Functional MRI at the NIH

Peter A. Bandettini, Ph.D.

Section on Functional Imaging Methods

http://fim.nimh.nih.gov

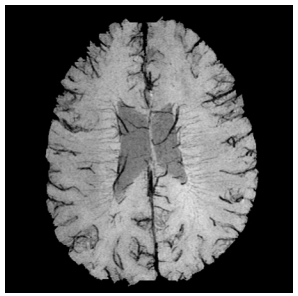
Laboratory of Brain and Cognition

&

Functional MRI Facility

http://fmrif.nimh.nih.gov

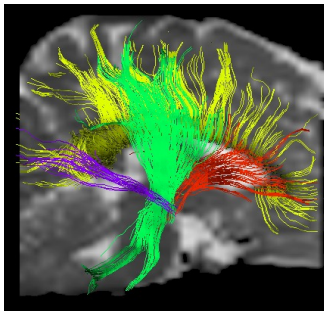
Venography



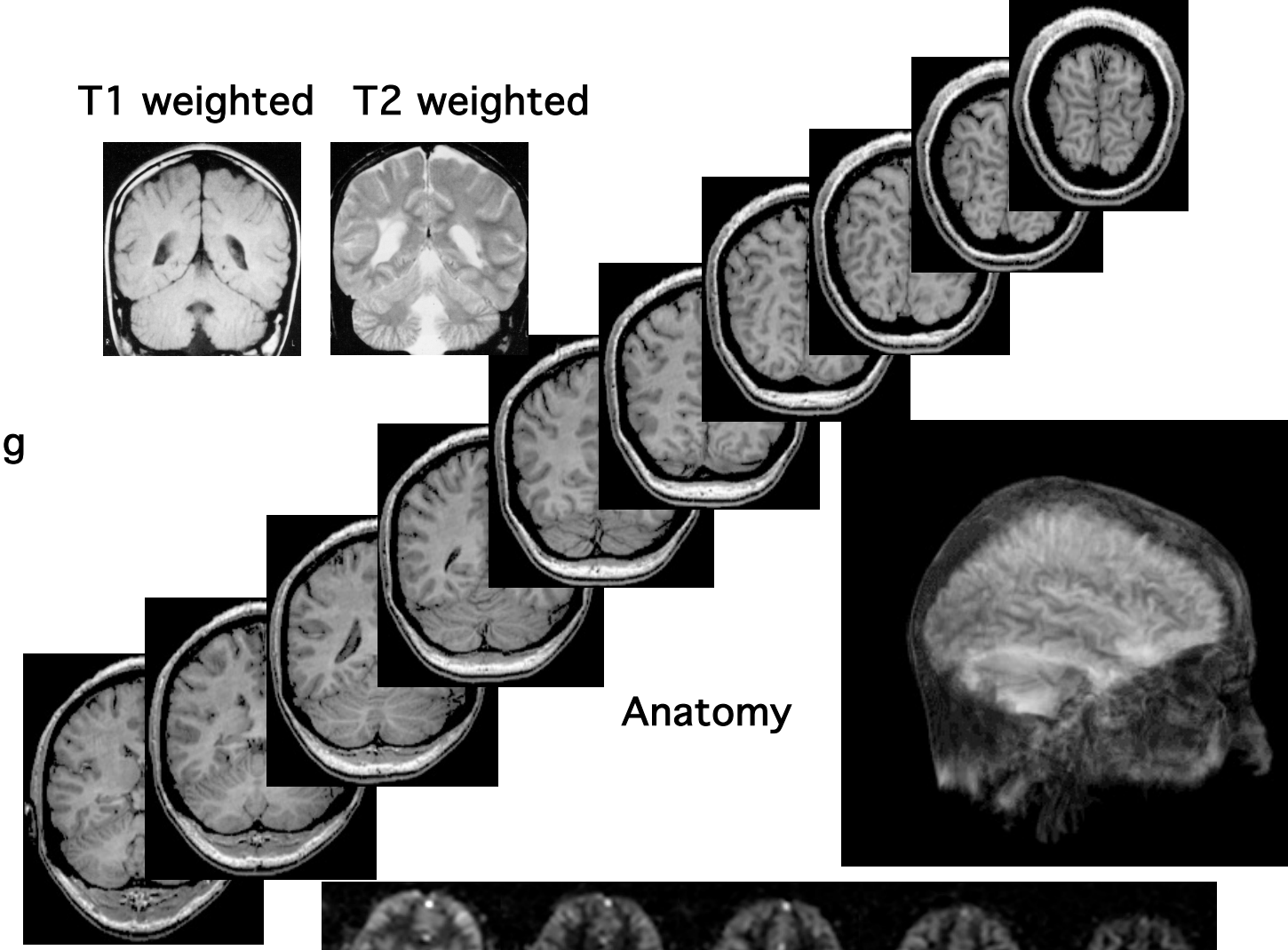
T1 weighted

T2 weighted

Fiber Track Imaging

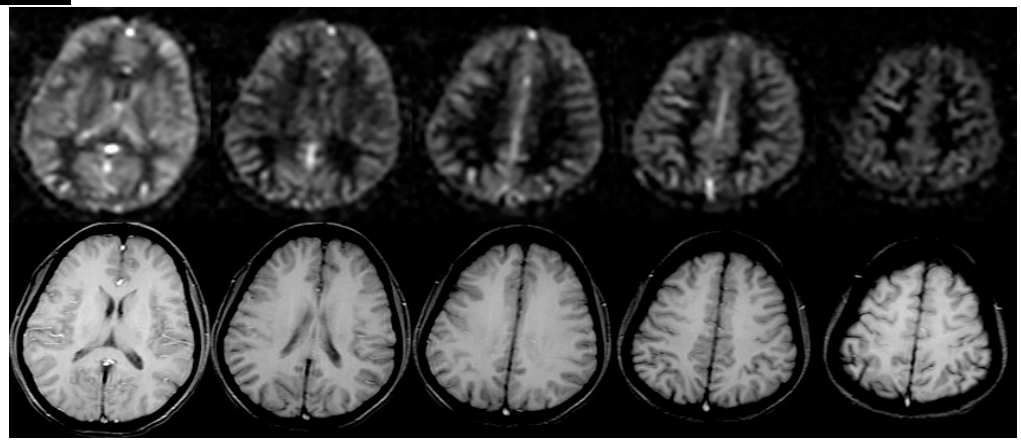


Anatomy



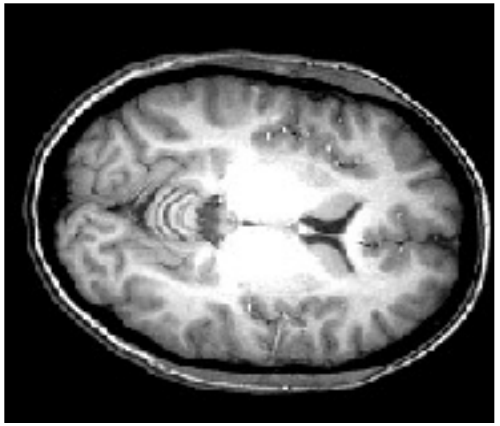
Angiography

Perfusion



MRI vs. fMRI

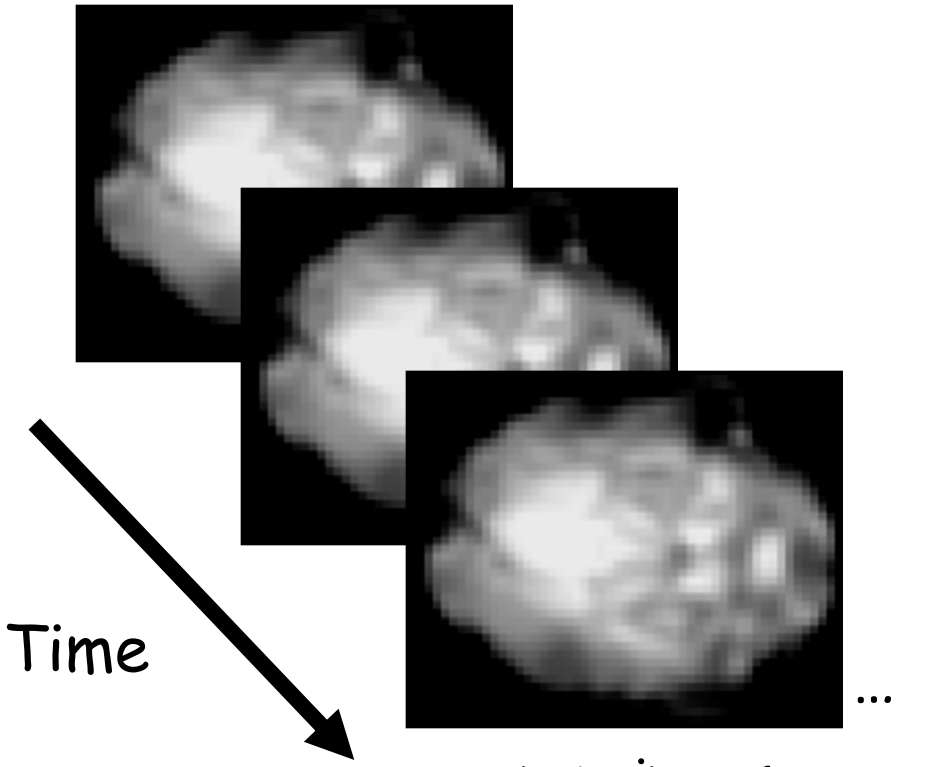
MRI



one image

high resolution
(1 mm or less)

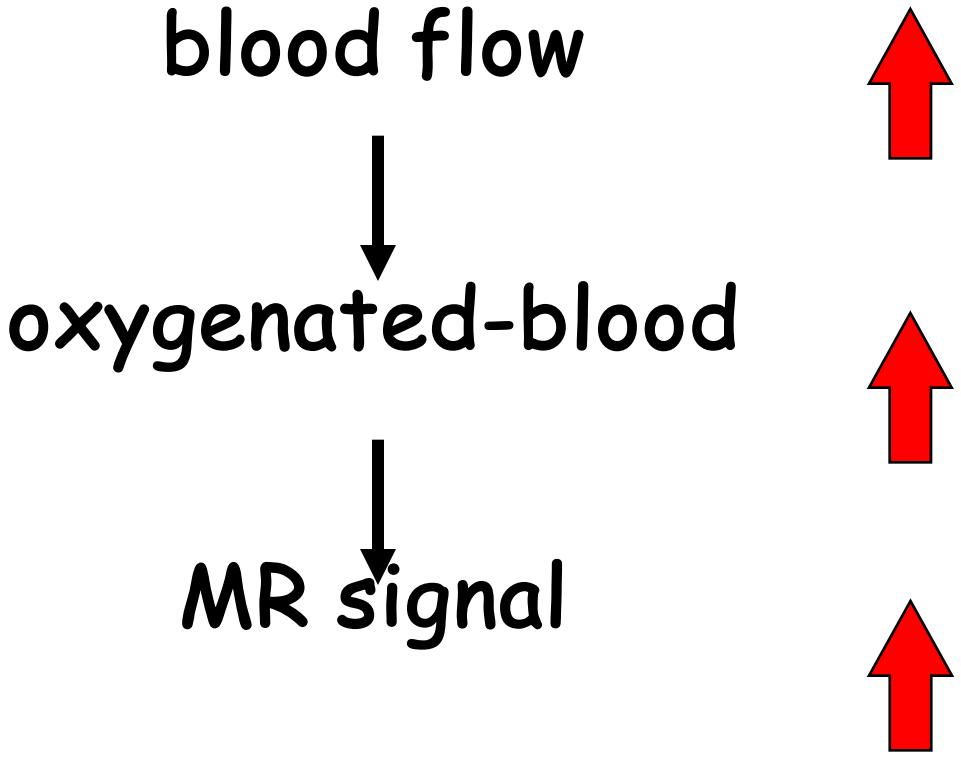
