

A neuroscientist sees the brain in action

Peter A. Bandettini, Ph.D.

Section on Functional Imaging Methods
Laboratory of Brain and Cognition

<http://fim.nimh.nih.gov>

&

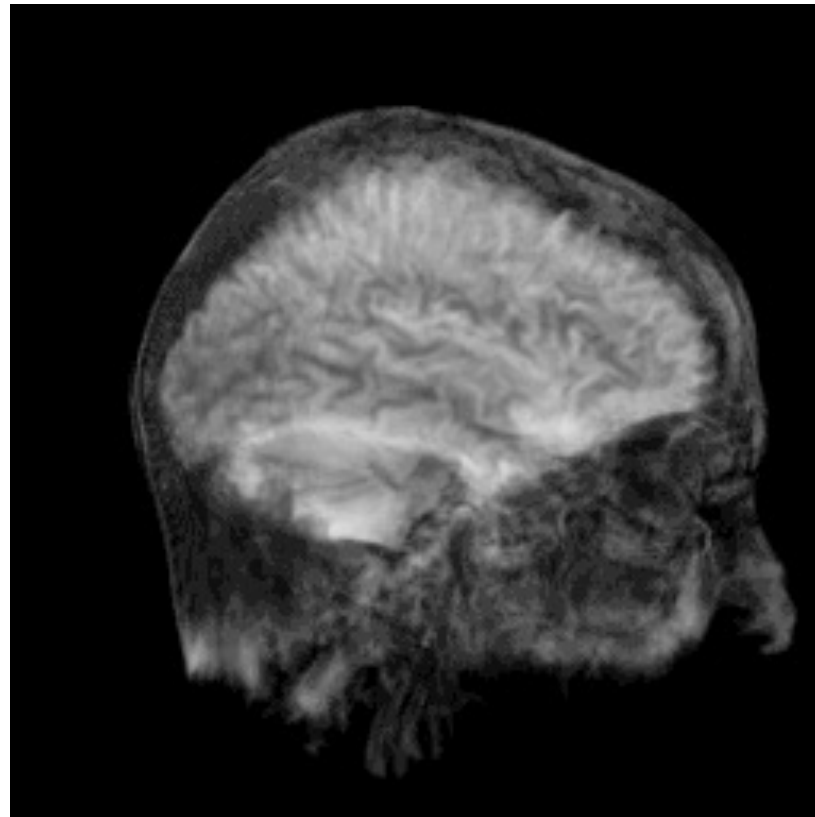
Functional MRI Facility

<http://fmrif.nimh.nih.gov>



Two Types of Neuroimaging

- Structural/Anatomical Imaging
- Functional Imaging



Magnetic Resonance Imaging

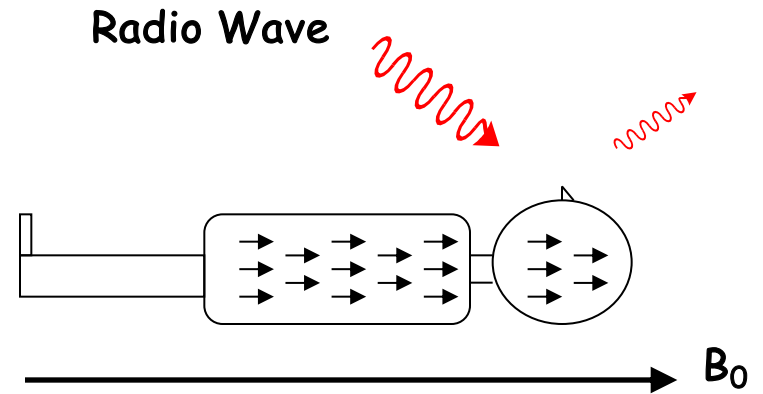
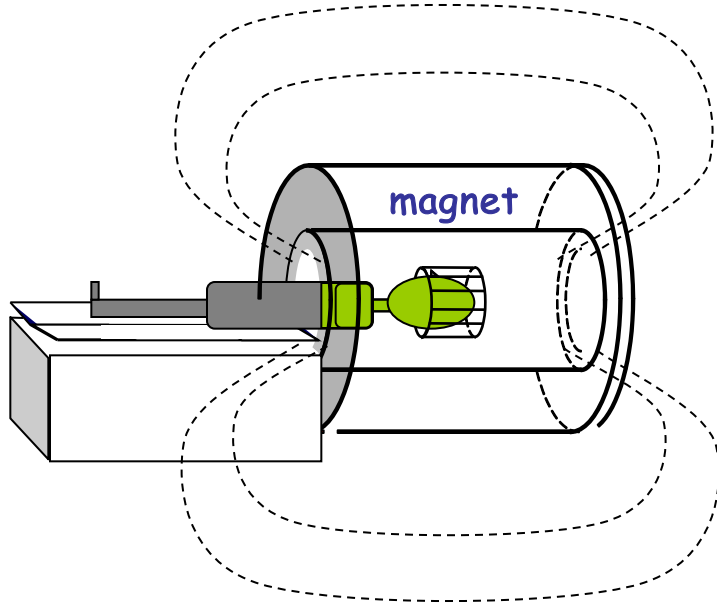


Magnet

Gradient
Coil

Radio-
Frequency
Coil

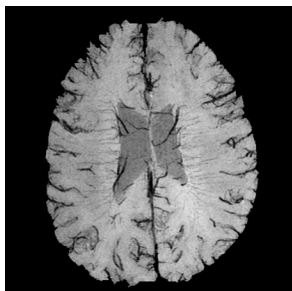
Magnetic Resonance Imaging (MRI)



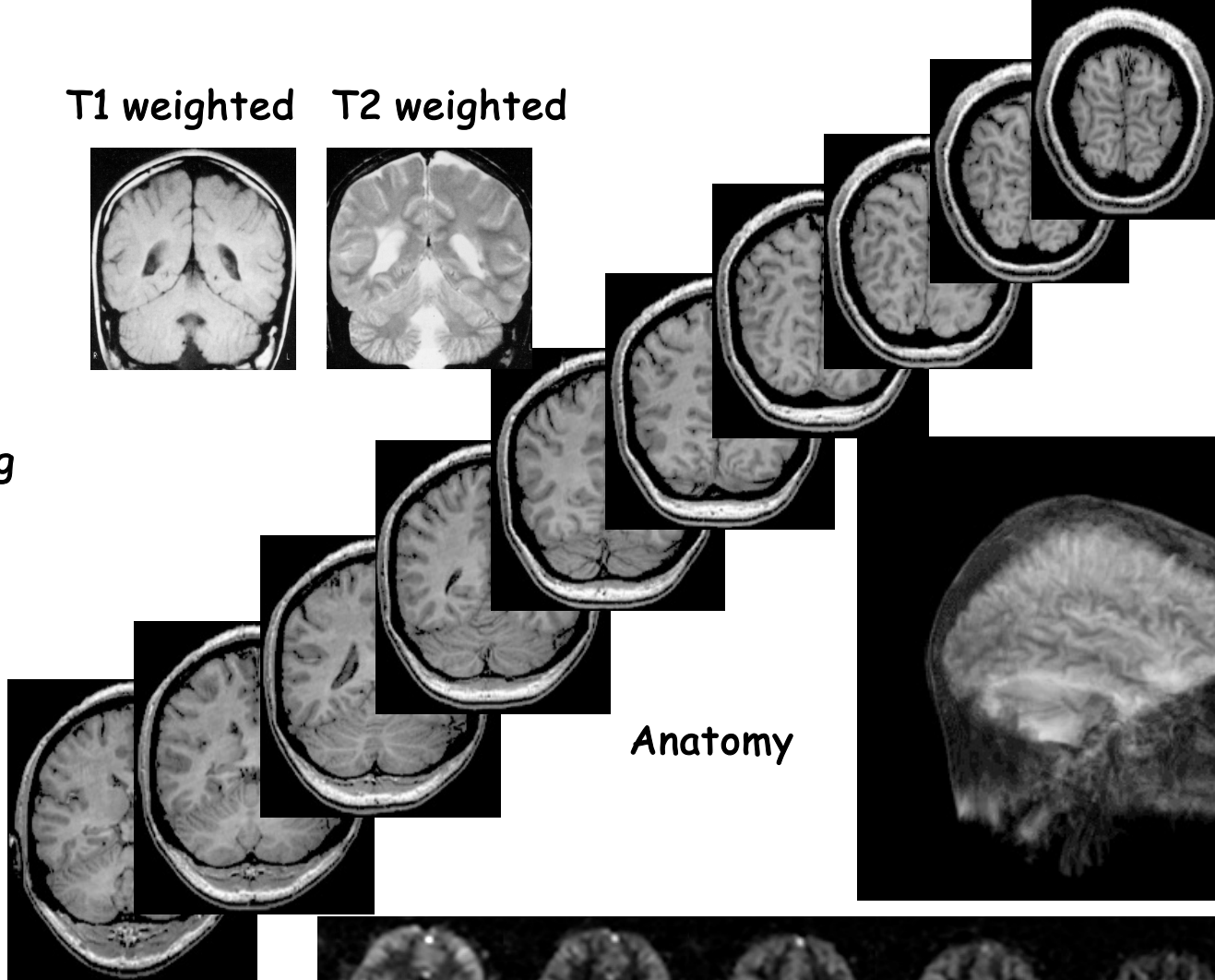
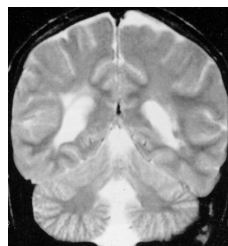
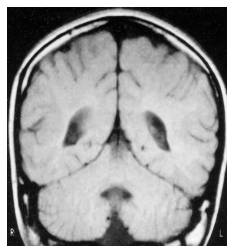
Sensitive to:

- # of protons (H_2O)
- Magnetic environment
 - Tissue structure

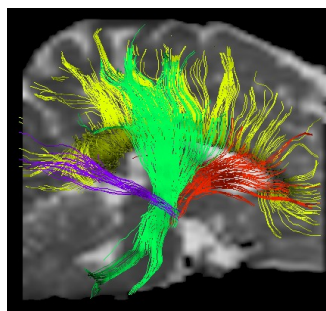
Venography



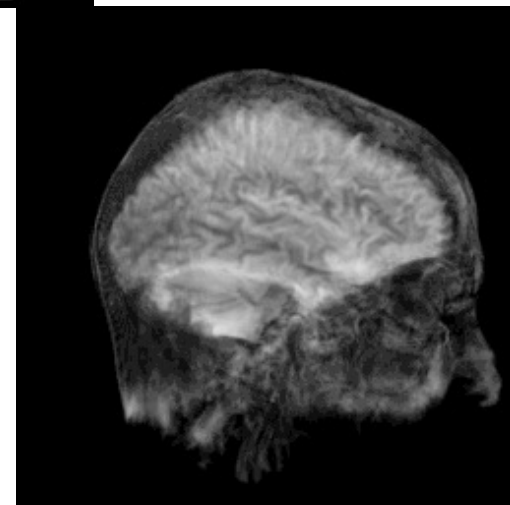
T1 weighted T2 weighted



Fiber Track Imaging



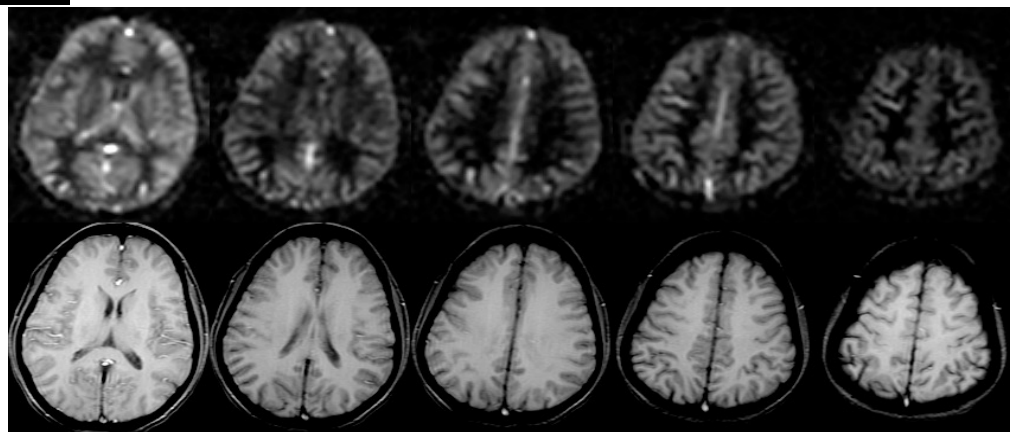
Anatomy



Angiography

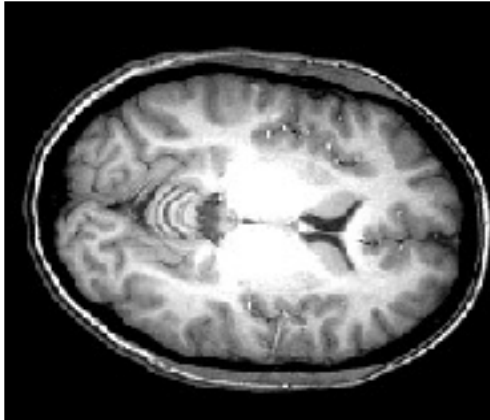


Perfusion



MRI vs. fMRI

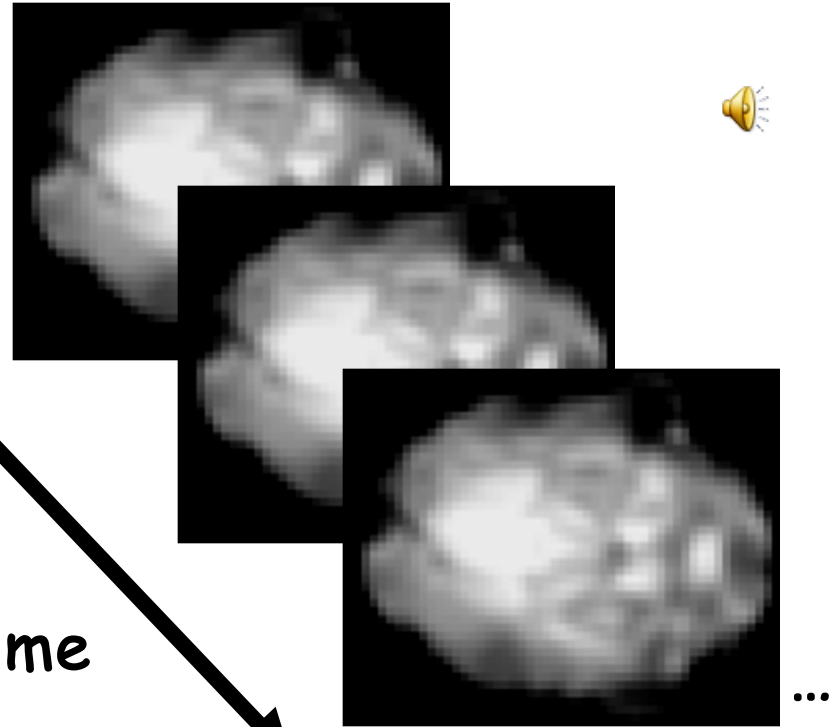
MRI



one image

high resolution
(1 mm or less)

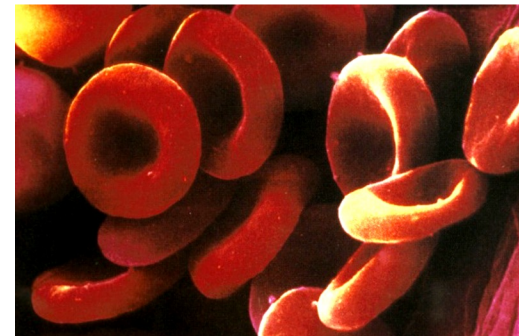
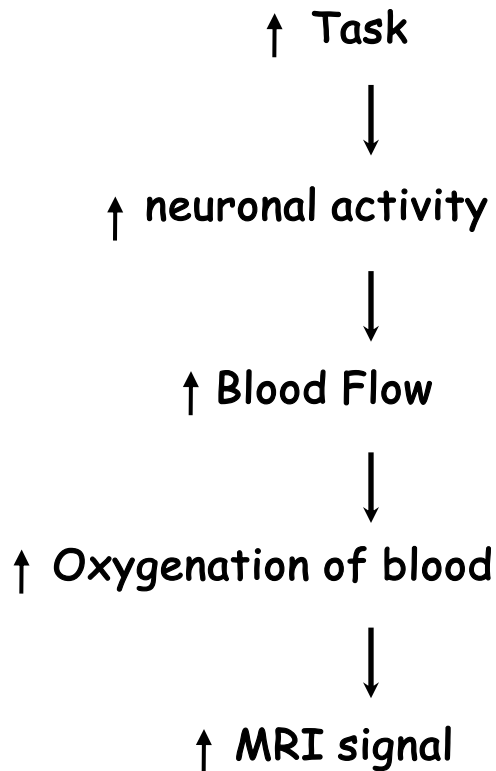
fMRI



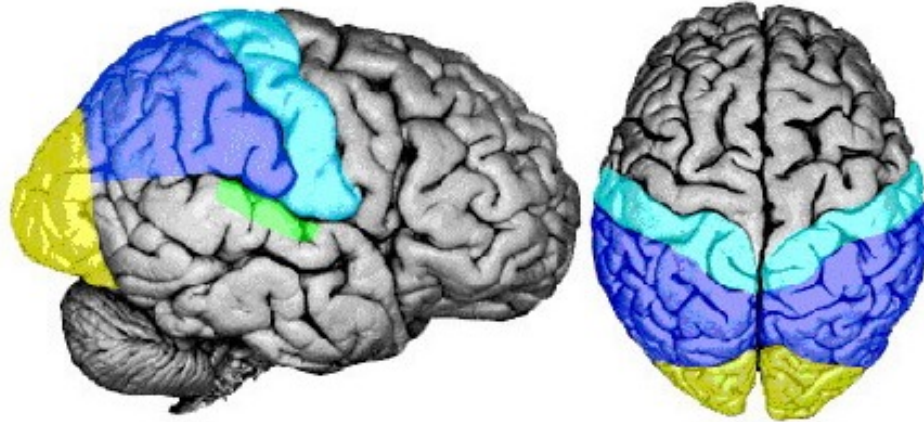
many images
(e.g., every 2 sec for 5
mins)

low resolution
(1.5 to 4 mm)

