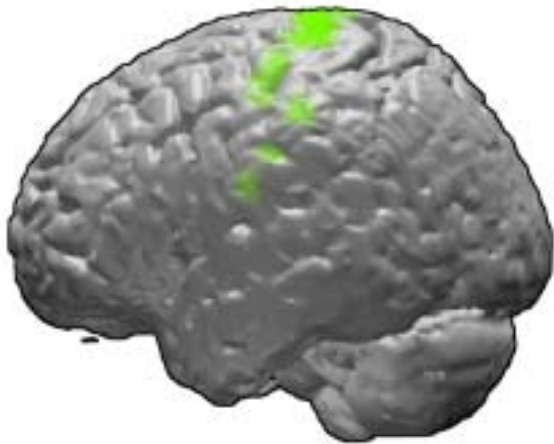
Motor cortex - BA4 shown in green

Visual cortex - BA 17,18,19 from rear view of brain

BA 17 is shown in red.

BA 18 is orange

BA 19 is yellow

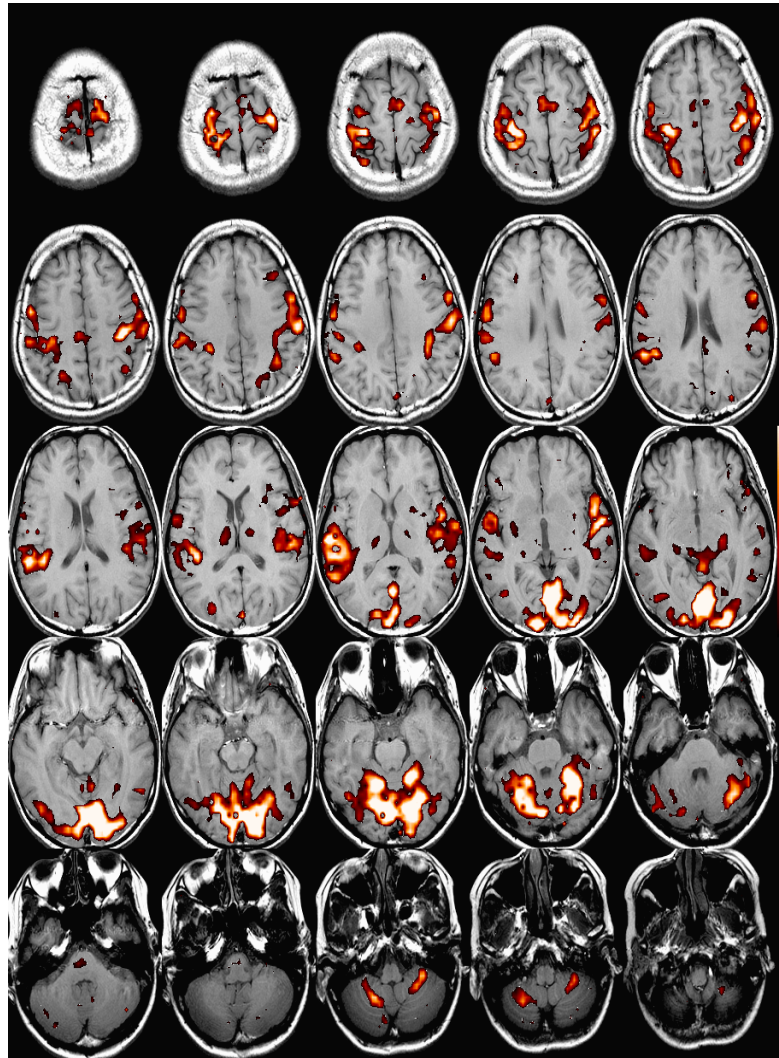


You'll see LEFT motor cortex (green), since the subject is responding with the right hand, and you'll see bilateral visual cortex.

Brain surface extracted from structural MRI data (Wellcome Dept. Imaging Neuroscience, UCL, UK). Brodmann Area data is based on information from the online Talairach demon (electronic version of Talairach and Tournoux, 1988).

