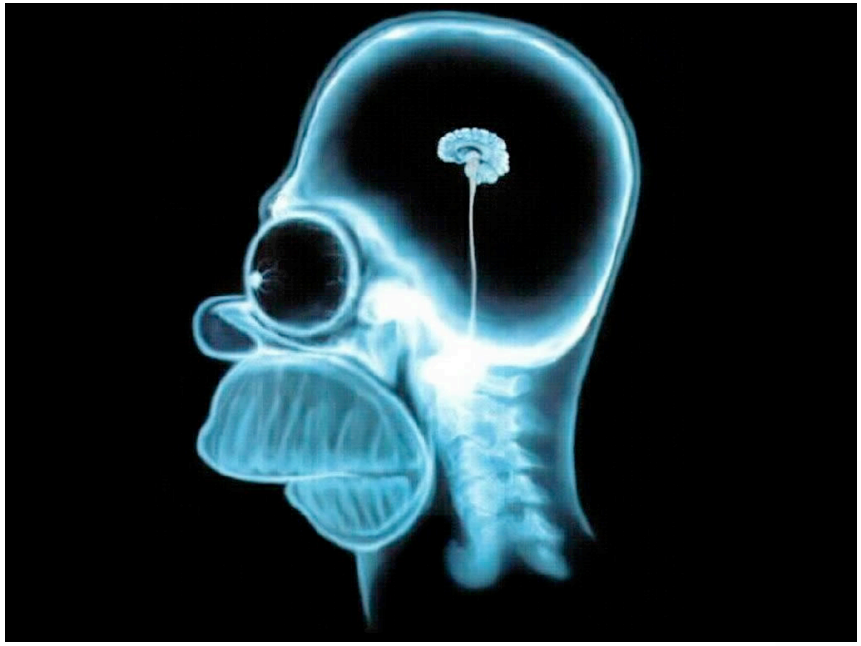
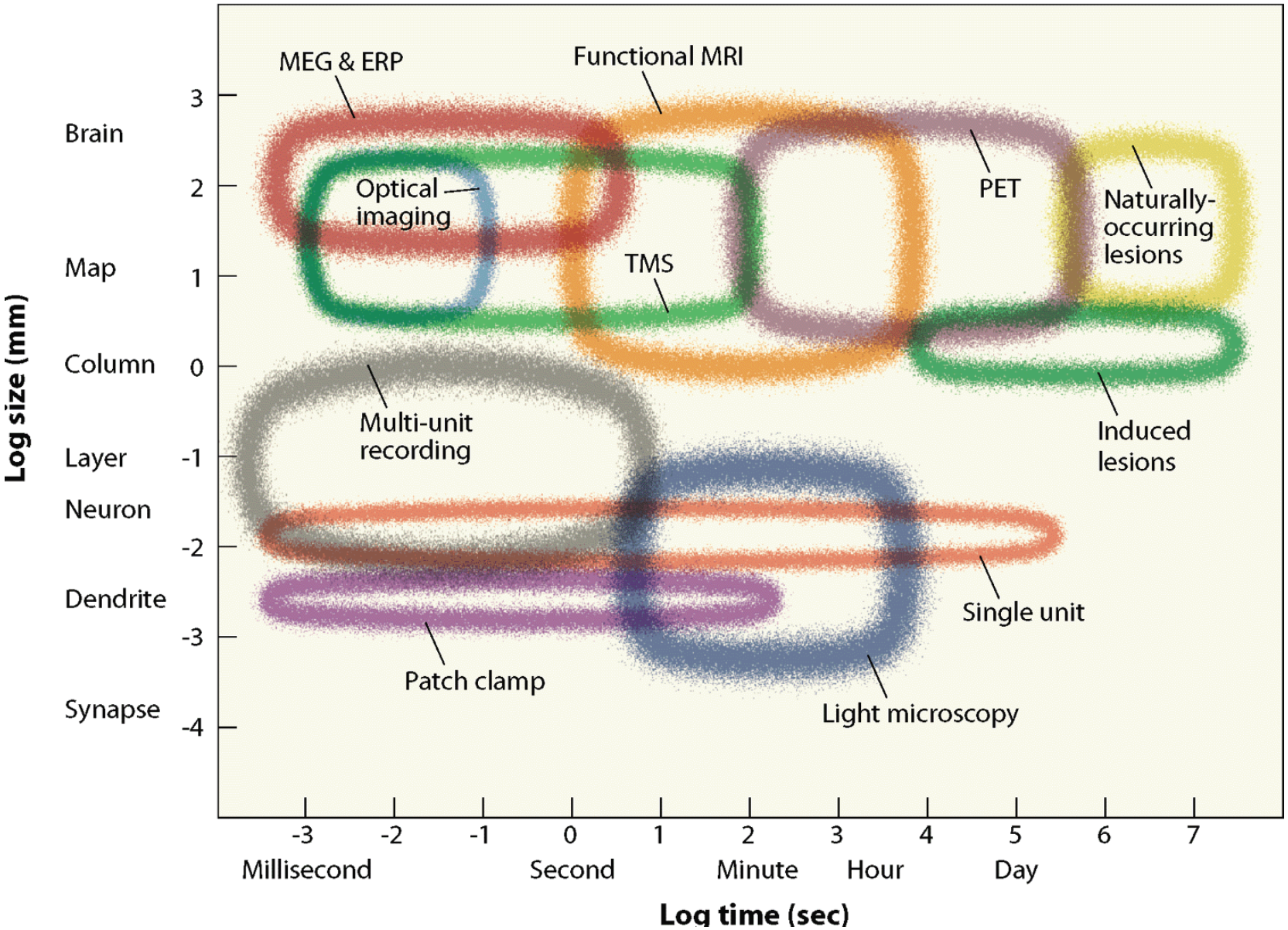
Methods



Not one ideal technique, but several pretty good ones...



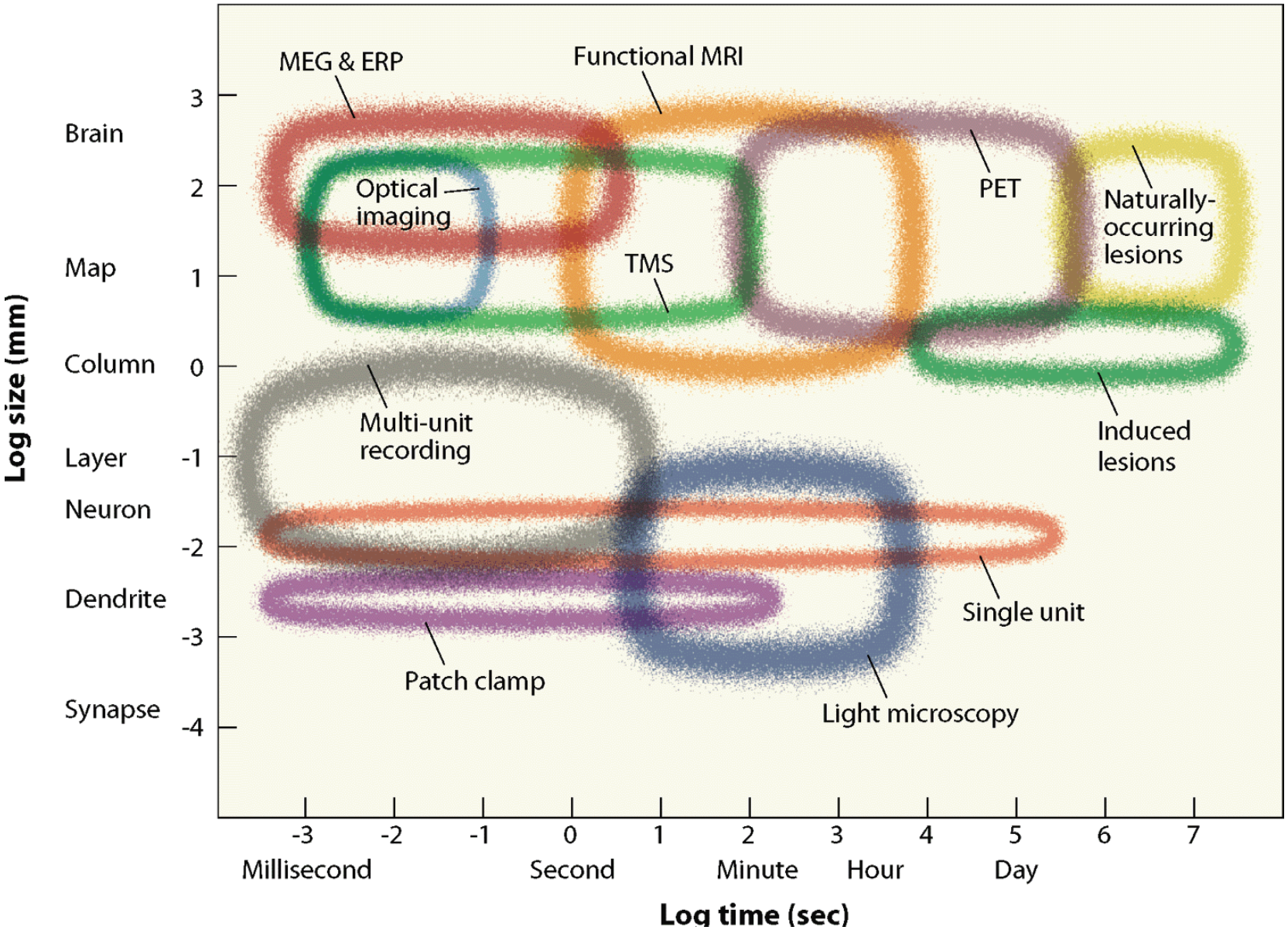
Hierarchy of the brain

- Behavior
- Systems, regions and pathways
- Neuronal population, centers, local circuits
- Neurons
- Synapses
- Molecules