Measuring Brain function with MRI

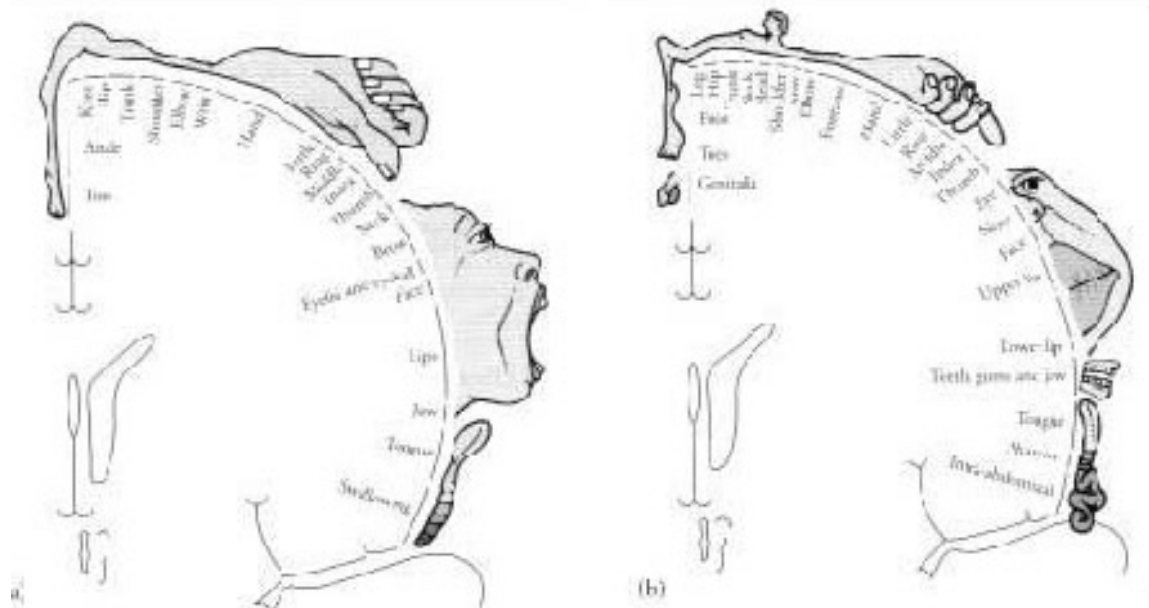


Red Blood Cells



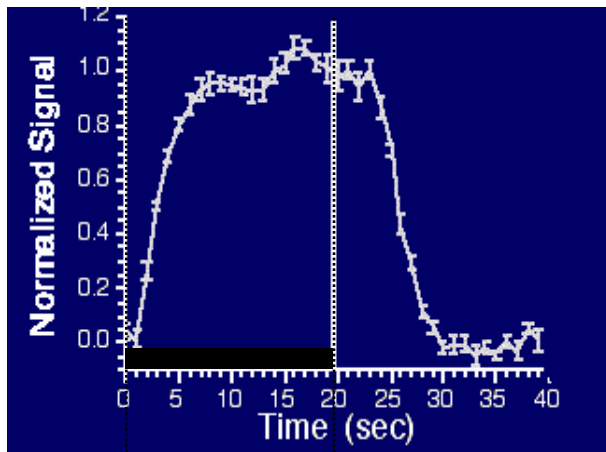
■ Parietal/
Somatosensory
■ Parietal/
Association Area

■ Occipital/Vision
■ Auditory

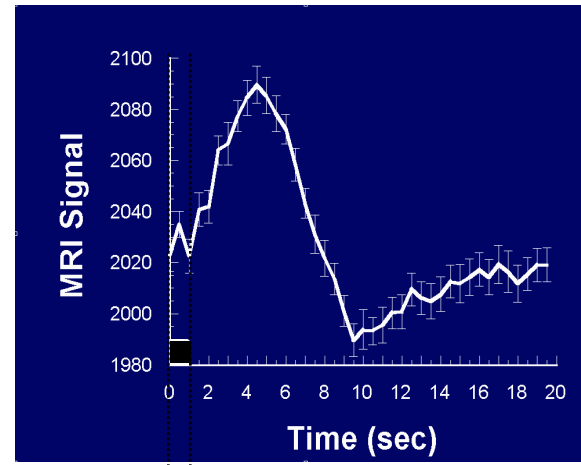




BOLD Contrast Imaging



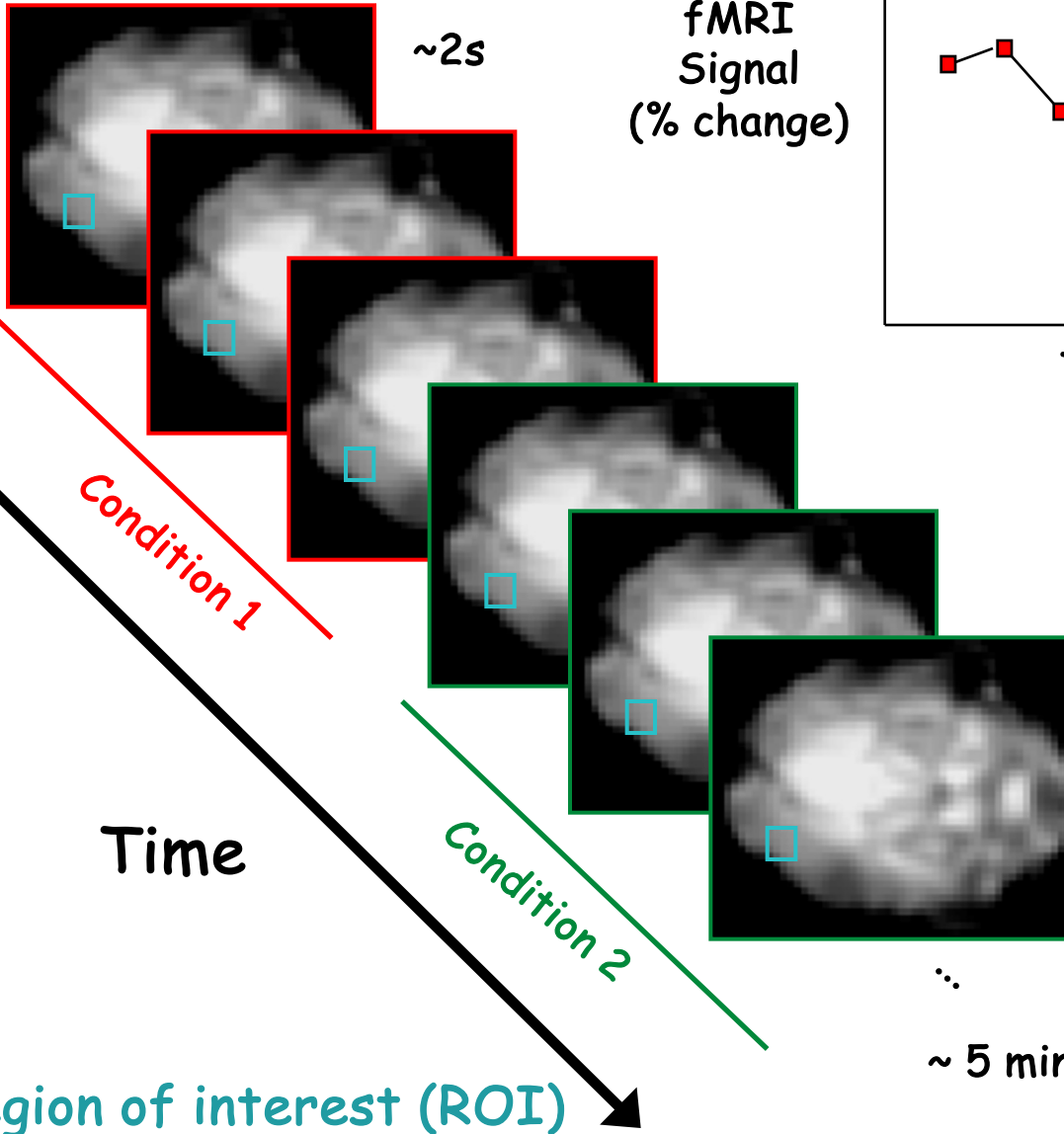
task



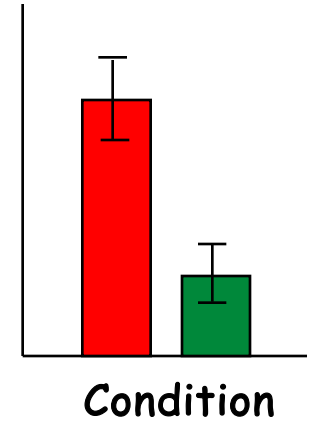
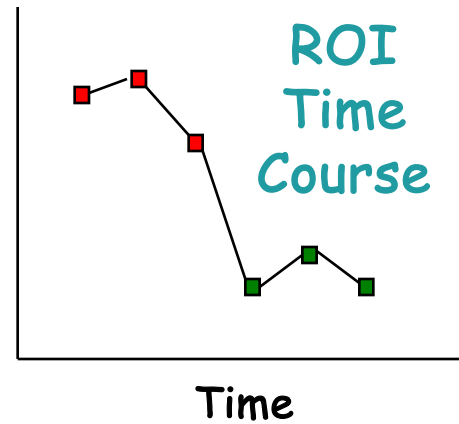
task

Activation Statistics

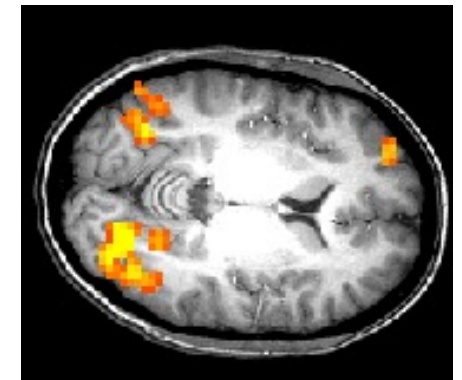
Functional images



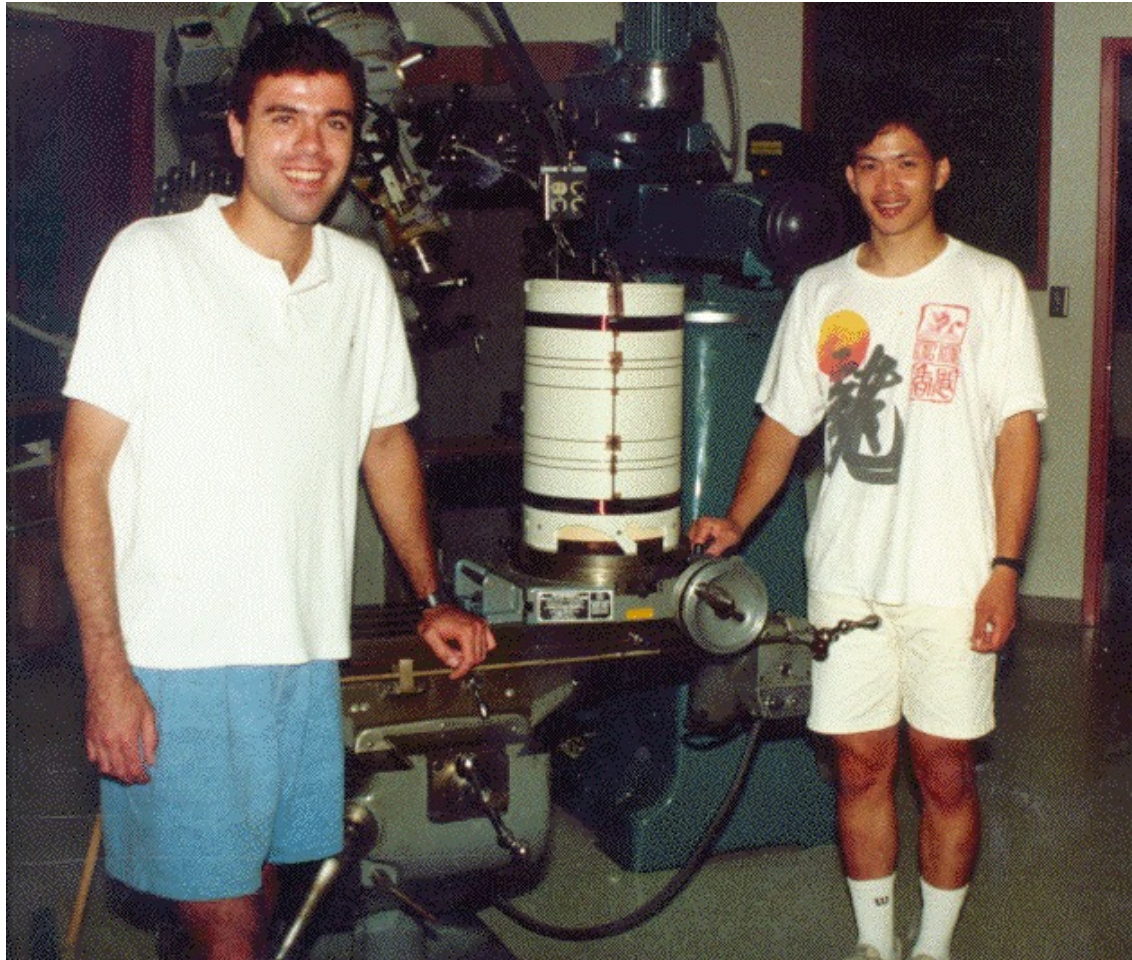
fMRI
Signal
(% change)



Statistical Map
superimposed on
anatomical MRI image





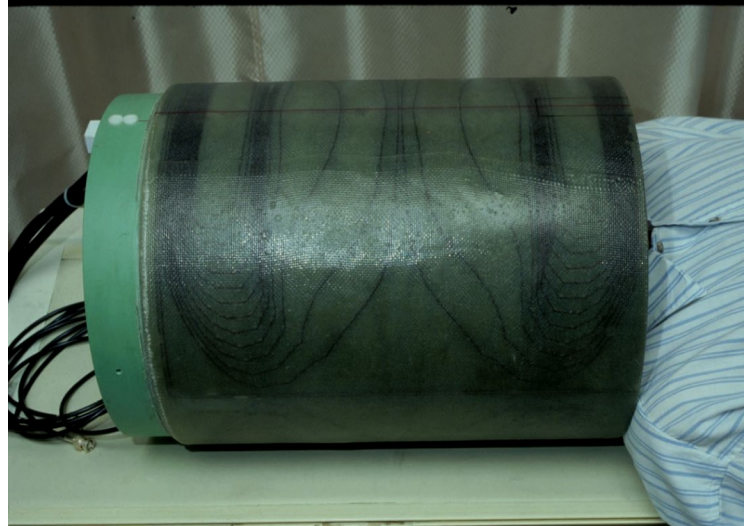


August, 1991

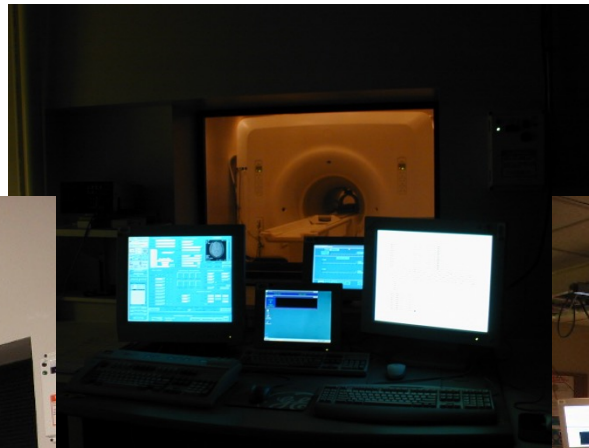
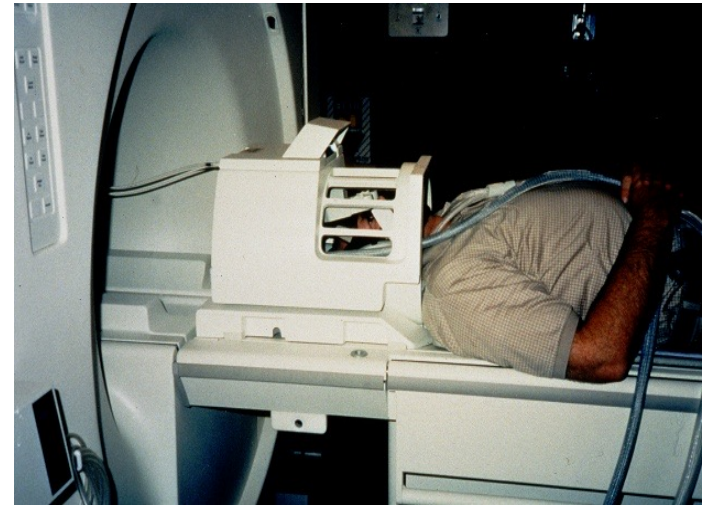
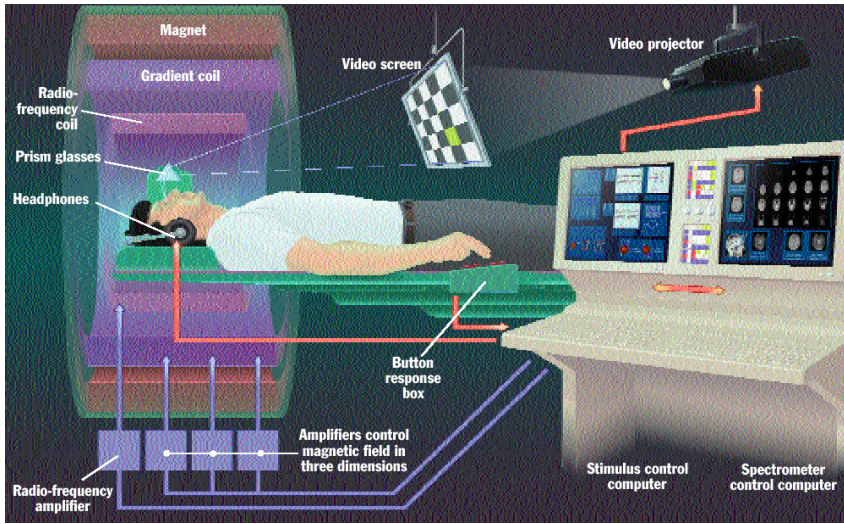
1991-1992