fMRI



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

low resolution
(1.5 to 4 mm)

BOLD (Blood Oxygen Level Dependent) Contrast

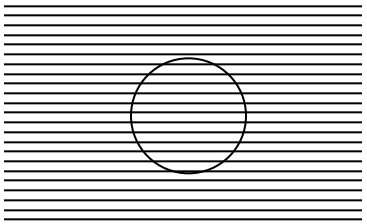


Basis of BOLD Contrast

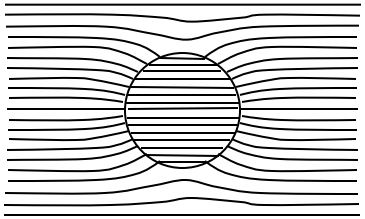
Oxygenated and deoxygenated red blood cells have different magnetic properties

red blood cells

oxygenated



deoxygenated

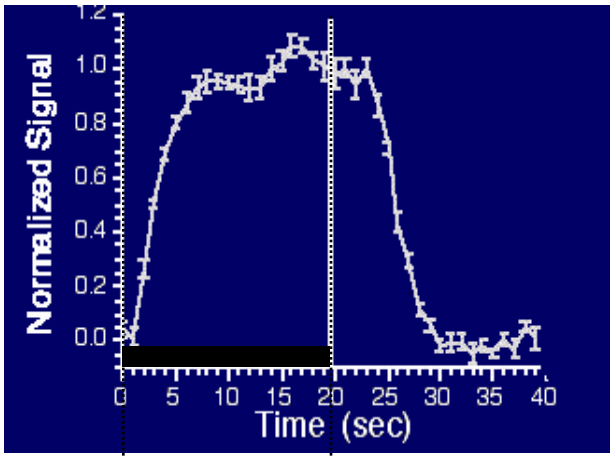


L. Pauling, C. D. Coryell, *Proc.Natl. Acad. Sci. USA 22, 210-216*, **1936**.

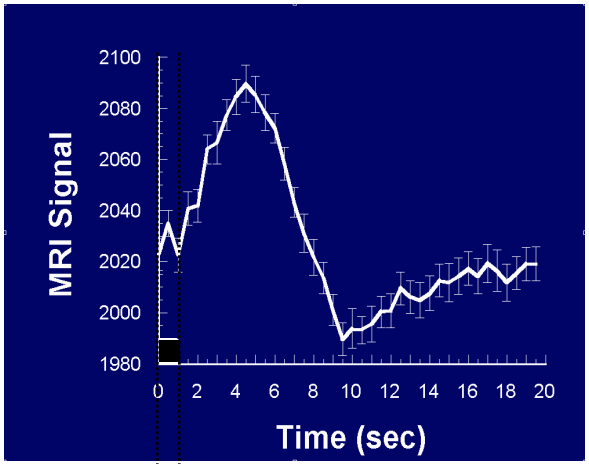
K.R. Thulborn, J. C. Waterton, et al., *Biochim. Biophys. Acta. 714: 265-270*, **1982**.