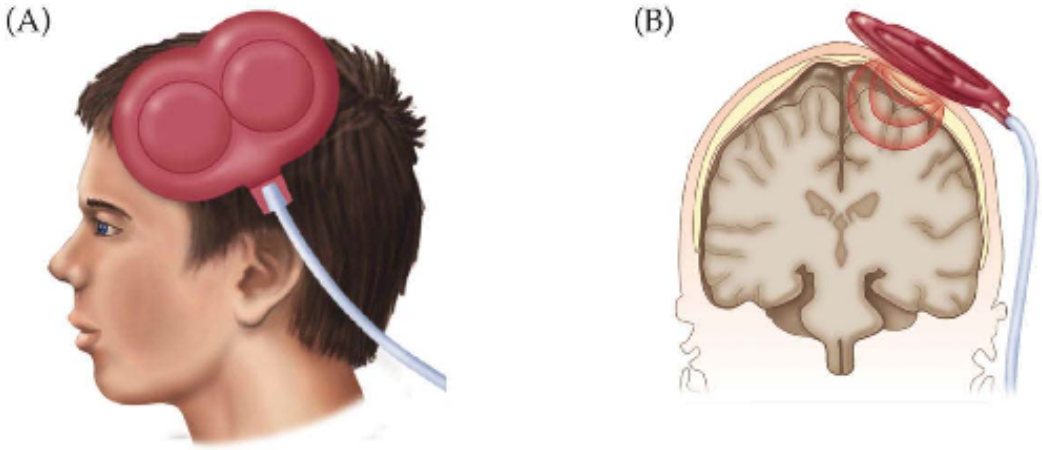
So what is a system?

- Performs complex, though fundamental functions (operationally defined).
- Invariably involve many brain regions.
- Because of feedback, hierarchy gets lost.
- Though neurons are the building blocks, the essence of the function is contained in the network.
- The activity of one neuron is rarely important.
- Thousands or millions of neurons are usually involved in a percept.
- The way in which the information is combined is largely unknown.

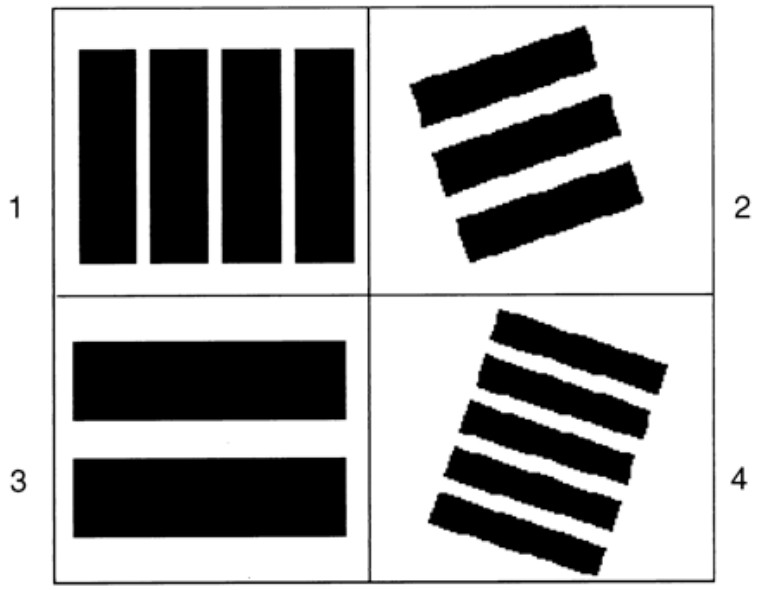
Not one ideal technique, but several pretty good ones...

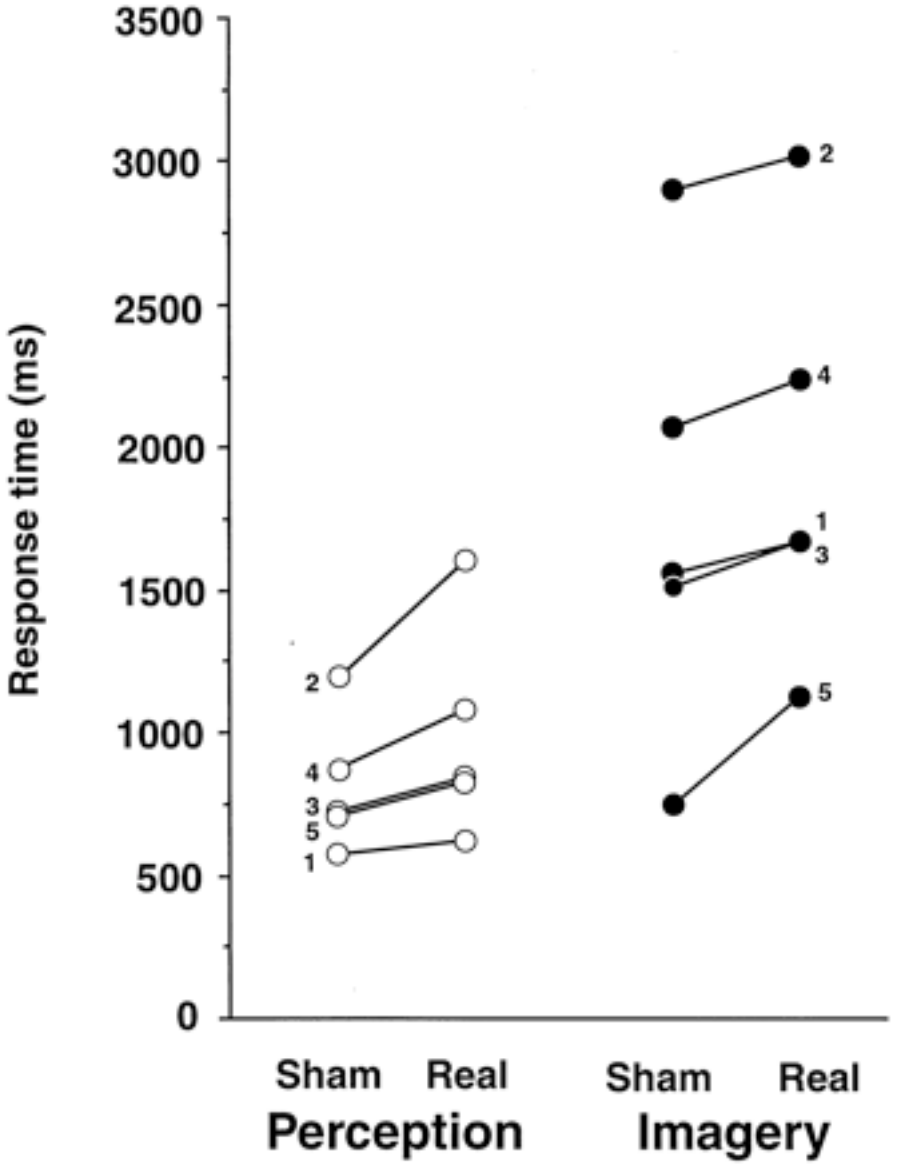


Transcranial Magnetic Stimulation (TMS)



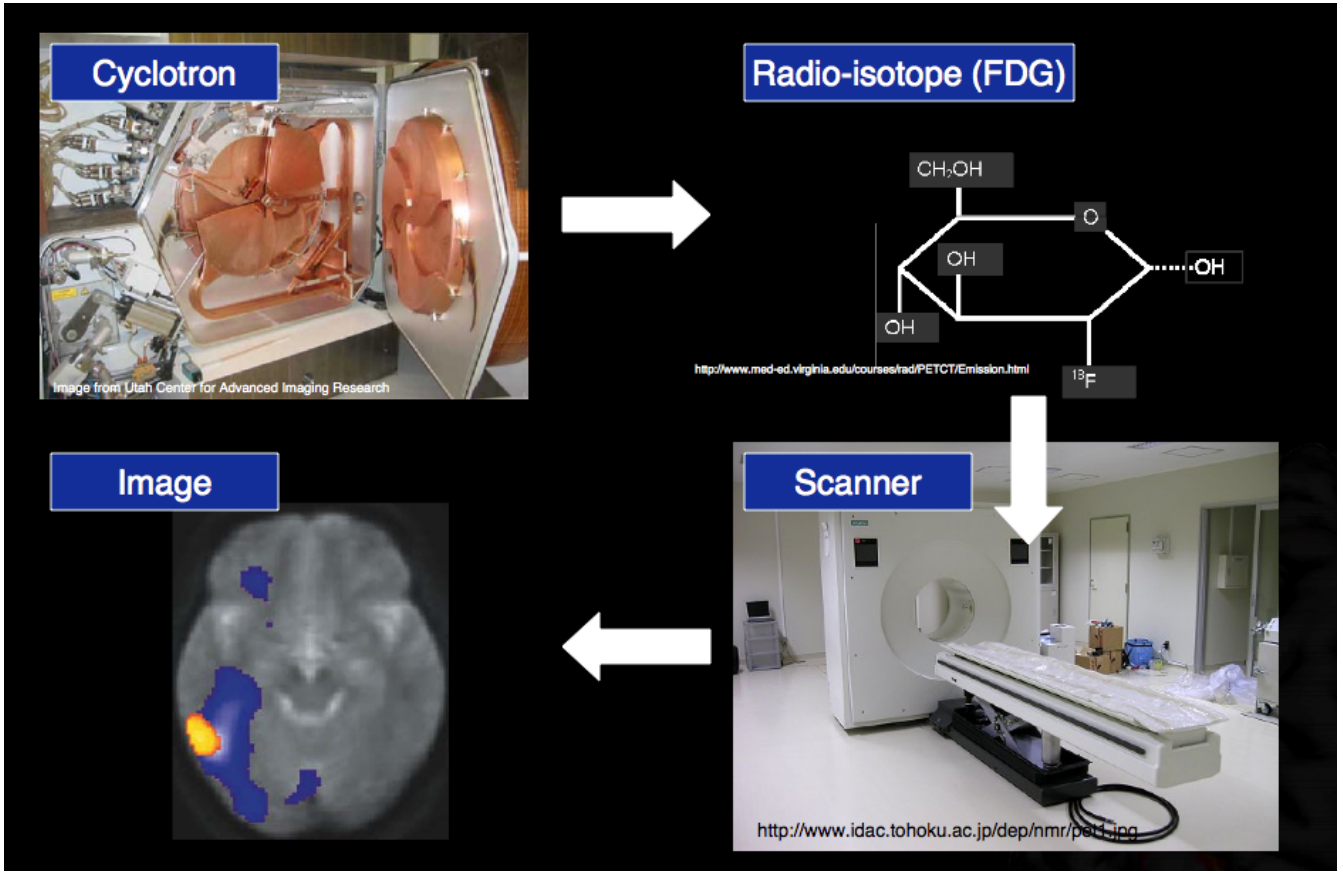
Transient and safe disruption of local neuronal activity
'reversible lesions' -> causal link