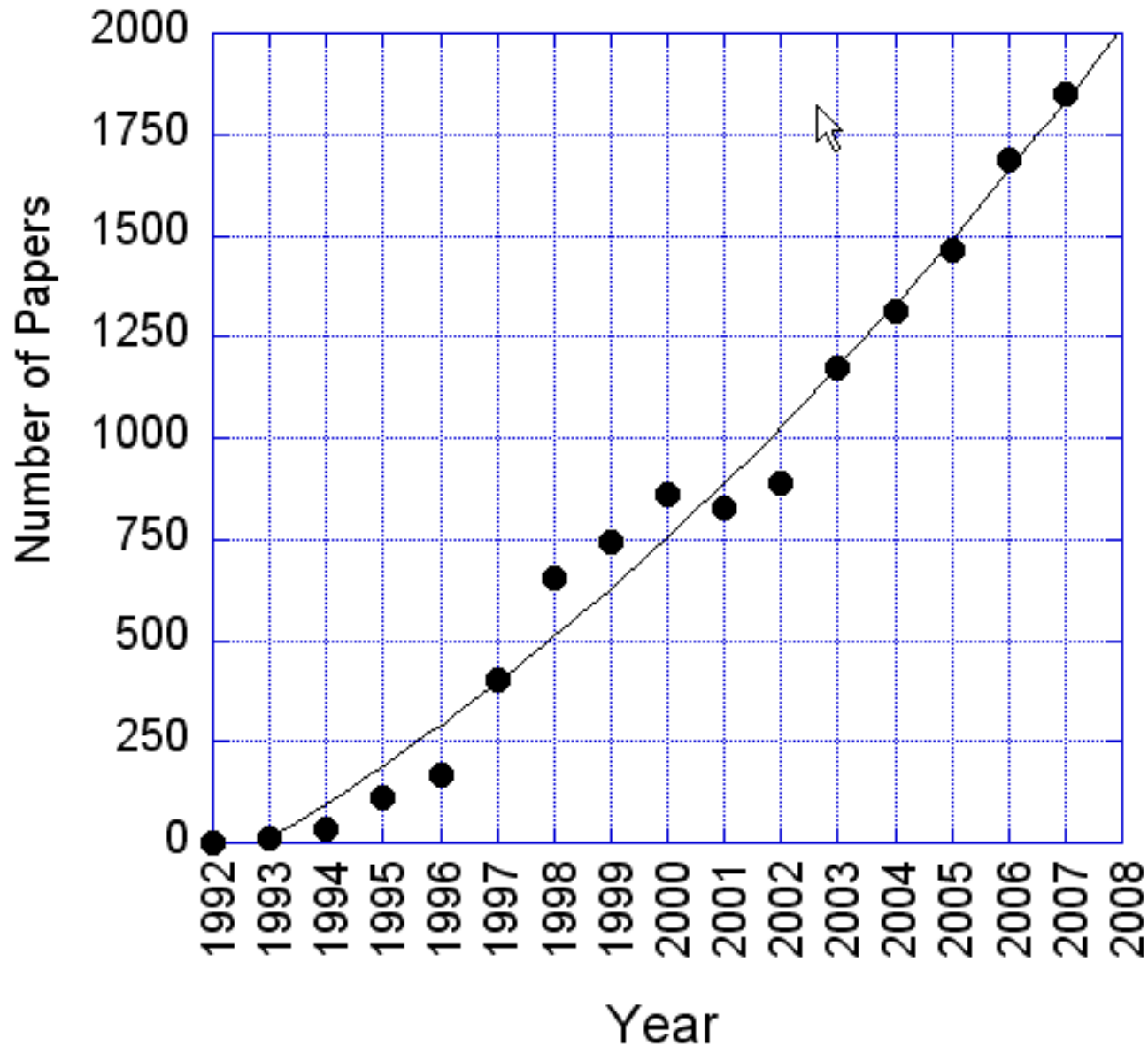
1992-1999



fMRI Setup

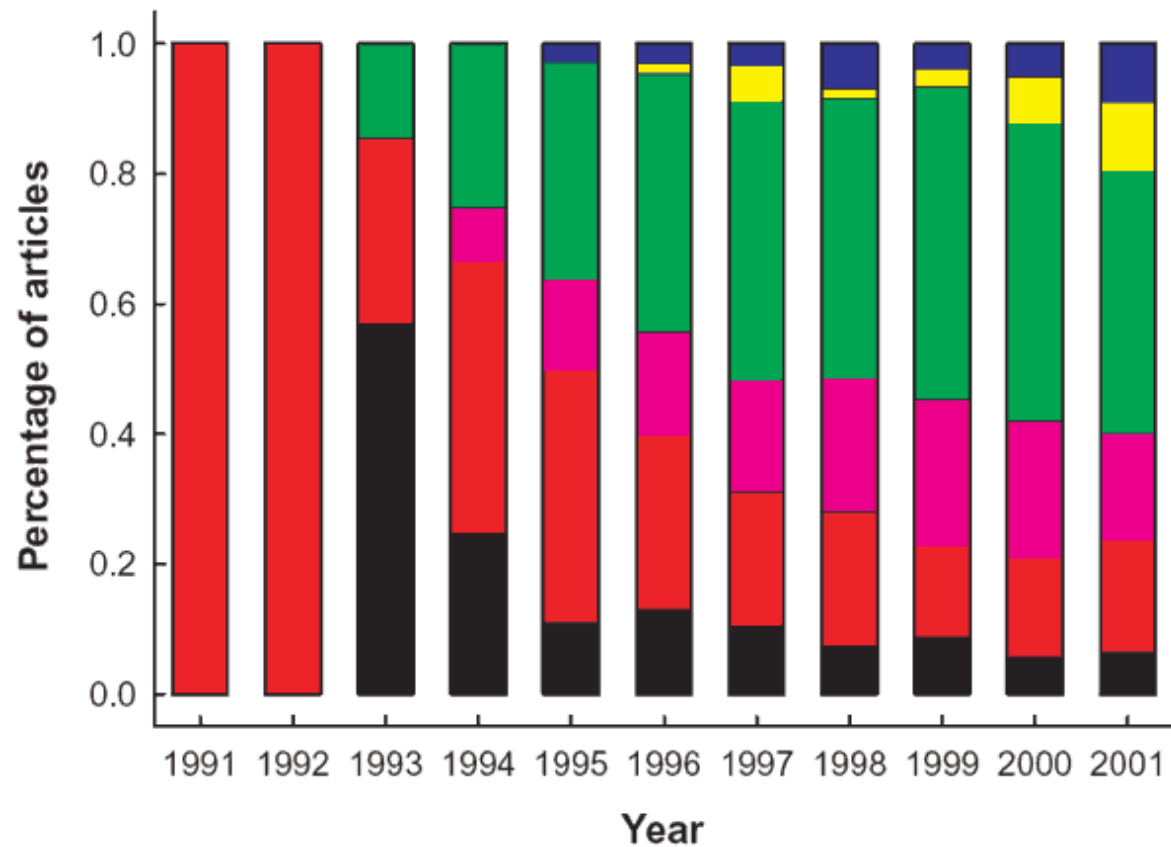


Scopus: **Articles** or **Reviews** Published per Year
"fMRI" or "functional MRI"



Type of fMRI research performed

Motor
Primary Sensory
Integrative Sensory
Basic Cognition
High-Order Cognition
Emotion



J. Illes, M. P. Kirschen, J. D. E. Gabrielli,
Nature Neuroscience, 6 (3) p.205, 2001

Log Size (mm)

Brain

Map

Column

Layer

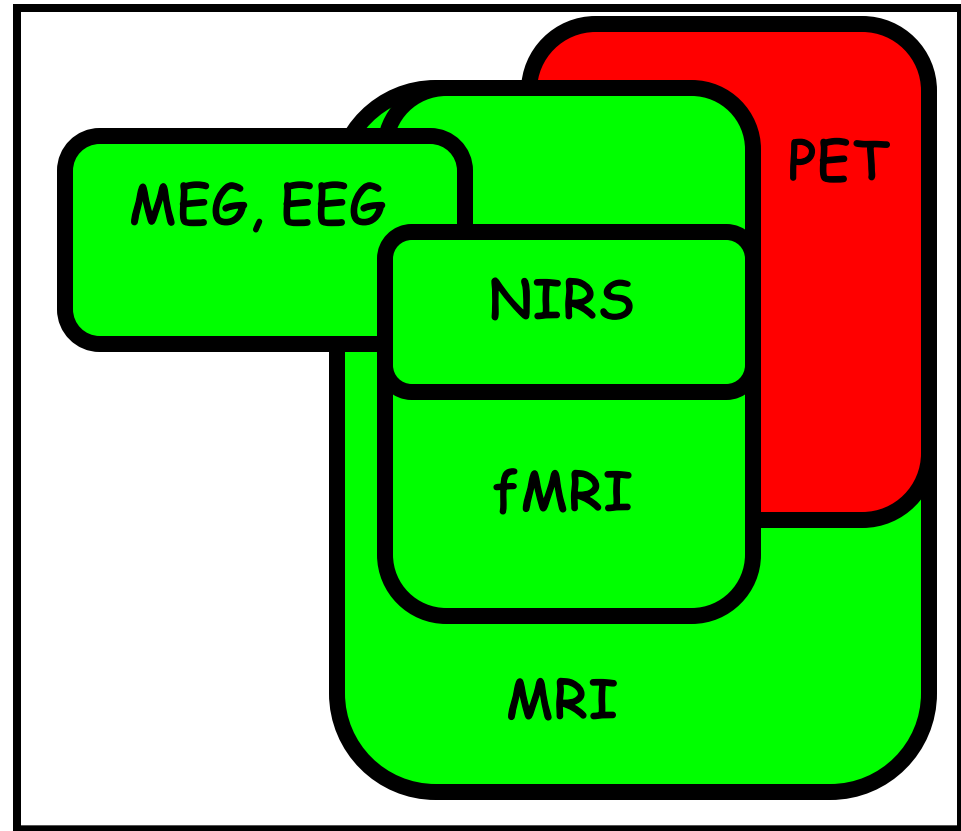
3

2

1

0

-1



MEG, EEG

NIRS

fMRI

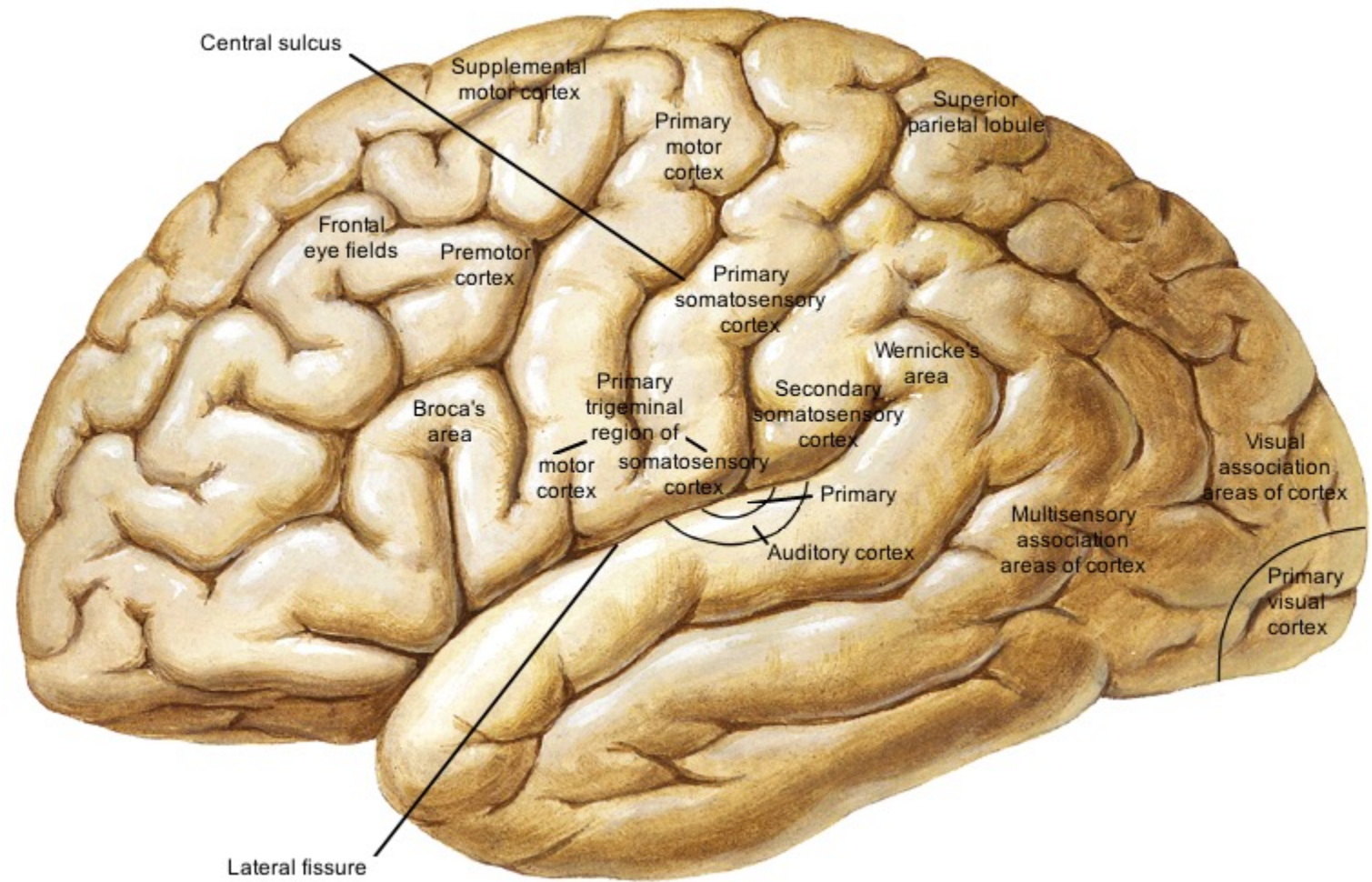
MRI

PET

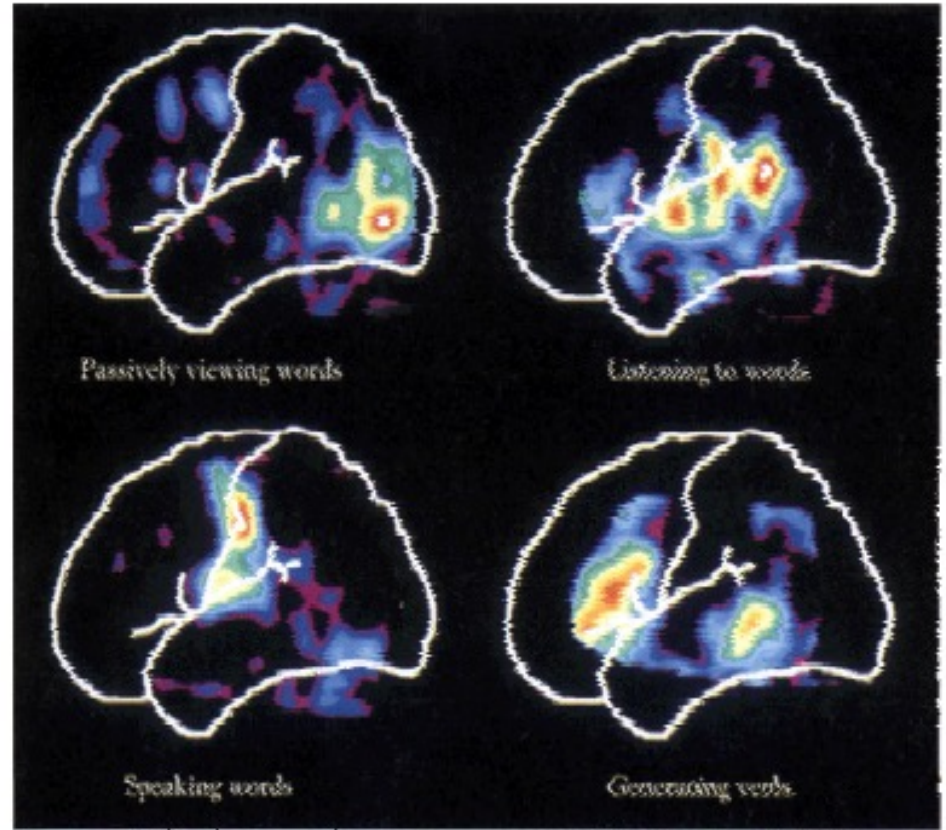
-3 -2 -1 0 1 2 3 4 5 6 7

Millisecond Second Minute Hour Day

Log Time (sec)



Positron Emission Tomography (PET)



