Functional Magnetic Resonance Imaging **(fMRI)**

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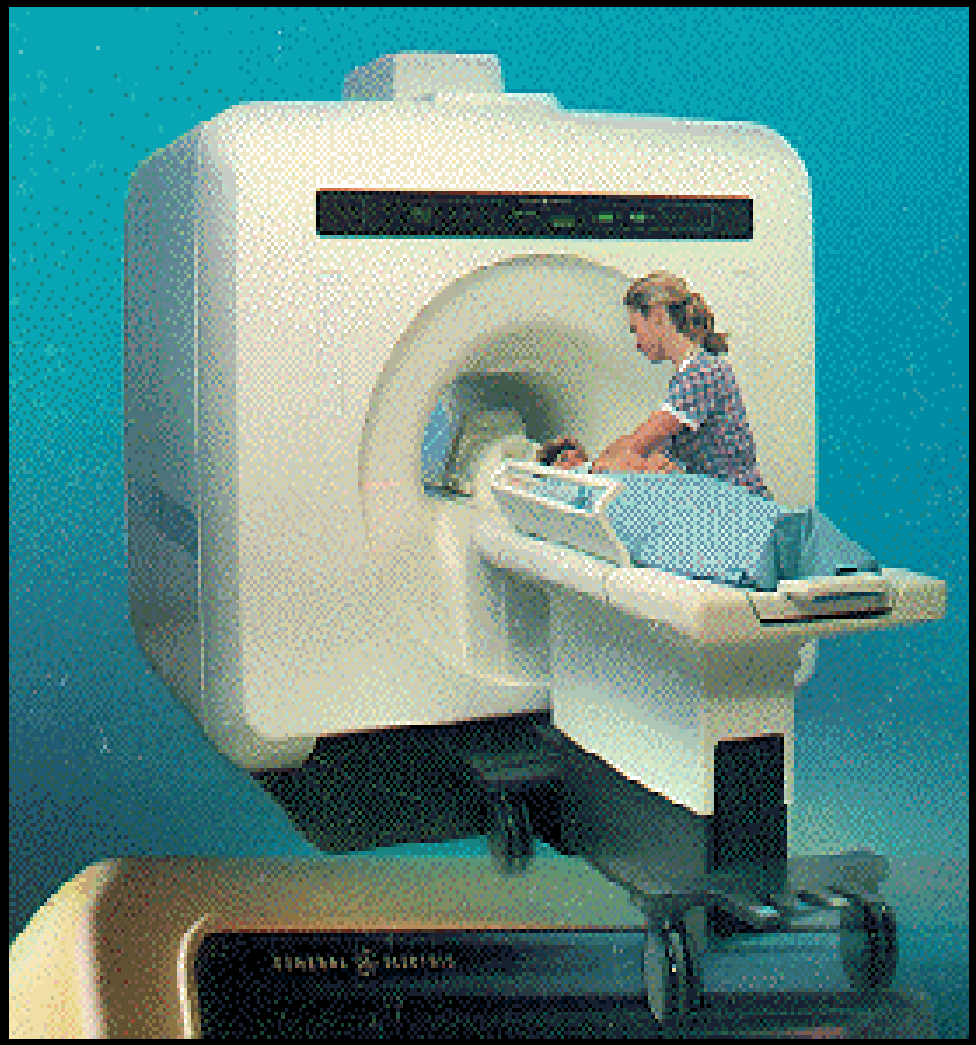
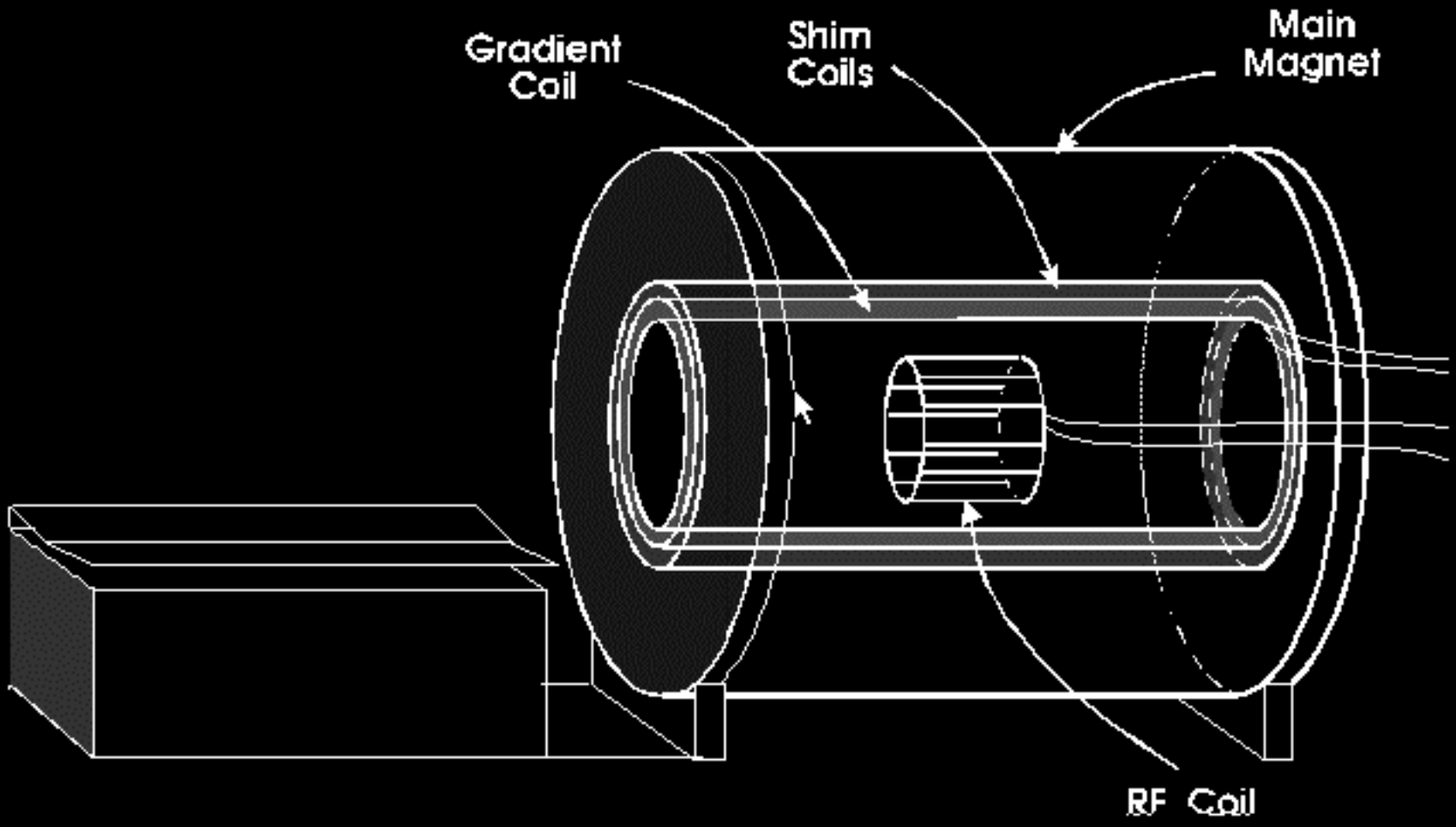
Magnetic Resonance Imaging

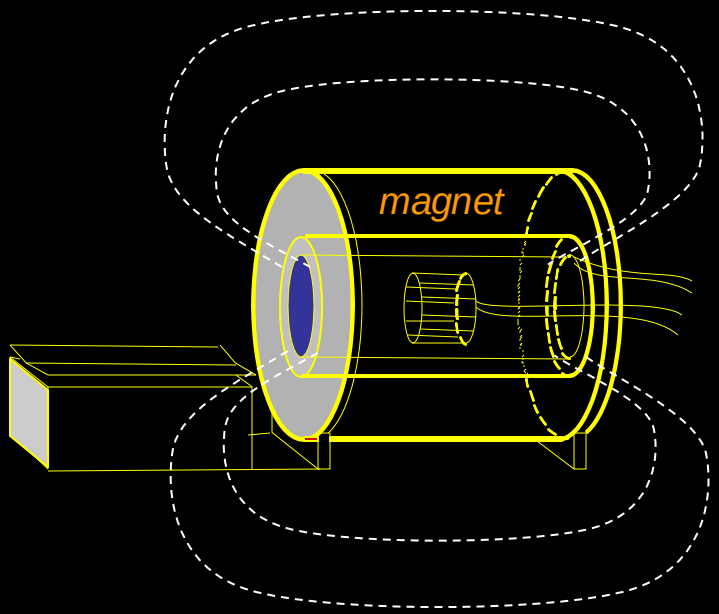


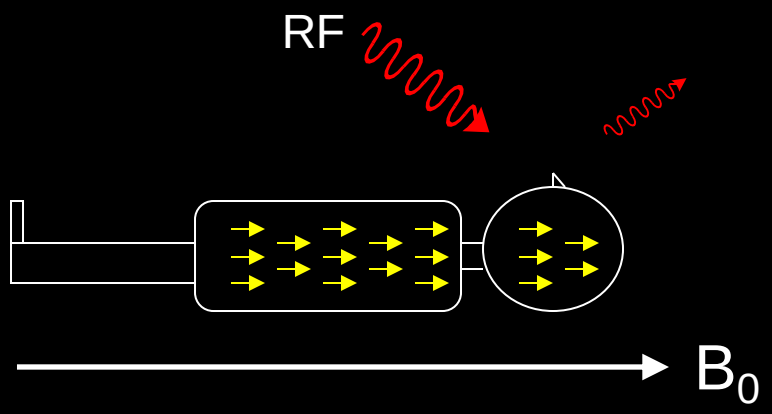
Water: 42 MHz/Tesla

1.5 Tesla = 63 MHz
3 Tesla = 126 MHz
7 Tesla = 294 MHz


Gradient Coil
Shim Coils
Main Magnet
RF Coil

Magnetic Resonance Imaging (MRI)

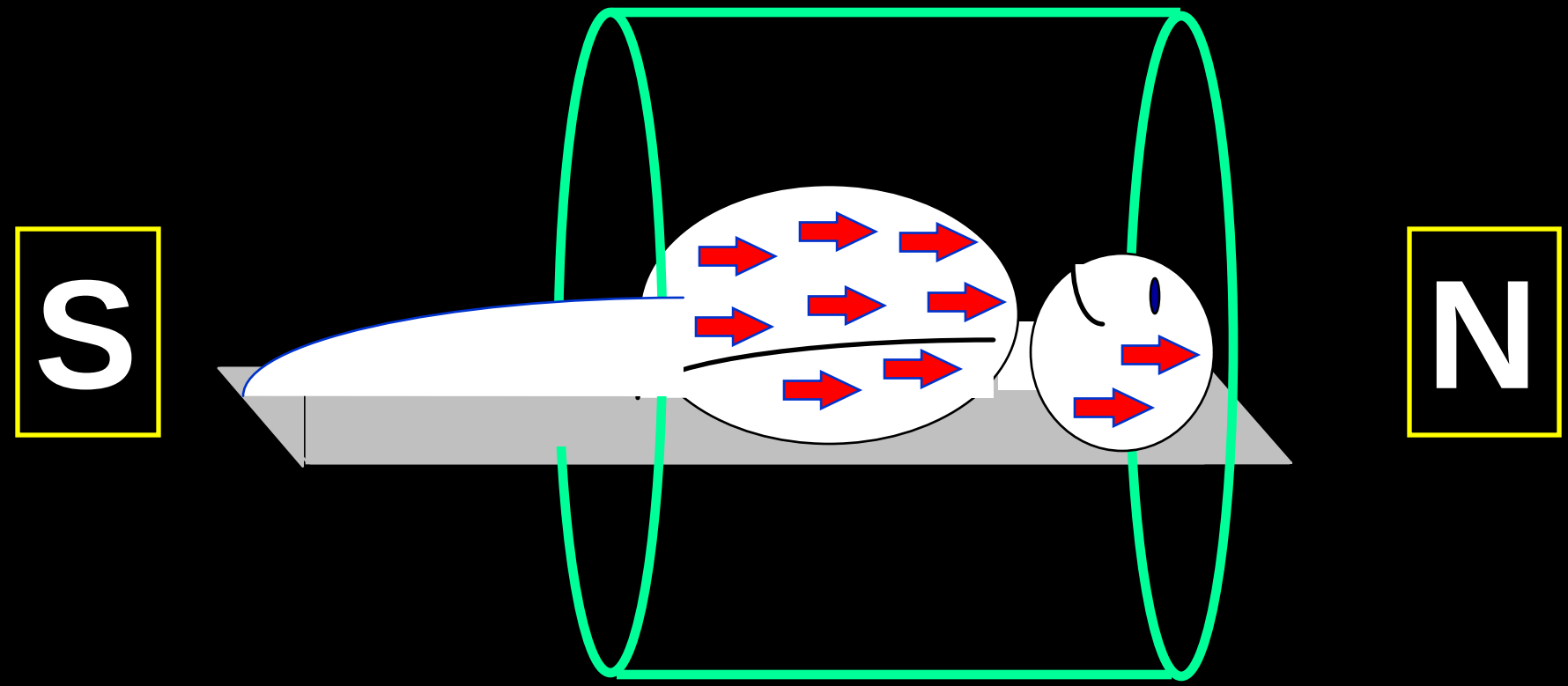




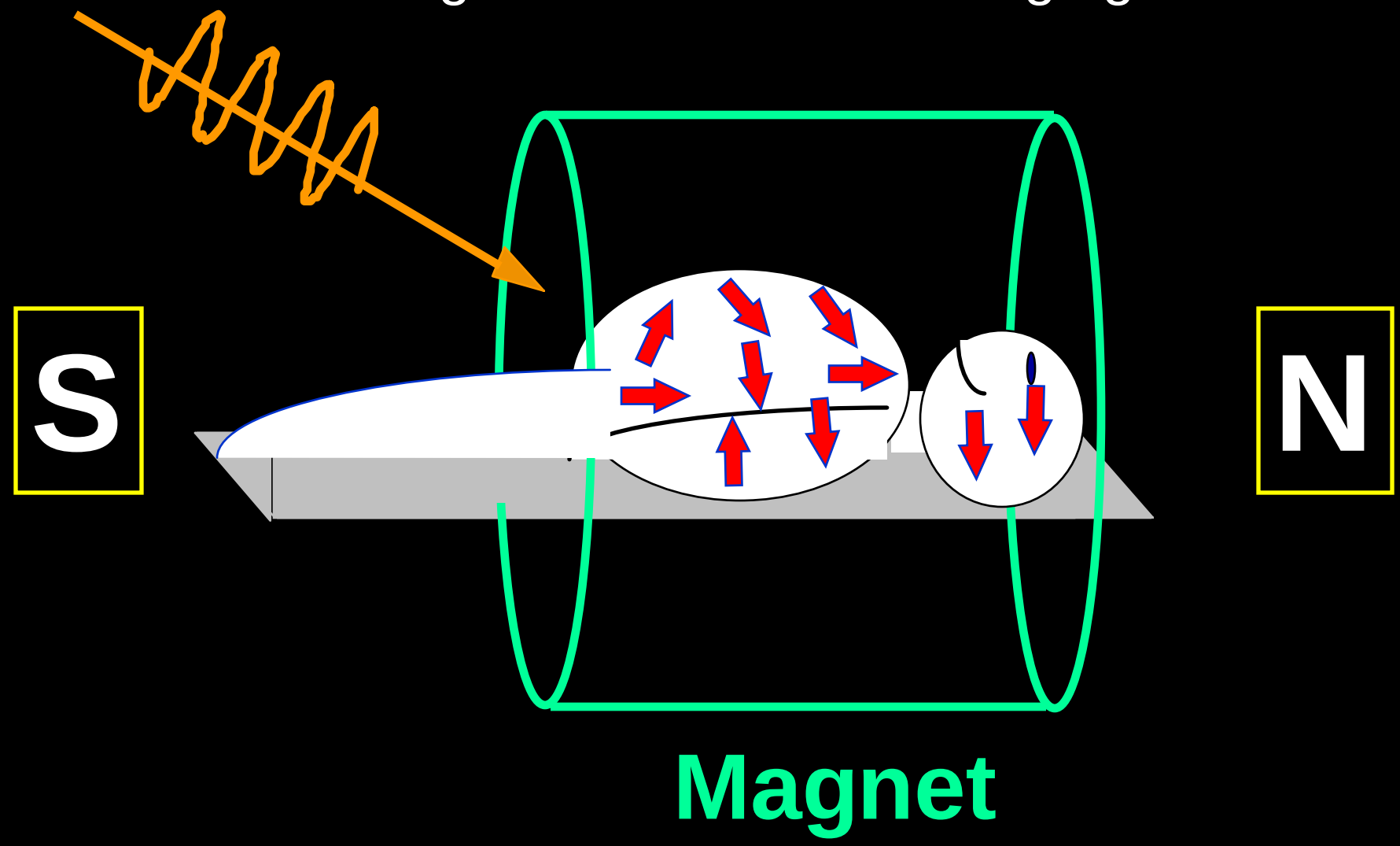
Sensitive to:

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

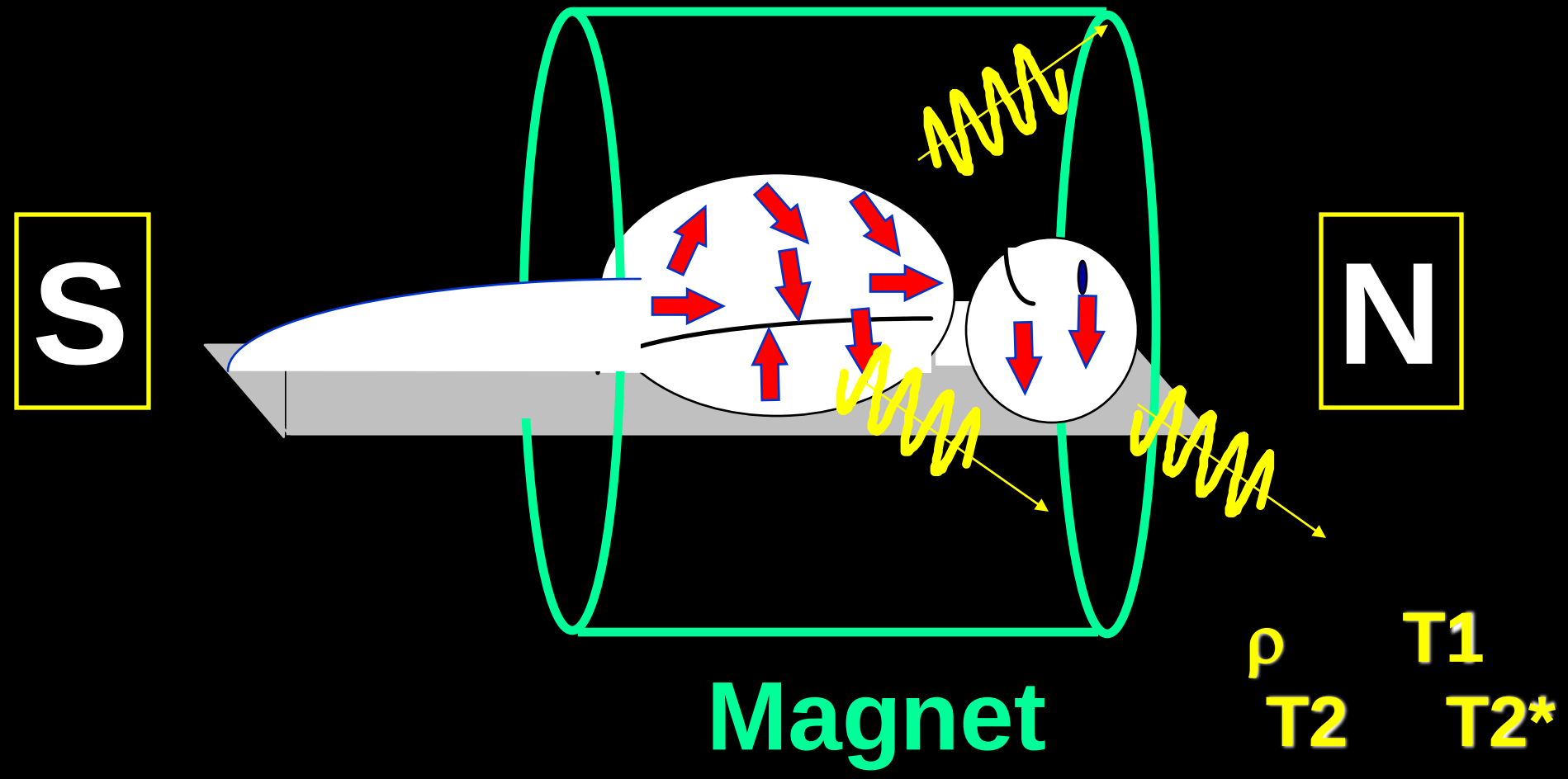
Magnetic Resonance Imaging



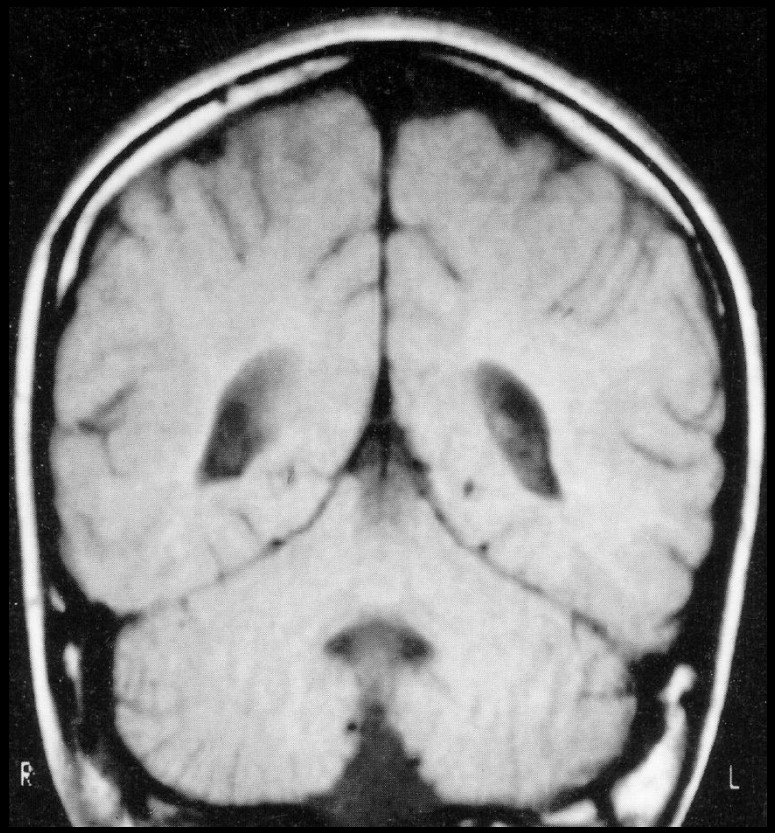
Magnetic Resonance Imaging

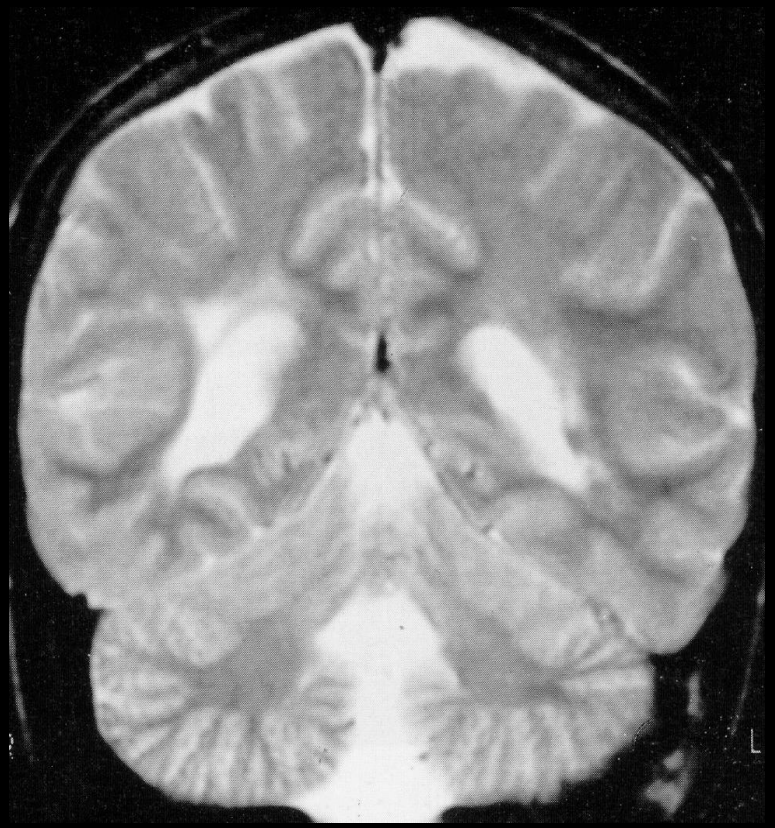


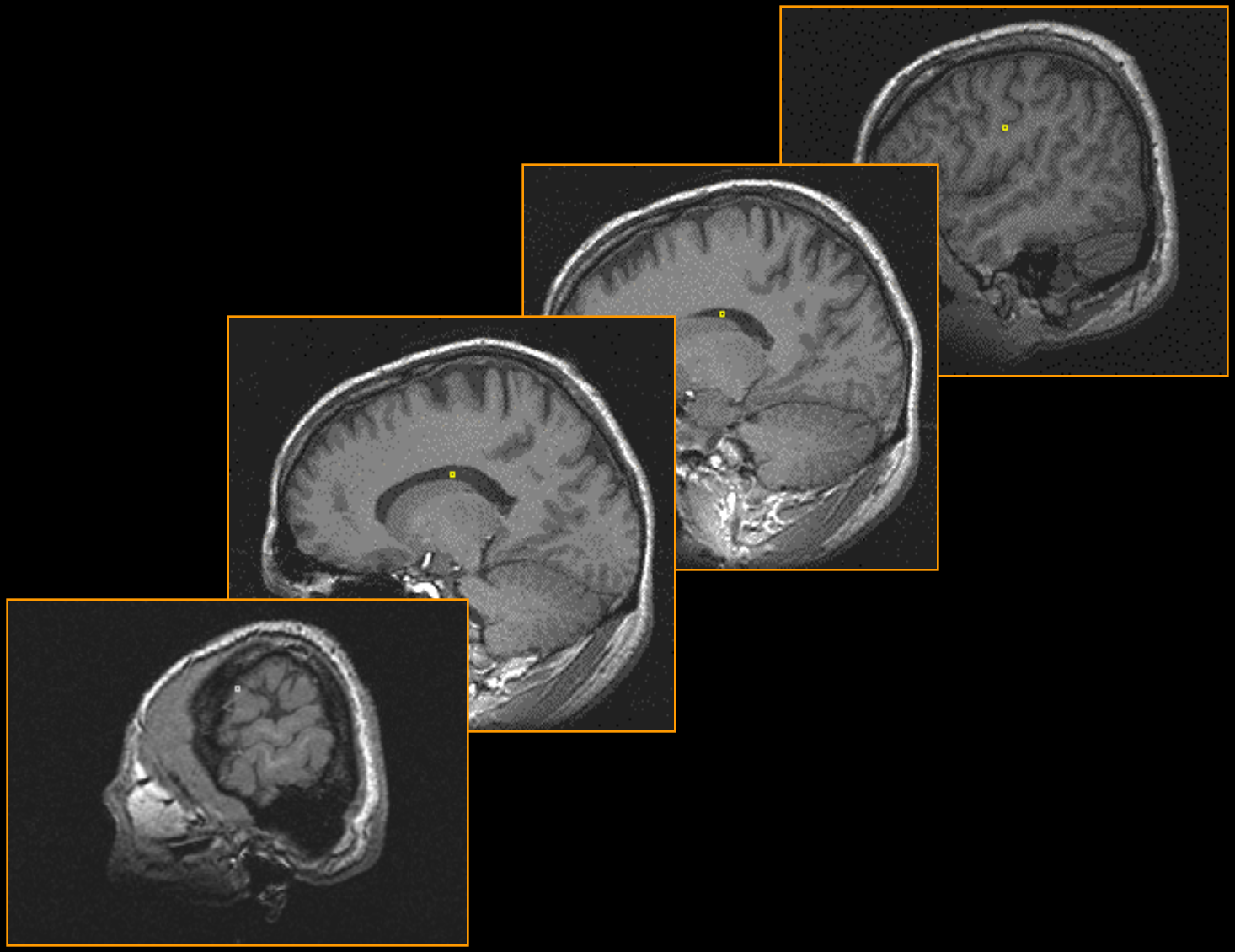
Magnetic Resonance Imaging



MRI Images with Different Contrast Weighting

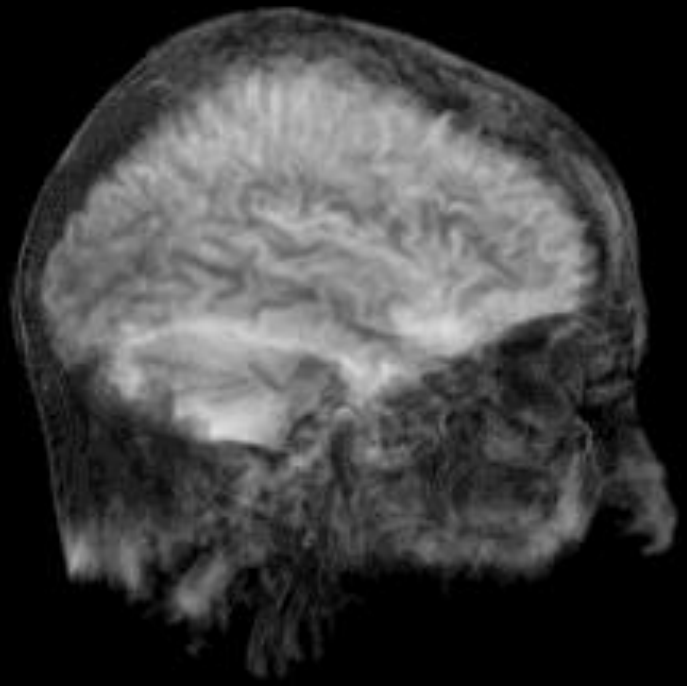




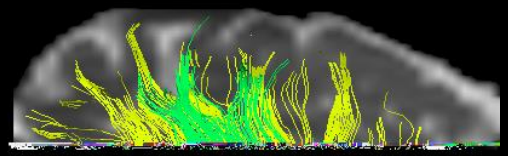


Two Types of Neuroimaging

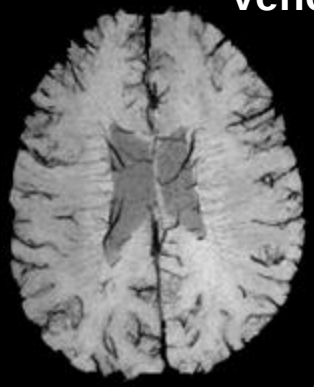
- Structural/Anatomical Imaging
- Functional Imaging