Kosslyn et al., 1999

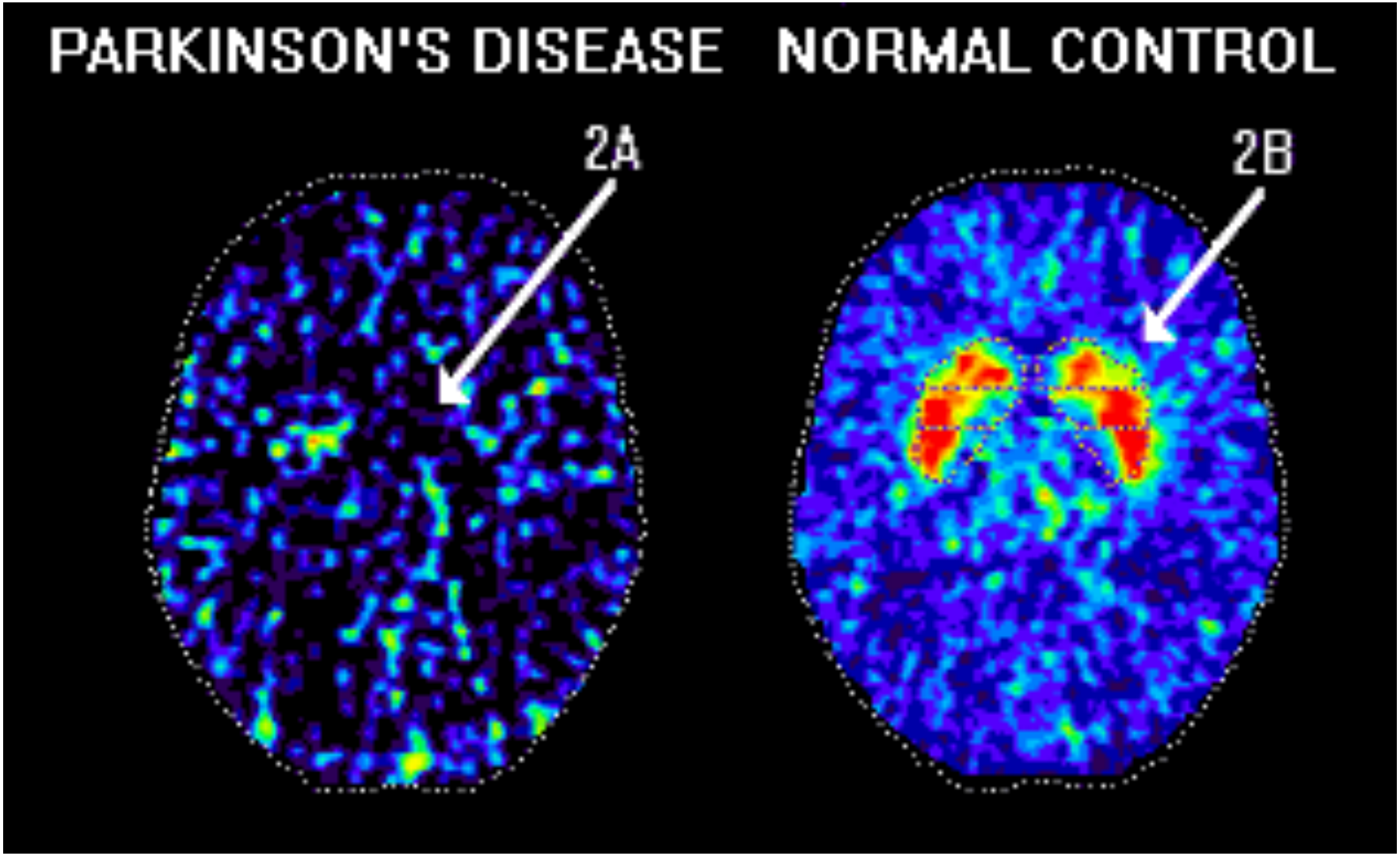
Positron Emission Tomography (PET)



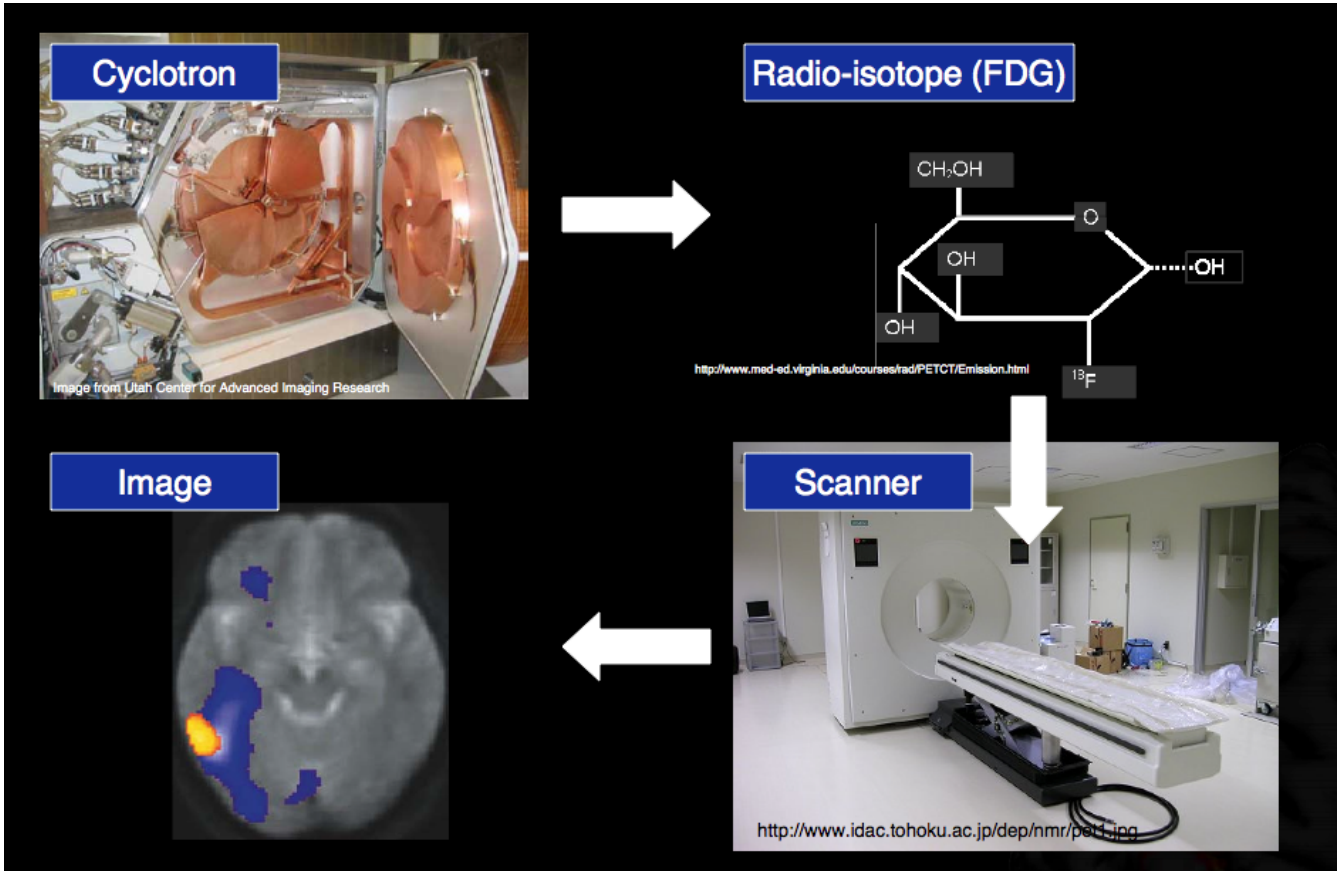
Measures metabolic needs of the brain

Follows glucose to see which areas are active during a task

PET



Positron Emission Tomography (PET)