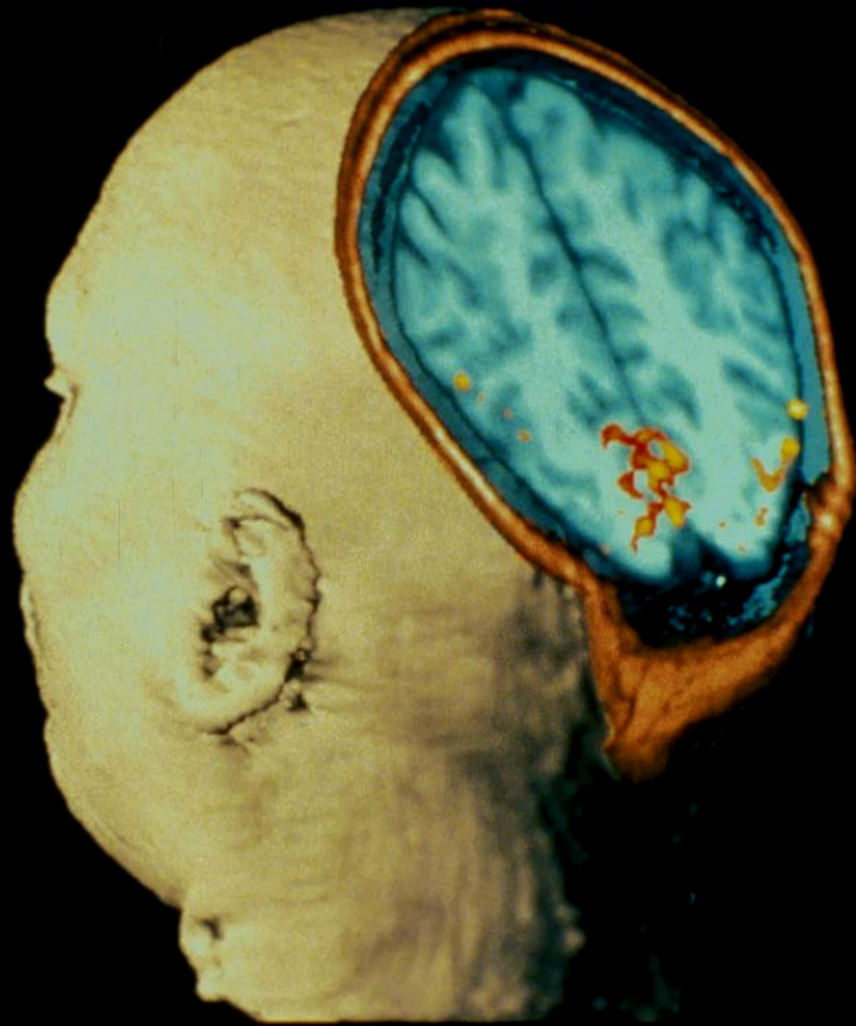
The first fMRI paper

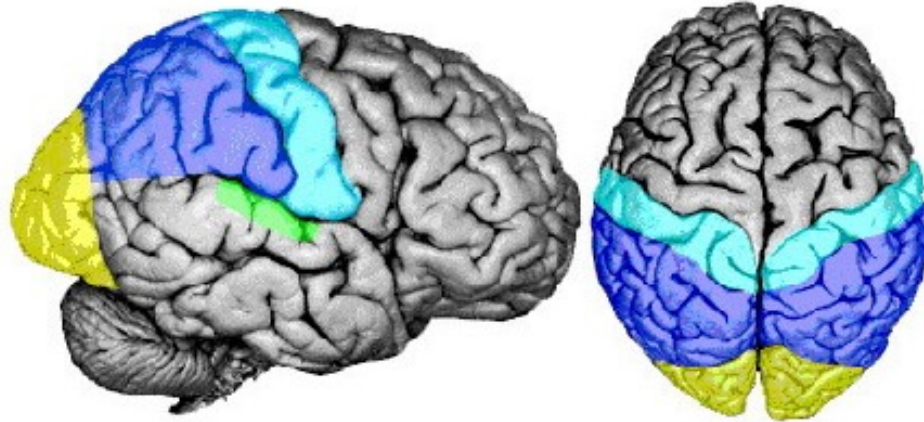
Photic Stimulation

MRI Image showing
activation of the
Visual Cortex

From Belliveau, et al.
Science Nov 1991

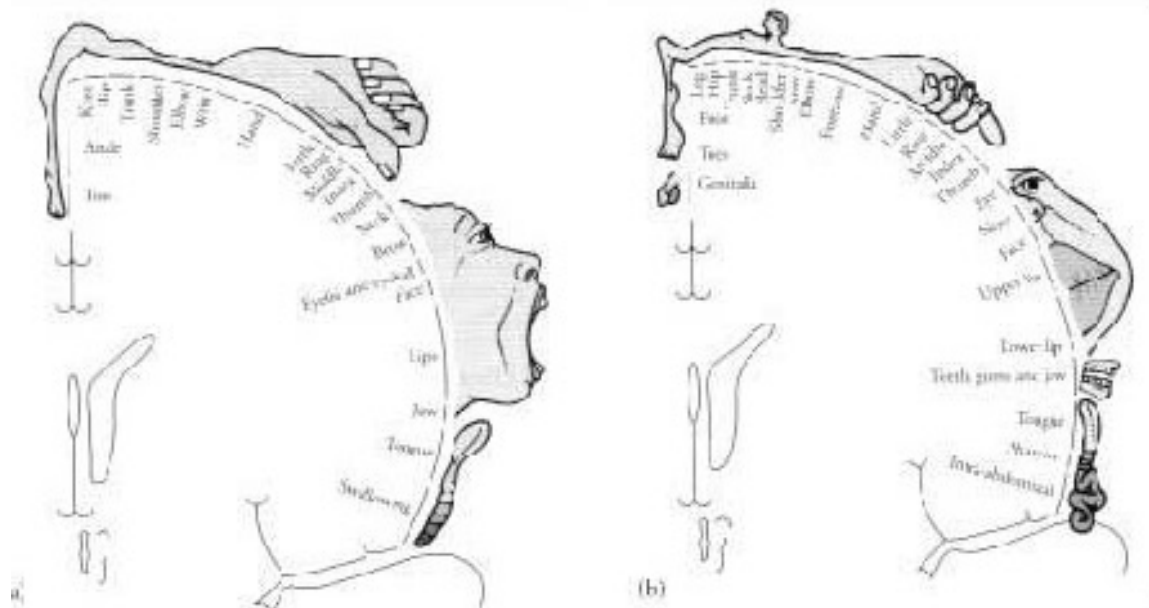
MSC - perfusion



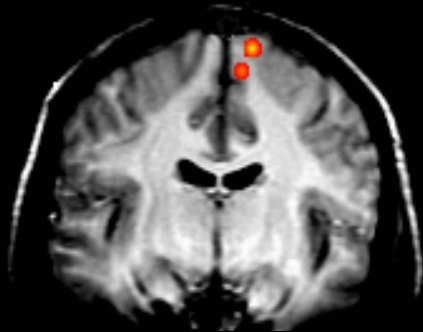
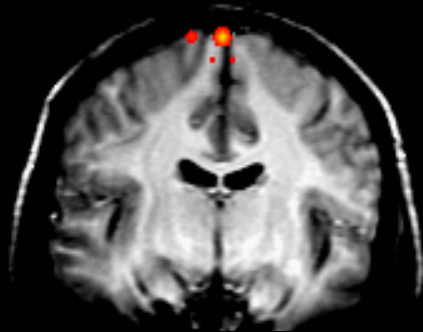


■ Parietal/
Somatosensory
■ Parietal/
Association Area

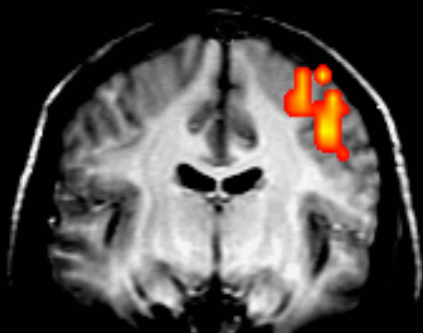
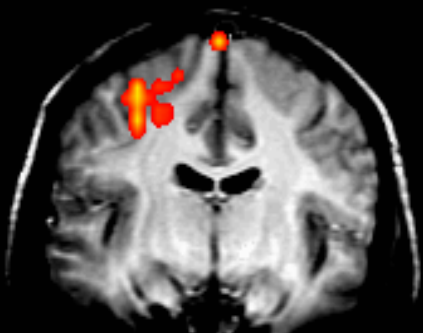
■ Occipital/Vision
■ Auditory