S. Ogawa, T. M. Lee, A. R. Kay, D. W. Tank, *Proc. Natl. Acad. Sci. USA 87, 9868-9872*, **1990**.

BOLD Contrast Imaging



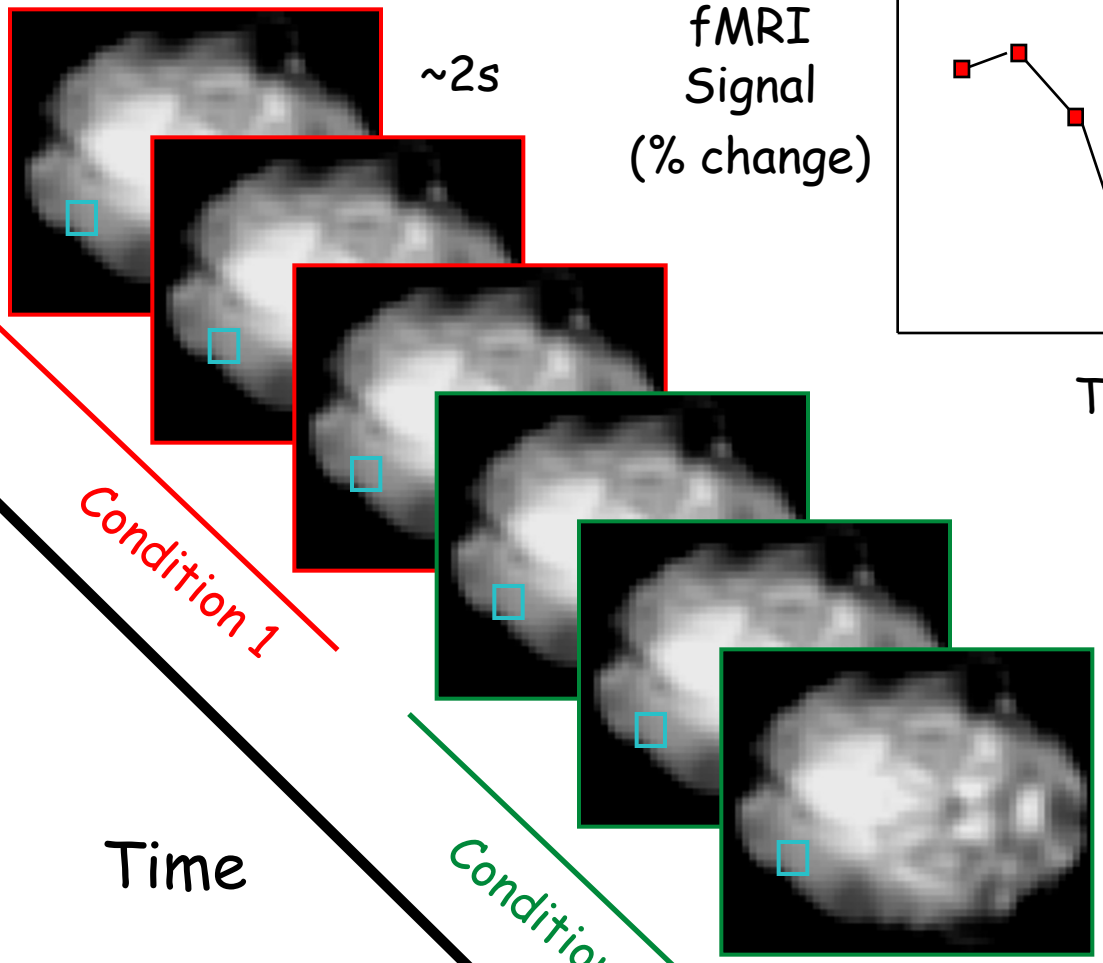
task



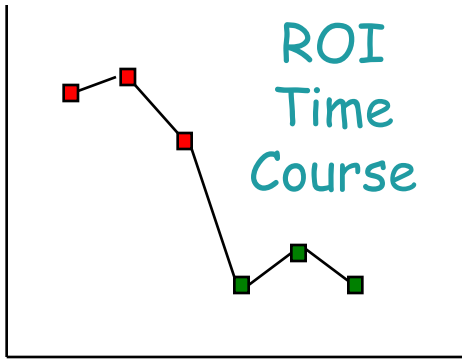
task

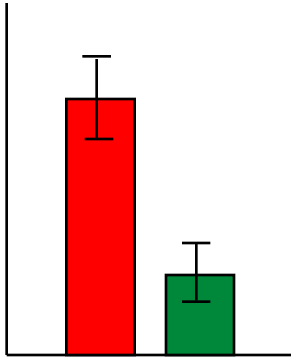
Activation Statistics

Functional images

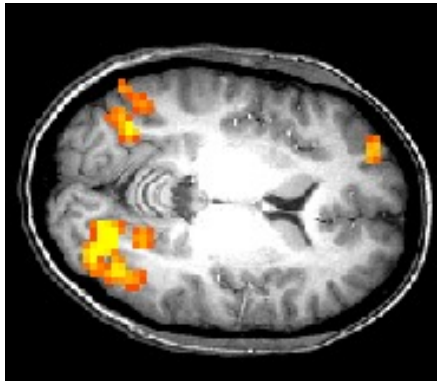


fMRI Signal (% change)