Fiber Track Imaging



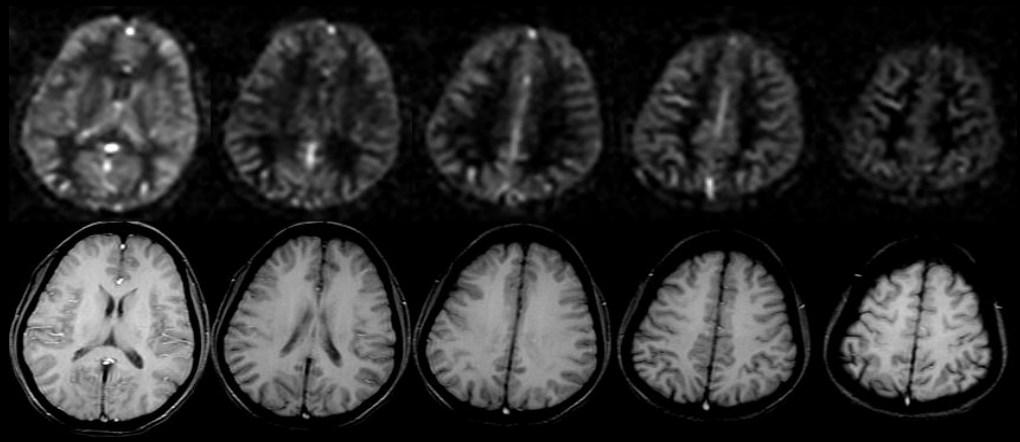
Venography

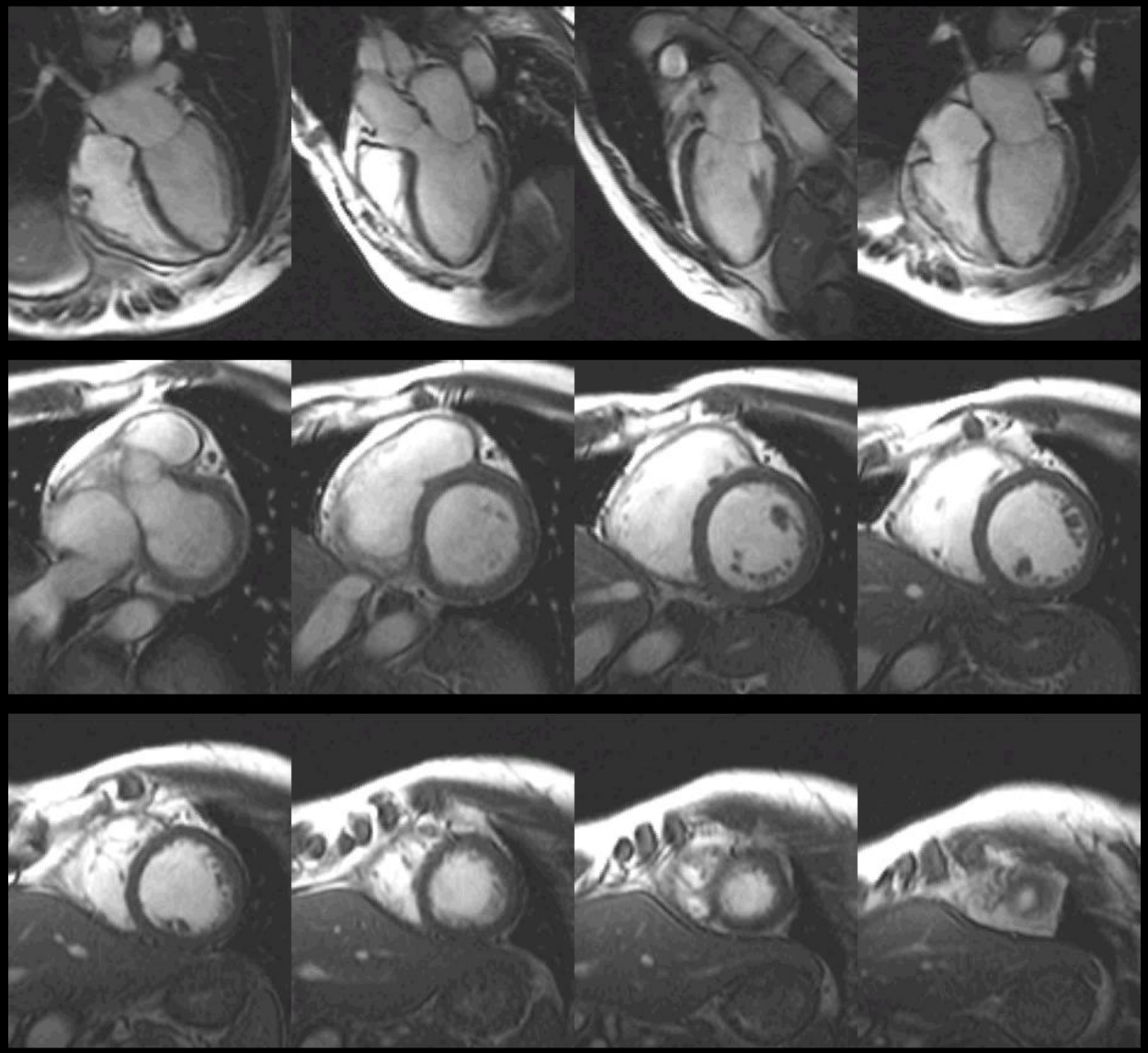


Anatomy

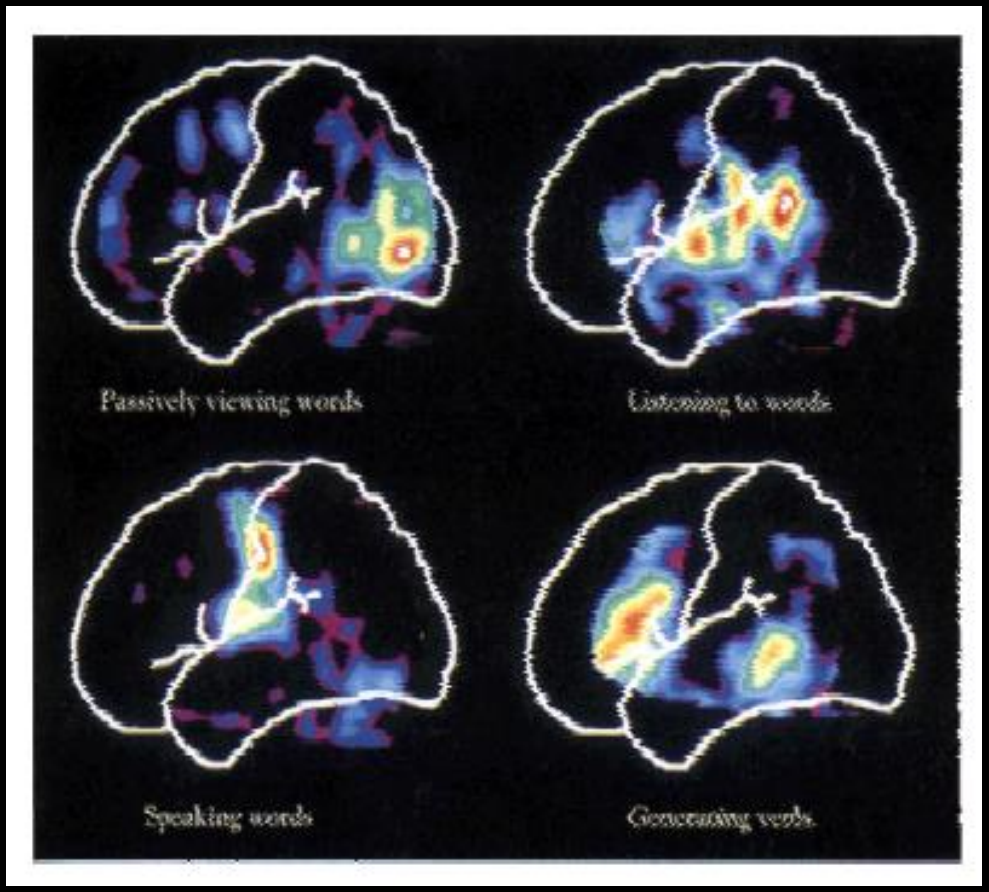
Angiography

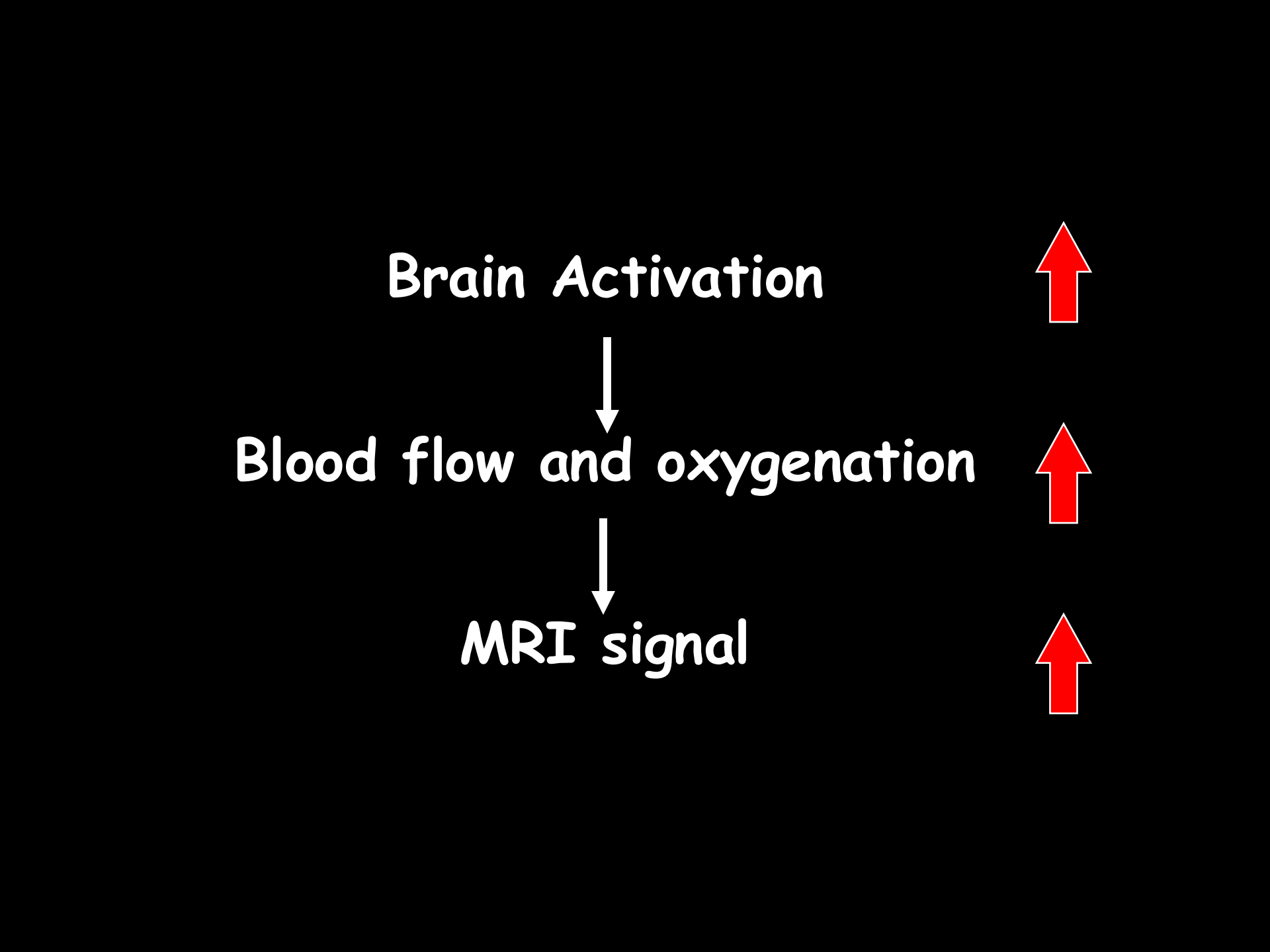
Perfusion





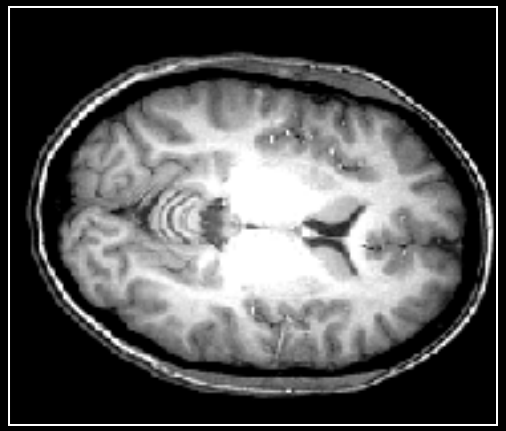
- Functional Imaging
  - Xenon Computerized Tomography (Xe CT)
  - Positron Emission Tomography (PET)
  - Single Photon Computed Tomography (SPECT)
  - Functional MRI (fMRI)
  - Electroencephalography (EEG)
  - Magnetoencphalography (MEG)
  - Transcranial Magnetic Stimulation (TMS)


Passively viewing words
Listening to words
Speaking words
Generating verbs


Brain Activation
Blood flow and oxygenation
MRI signal

MRI vs. fMRI

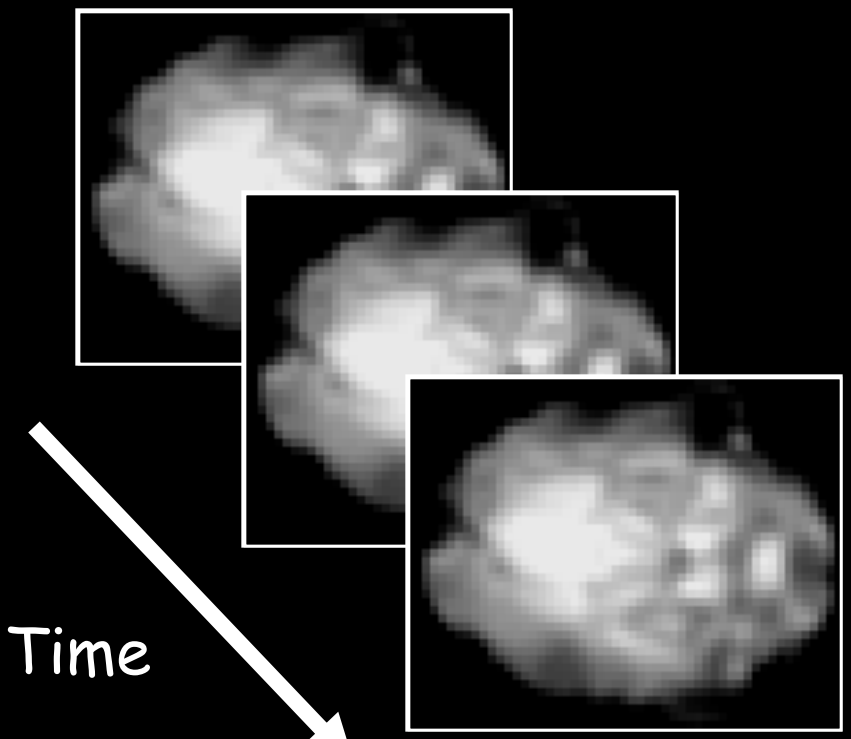
MRI



one image

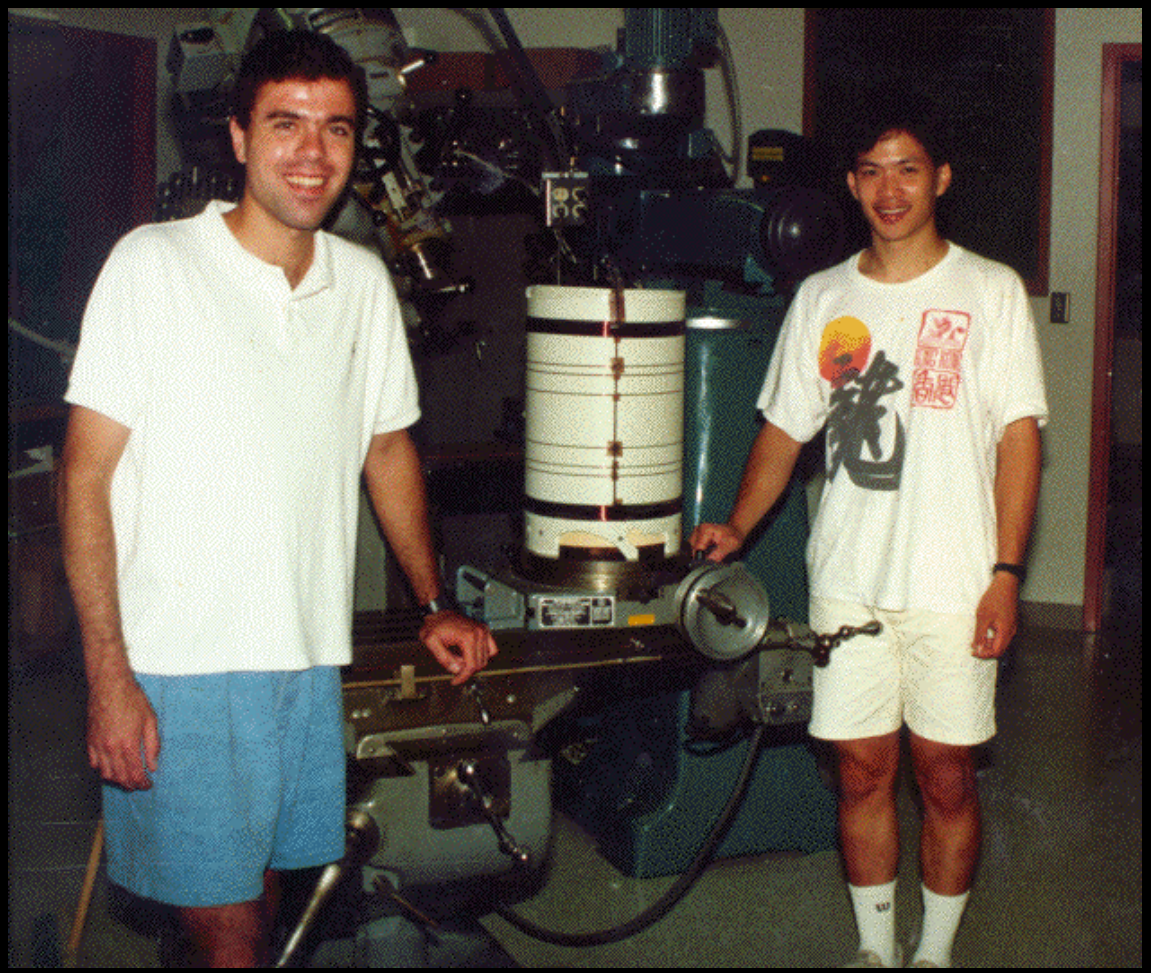
high resolution
(1 mm or less)

fMRI



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

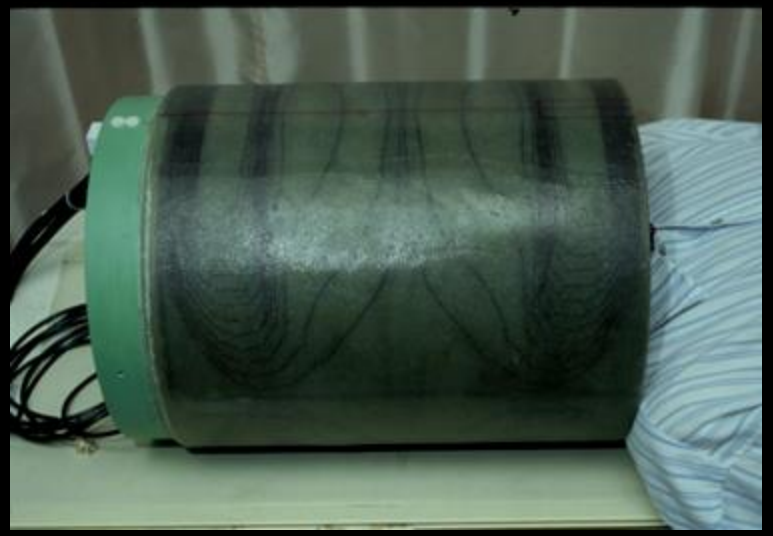
low resolution
(1.5 to 4 mm)