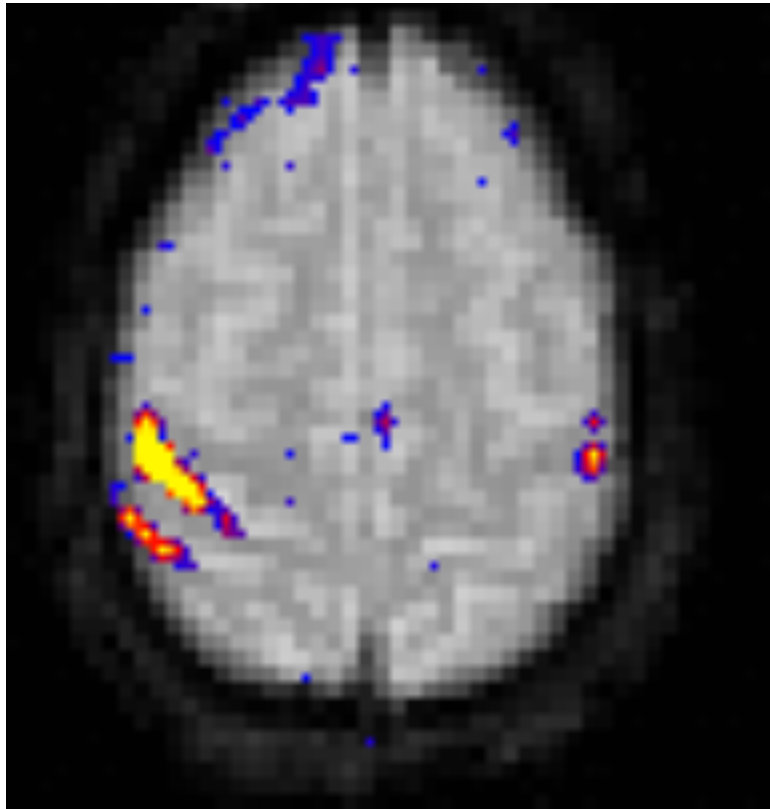
Toe movement



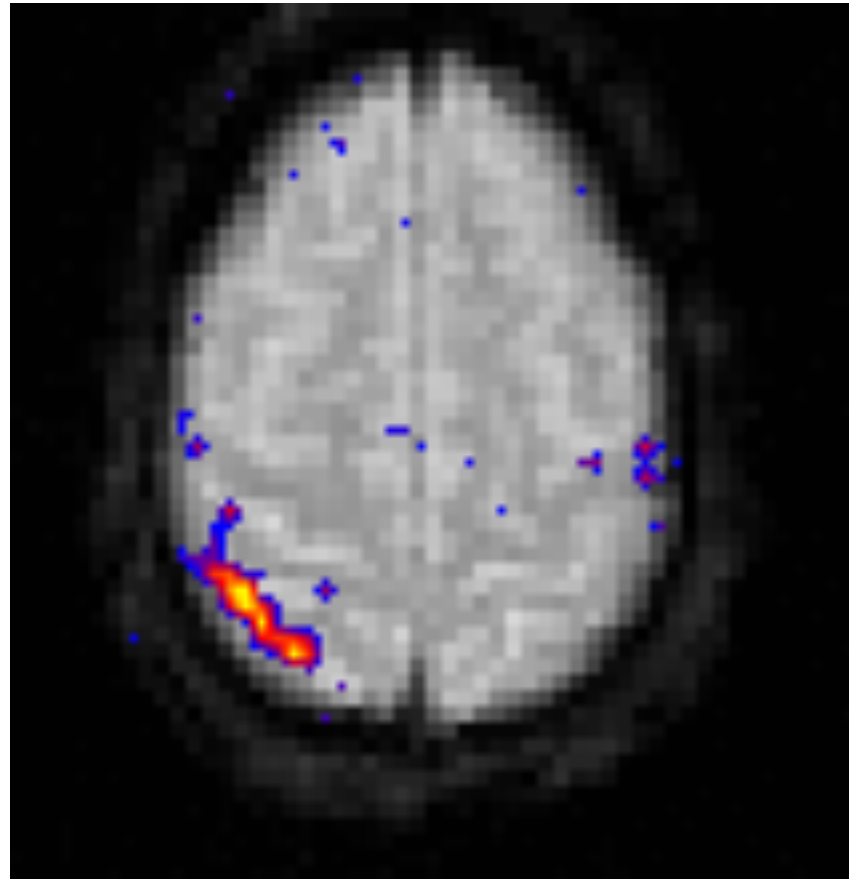
Finger movement



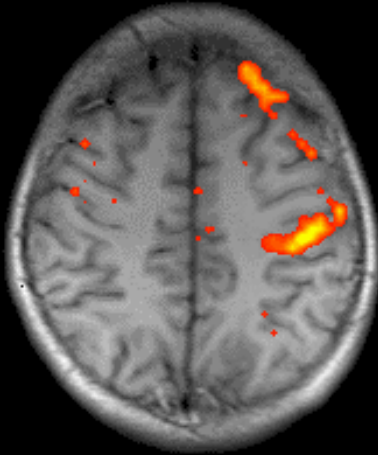
Finger Movement



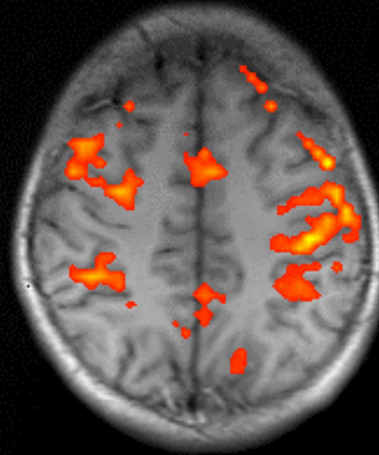
Tactile Stimulation



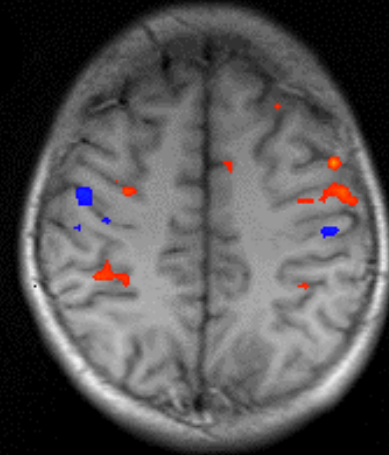
Simple Right



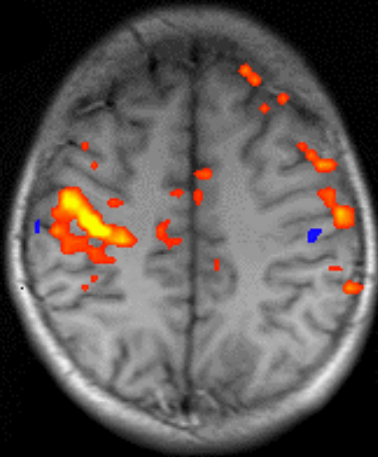
Complex Right



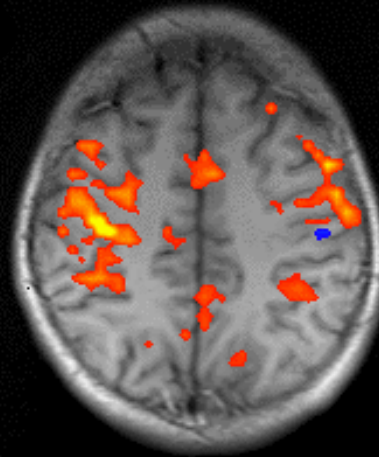
Complex Right



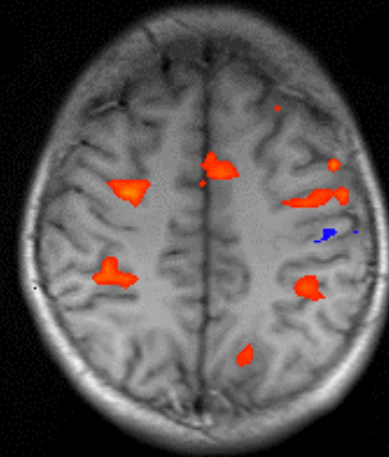
Simple Left



Complex Left

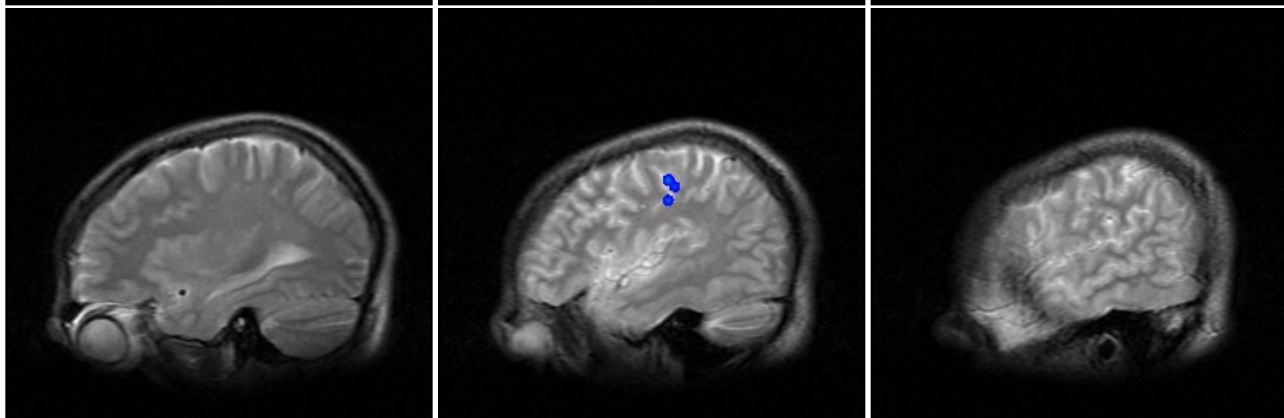
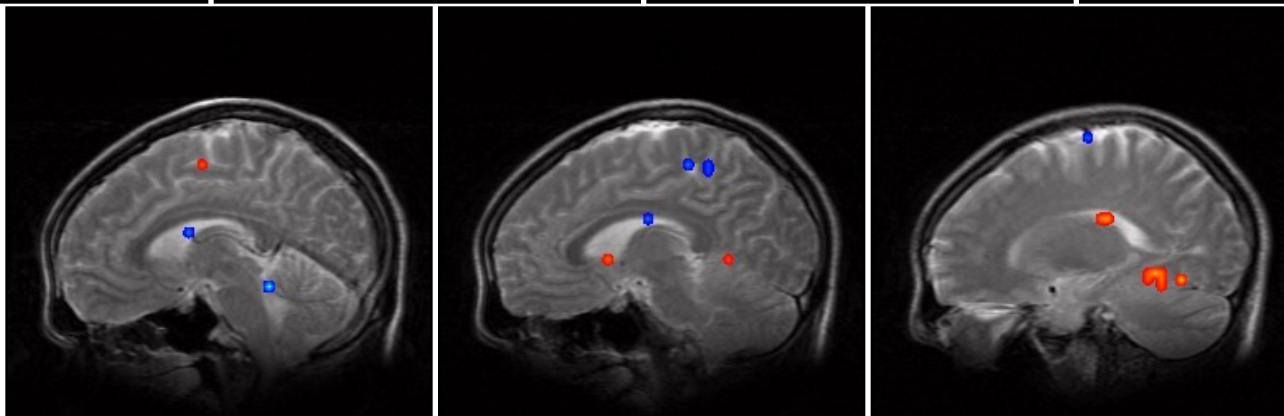
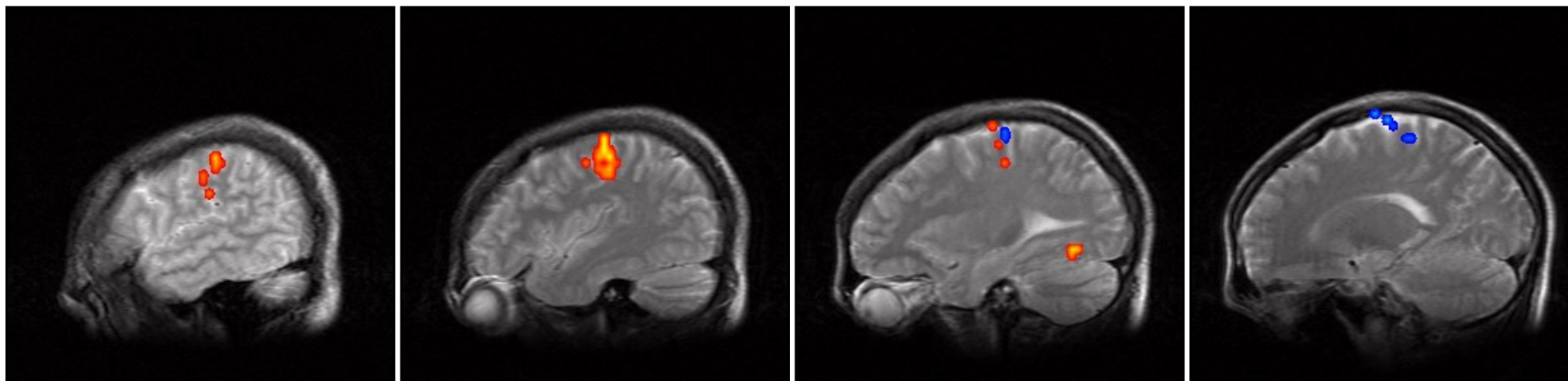


Imagined
Complex Left



Left

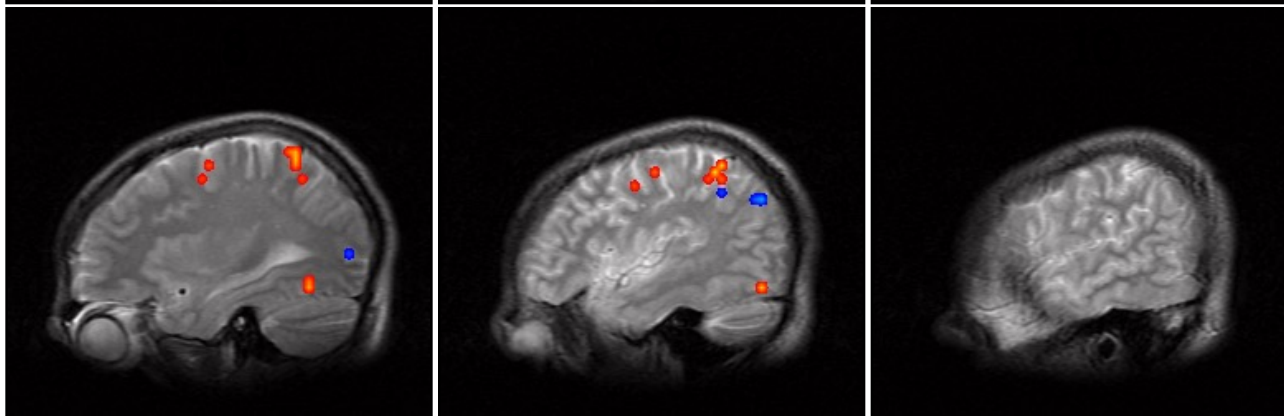
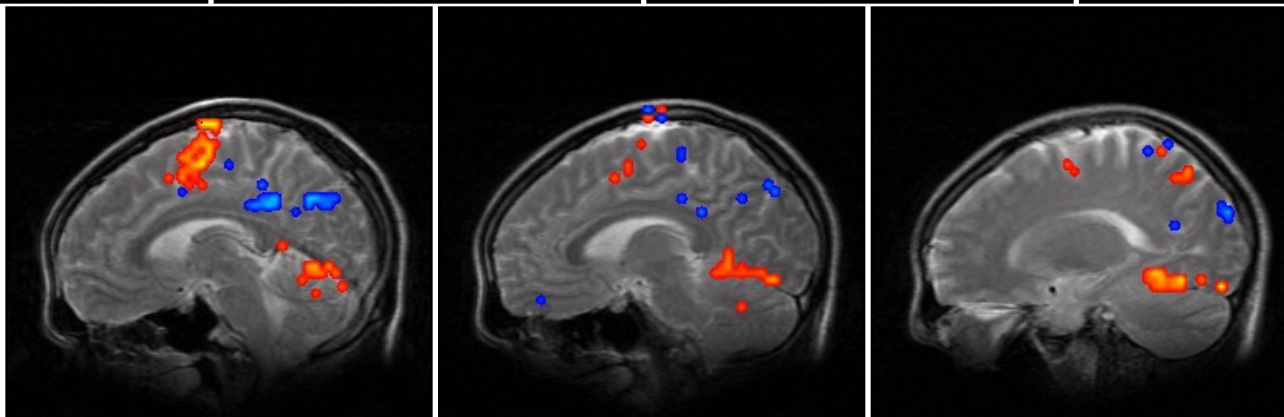
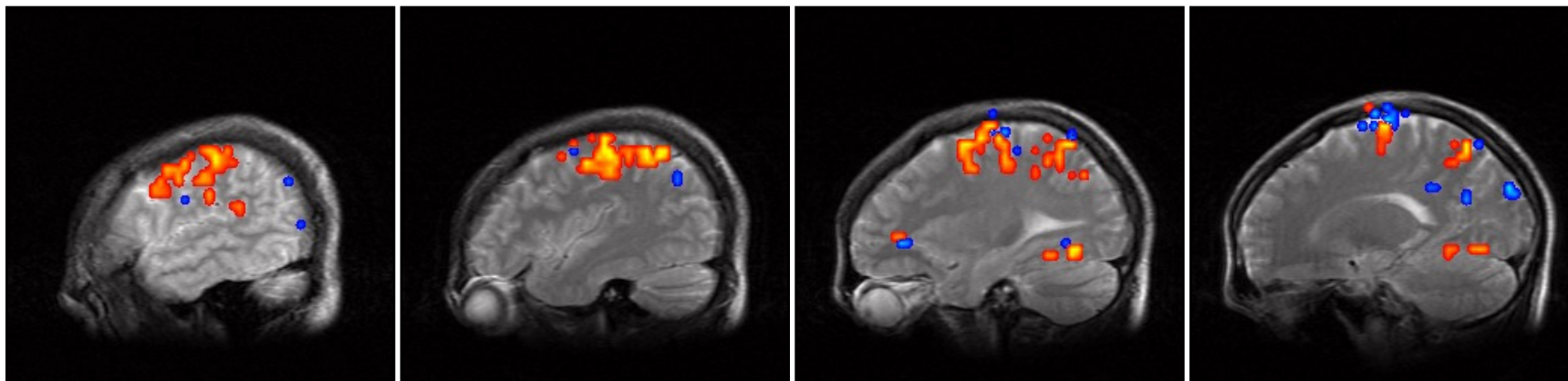
Simple Finger Movement on the Right Hand



Right

Left

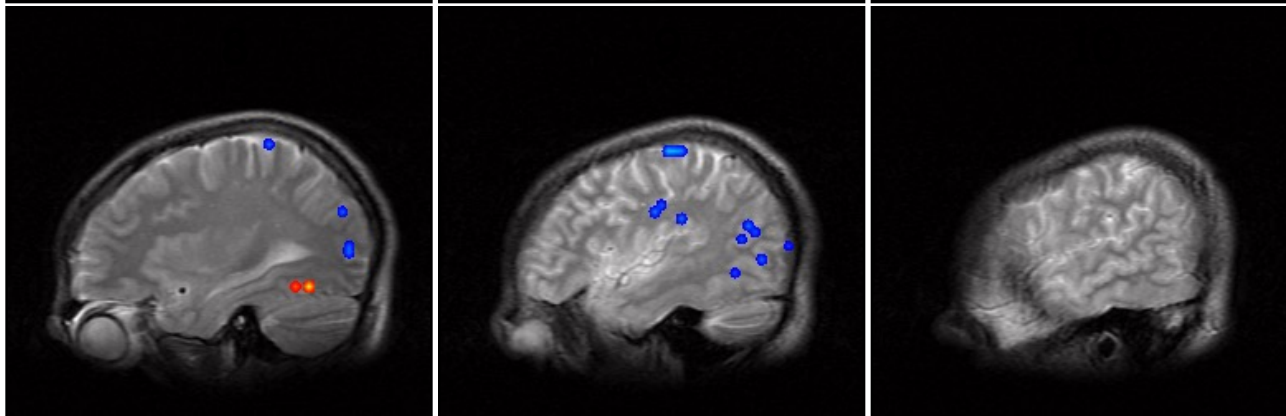
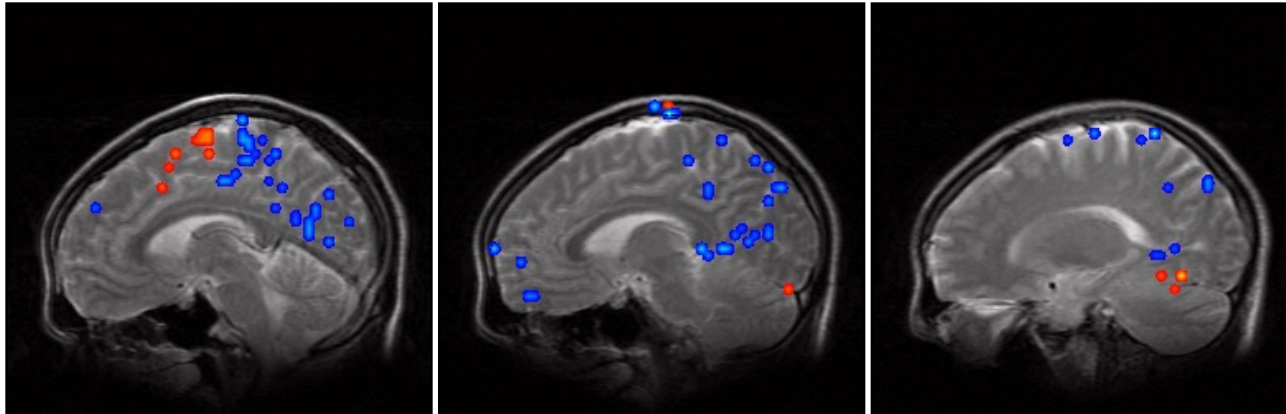
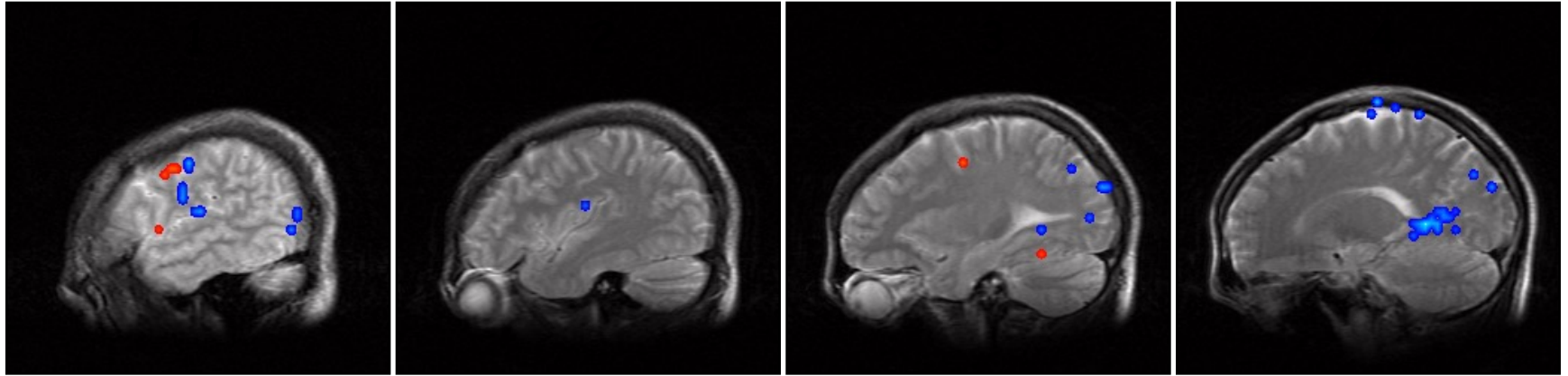
Complex Finger Movement on the Right Hand