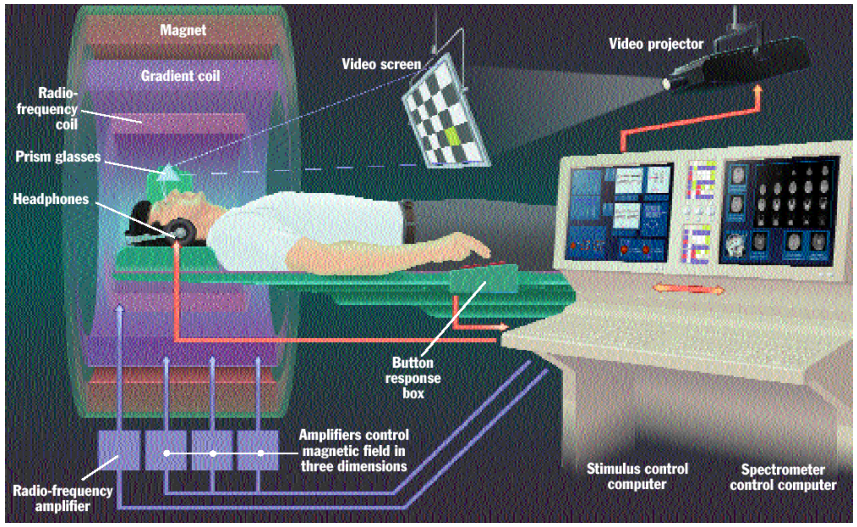


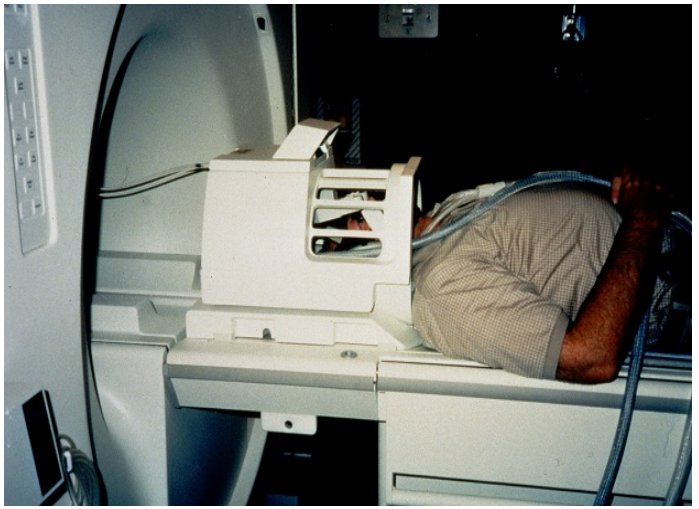


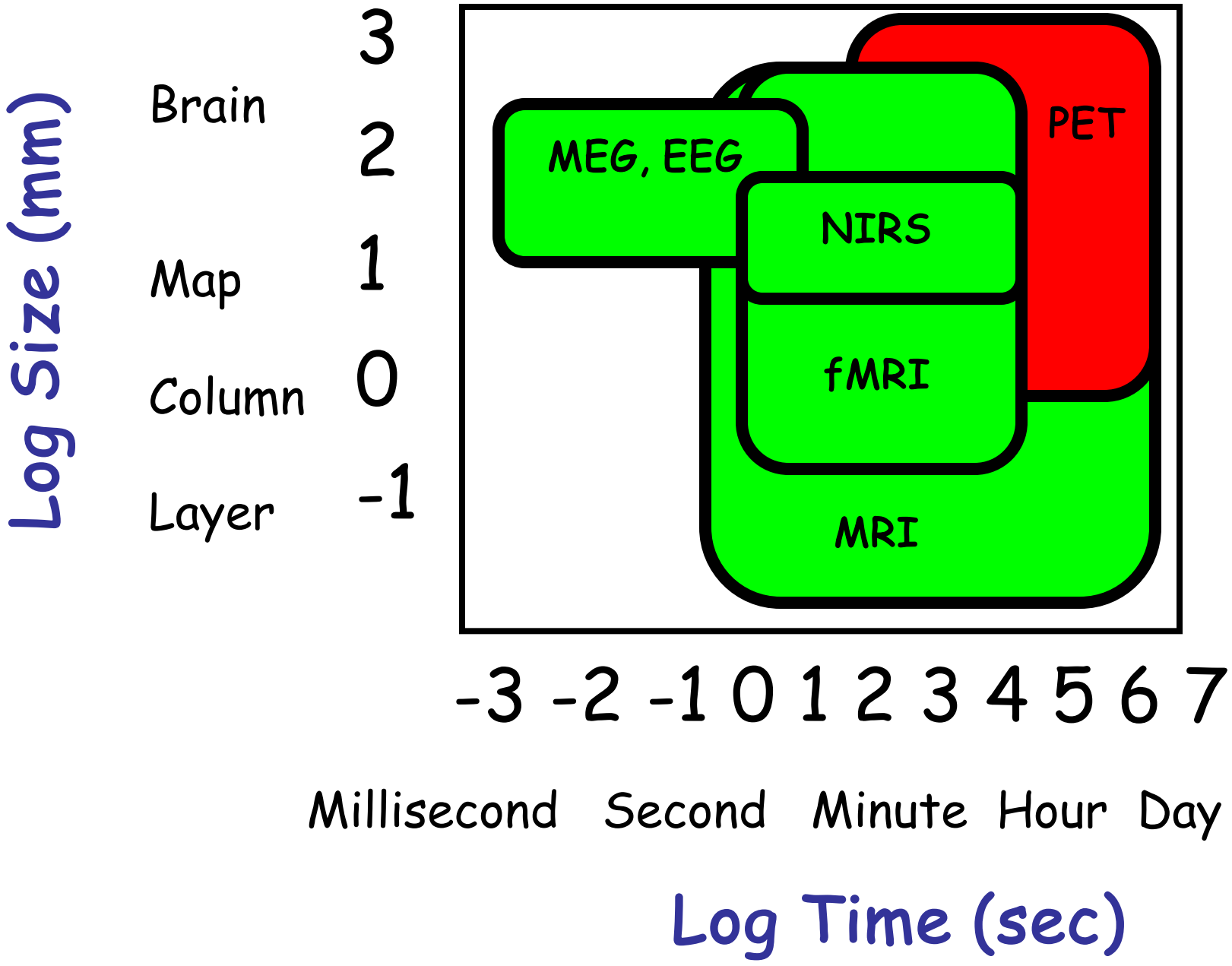
Statistical Map
superimposed on anatomical MRI image