August, 1991

1991-1992

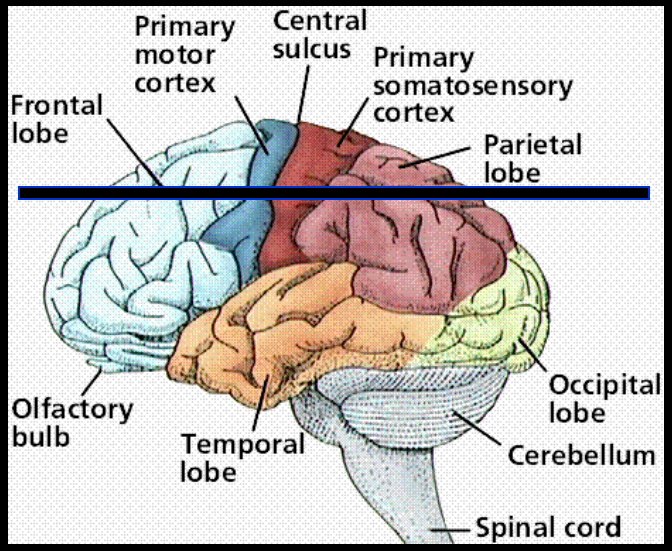
1992-1999

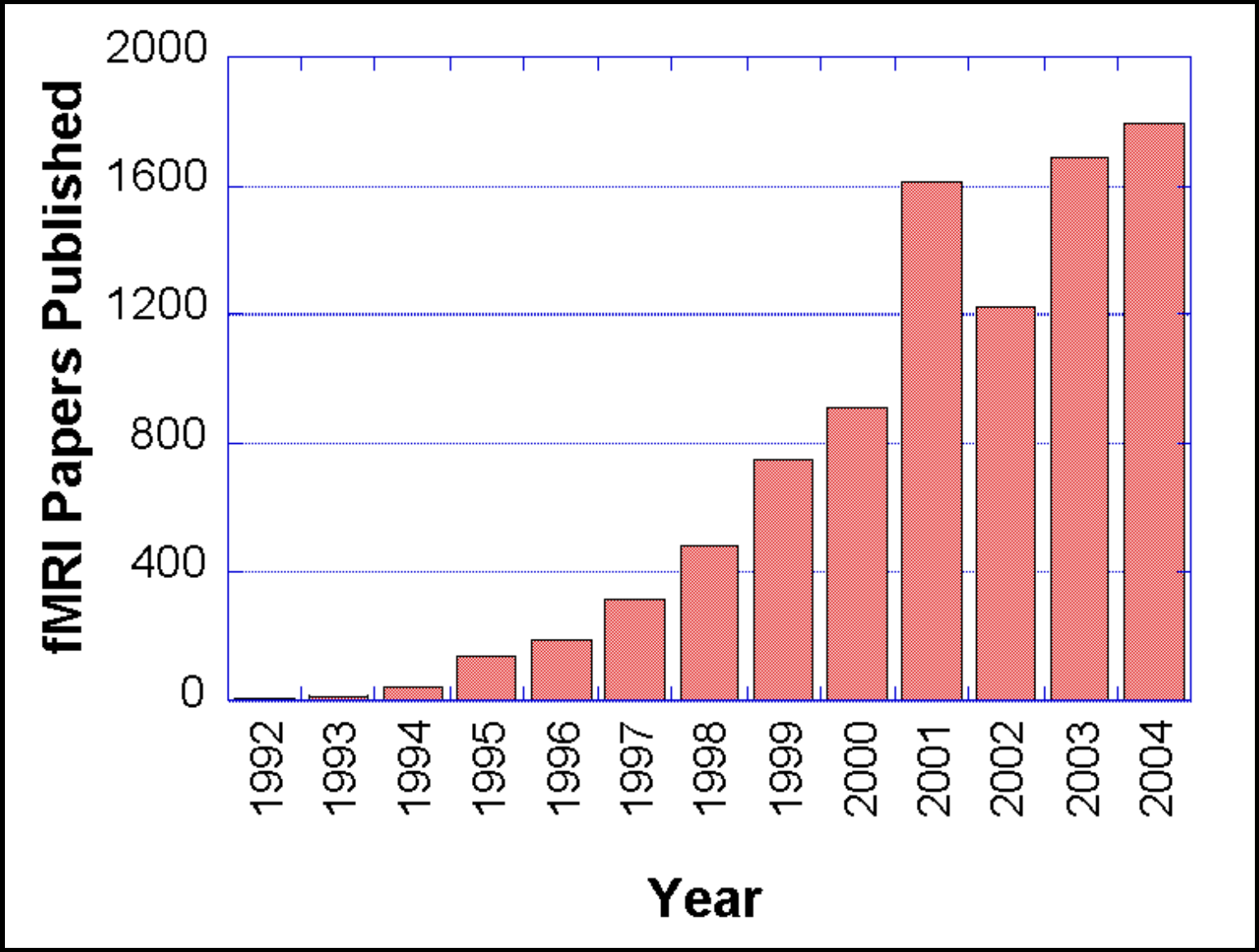


Alternating Left and Right Finger Tapping

~ 1992

Alternating Left and Right Finger Tapping

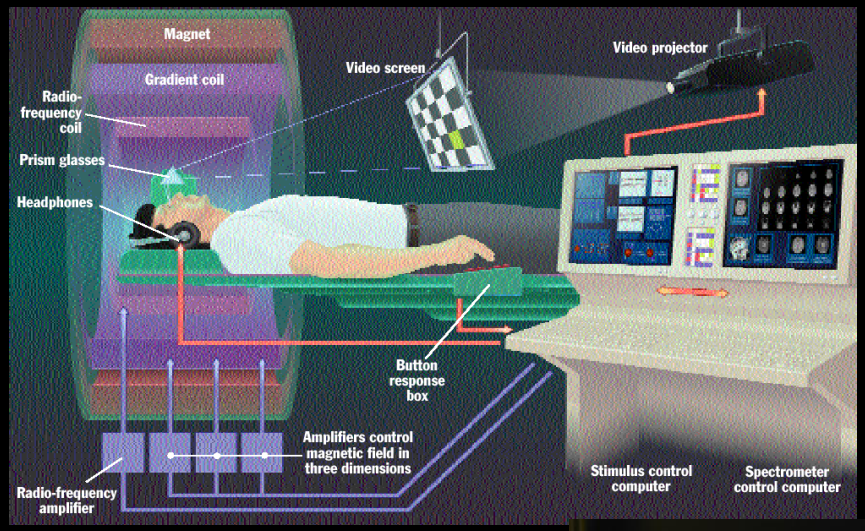



fMRI Papers Published
2000
1600
1200
800
400
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year

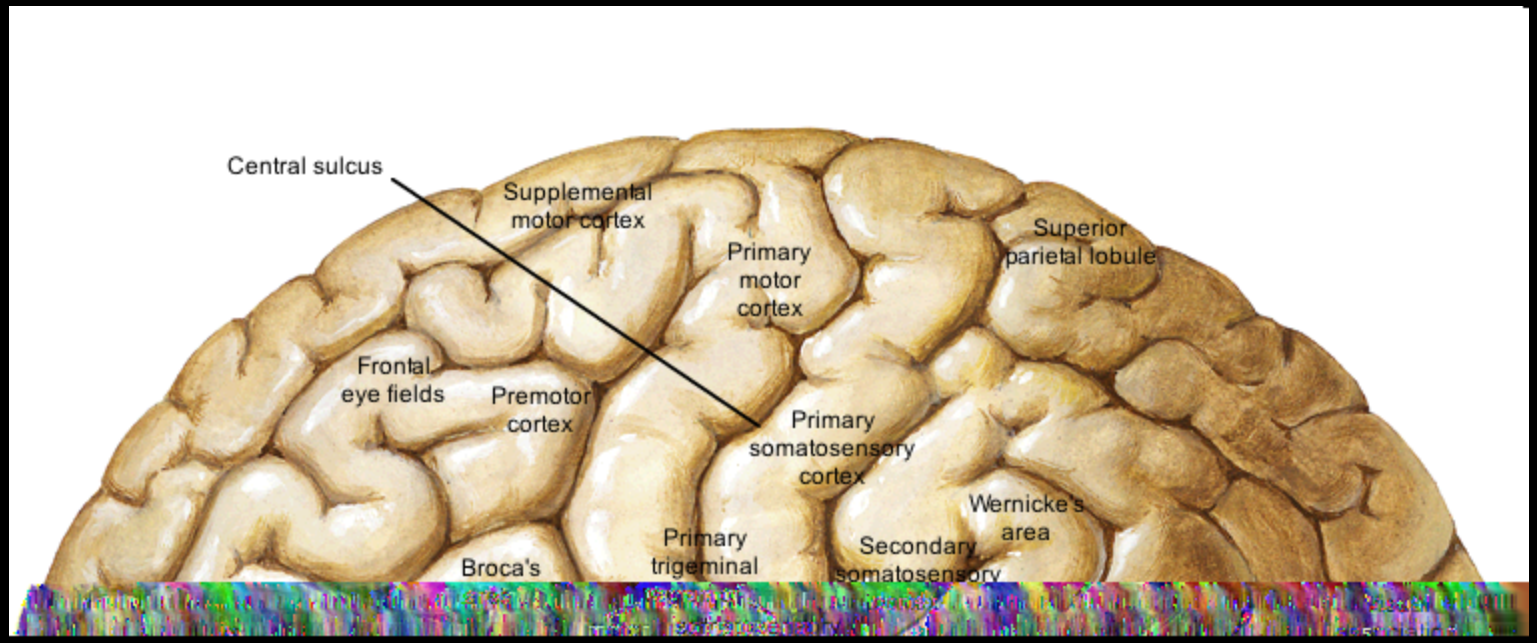
Topics Studied with fMRI at the NIH

- Epilepsy
- Visual processing
- Mood disorders
- Learning
- Habituation
- Plasticity
- Motor Function
- Auditory processing
- Attention
- Language
- Speech
- Stroke
- Social Interaction
- Development
- Aging
- Genetics

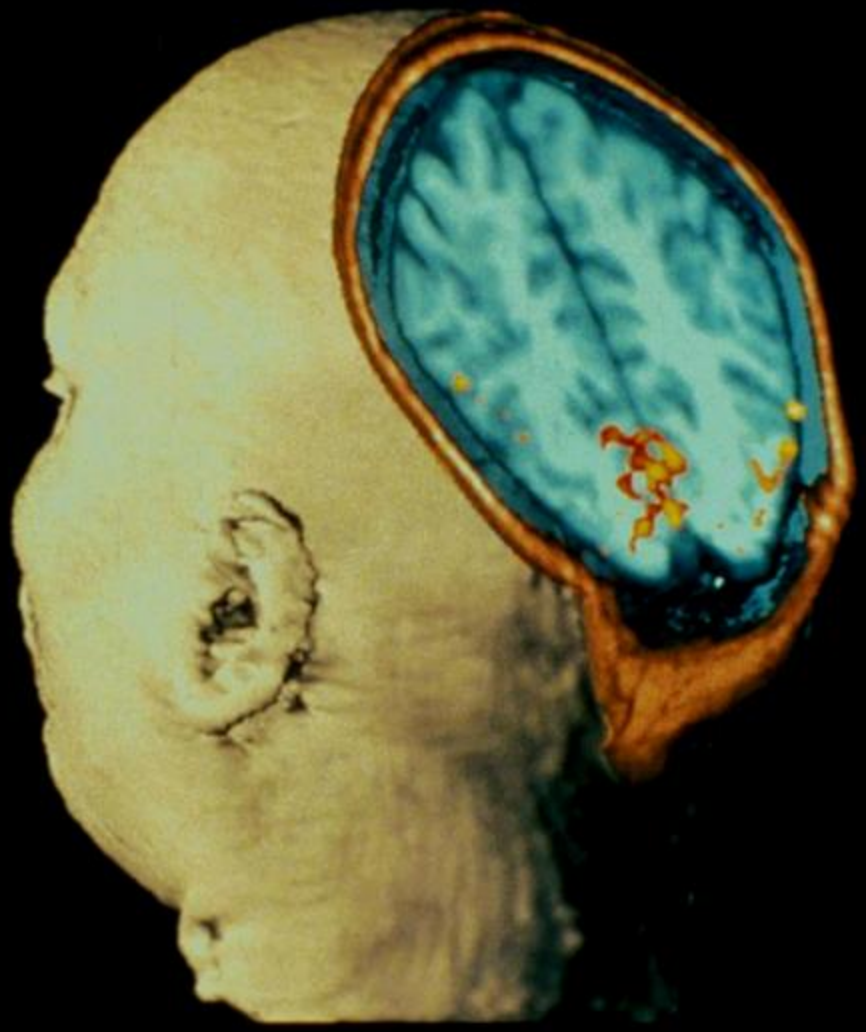
fMRI Setup


Magnet
Gradient coil
Radio-frequency coil
Prism glasses
Headphones
Video screen
Video projector
Button response box
Amplifiers control magnetic field in three dimensions
Radio-frequency amplifier
Stimulus control computer
Spectrometer control computer

A typical day at the MRI scanner

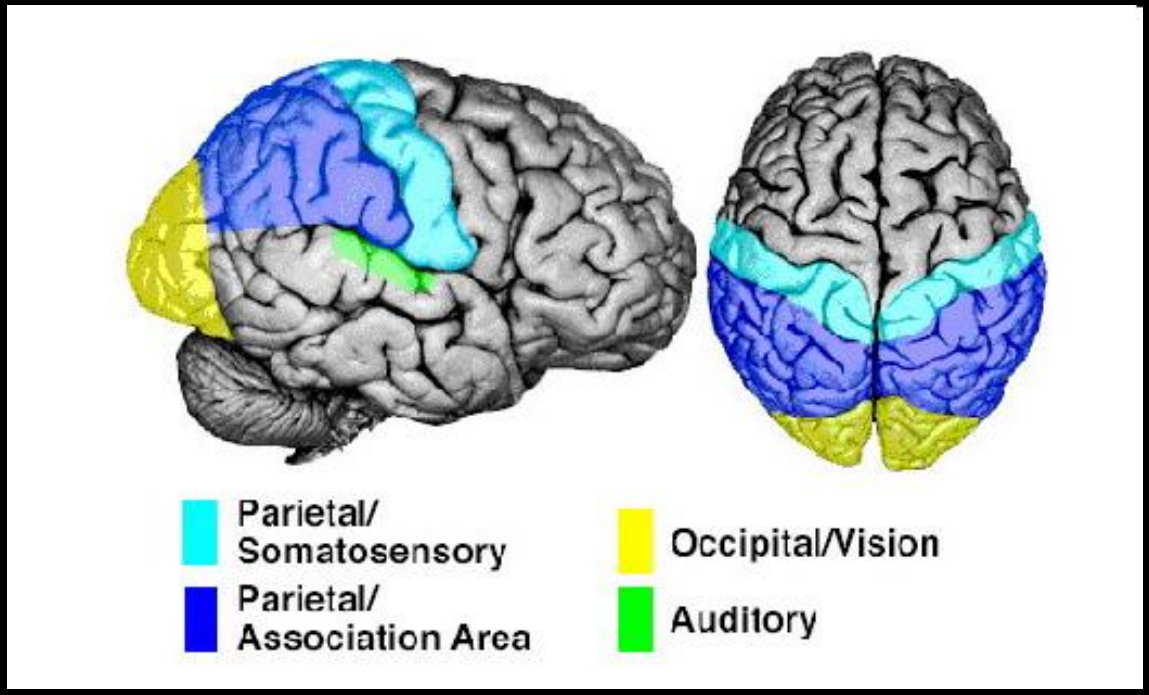

Central sulcus
Supplemental motor cortex
Primary motor cortex
Superior parietal lobule
Frontal eye fields
Premotor cortex
Primary somatosensory cortex
Wernicke's area
Primary trigeminal
Secondary somatosensory
Broca's

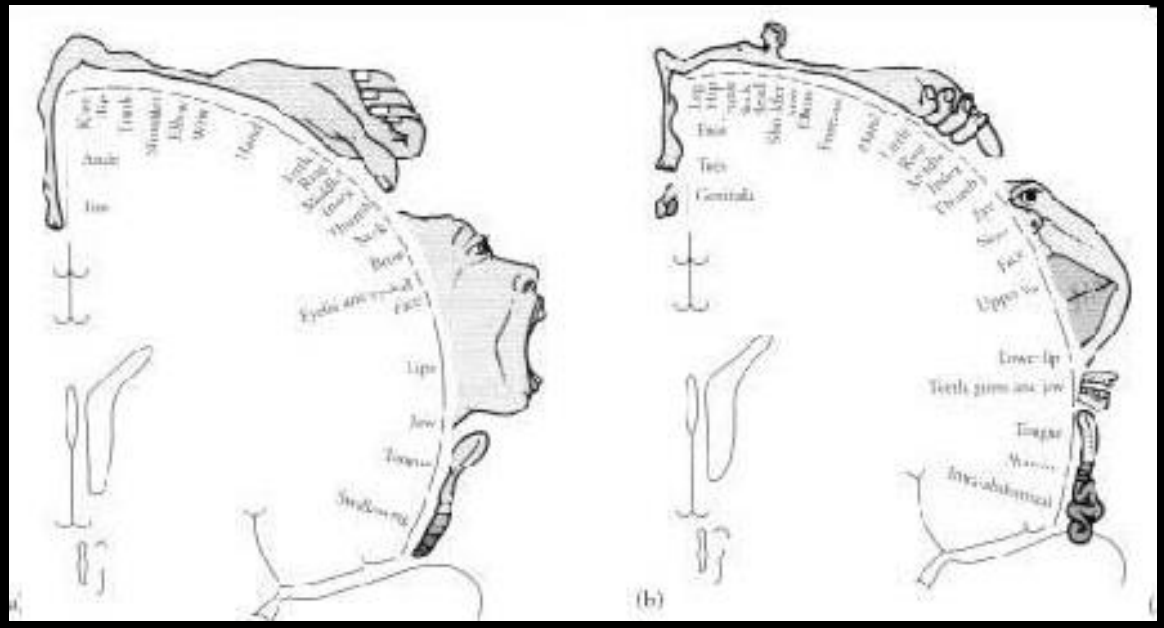
Photic Stimulation



MRI Image showing activation of the Visual Cortex

From Belliveau, et al. Science Nov 1991

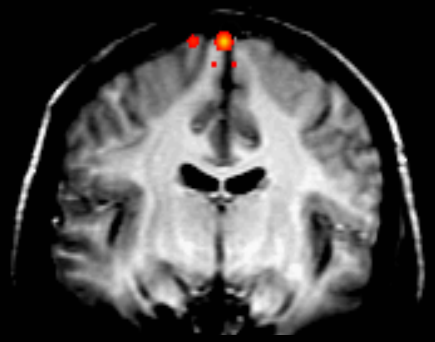

Parietal/
Somatosensory
Parietal/
Association Area
Occipital/Vision
Auditory

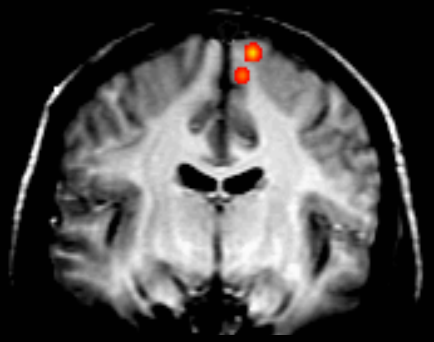

(b)