Right

Left

Imagined Complex Finger Movement on the Right Hand



Right

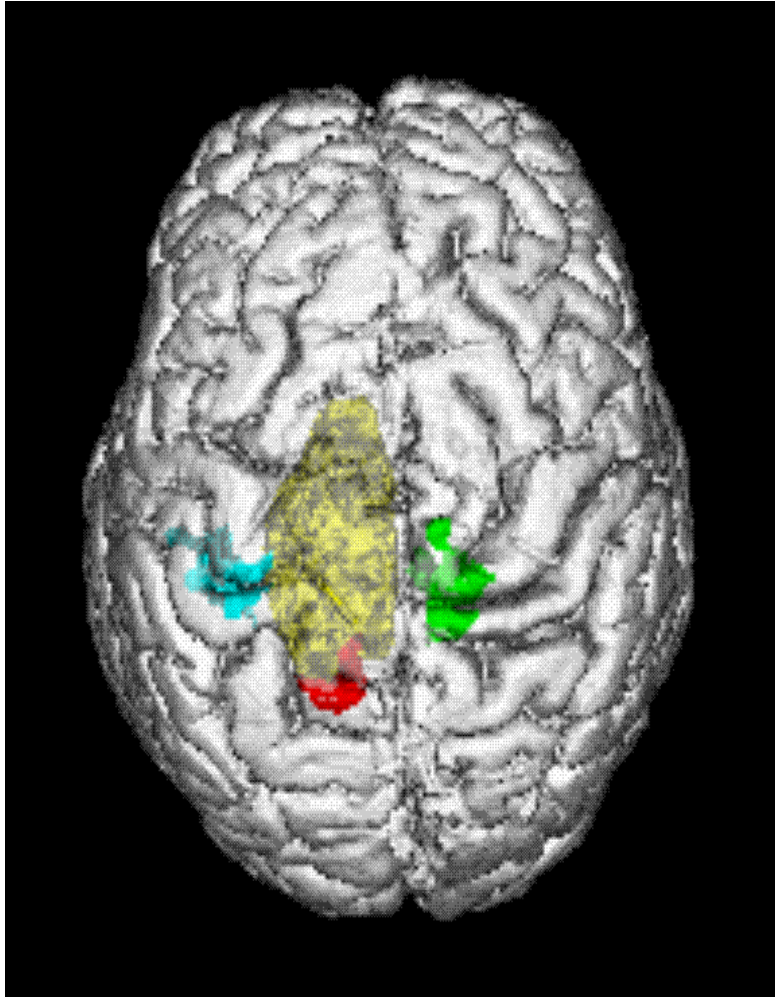
Presurgical Mapping

Left Foot

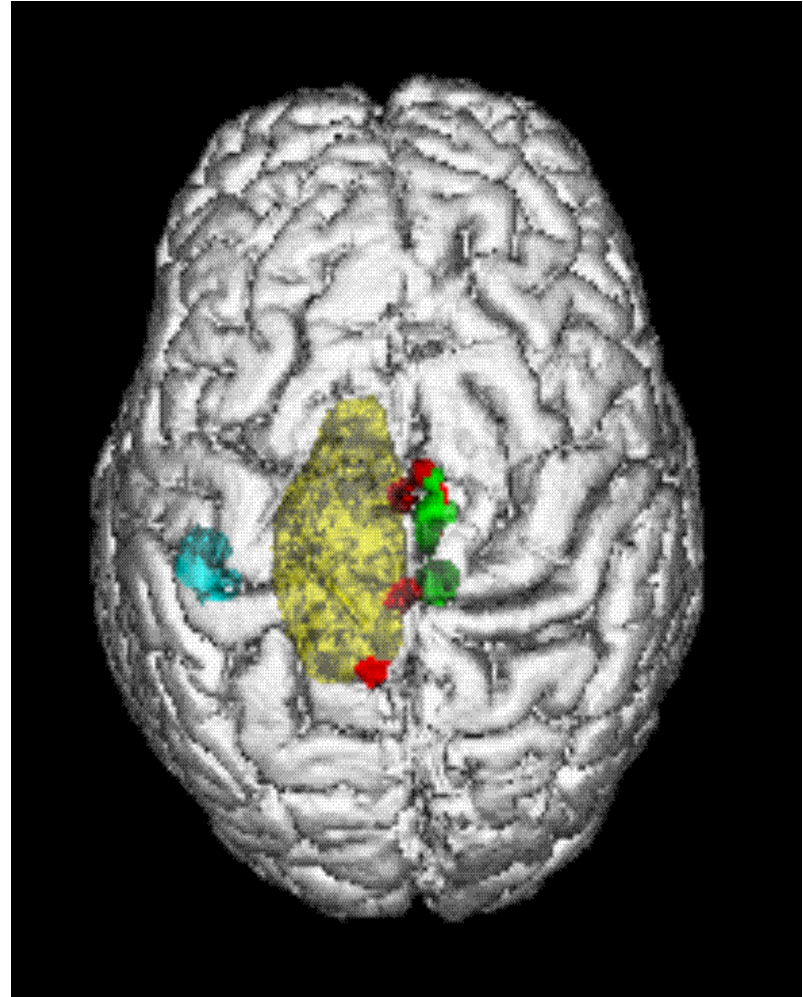
Tumor

Right Foot

Right Hand

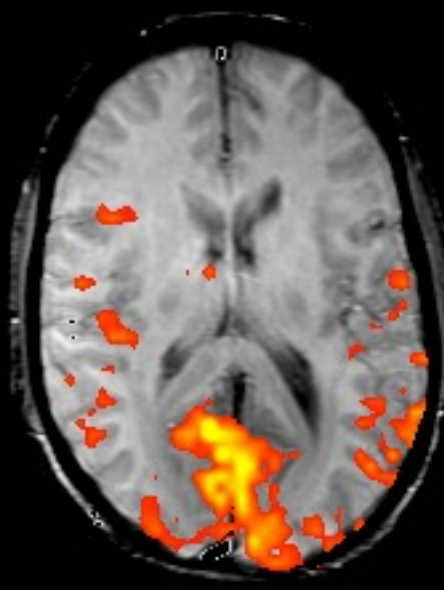
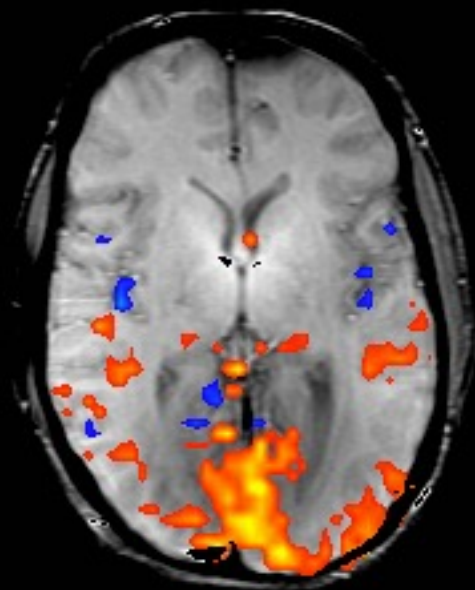


fMRI

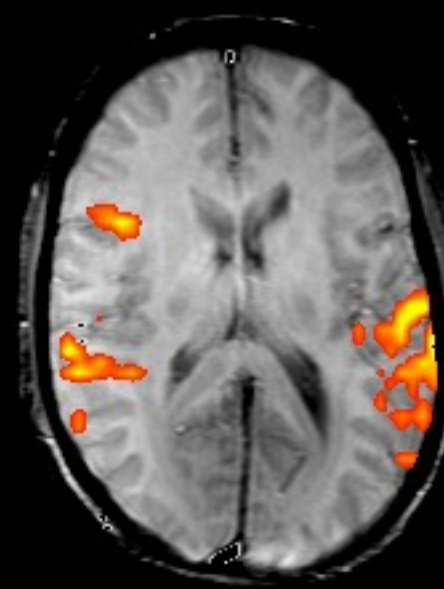
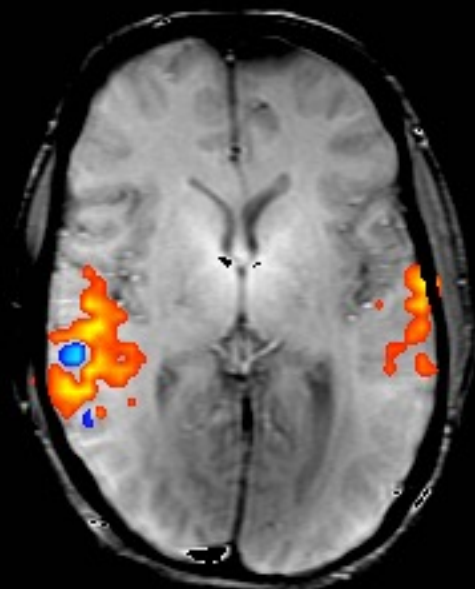


O-15 PET

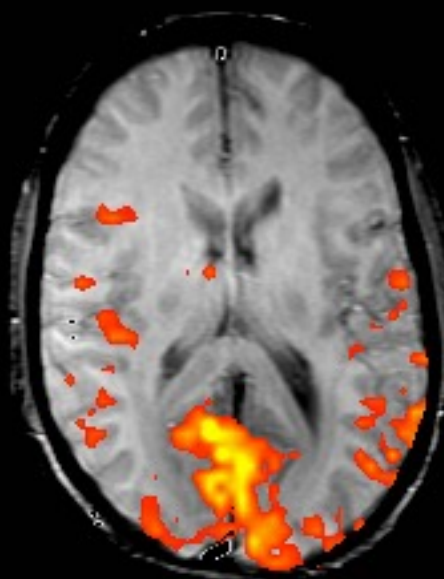
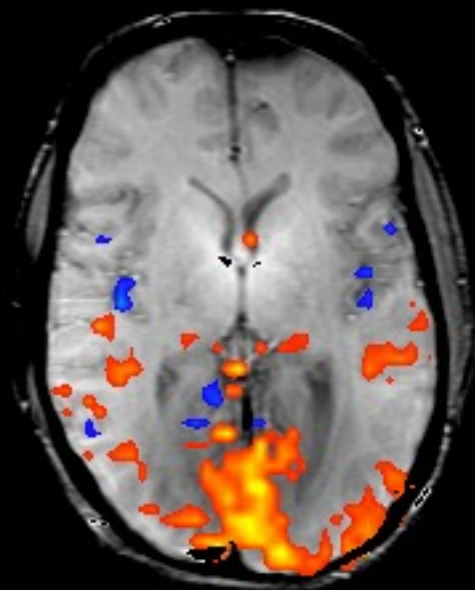
Reading



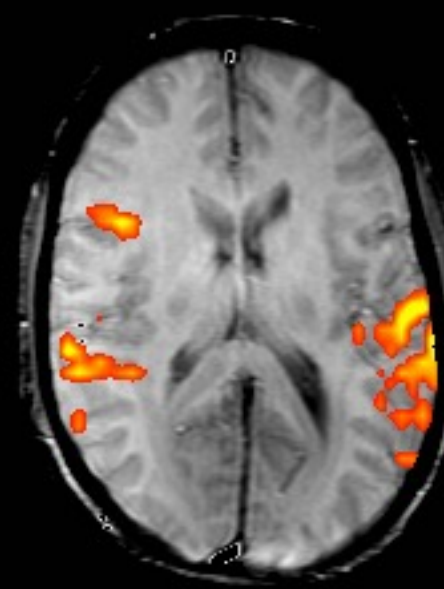
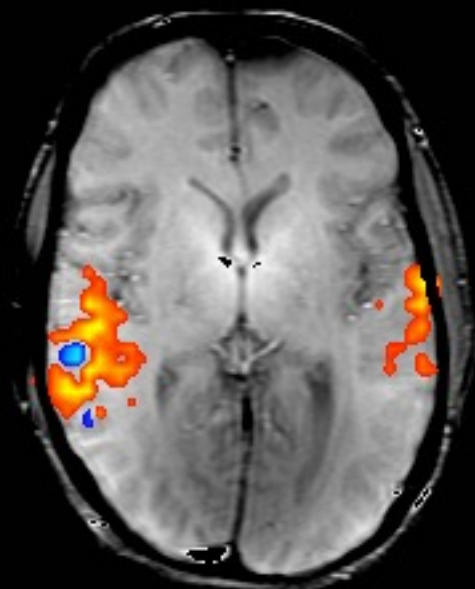
Listening

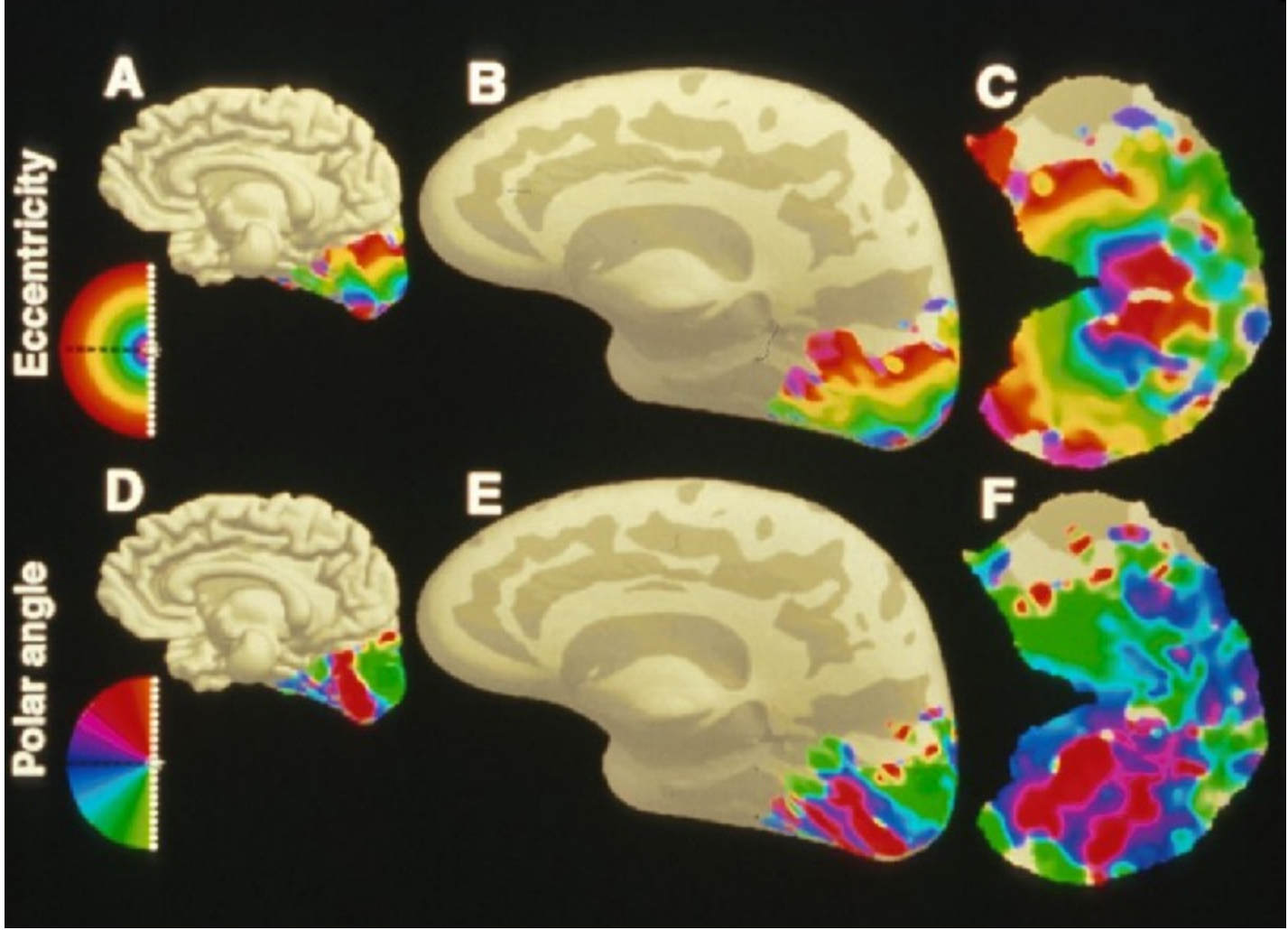


Reading

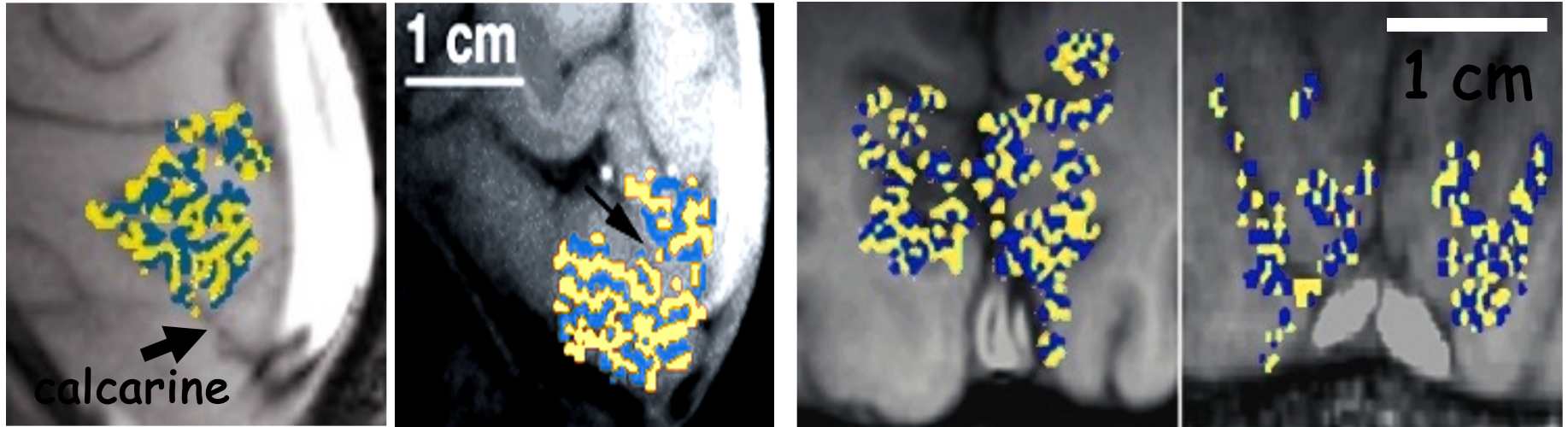


Listening





ODC Maps using fMRI



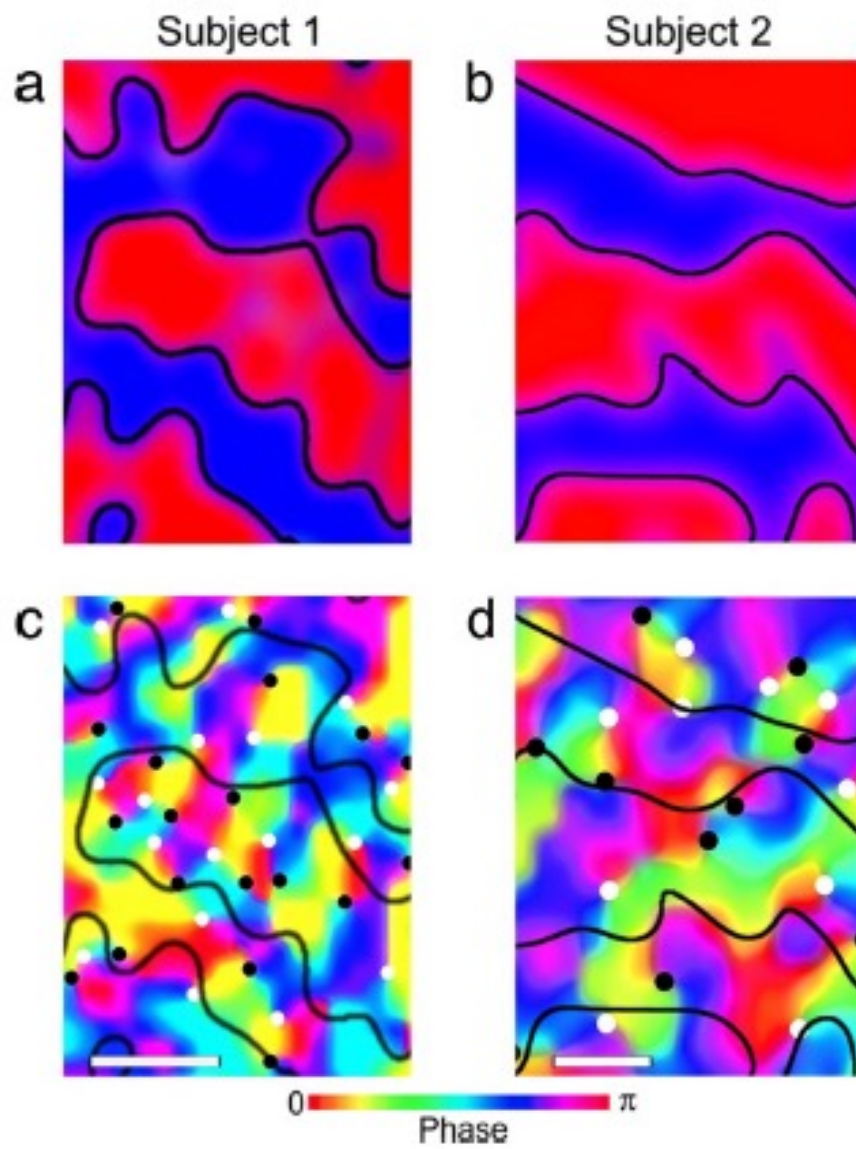
• Identical in size, orientation, and appearance to those obtained by optical imaging¹ and histology^{3,4}.