Pros:

Allows imaging of anything that can be tagged

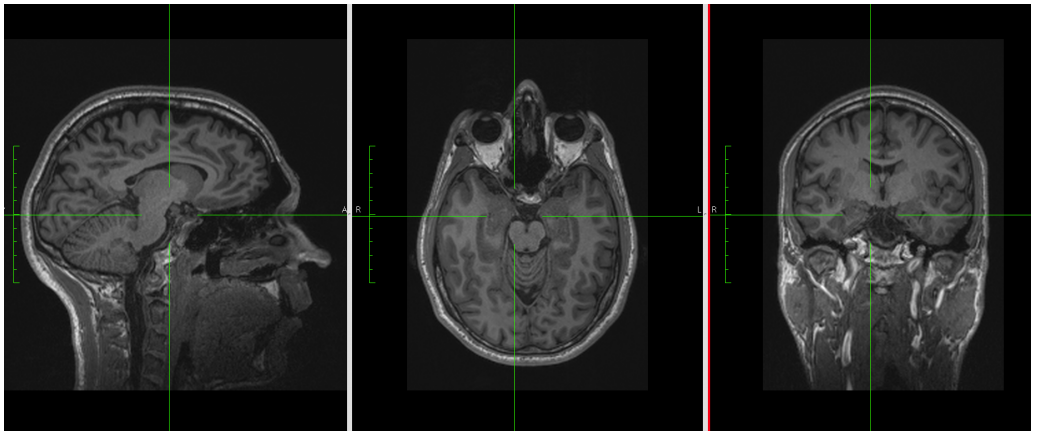
Cons:

Poor temporal resolution

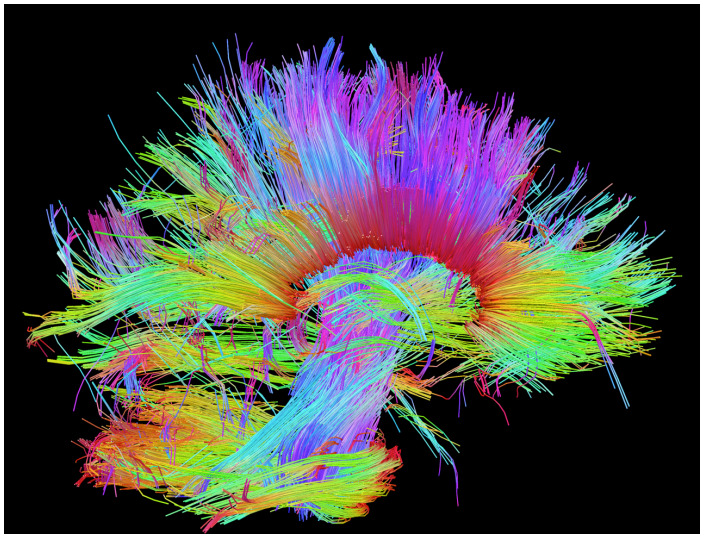
Poor spatial resolution

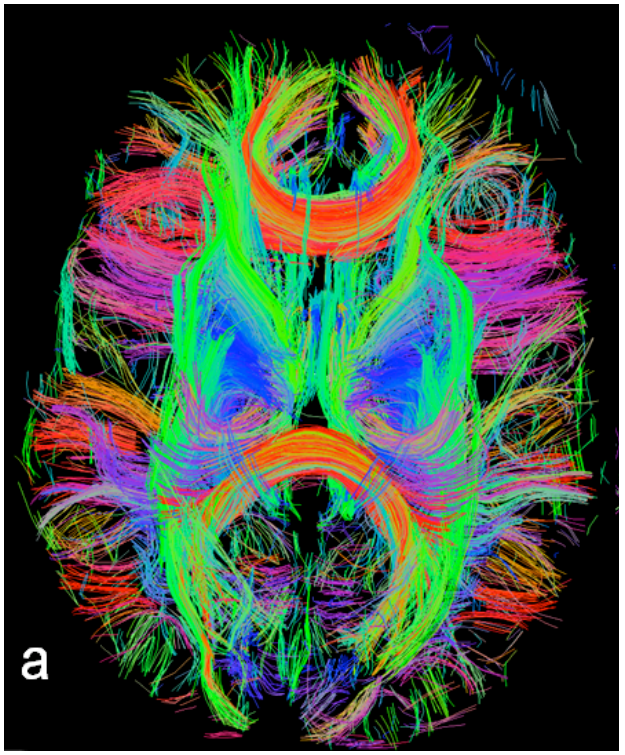
Requires injection of radioactive material

Magnetic Resonance Imaging (MRI)

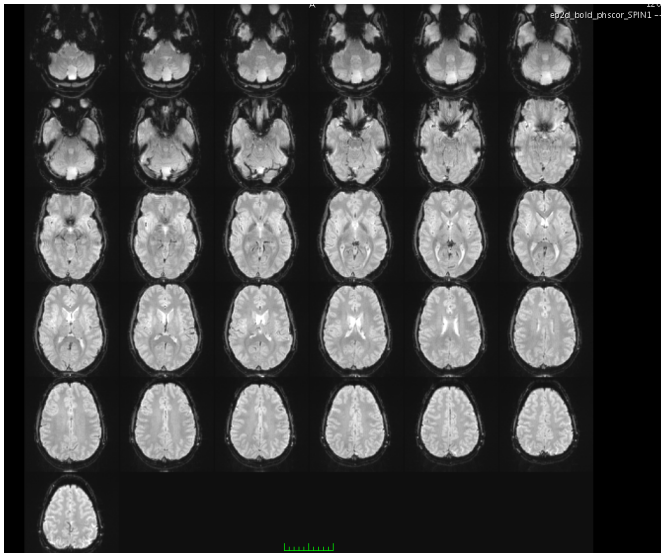


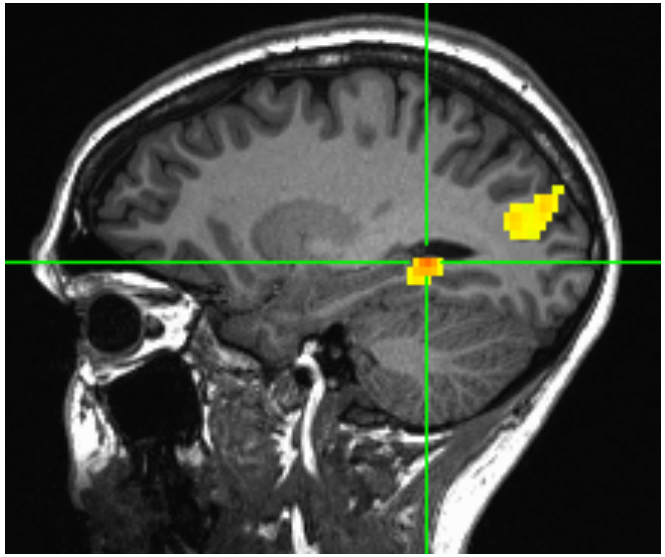
Diffusion Tensor (Spectral) Imaging (DTI/DSI)





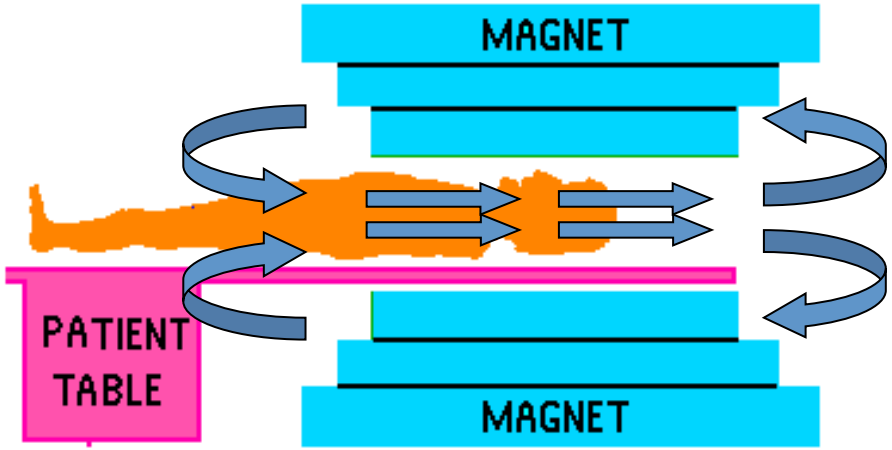
functional Magnetic Resonance Imaging (fMRI)





How does fMRI work?