Left

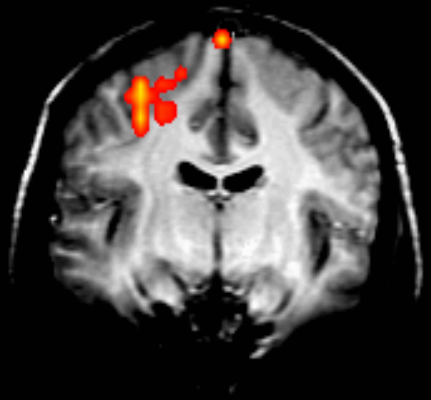
Right

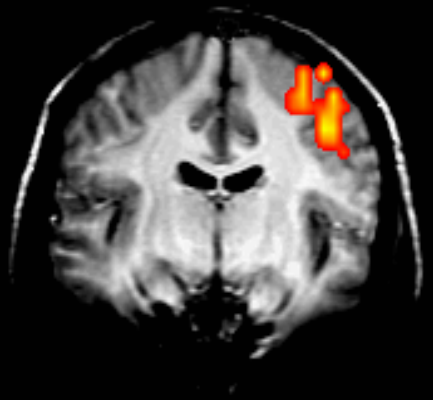
Toe movement



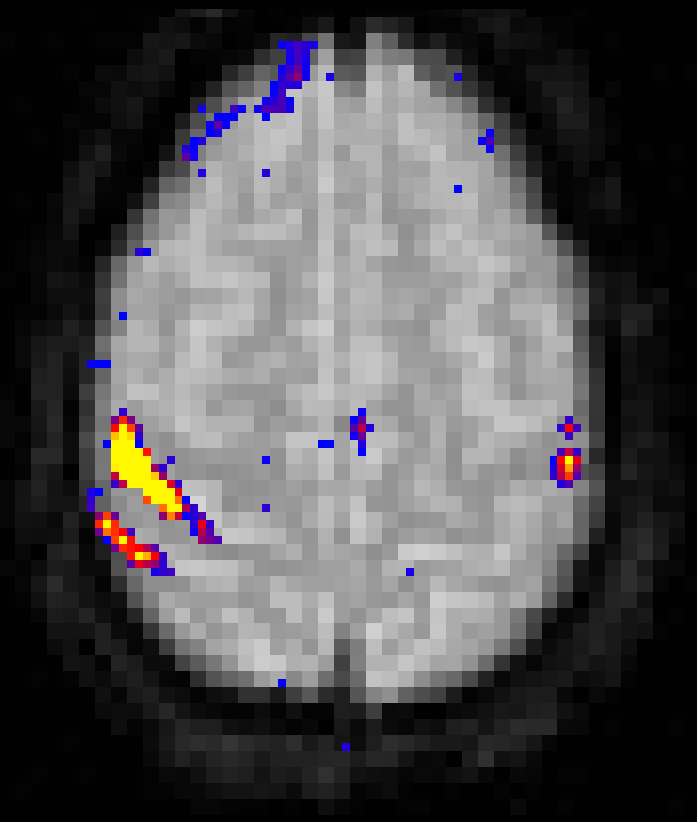


Finger movement

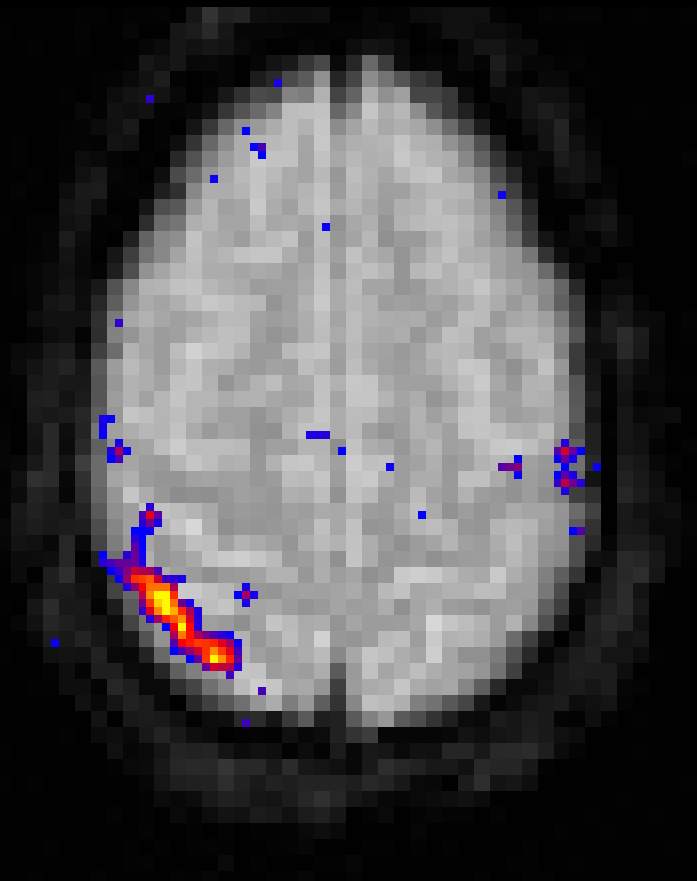




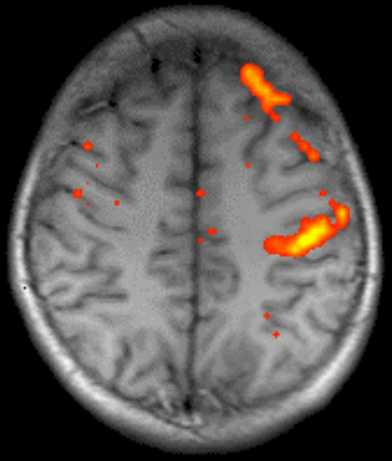
Finger Movement



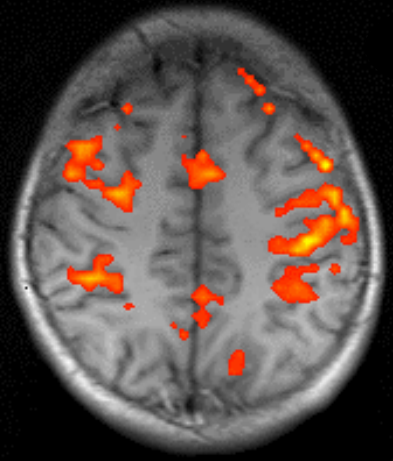
Tactile Stimulation



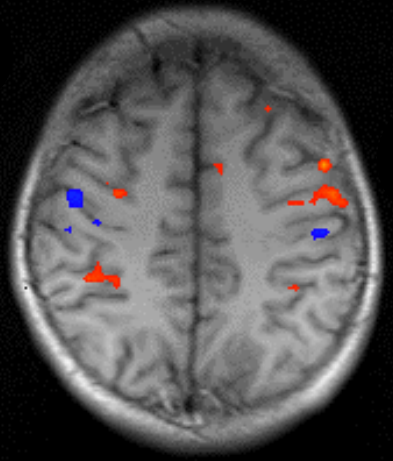
Simple Right



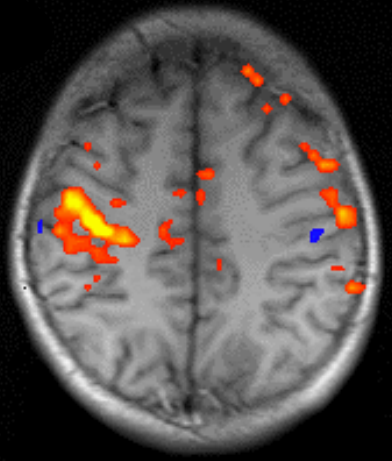
Complex Right



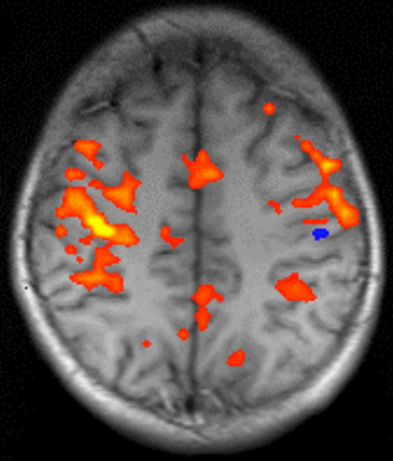
Imagined Complex Right



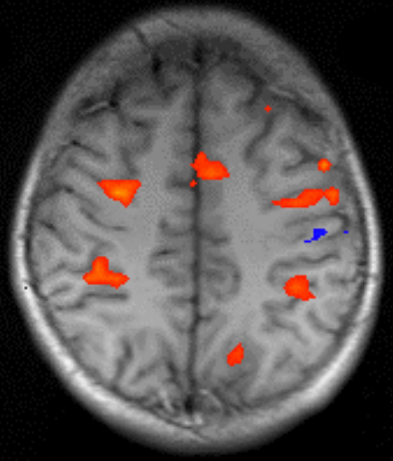
Simple Left

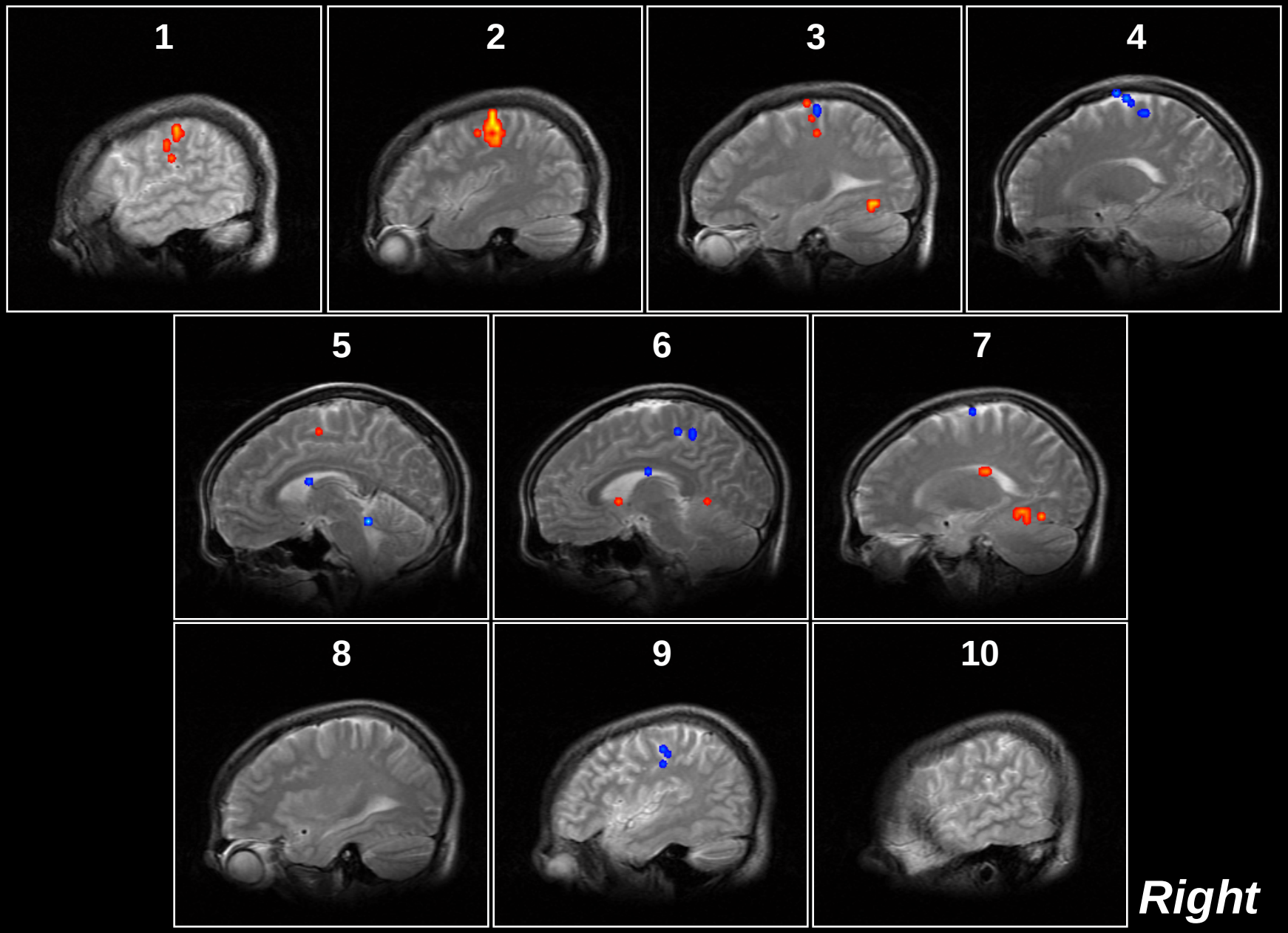


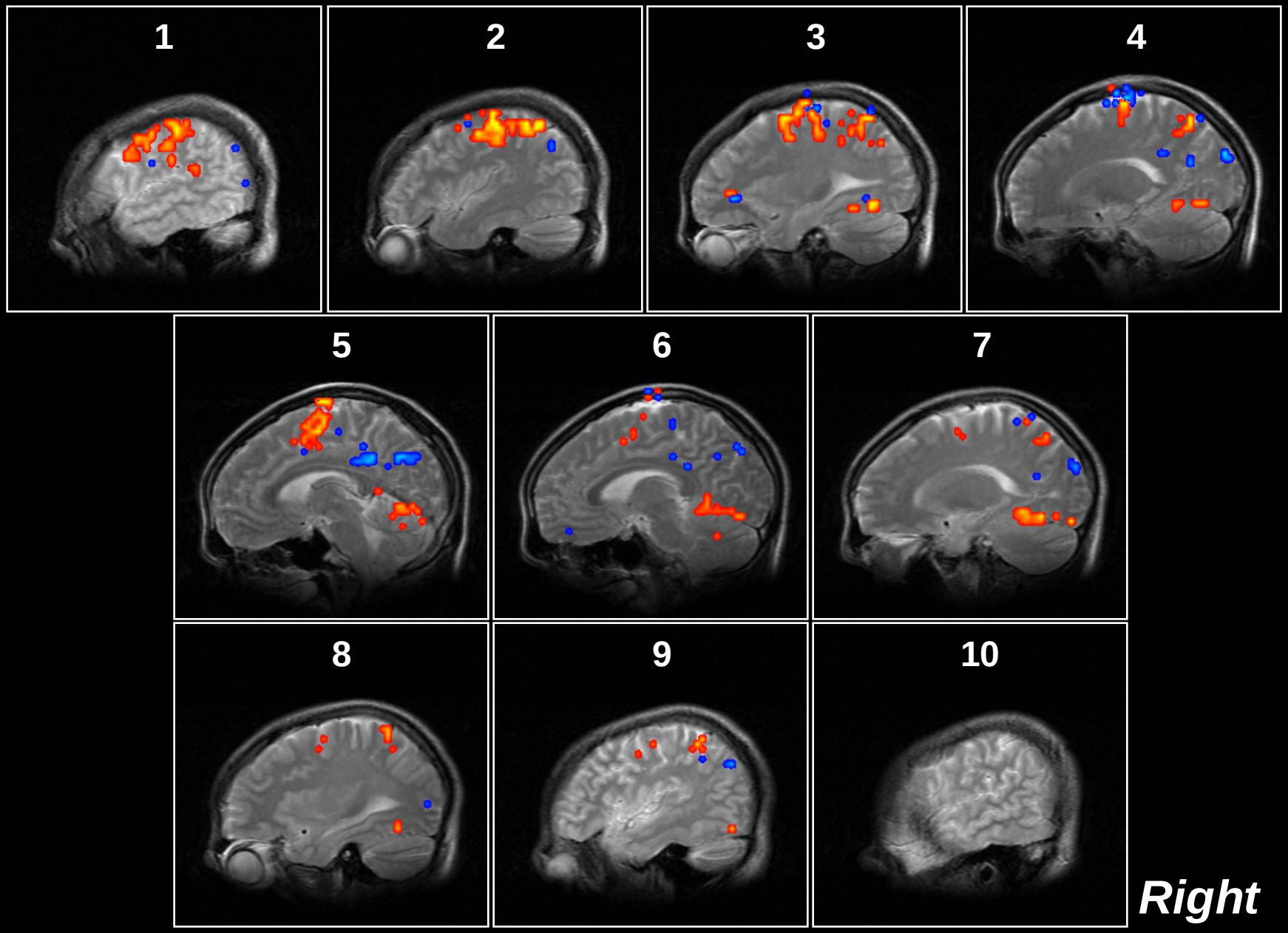
Complex Left

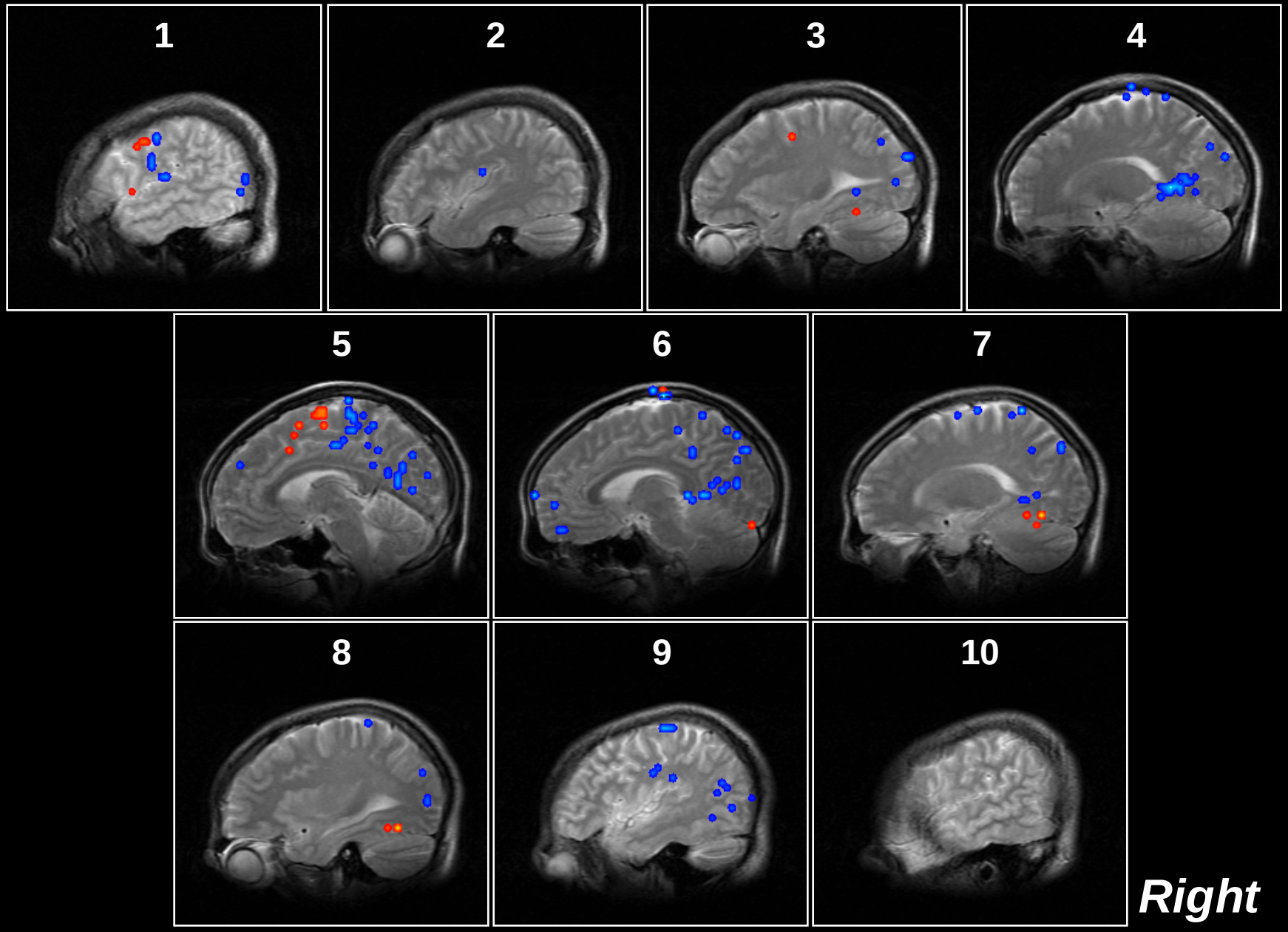


Imagined Complex Left