Menon et al.

¹Malonek D, Grinvald A. *Science* 272, 551-4 (1996).

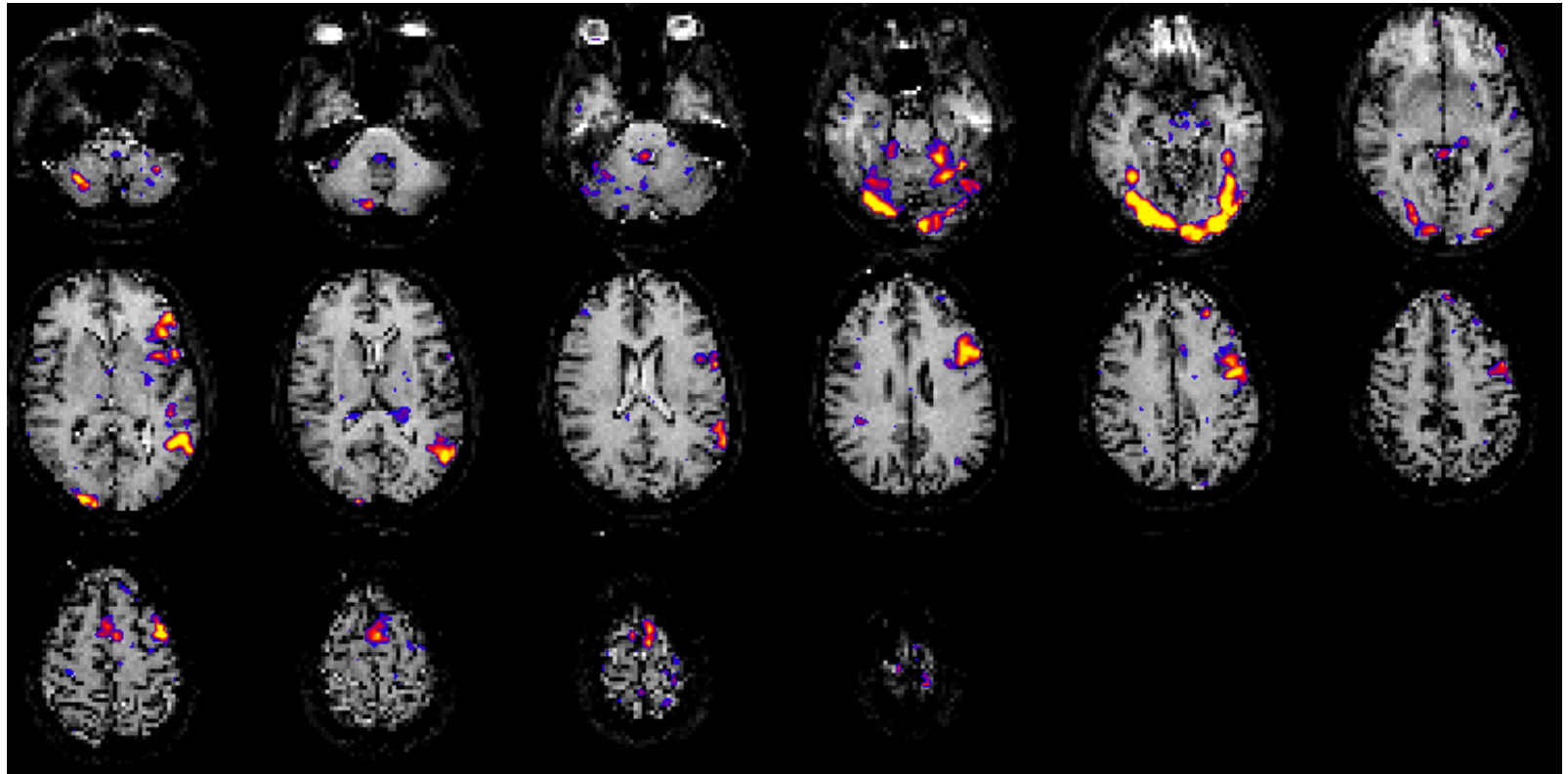
³Horton JC, Hocking DR. *J Neurosci* 16, 7228-39 (1996).

⁴Horton JC, et al. *Arch Ophthalmol* 108, 1025-31 (1990).



Yacoub et al. PNAS 2008

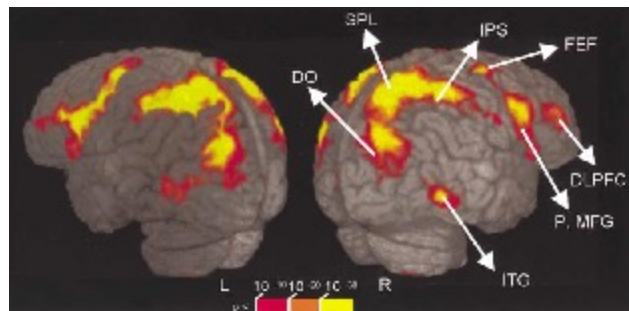
Word stem completion



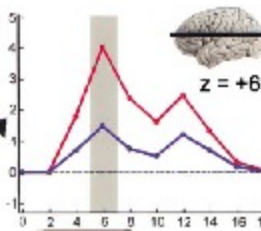


Neural Correlates of Visual Working Memory: fMRI Amplitude Predicts Task Performance

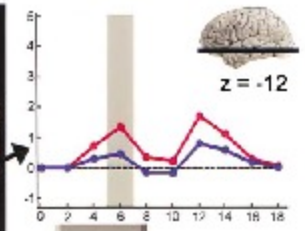
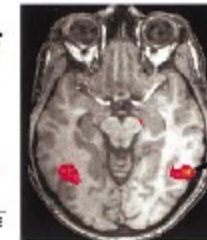
Luiz Pessoa,¹ Eva Gutierrez, Peter A. Bandettini,
and Leslie G. Ungerleider
Laboratory of Brain and Cognition
National Institute of Mental Health
National Institutes of Health
Bethesda, Maryland 20892



A. Encoding

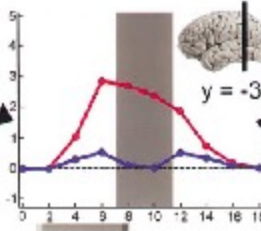


Right Dorsal Occipital

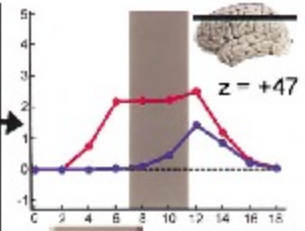
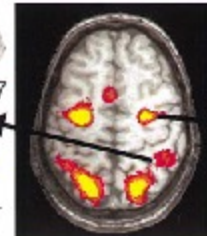


Right Ventral Temporal

B. Delay

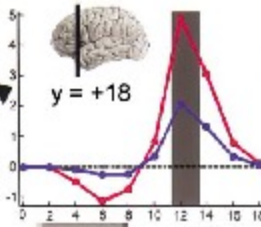


Right IPS

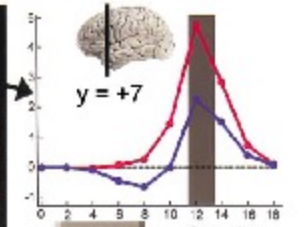
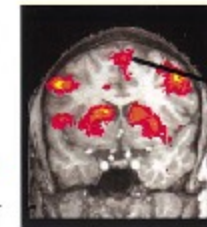


Right FEF

C. Test



Right Anterior Insula

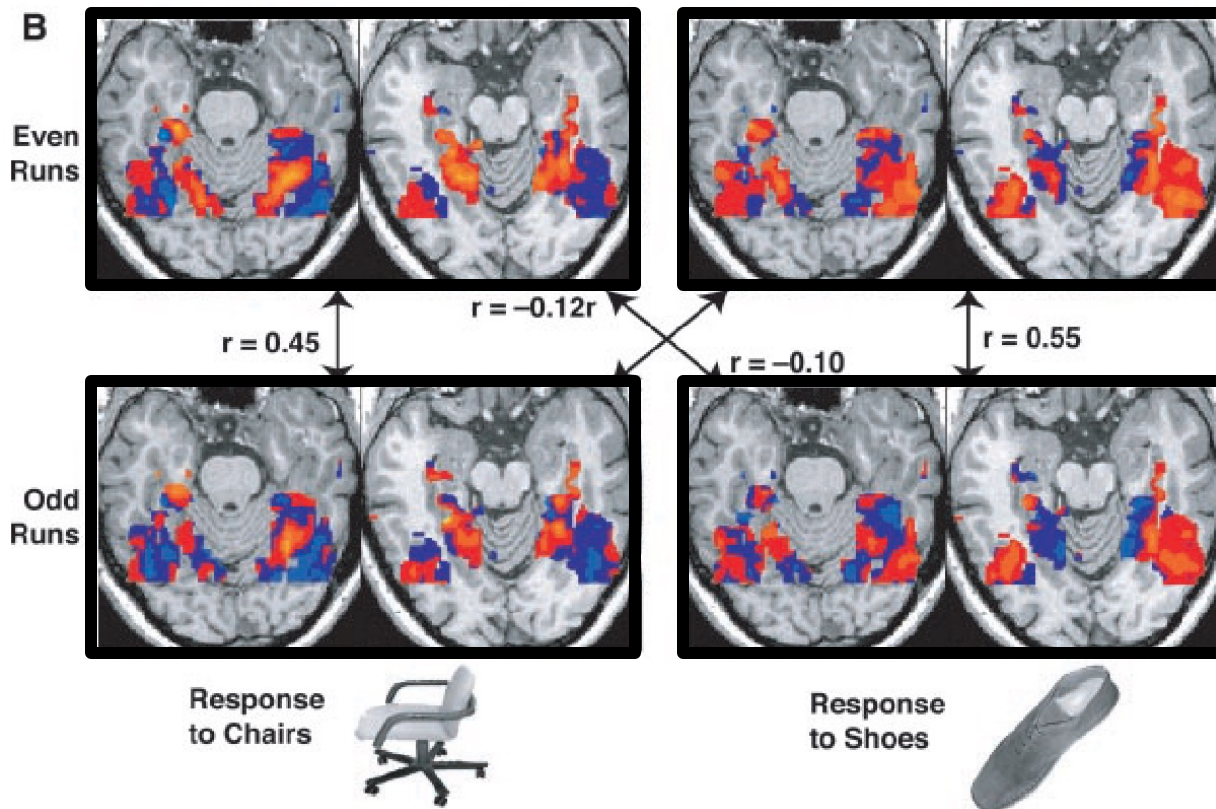


Pre-SMA



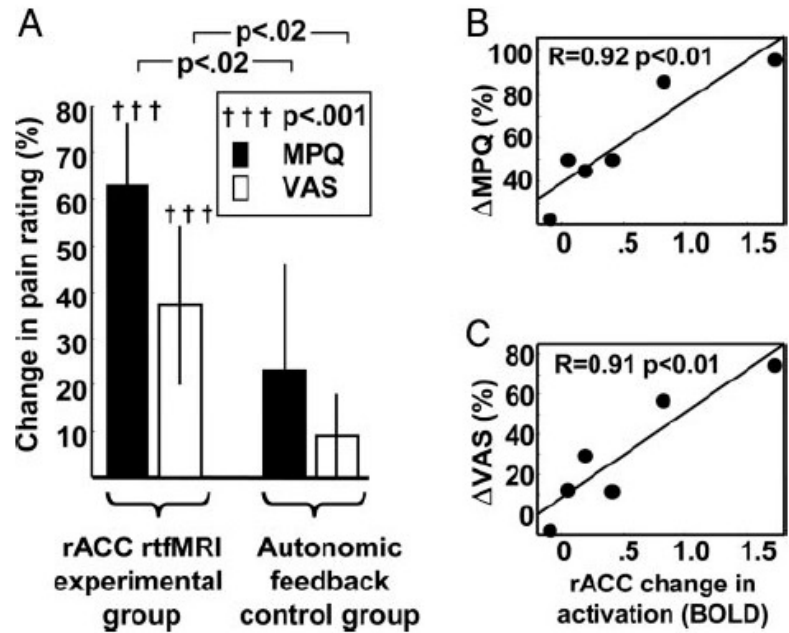
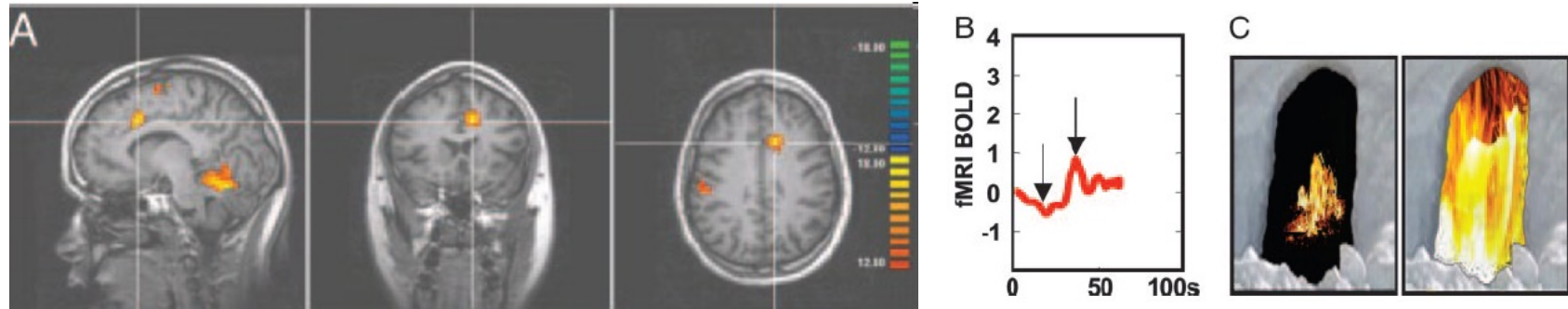
Ventral temporal category representations

Object categories are associated with distributed representations in ventral temporal cortex



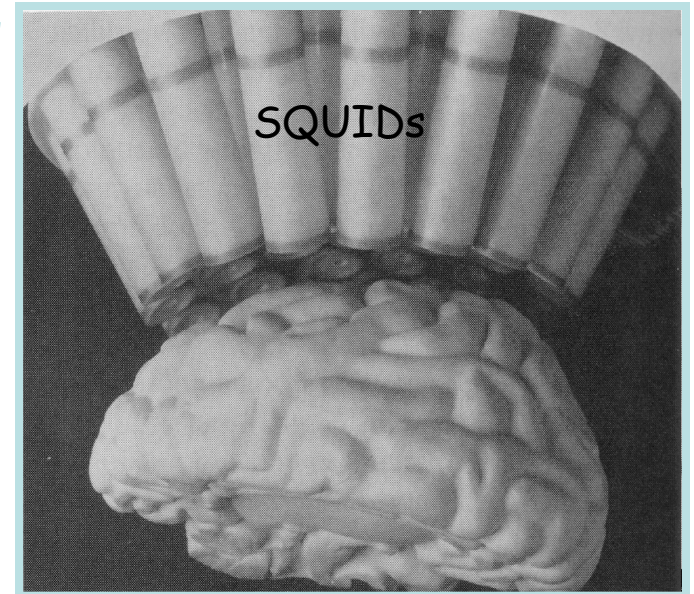
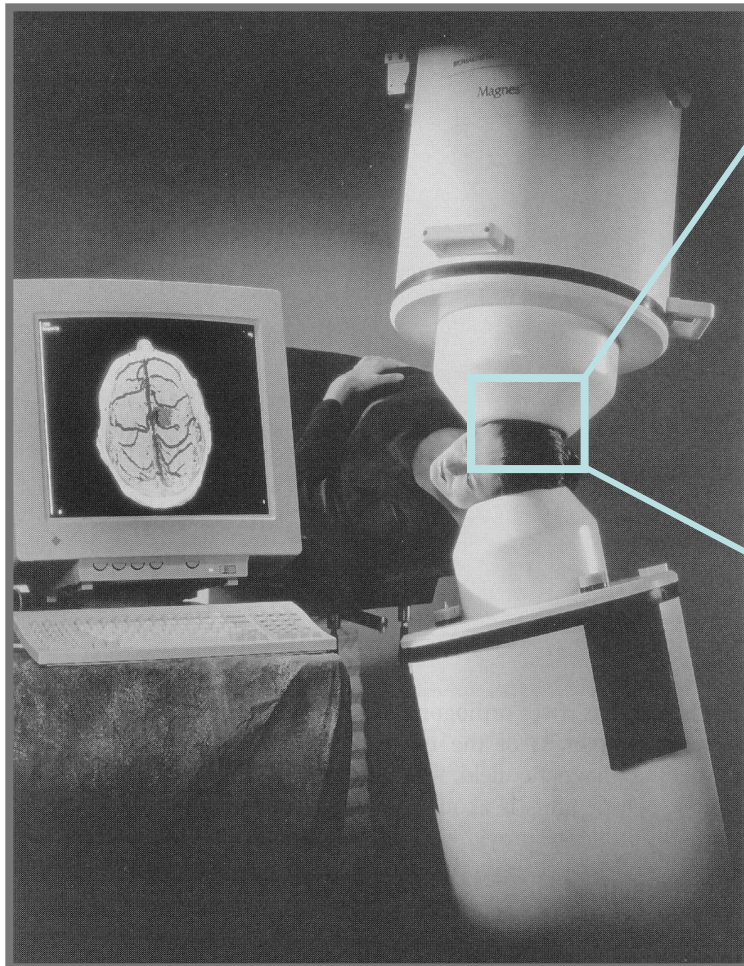
Haxby et al. 2001