Example of Sensorimotor Task activation

(with visual, motor & auditory)

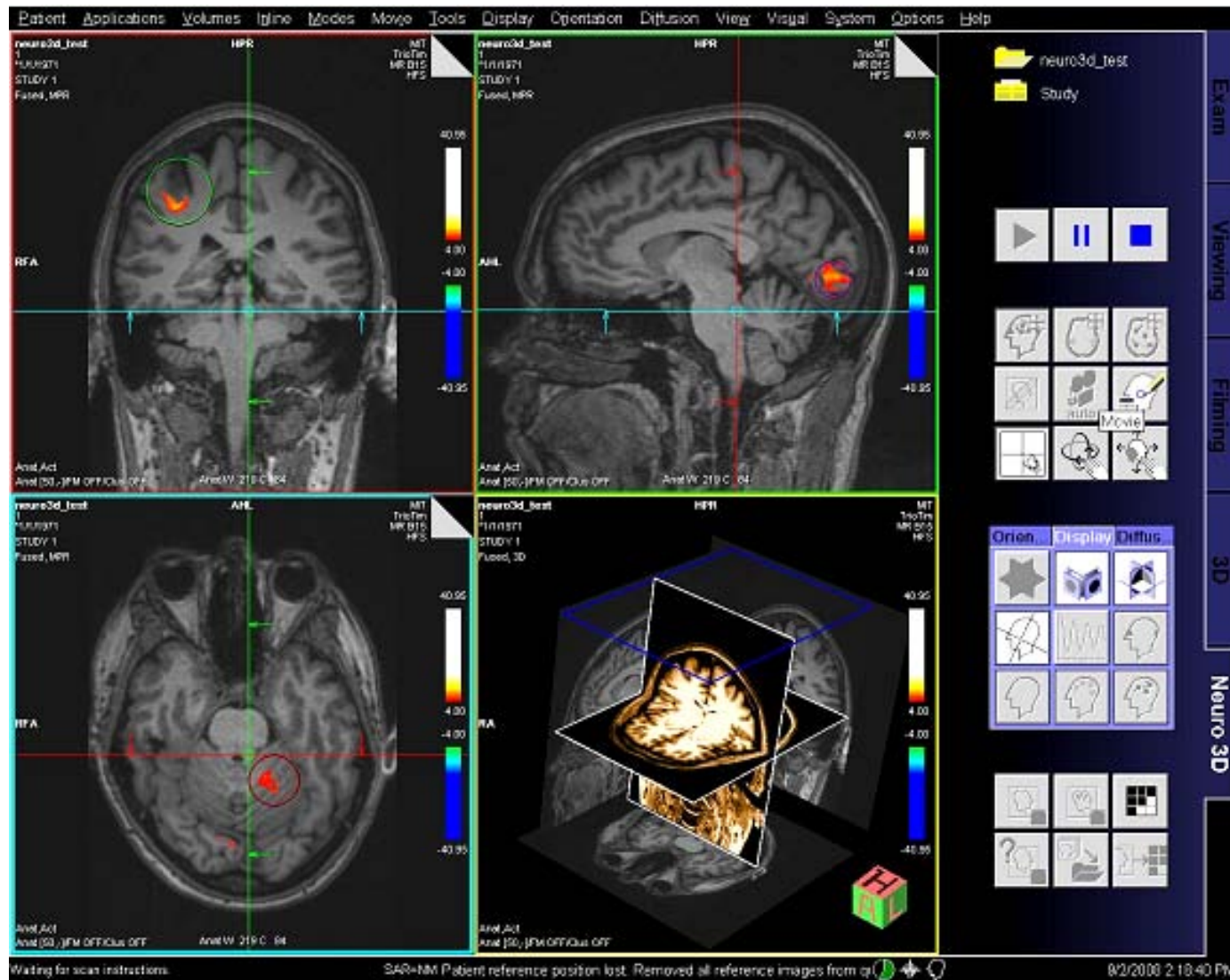


Note: This task has an additional auditory component so you see temporal lobe activation as well as motor and visual. In addition, the subject is responding with both hands so you see bilateral motor activation as opposed to only the left hemisphere motor (contralateral to response hand)

Courtesy of Gary Glover. Used with permission.

fBIRN (functional biomedical informatics research network)
Gary Glover, Stanford University

Neuro3D & Sensorimotor Task



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