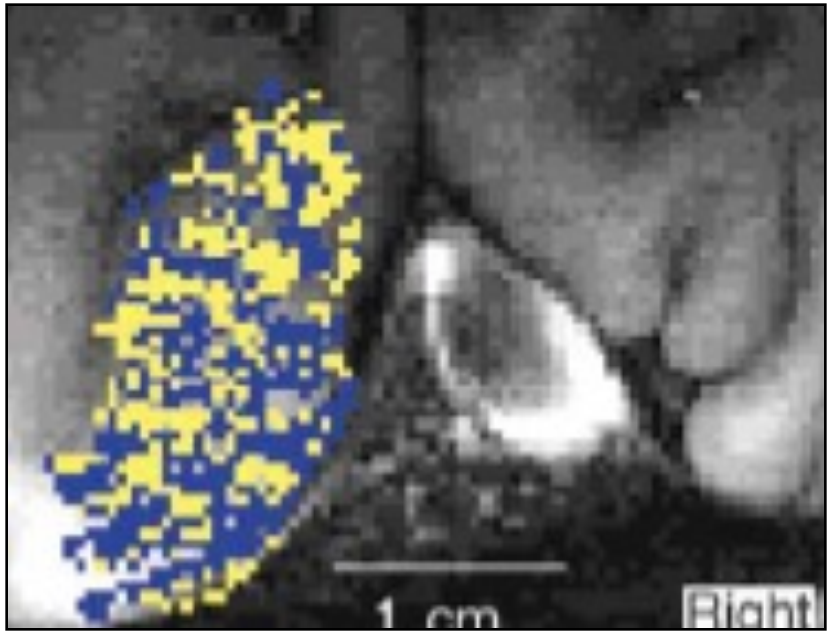
fMRI Setup


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



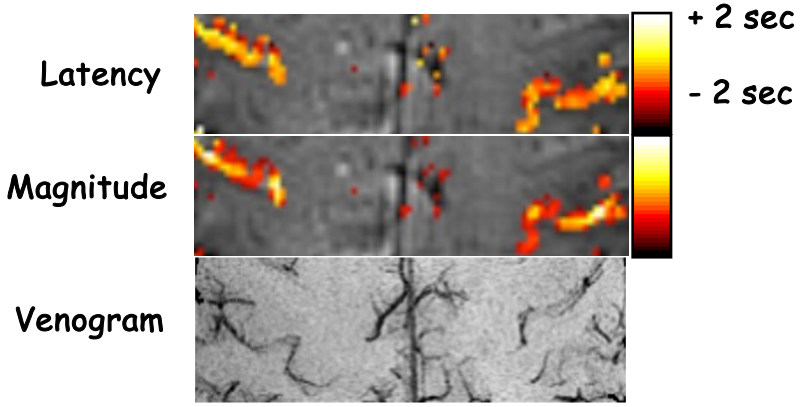

Log Size (mm)
Brain
Map
Column
Layer
3
2
1
0
-1
MEG, EEG
PET
NIRS
fMRI
MRI
-3 -2 -1 0 1 2 3 4 5 6 7
Millisecond
Second
Minute
Hour
Day
Log Time (sec)