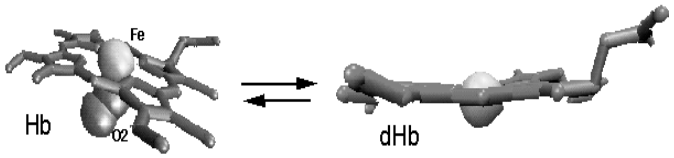
The scanner is essentially a large magnet



x 30,000 times that of the earth (for 1.5T)

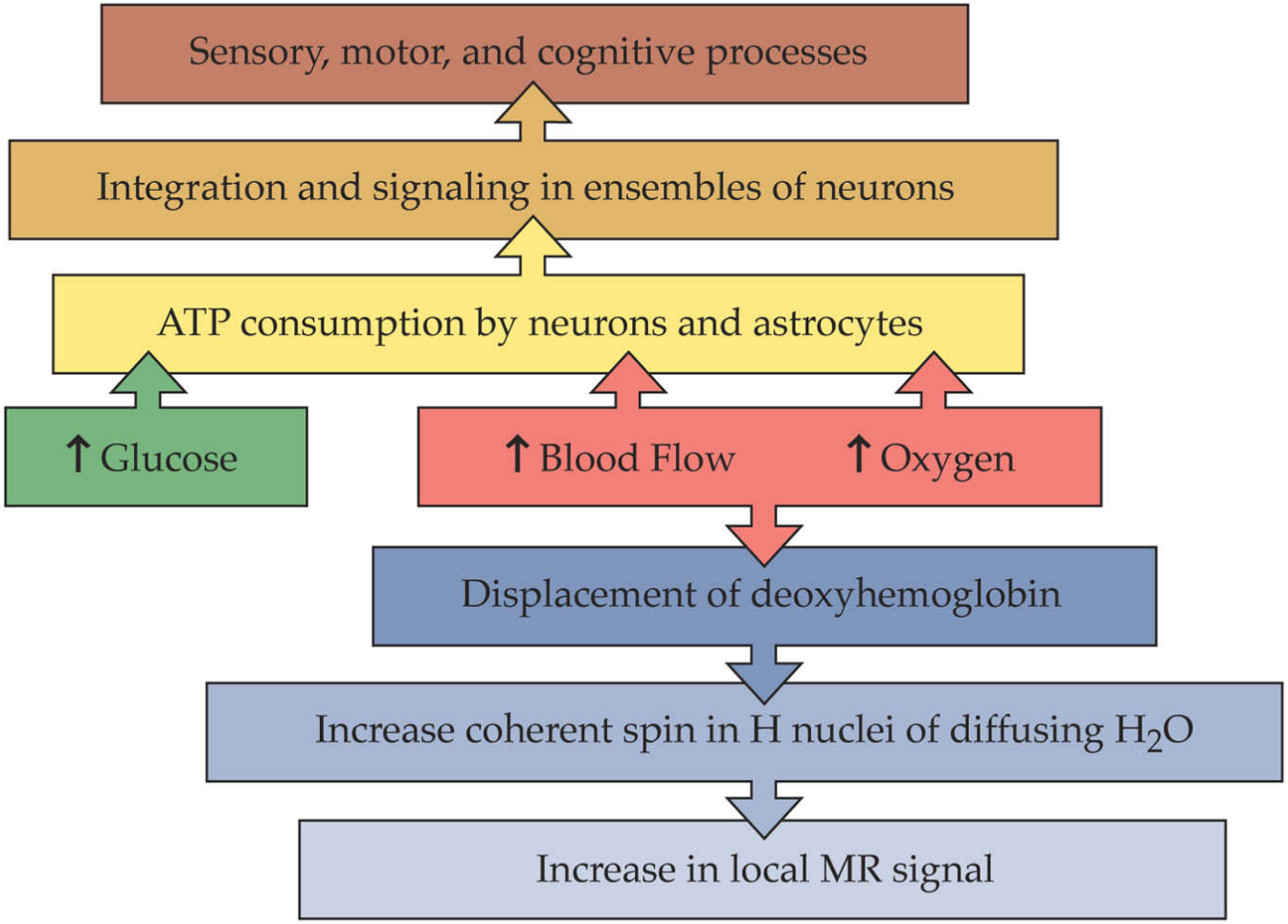
The scanner and its associated hardware is responsible for both generating the magnetic field and detecting how it is affected by brain tissue. Different brain tissues react differently to magnetic pulses.

Strength of the magnetic field in the brain is affected by the relative concentration of deoxyhemoglobin/oxyhemoglobin.

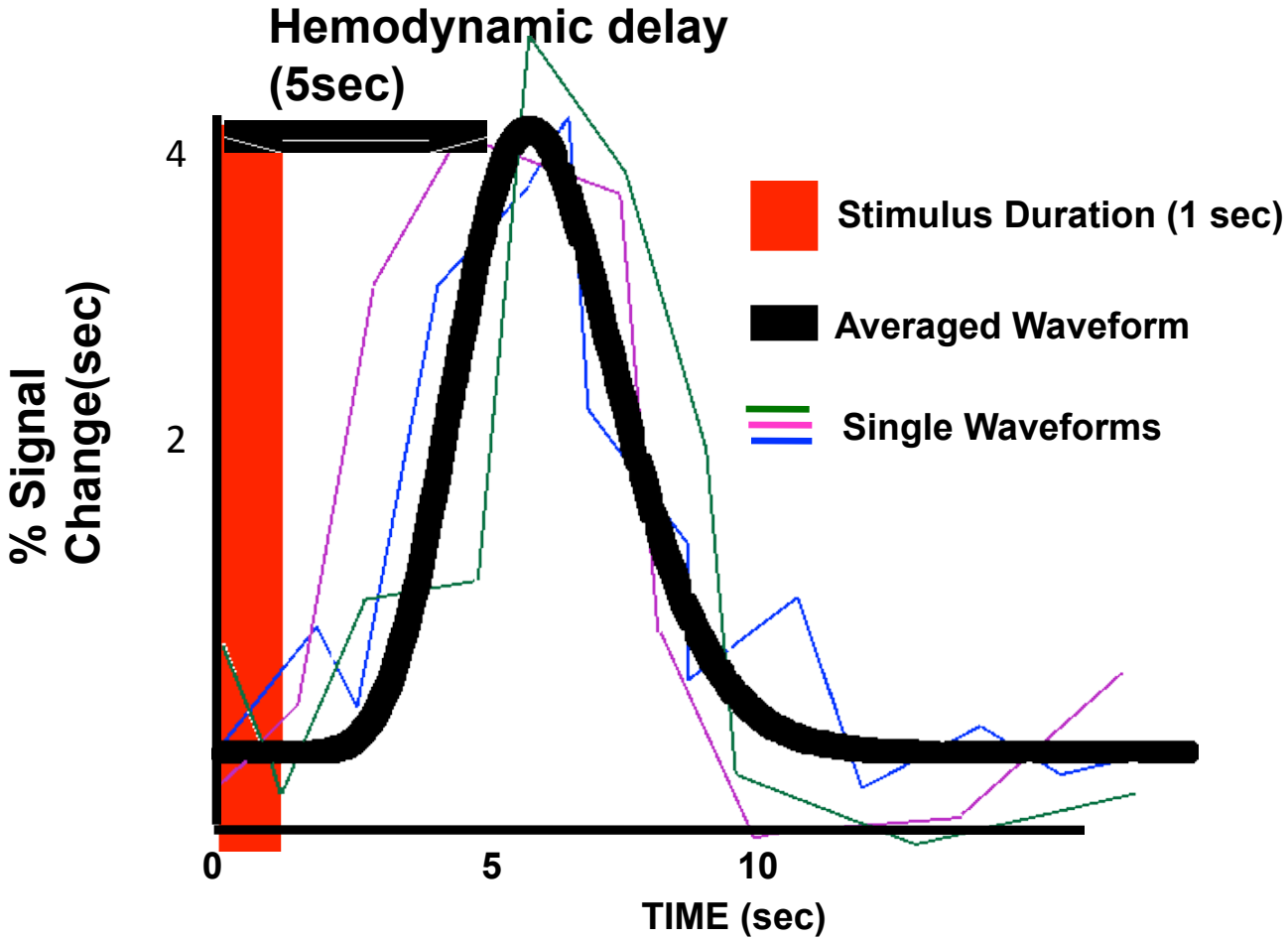


De-oxyhemoglobin in a brain region locally reduces the homogeneity of the magnetic field, thereby decreasing the magnetic signal that is emitted by that brain region.

Basic Model of Relationship Between BOLD fMRI & Neuronal Activity



Temporal Characteristic (Hemodynamic Response)



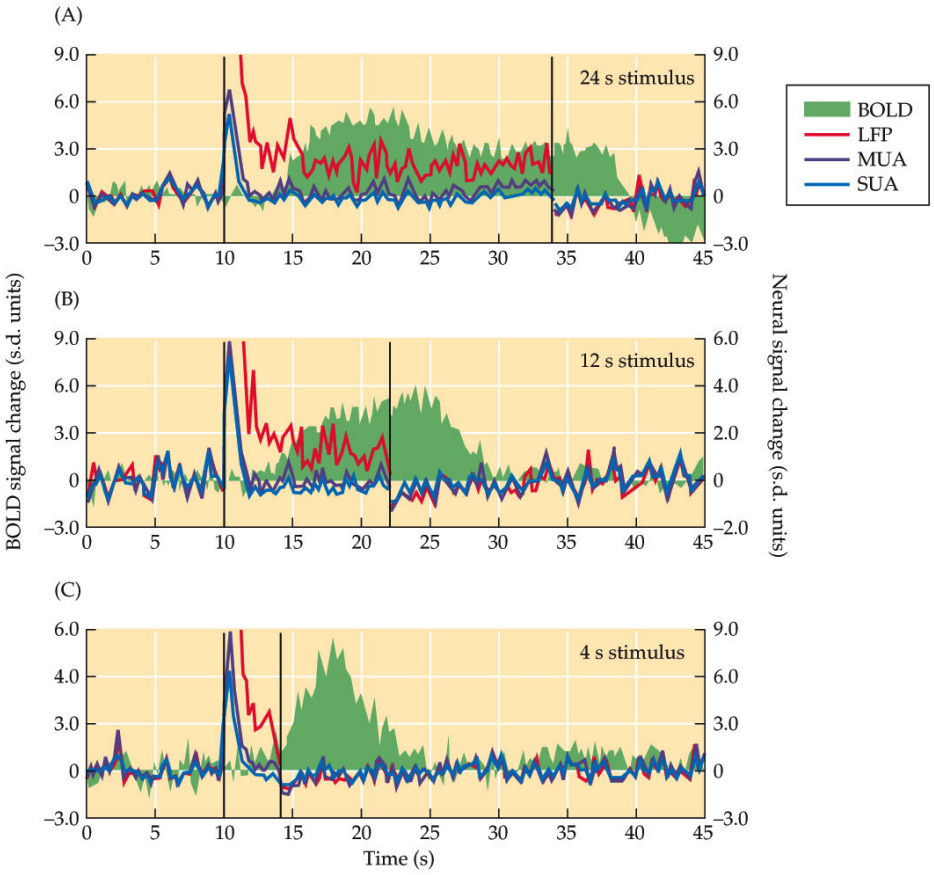
Temporal resolution of fMRI signal is mostly limited by the sluggishness in the hemodynamic response to the stimulus presentation.