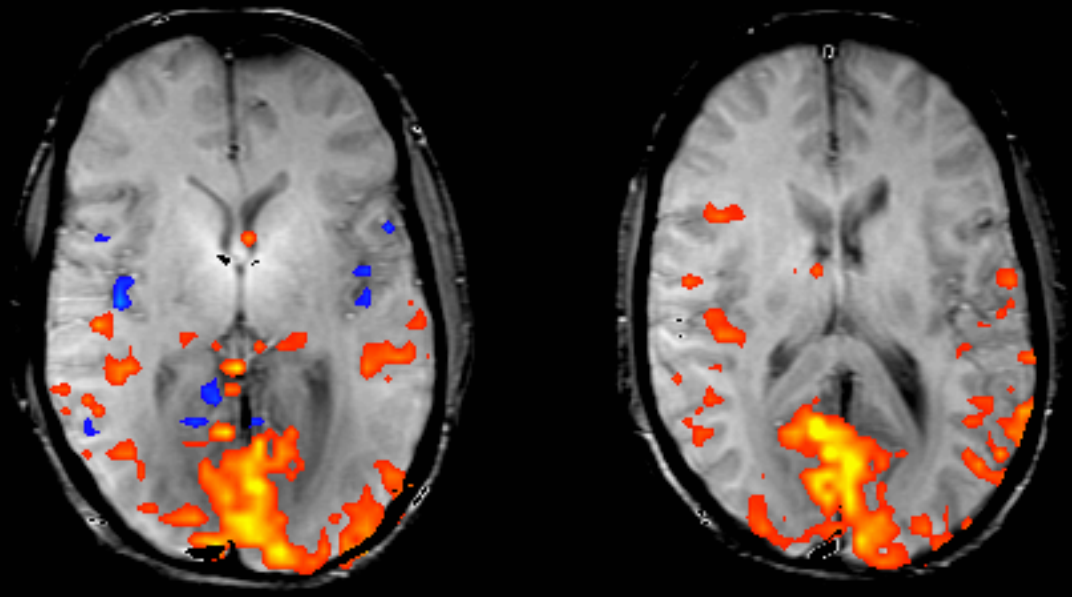



Left
Simple Finger Movement on the RIght Hand
1
2
3
4
5
6
7
8
9
10
Right

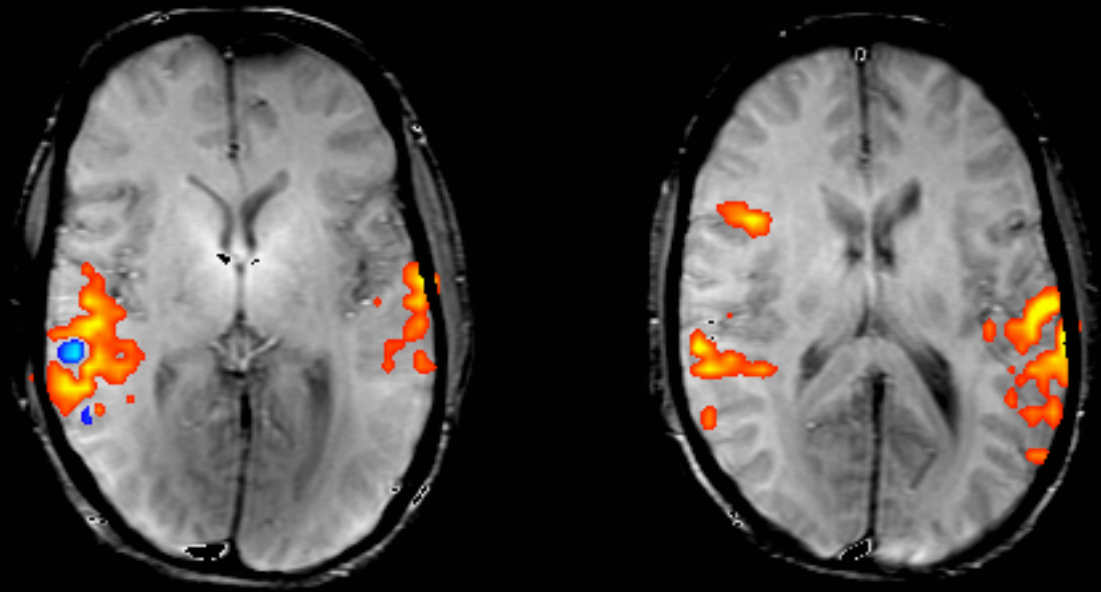

Left
Complex Finger Movement on the Right Hand
1
2
3
4
5
6
7
8
9
10
Right


Left
Imagined Complex Finger Movement on the Right Hand
1
2
3
4
5
6
7
8
9
10
Right

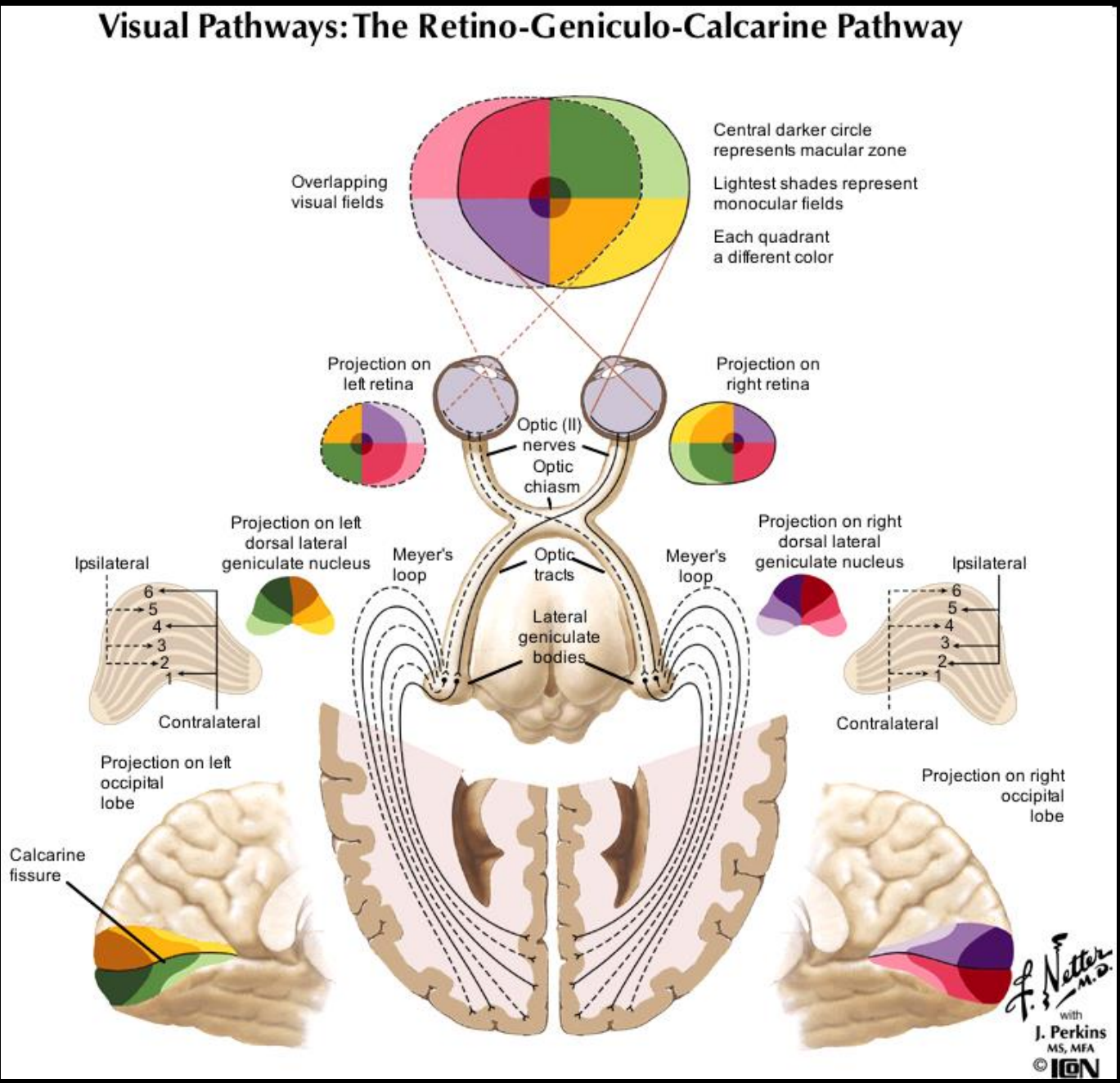
Reading

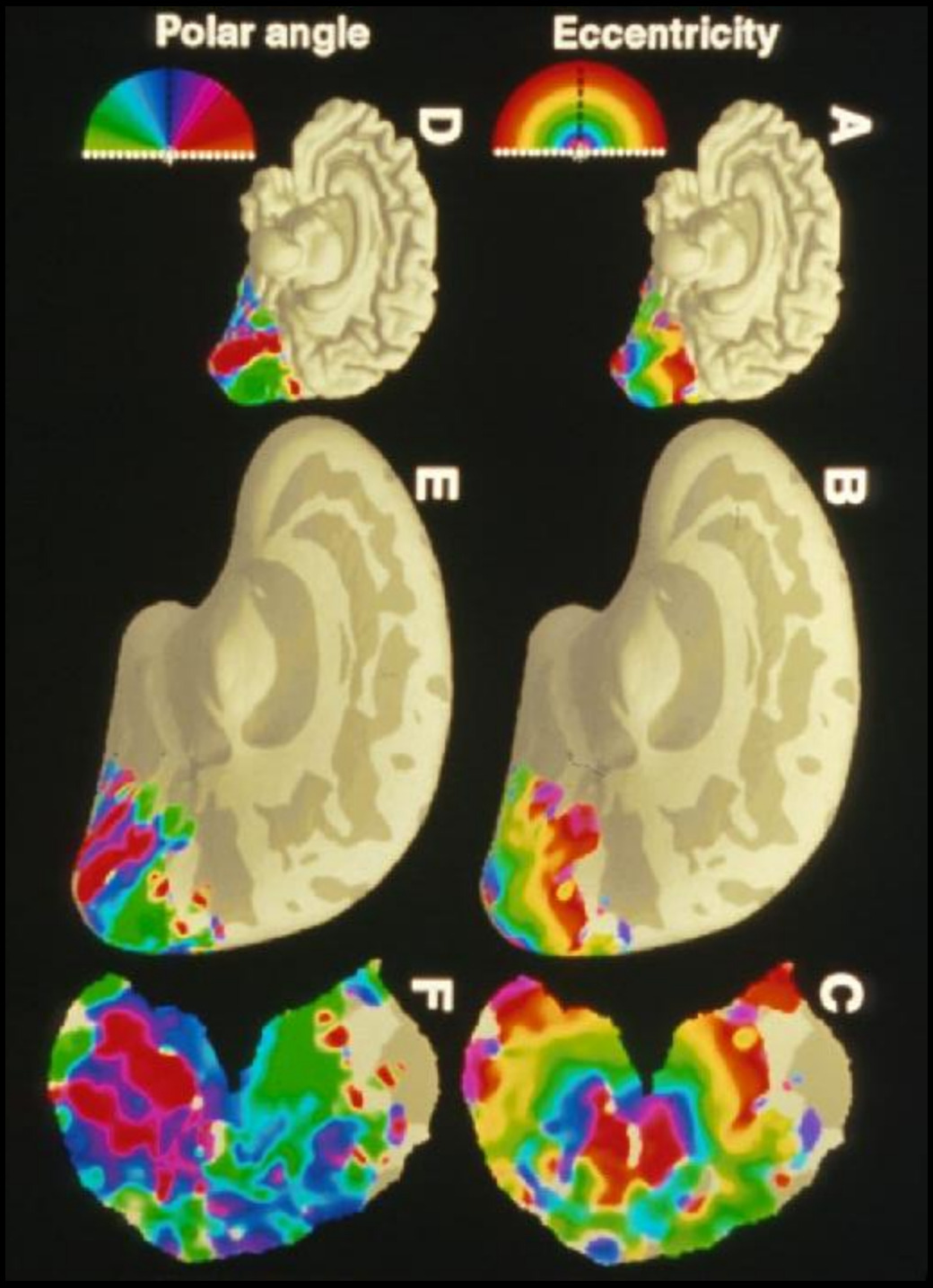


Listening

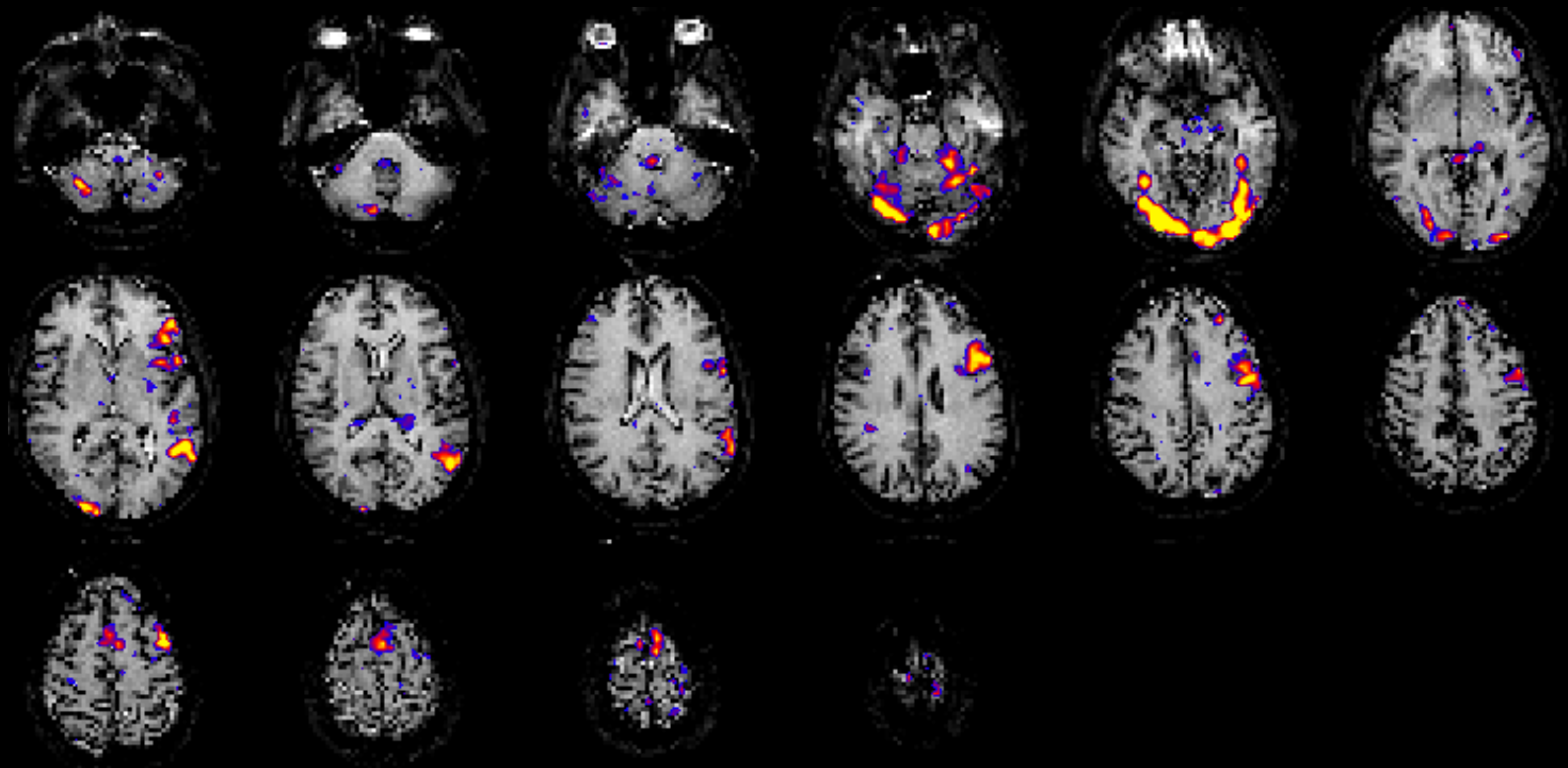


Visual Pathways: The Retino-Geniculo-Calcarine Pathway



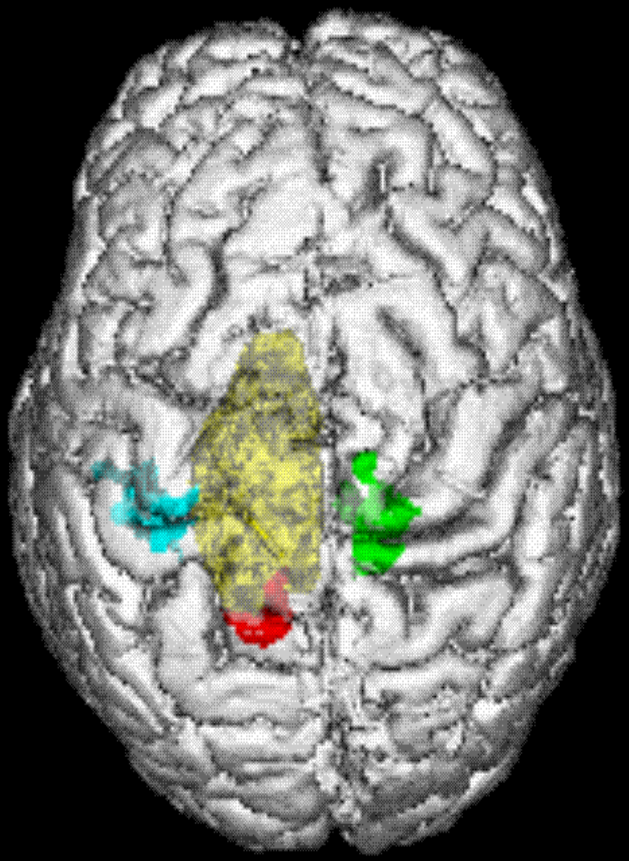

Polar angle
Eccentricity
D
A
E
B
F
C

Word stem completion

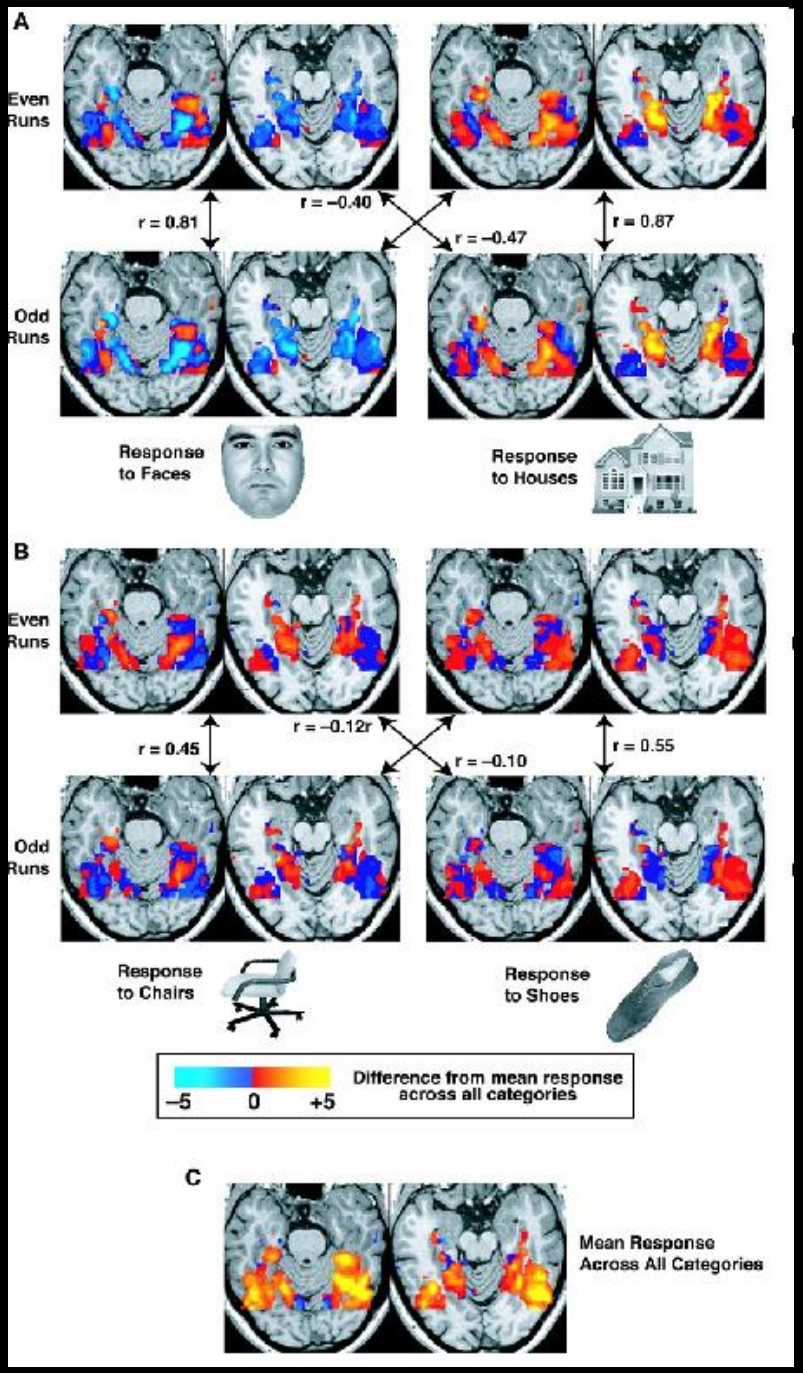


Presurgical Mapping

Left Foot Tumor Right Foot Right Hand



fMRI



Haxby et al (2001)