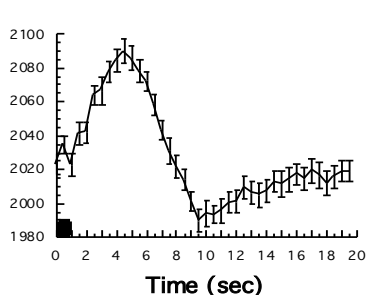
Spatial and Temporal Resolution

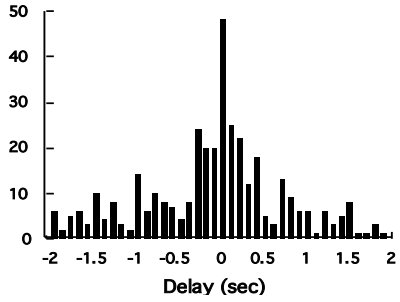


Cheng, et al. (2001) Neuron,32:359-374

Latency Variation…







P. A. Bandettini, (1999) "Functional MRI" 205-220.

Spatial

Temporal

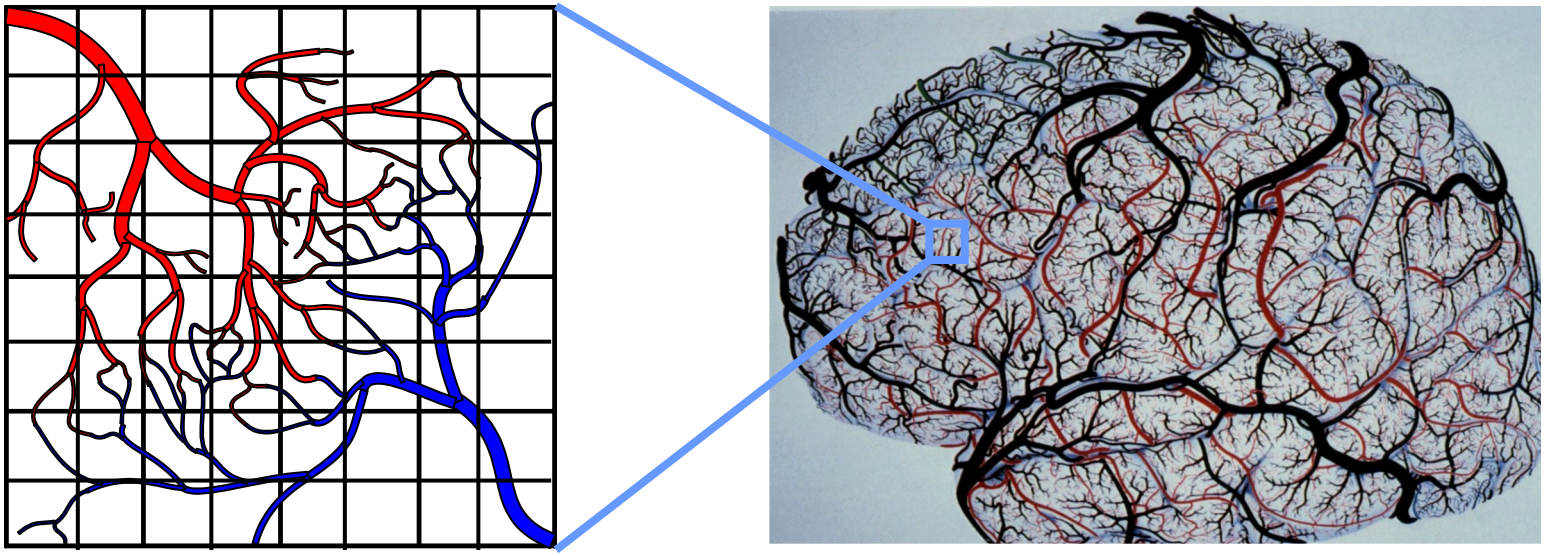
Interpretation

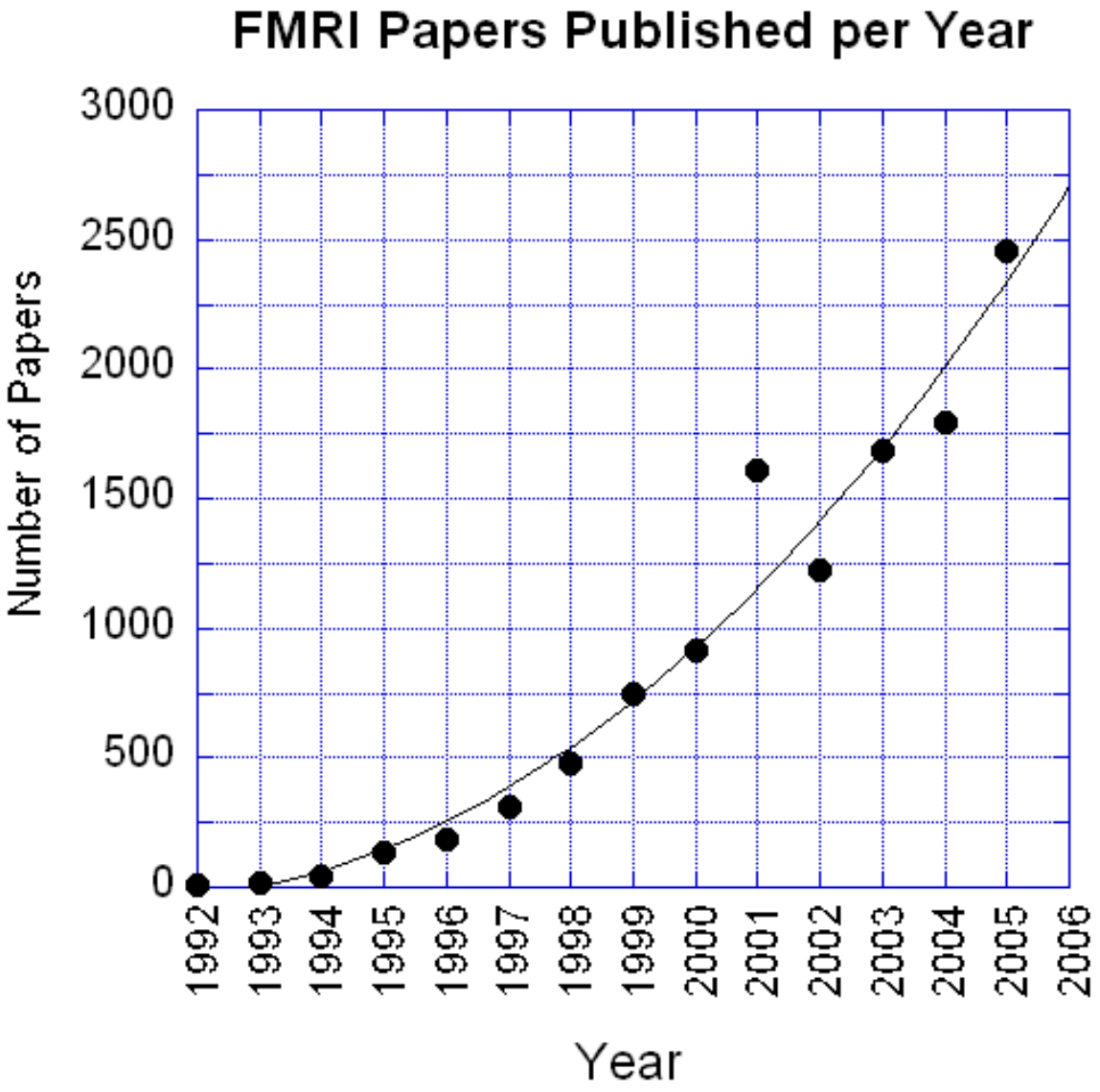
Neuronal Activation ? Measured Signal

? ? ? ?

Hemodynamics

Noise

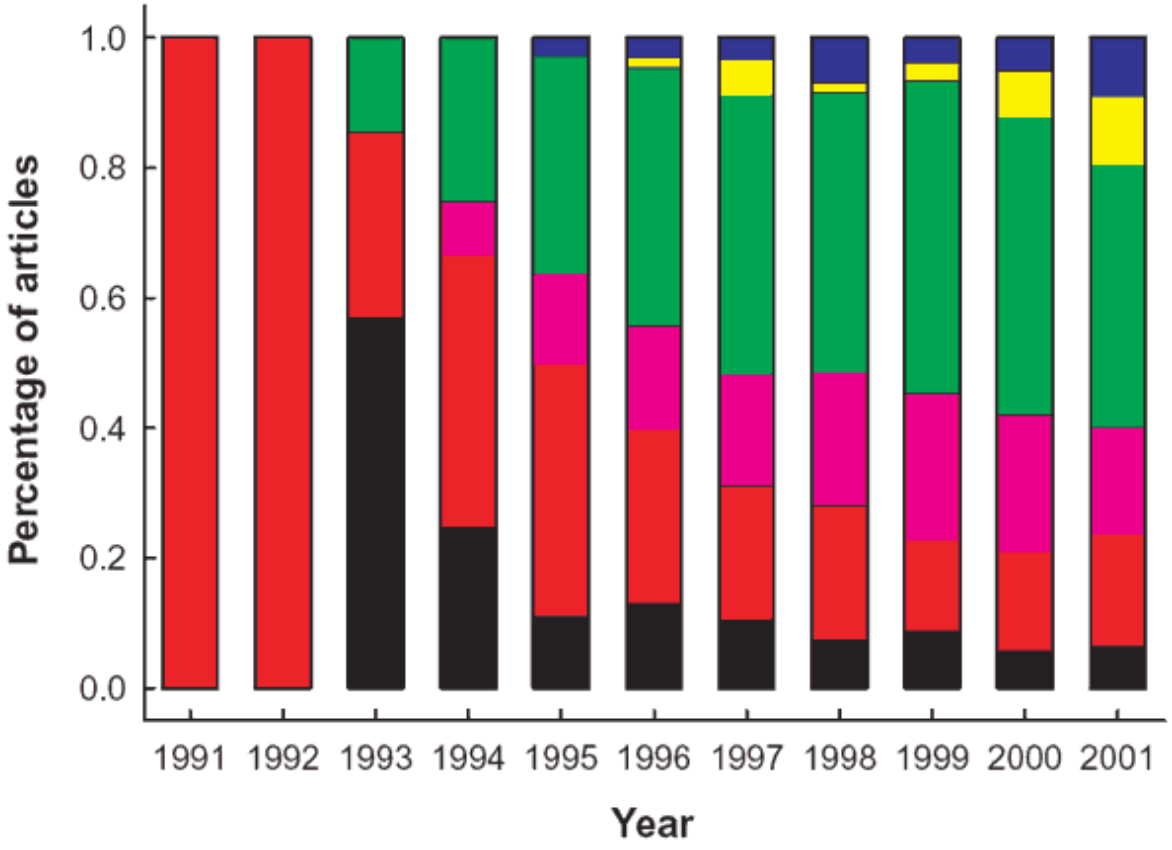




"fMRI" or "functional MRI"

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

Users

NIMH:
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James Blair, Ph.D.
Jay Giedd, M.D.
Christian Grillon, Ph.D.
Wayne Drevets, M.D.
Ellen Liebenluft, M.D.
Alex Martin, Ph.D
Husseini Manji, M.D.
Andreas Meyer-Lindenberg, M.D.
Mort Mishkin, Ph.D
Elizabeth Murray, Ph.D
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Judith Rapaport, M.D.
Jun Shen, Ph.D.
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Leslie Ungerleider, Ph.D.
Daniel Weinberger, M.D.

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Henry F. McFarland, M.D.
Edward Oldfield, M.D.
William Theodore, M.D.

NIAAA:
Daniel Hommer, M.D.

NICHD:
Peter Basser, Ph.D.
Allen Braun, M.D.

NCI:
Kathy Warren, M.D.

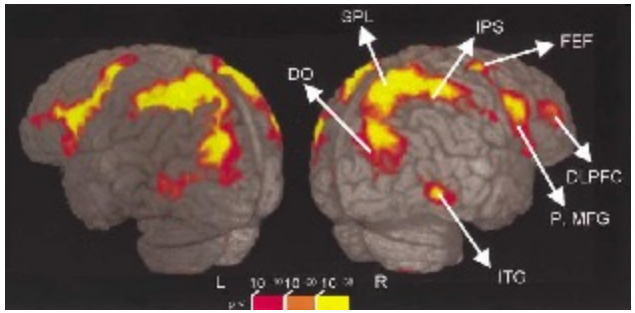
fMRI Studies at the NIH..