functional Magnetic Resonance Imaging (fMRI)

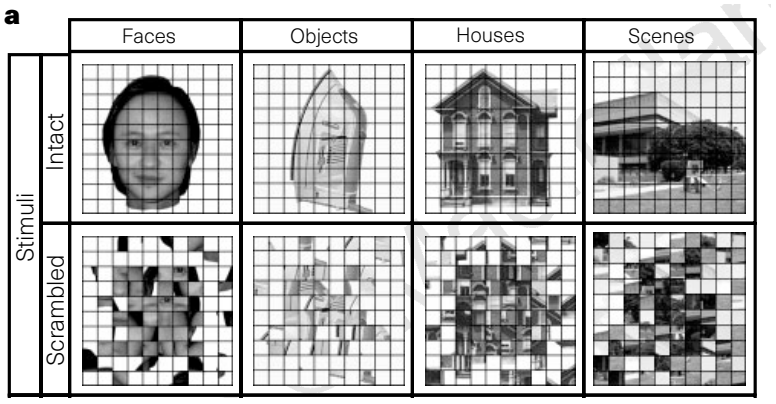
Pros:	Cons:
Great spatial resolution	Poor temporal resolution
Non-invasive	Indirect measure of neural activity

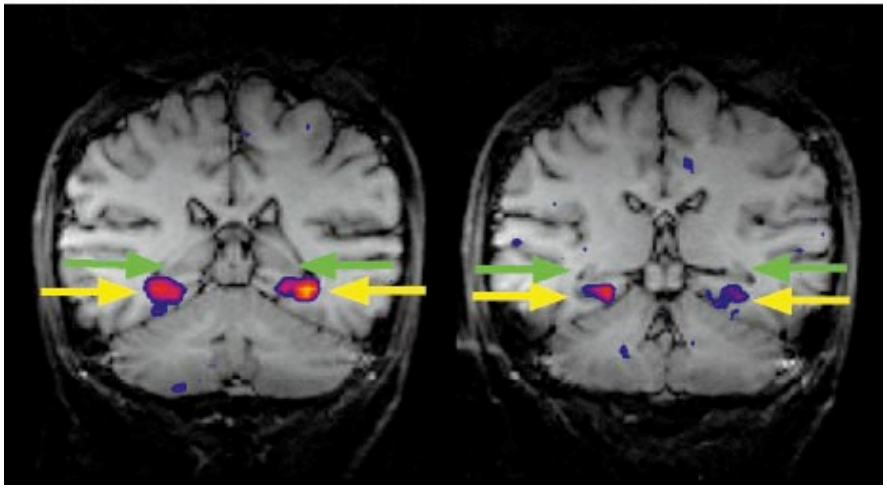
BOLD vs Neuronal Activity

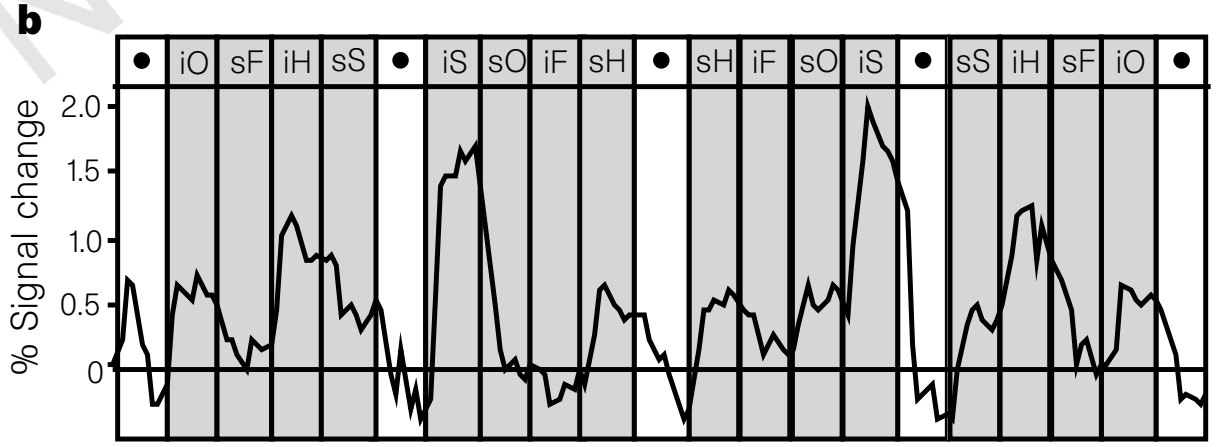
- Logothetis, et al., 2001 recorded LFP, MUA, SUA, and BOLD simultaneously
- BOLD response best explained by changes in LFP
- Suggests BOLD reflects “incoming input and local processing rather than spiking activity”
- ”The BOLD contrast mechanism directly directly reflects the neural responses elicited by a stimulus.”



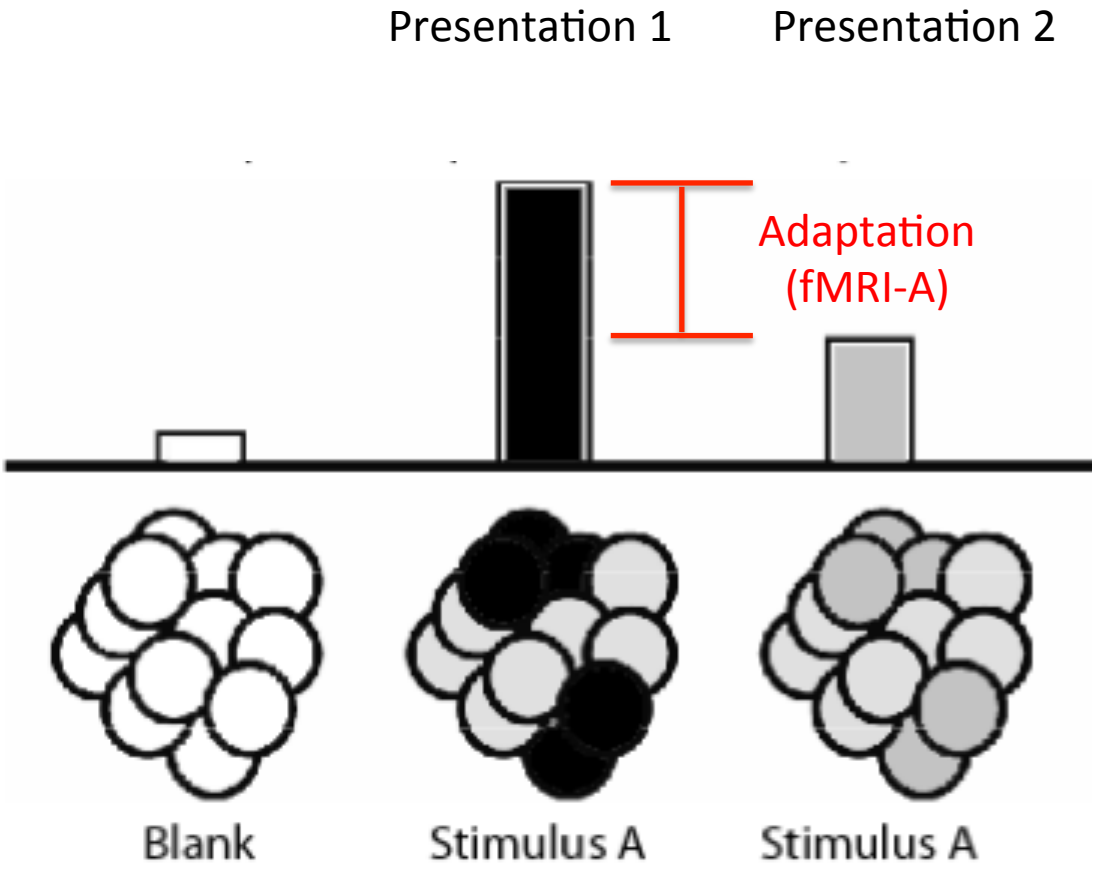
fMRI contrast (univariate results)