Neuron, Vol. 35, 975–987, August 29, 2002, Copyright ©2002 by Cell Press

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

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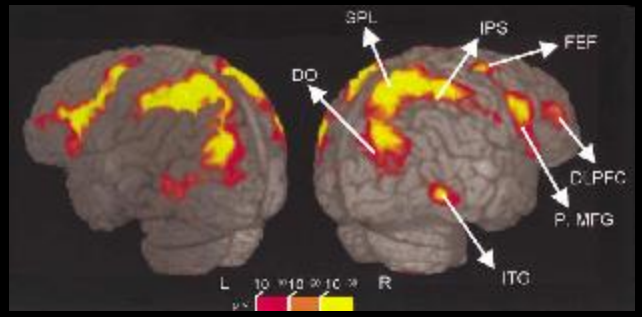
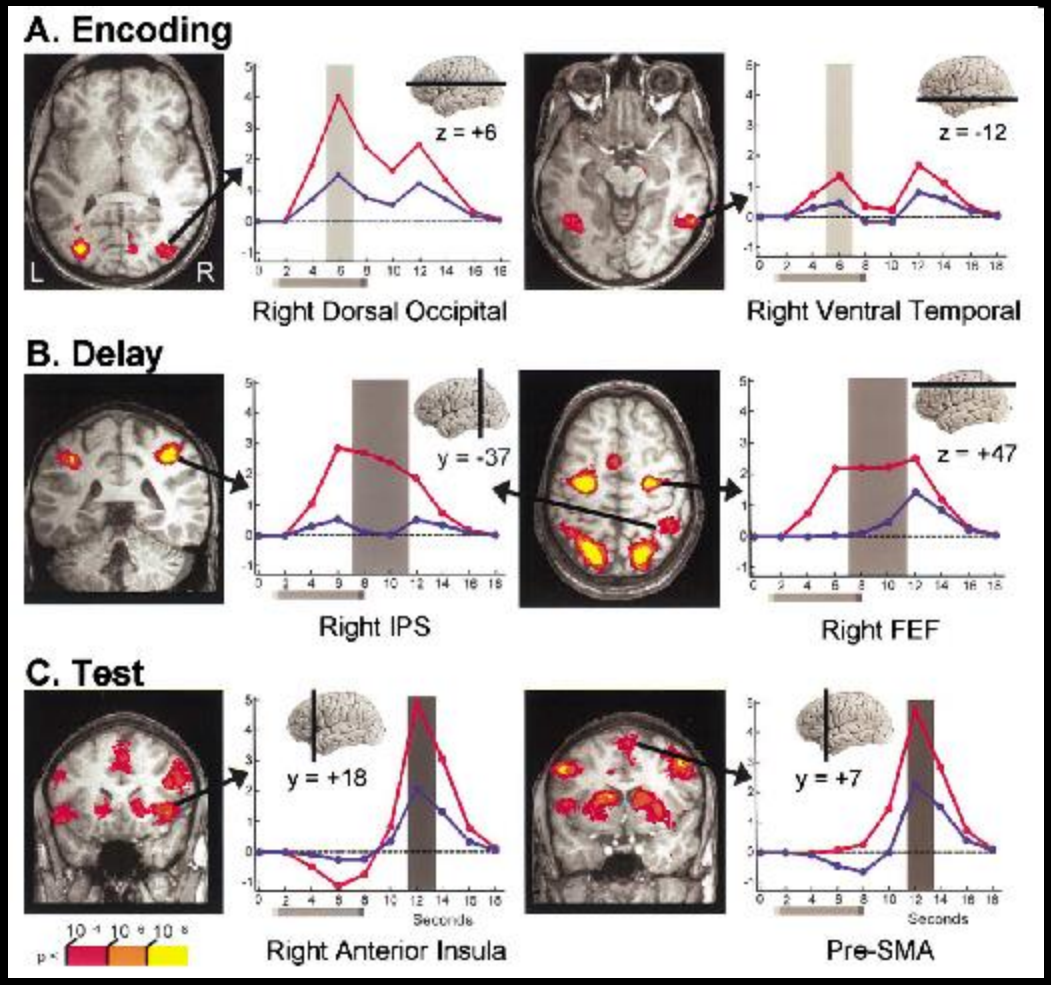




◆ Human Brain Mapping 15:157–164(2002) ◆
DOI 10.1002/hbm.10020

Lie Detection by Functional Magnetic Resonance Imaging

Tatia M.C. Lee,[1*] Ho-Ling Liu,[2] Li-Hai Tan,[3] Chetwyn C.H. Chan,[4]
Srikanth Mahankali,[5] Ching-Mei Feng,[5] Jinwen Hou,[5]
Peter T. Fox,[5] and Jia-Hong Gao[5]

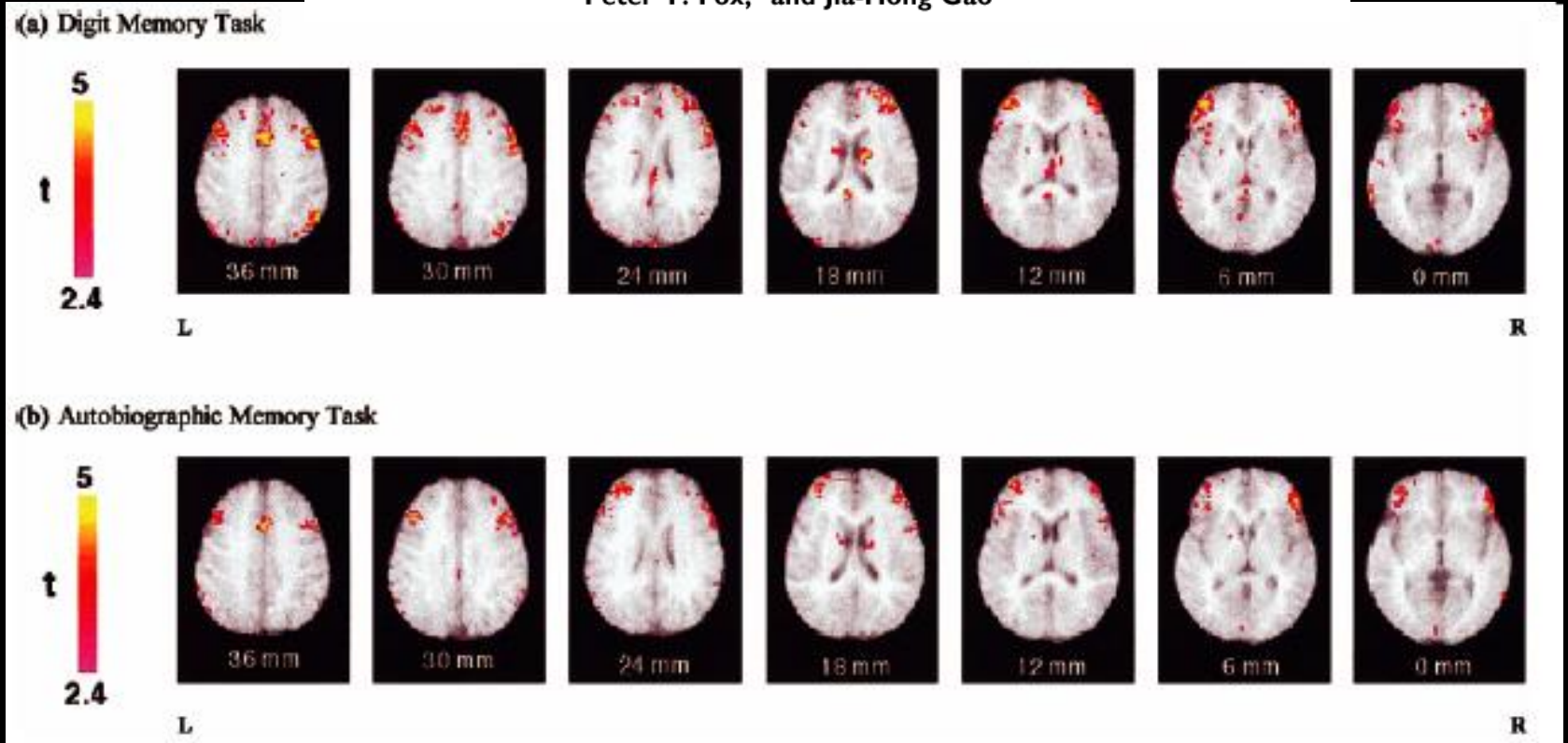
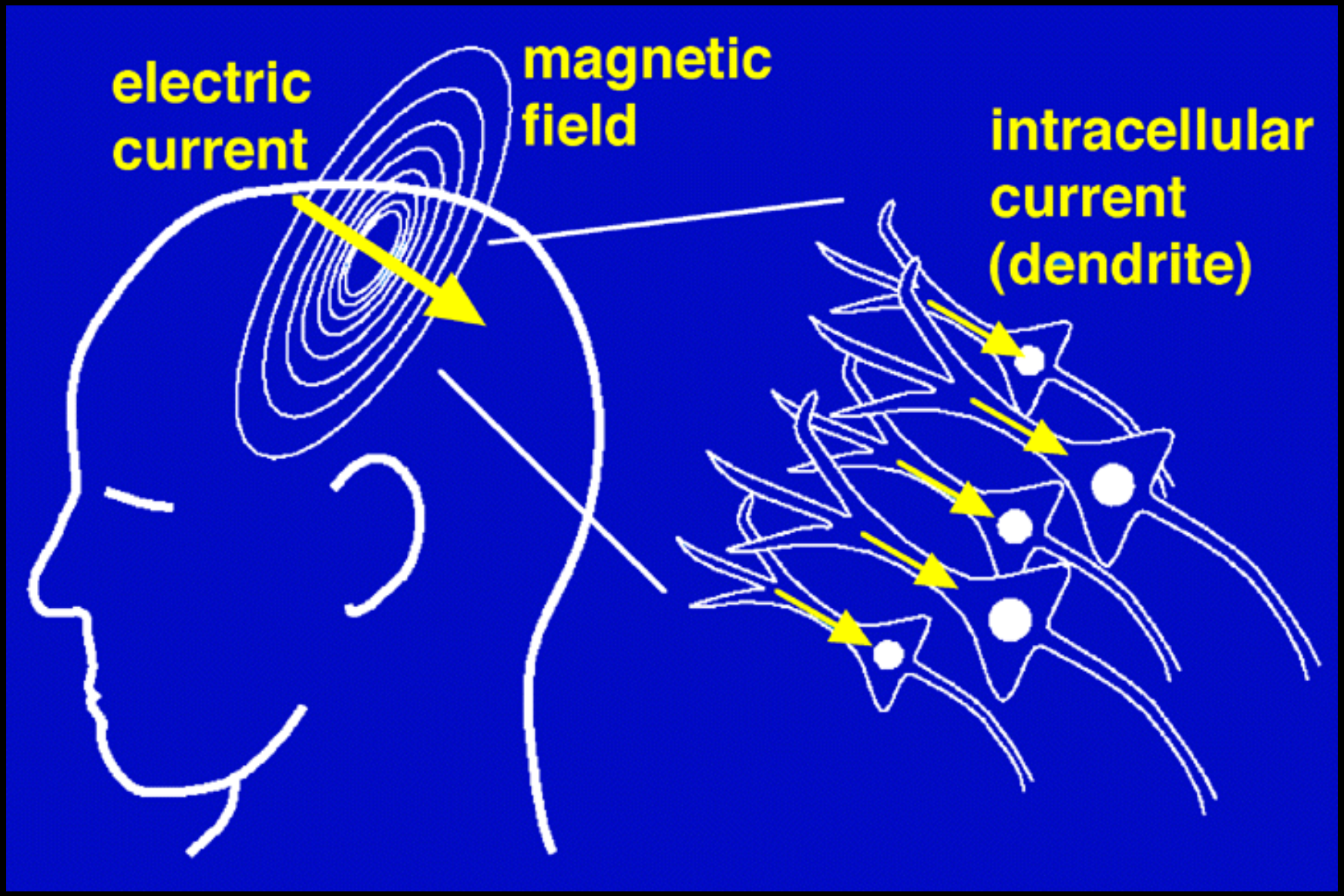
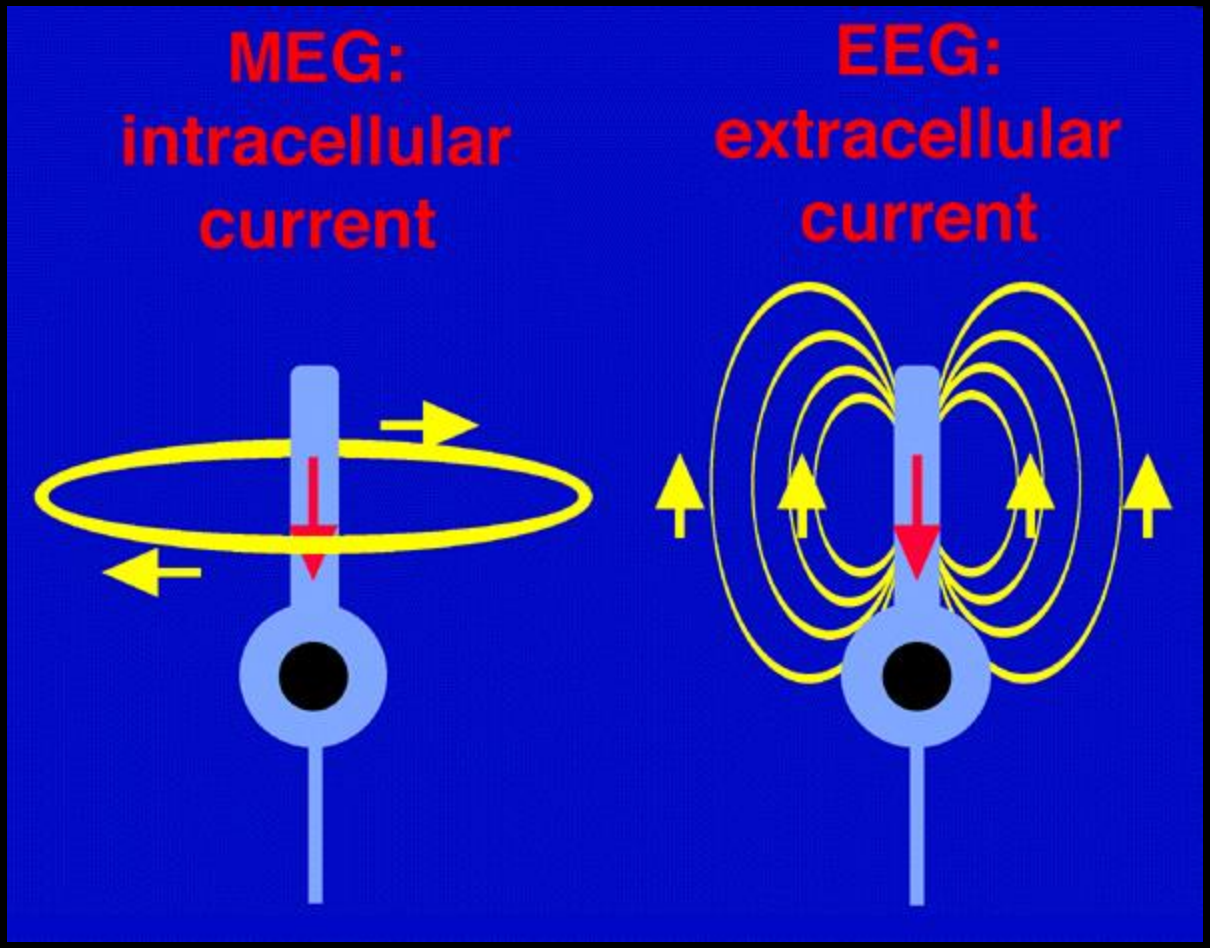


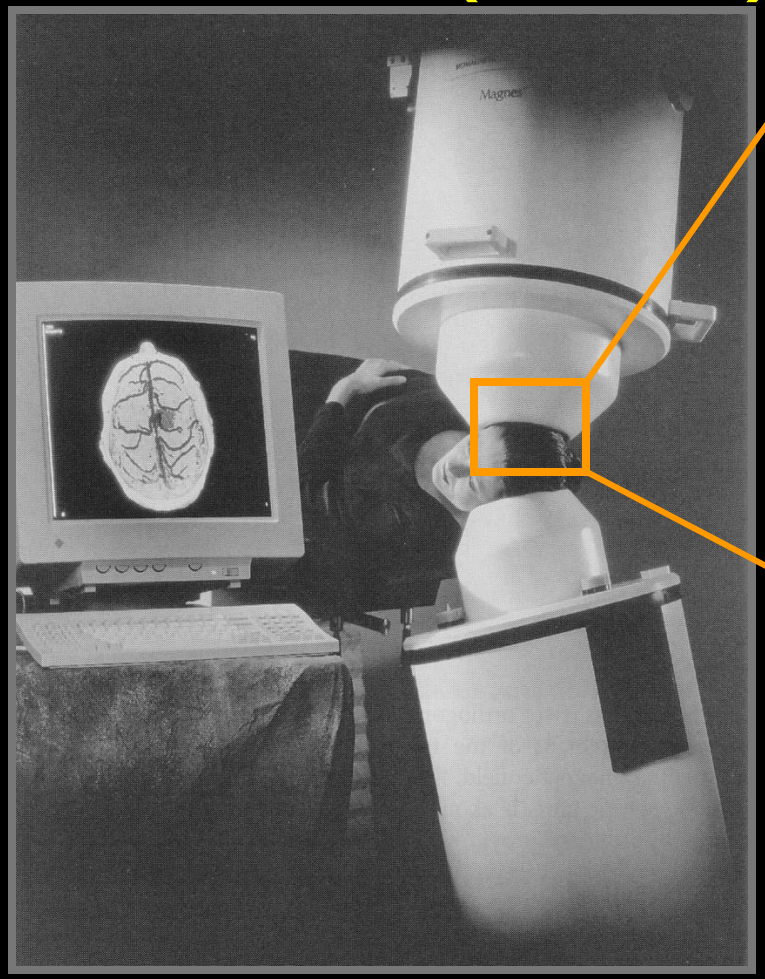
Figure 1.