Real time fMRI feedback to reduce chronic pain



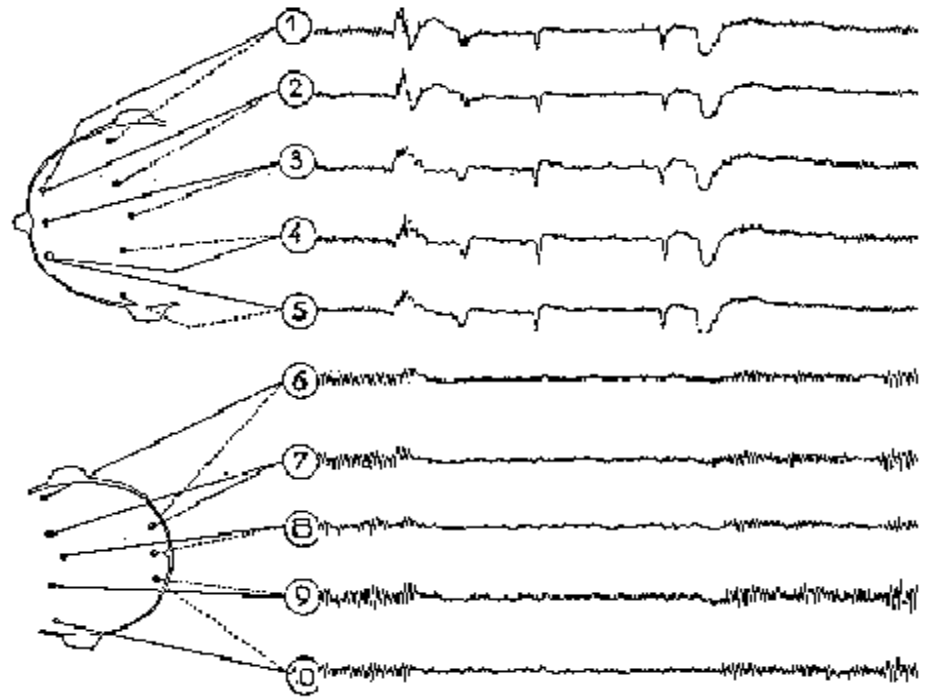
Control over brain activation and pain learned by using real-time functional MRI, R. C. deCharms, et al. PNAS, 102; 18626-18631 (2005)

Magnetoencephalography (MEG)



SQUID:
Superconducting Quantum
Interference Device

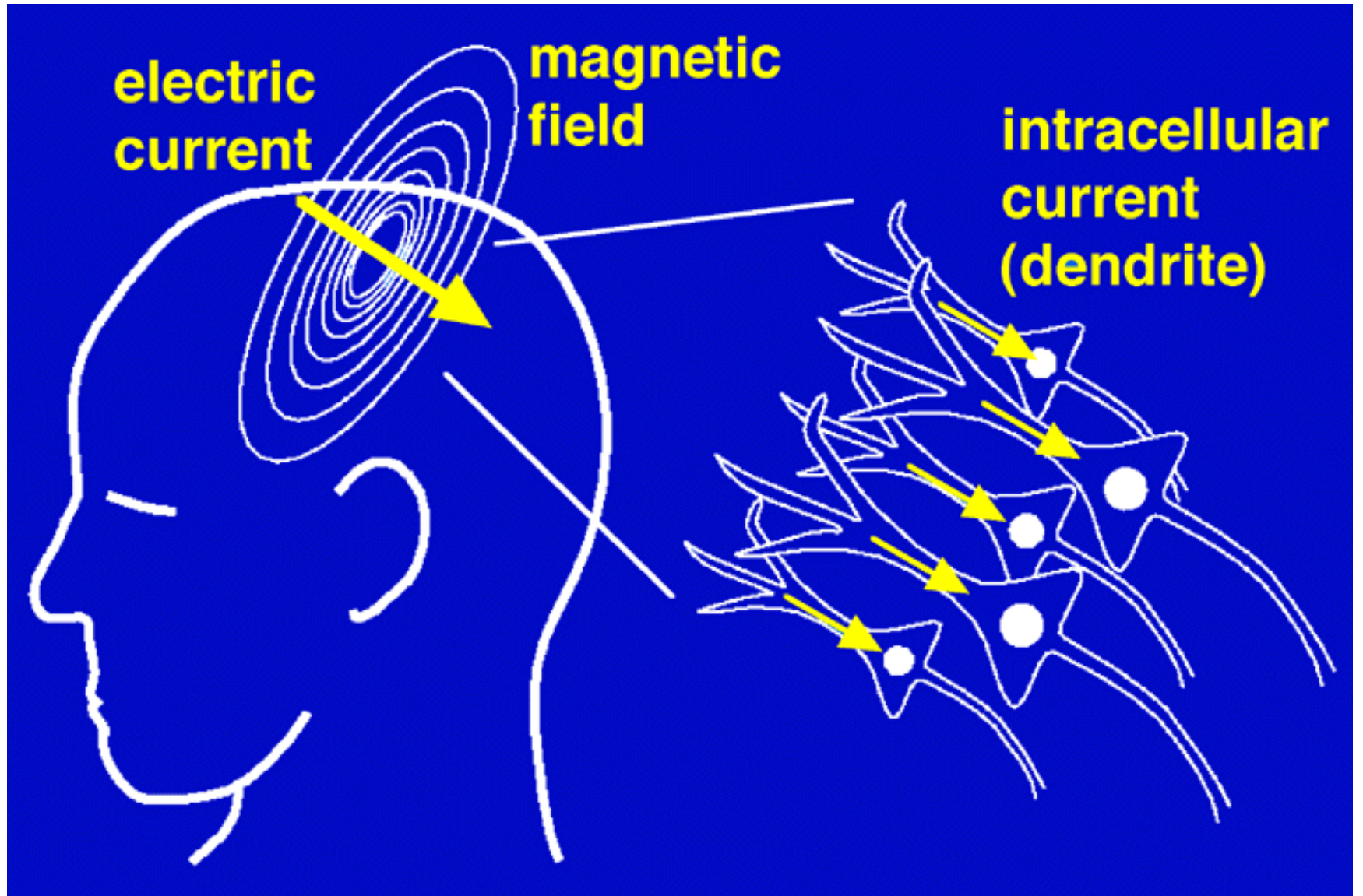
Electroencephalography (EEG)

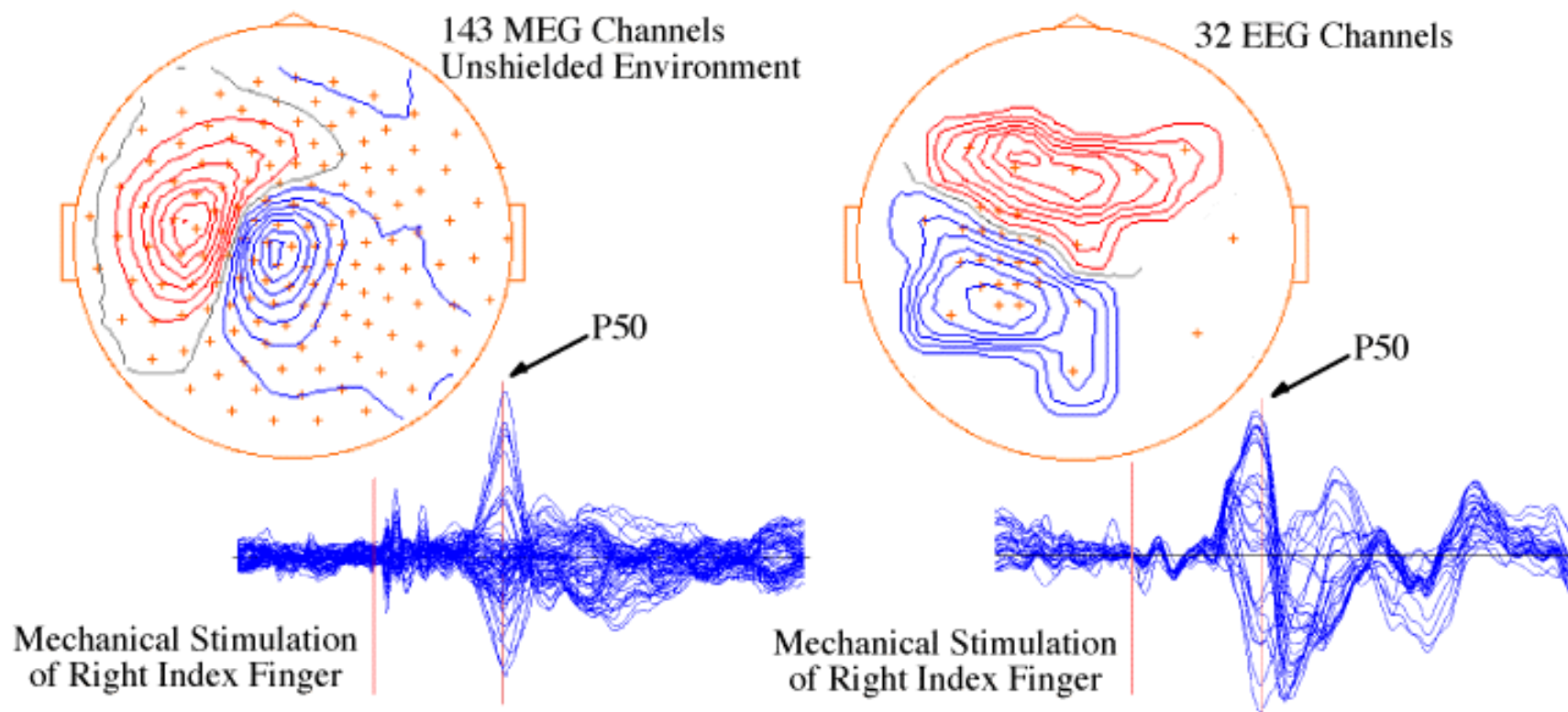


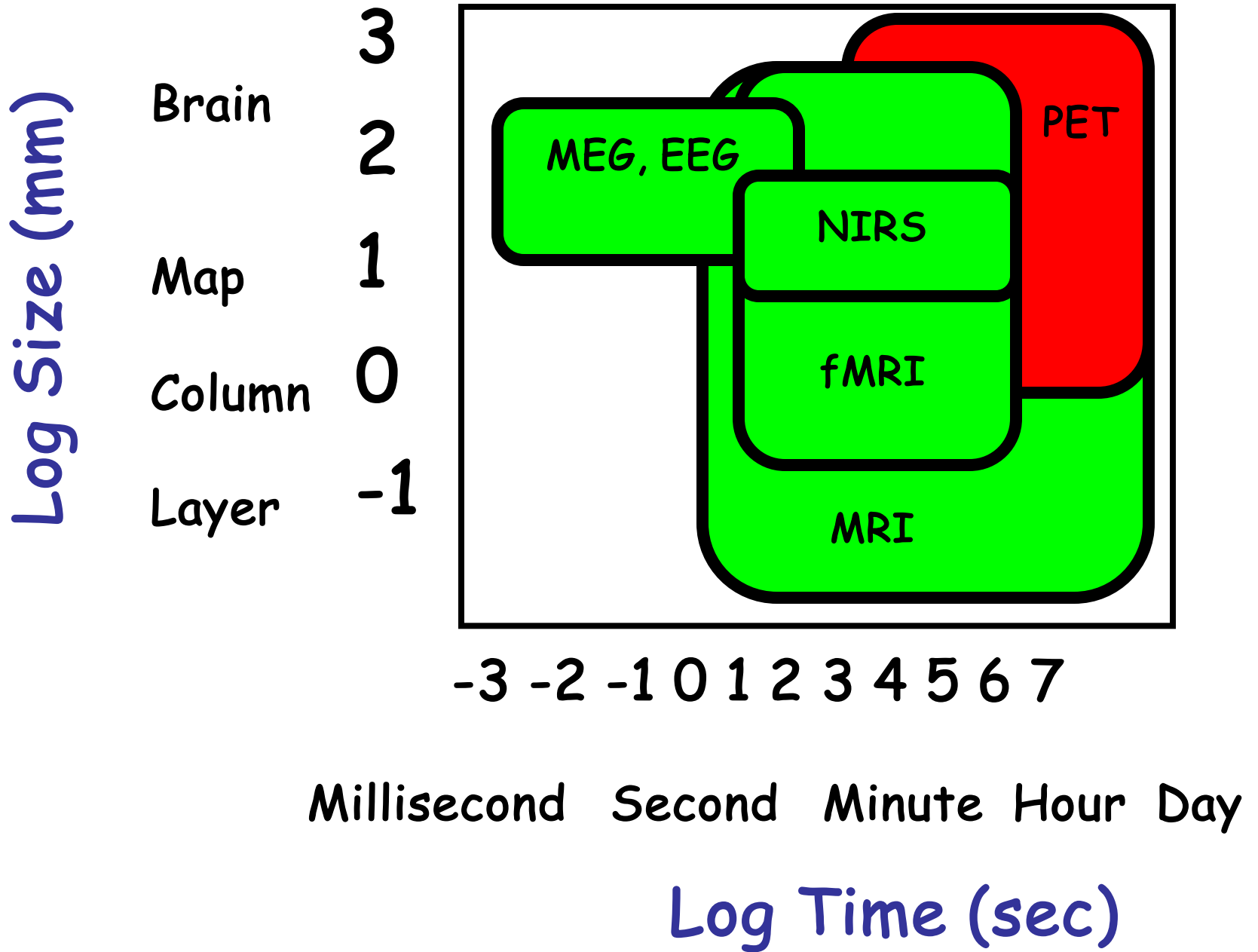
**electric
current**

**magnetic
field**

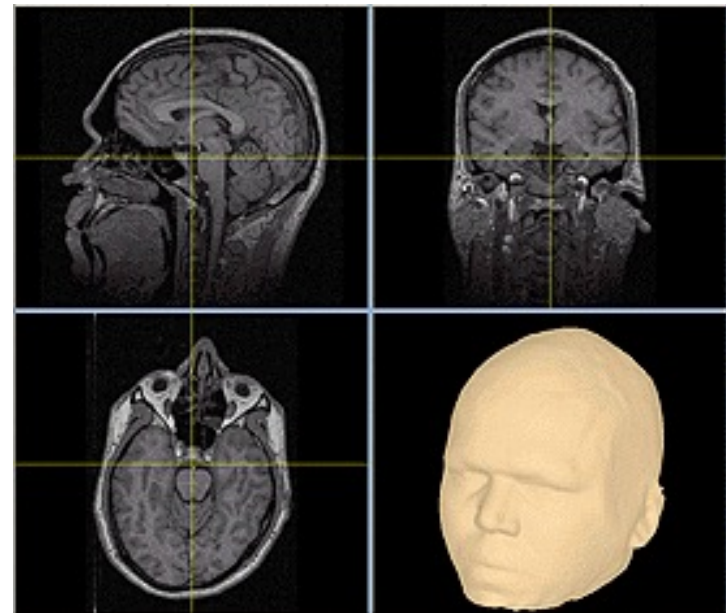
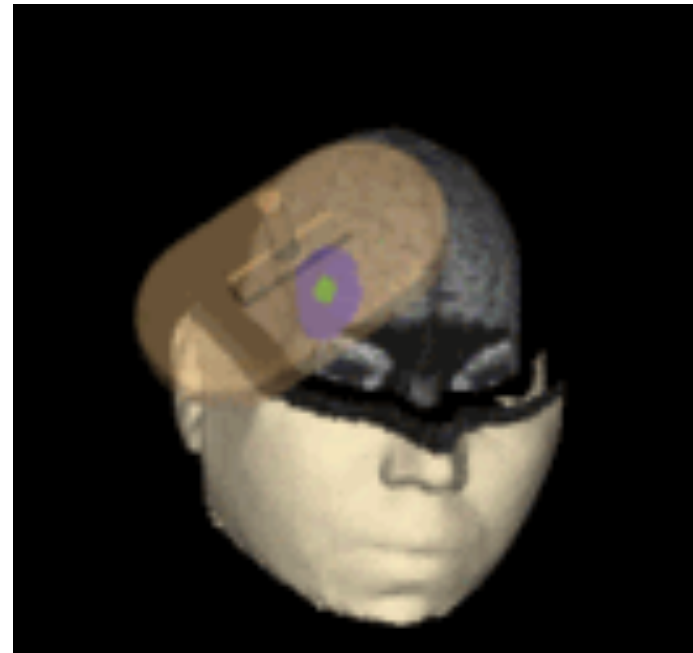
**intracellular
current
(dendrite)**



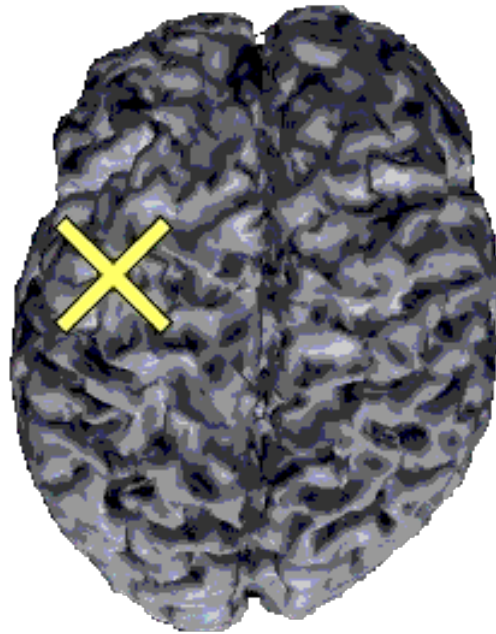




Transcranial Magnetic Stimulation



Transcranial Magnetic Stimulation (TMS)





Section on Functional Imaging Methods & FMRI Facility