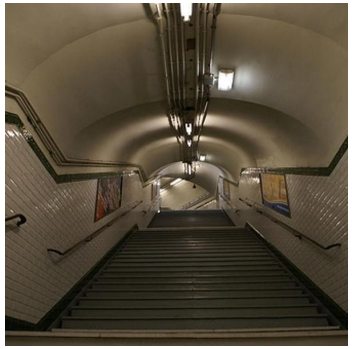
fMRI adaptation

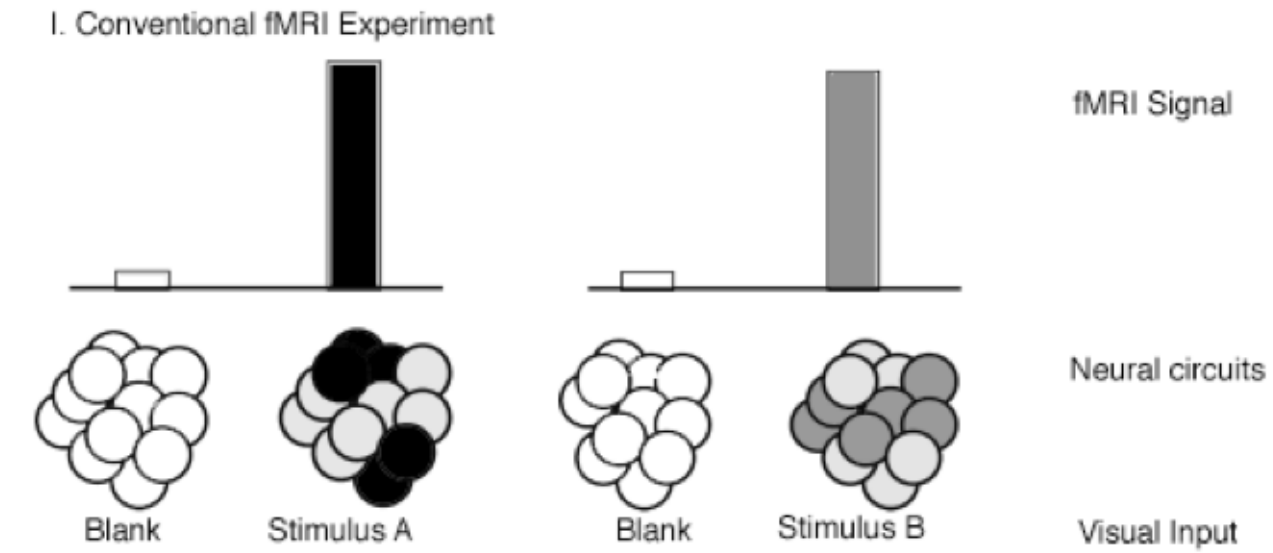


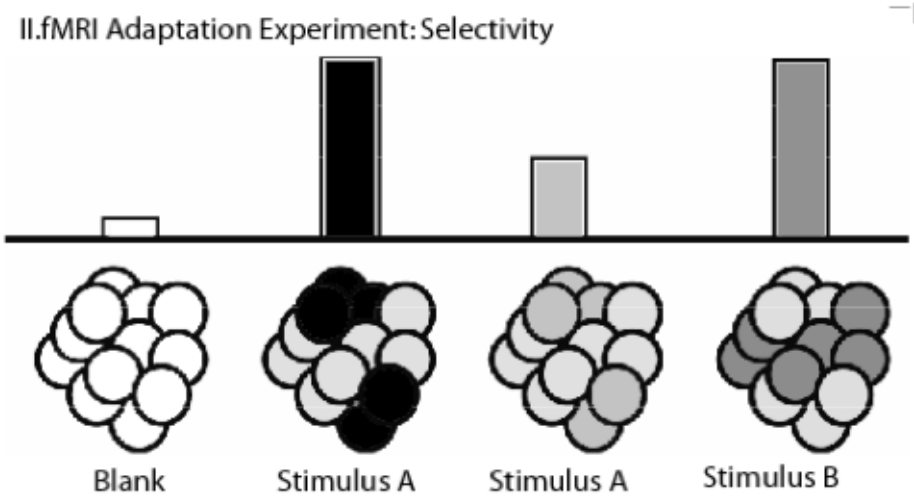
fMRI adaptation

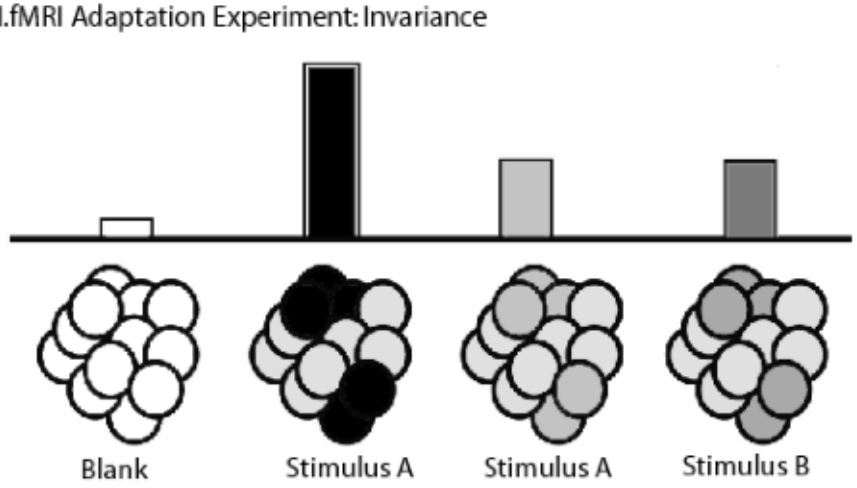
Stim A

Stim B

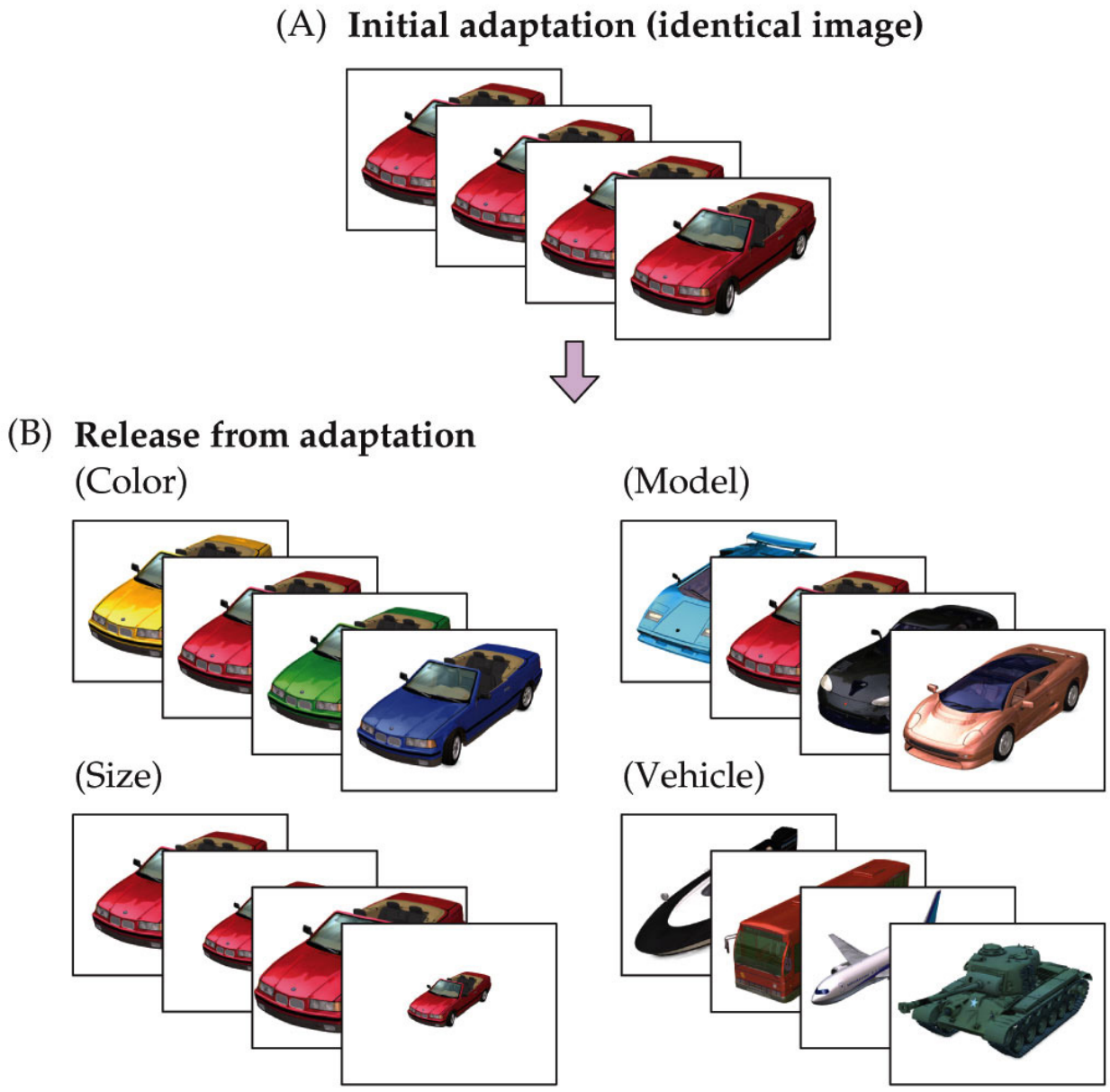








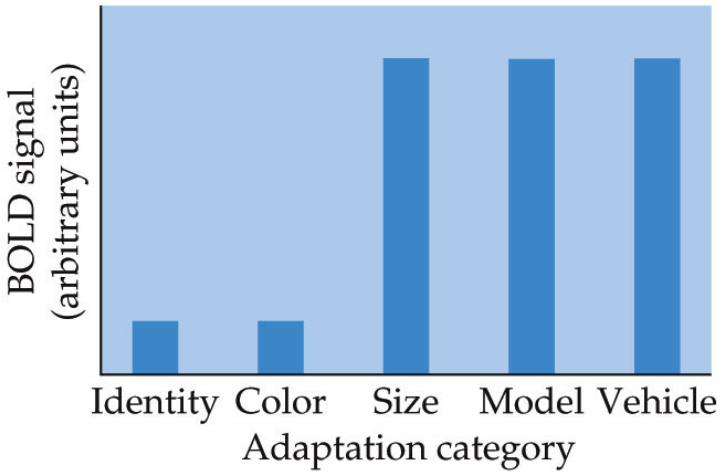
fMRI adaptation



***Functional Magnetic Resonance Imaging 2e*, Figure 7.32 (Part 1)**

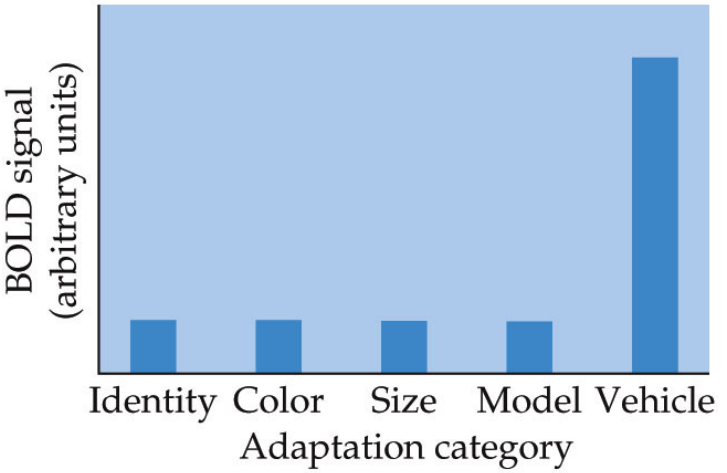
fMRI adaptation

- Top graph - *release* of response to attributes other than color thus this area **preferentially responds to changes in physical characteristics**

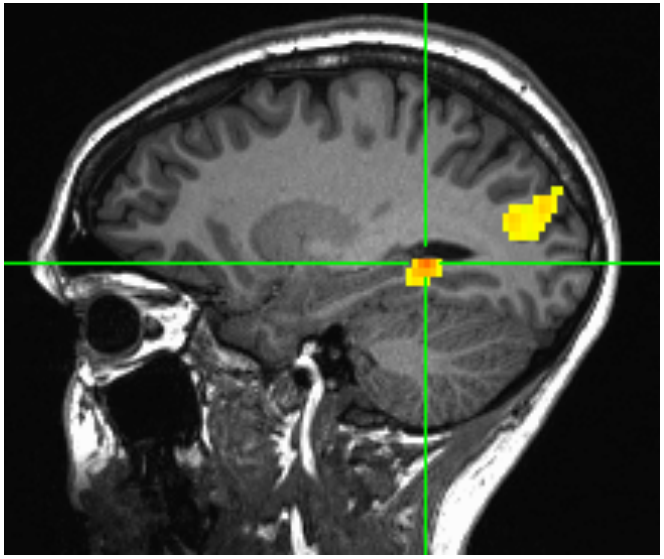


(D)

- Bottom graph - *release* of response only to vehicle type thus this area preferentially responds to **complex object categories**