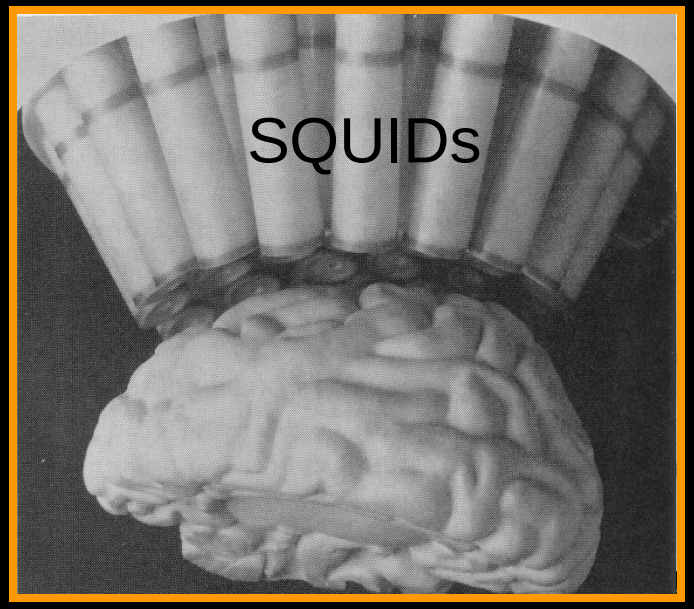
Functional maps. Normalized activation brain maps averaged across five subjects demonstrating the statistically significant activations ($P < 0.01$) in the faking memory impairment condition with the activation for making accurate recall removed when performing on forced choice testing using (**a**) Digit Memory and (**b**) Autobiographic Memory tasks. Planes are axial sections, labeled with the height (mm) relative to the bicommissural line. L, left hemisphere; R, right hemisphere.


electric
current
magnetic
field
intracellular
current
(dendrite)

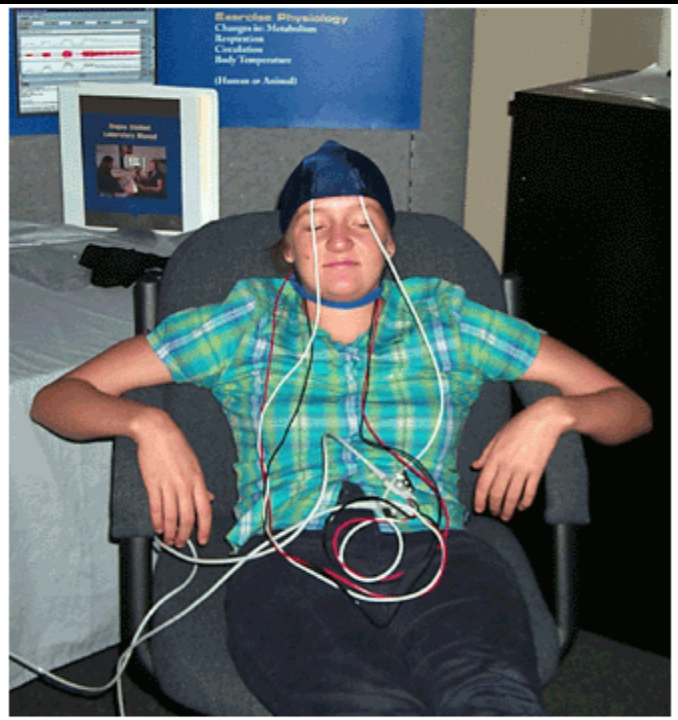

MEG:
intracellular
current
EEG:
extracellular
current

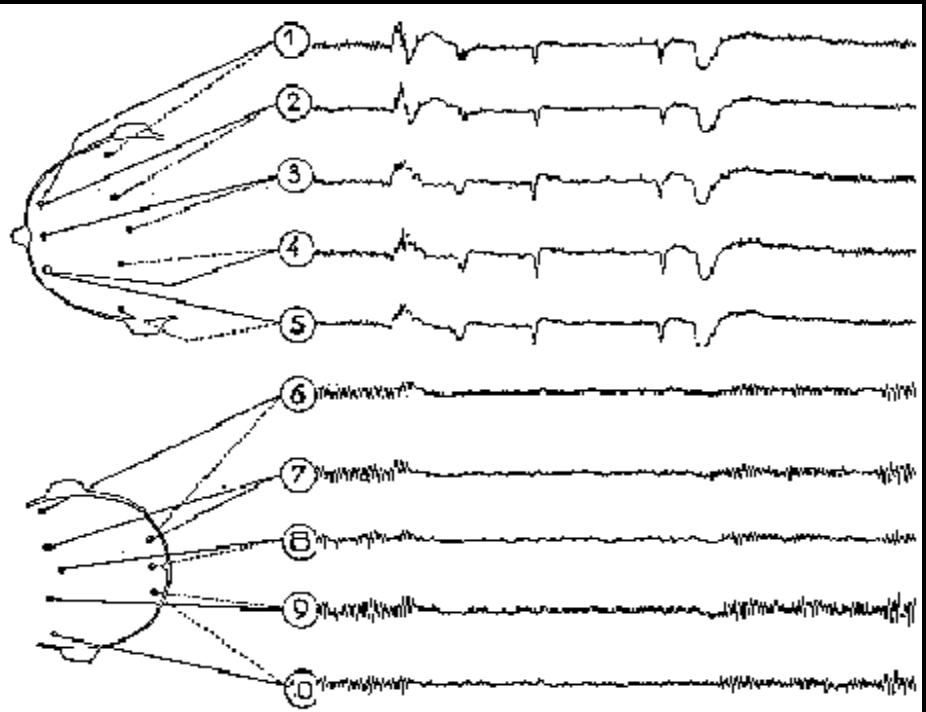
Magnetoencephalography (MEG)



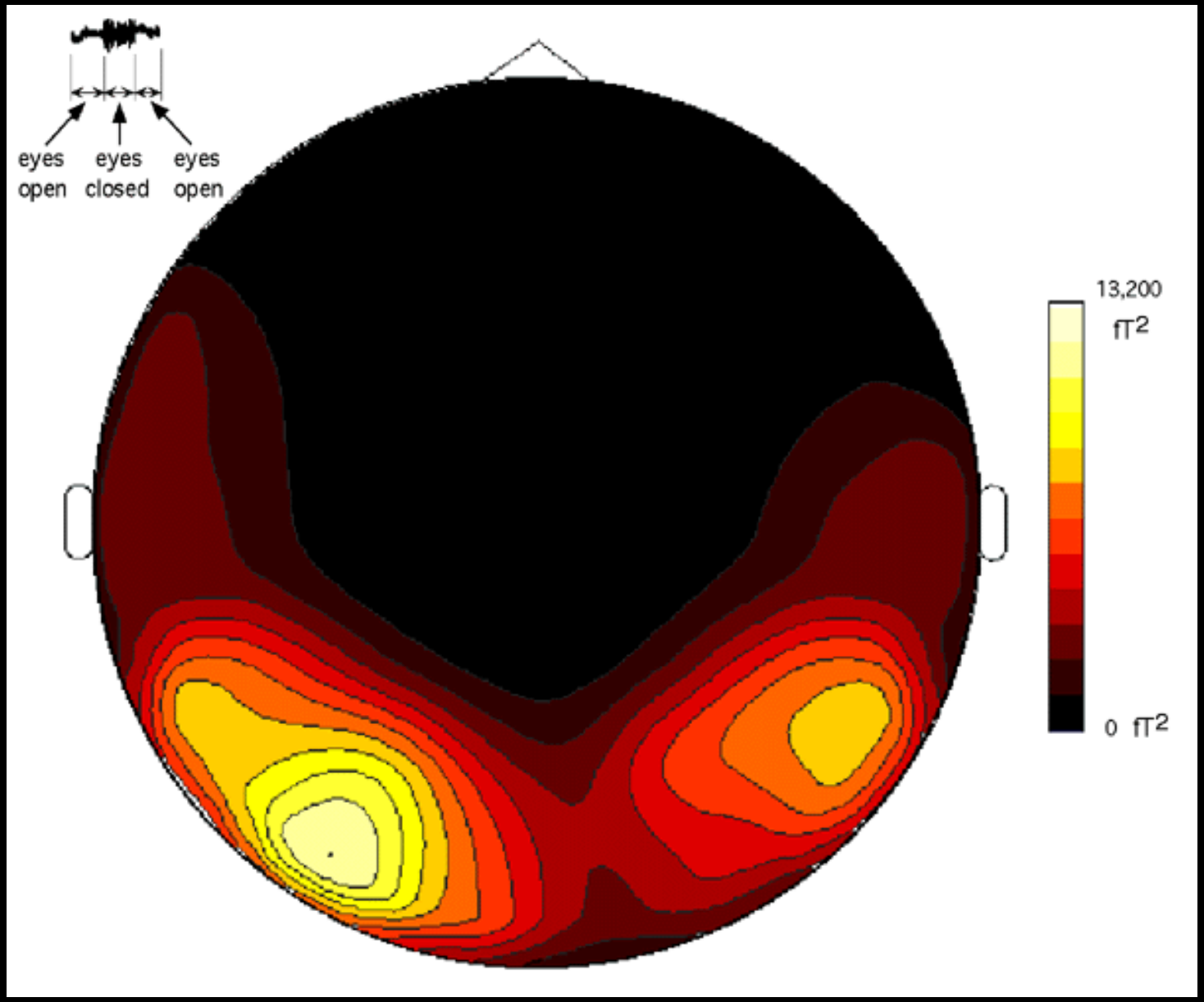


SQUID:
Superconducting Quantum Interference Device

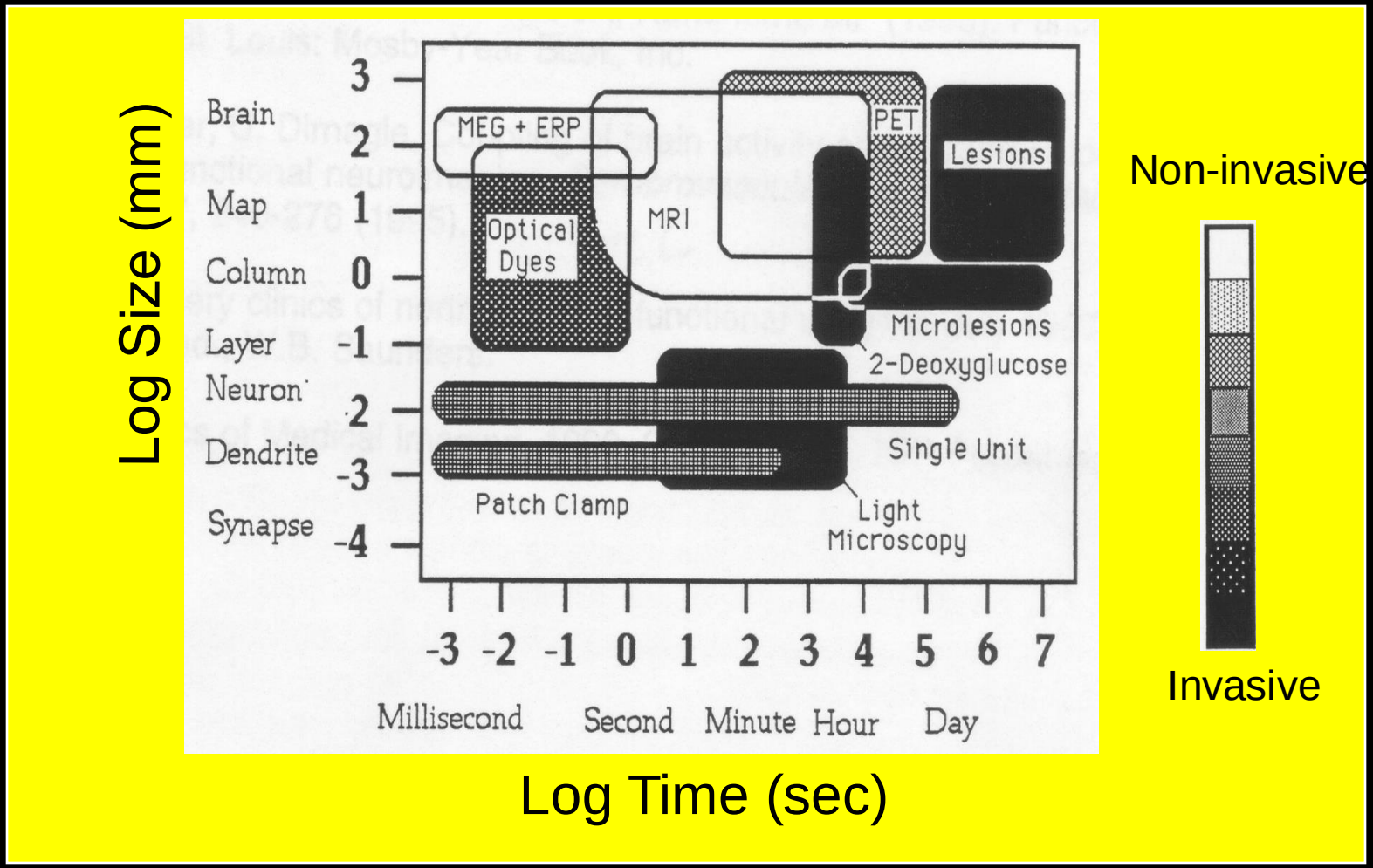

Exercise Physiology
Changes in Metabolism
Respiration
Circulation
Body Temperature
(Human or Animal)


1
2
3
4
5
6
7
8
9
0

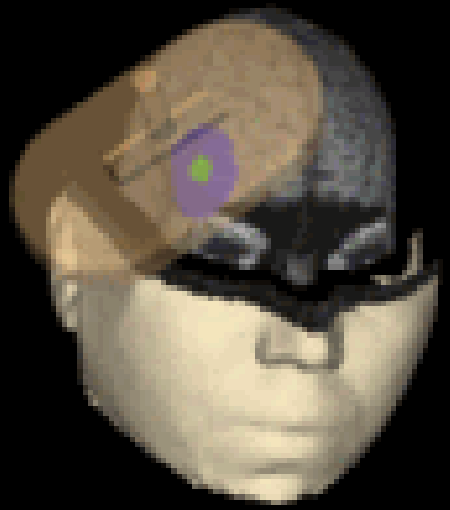
Alpha Wave Activity Mapped with MEG

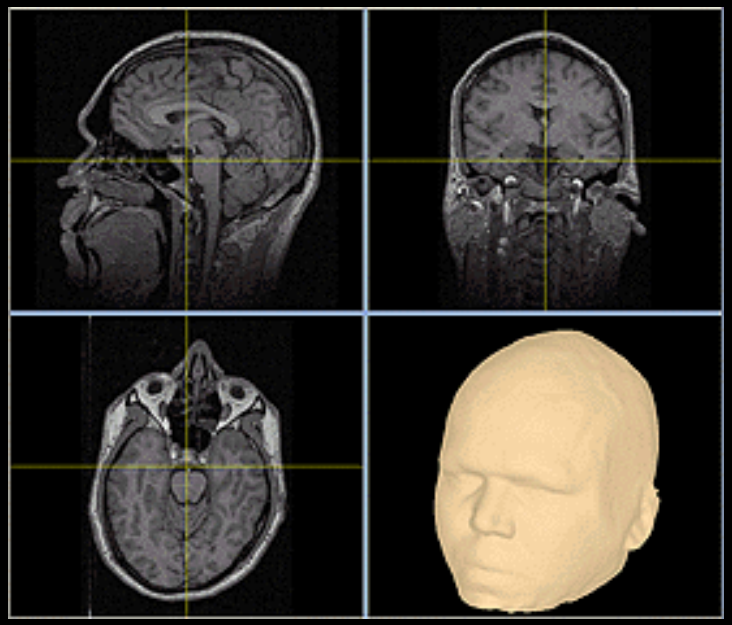


Functional Neuroimaging Techniques



Transcranial Magnetic Stimulation





Transcranial Magnetic Stimulation (TMS)

Section on Functional Imaging Methods & Functional MRI Facility Jan 19, 2007

Back row: Wenming Luh, Niko Kriegeskorte, Rasmus Birn, Tyler Jones, Sean Marrett
Middle row: Jon West, Kay Kuhns, Anthony Boemio, Peter Bandettini, Joey Dunsmoor, Doug Ruff, Kevin Murphy
Front row: Dorian Van Tassel, Jerzy Bodurka, Adam Thomas, Marieke Mur, David Knight