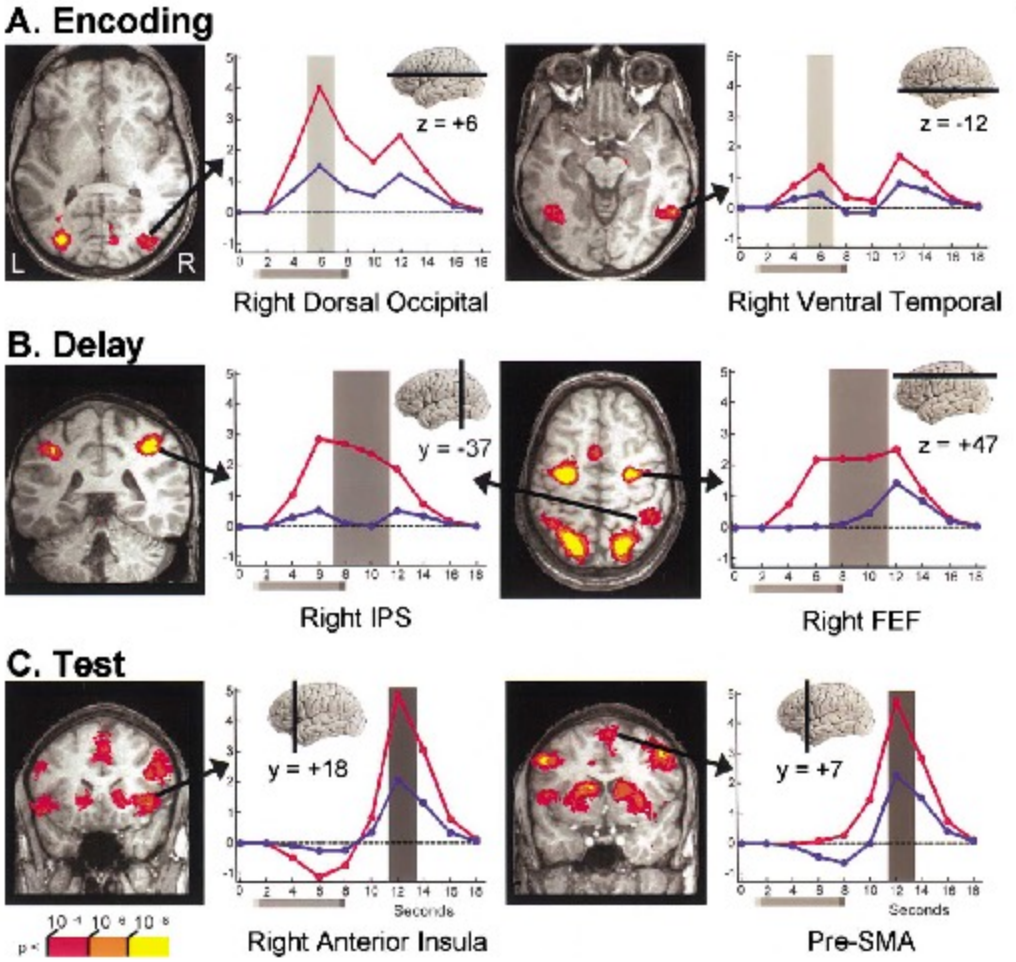
- Epilepsy
- Visual processing
- Mood disorders
- Learning
- Habituation
- Plasticity/Recovery
- Motor Function
- Auditory processing
- Attention
- Language
- Speech
- Stroke
- Social Interaction
- Development
- Aging
- Genetics
- Decision making
- Mood disorders

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

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

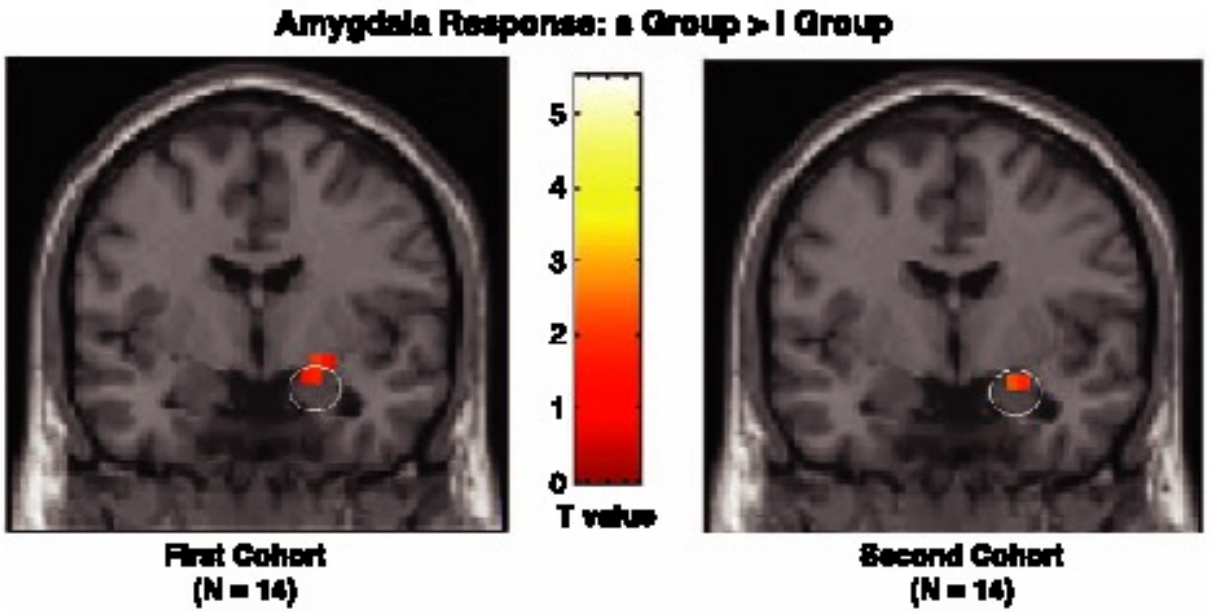




Comparison of two groups of *normal* individuals with differences in the Serotonin Transporter Gene

Serotonin Transporter Genetic Variation and the Response of the Human Amygdala

Ahmad R. Hariri,[1] Venkata S. Mattay,[1] Alessandro Tessitore,[1]
Bhaskar Kolachana,[1] Francesco Fera,[1] David Goldman,[2]
Michael F. Egan,[1] Daniel R. Weinberger[1]*



Uses

Understanding normal brain organization and changes

- -networks involved with specific tasks (low to high level processing)
- -changes over time (seconds to years)
- -correlates of behavior (response accuracy, performance changes…)

Clinical research

- -correlates of specifically activated networks to clinical populations
- -presurgical mapping