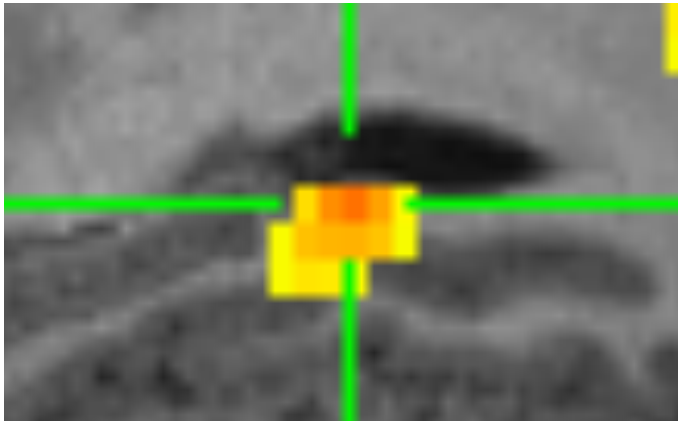


fMRI univariate contrasts and adaptation designs look at the average activation across an ROI

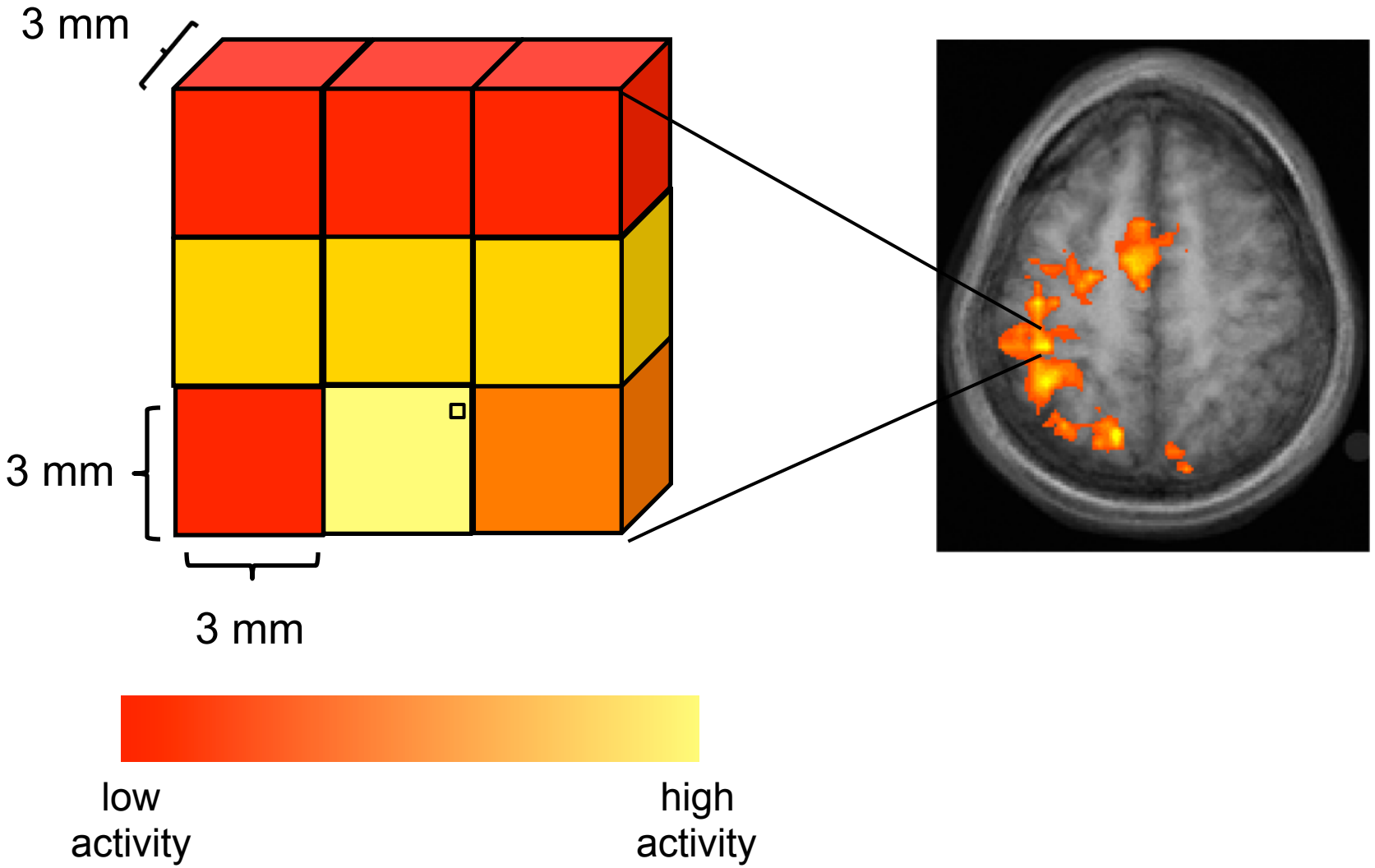


fMRI multivariate pattern analysis (MVPA):

Looks at the pattern of activity voxel-by-voxel

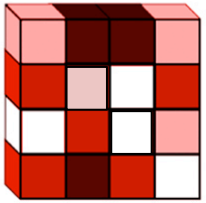
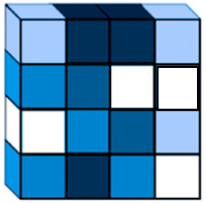


fMRI MVPA



fMRI MVPA



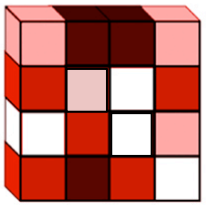
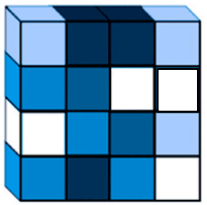
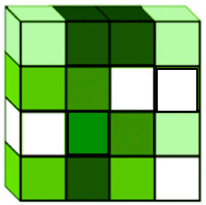





More similar – the more evidence they are represented by similar means

fMRI MVPA




- Representational Similarity Analysis
- Machine-learning classifier techniques (linear svm)

Keep in mind:

- Spatial resolution
- Temporal resolution
- Enough power?
- Individual variability
- noise