Future Uses

Complementary use for clinical diagnosis

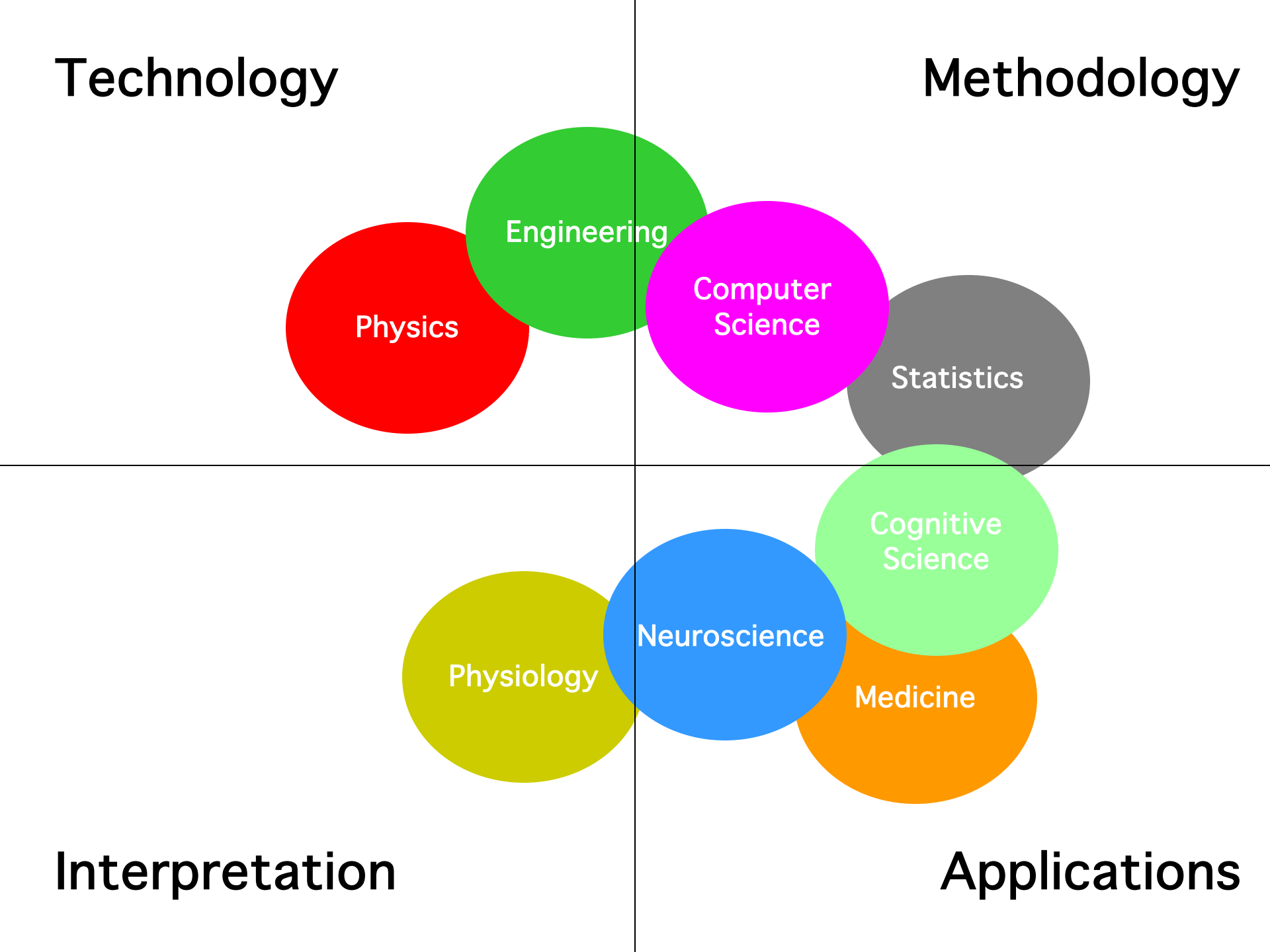
- -utilization of clinical research results
- -prediction of pathology

Clinical treatment and assessment

- -drug, therapy, rehabilitation, biofeedback
- -epileptic foci mapping
- -drug effects

Non clinical uses

- -complementary use with behavioral, anatomical, other modality results
- -lie detection
- -prediction of behavior tendencies
- -brain/computer interface


Technology
Methodology
Engineering
Physics
Computer Science
Statistics
Cognitive Science
Neuroscience
Physiology
Medicine
Interpretation
Applications

•P.S.F. Bellgowan, Z. S. Saad, P. A. Bandettini, Understanding neural system dynamics through task modulation and measurement of functional MRI amplitude, latency, and width. *Proc. Nat'l. Acad. Sci. USA* **100**, 1415-1419 (2003).

•D. C. Knight, H. T. Nguyen, P. A. Bandettini, Expression of conditional fear with and without awareness, *Proc. Nat'l. Acad. Sci. USA* **100,** 15280-15283 (2003).

•H. R. Heekeren, S. Marrett, P. A. Bandettini, L. G. Ungerleider, A general mechanism for perceptual decision making in the human brain. *Nature* **43**, 859-862 (2004).

•R.M. Birn, R. W. Cox, P. A. Bandettini, Functional MRI experimental designs and processing strategies for studying brain activation associated with overt responses. *NeuroImage,* **23,** 1046-1058 (2004) .

•P. A. Bandettini, N. Petridou, J. Bodurka, Direct detection of neuronal activity with MRI: fantasy, possibility, or reality? *Applied MRI* **29 (1)** pp. 65-88. .

•R.M. Birn, P. A. Bandettini, The effect of stimulus duty cycle and "off" duration on BOLD response linearity. *NeuroImage*, **27**, 70-82 (2005).

•D. C. Knight, H. T. Nguyen, P. A. Bandettini, The role of the human amygdala in the production of conditioned fear responses. *NeuroImage*, **26,** 1193-1200 (2005).

•D. C. Knight, H. T. Nguyen, P. A. Bandettini, The role of awareness in delay and trace fear conditioning in humans. *Cognitive, Affective, and Behavioral Neuroscience*, 5 (2), 158-163 (2006).

•N. Kriegeskorte, R. Goebel, P. Bandettini, Information-based functional brain mapping. *Proc. Nat'l. Acad. Sci. USA*, 103, 3863-3868 (2006).

•N. Petridou, D. Plenz, A. C. Silva, J. Bodurka, M. Loew, P. A. Bandettini, Direct Magnetic Resonance detection of neuronal electrical activity, *Proc. Nat'l. Acad. Sci. USA*. 103, 16015-16020 (2006).

•R. M. Birn, J. B. Diamond, M. A. Smith, P. A. Bandettini, Separating respiratory variation-related fluctuations from neuronal activity-related fluctuations in fMRI, NeuroImage 31, 1536-1548 (2006)

•P. A. Bandettini, FMRI Today, International Journal of Psychophysiology, (in press) .

•P. S. F. Bellgowan, P. A. Bandettini, P. van Gelderen, A. Martin, J. Bodurka, Improved BOLD detection in the medial temporal region using parallel imaging and voxel volume reduction. *NeuroImage*, **29,** 1244-1251 (2006)

•H. R. Heekeren, S. Marrett, D. A. Ruff, P. A. Bandettini, L. G. Ungerleider, Involvement of human left dorsolateral prefrontal cortex in perceptual decision-making is independent of response modality. *Proc. Nat'l. Acad. Sci. USA*, 103, 10023-10028 (2006)

•J. Bodurka, F. Ye, N Petridou, P. A. Bandettini, Mapping the MRI voxel volume in which thermal noise matches physiological noise – implications for fMRI. *NeuroImage,* **34**, 542-549 (2007)

•K. Murphy, J. Bodurka, P. A. Bandettini, How long to scan? The relationship between fMRI temporal signal to noise and the necessary scan duration. *NeuroImage*, **34**, 565-574 (2007)

What is the overall objective of your research program?

What educational background is needed for student participation in your research area?

With whom would the student primarily work?

What are the most exciting prospects in your research field?