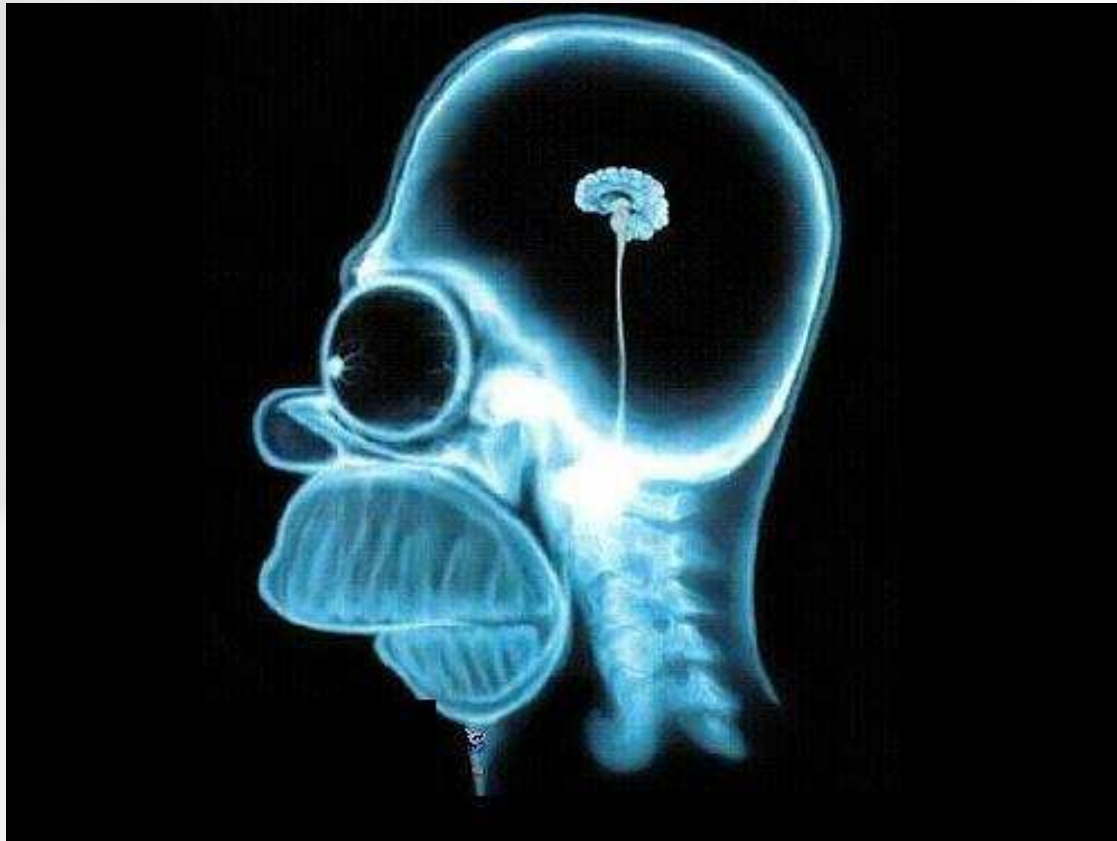
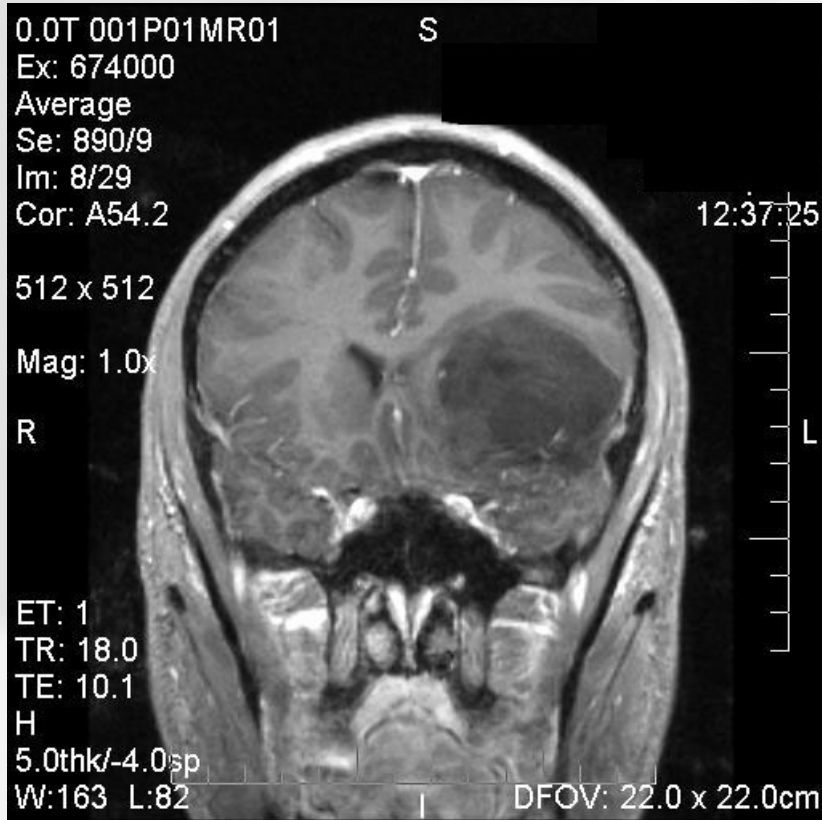


functional MRI (fMRI)

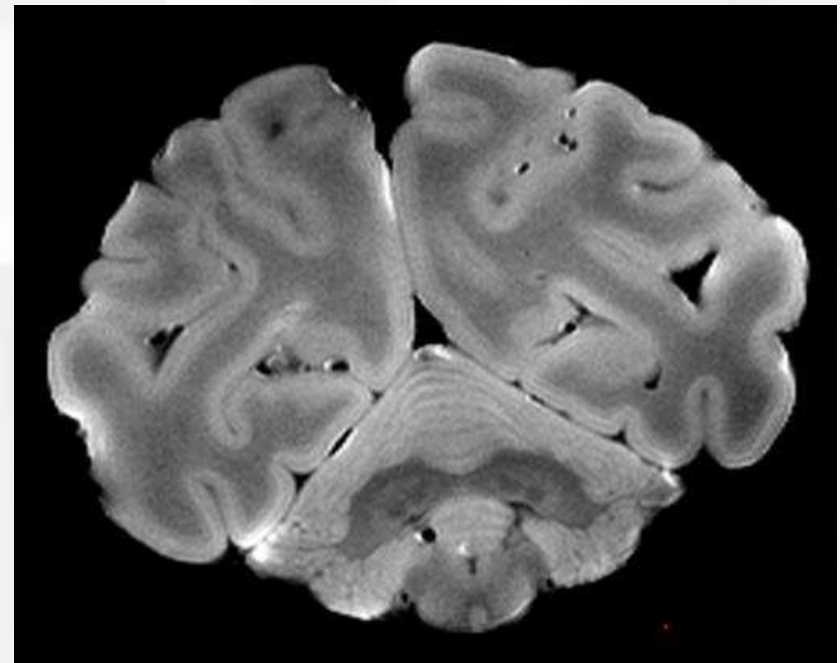
Traditional MRI relies on the differences in magnetic susceptibility of tissue, such as gray matter, white matter, CSF etc.



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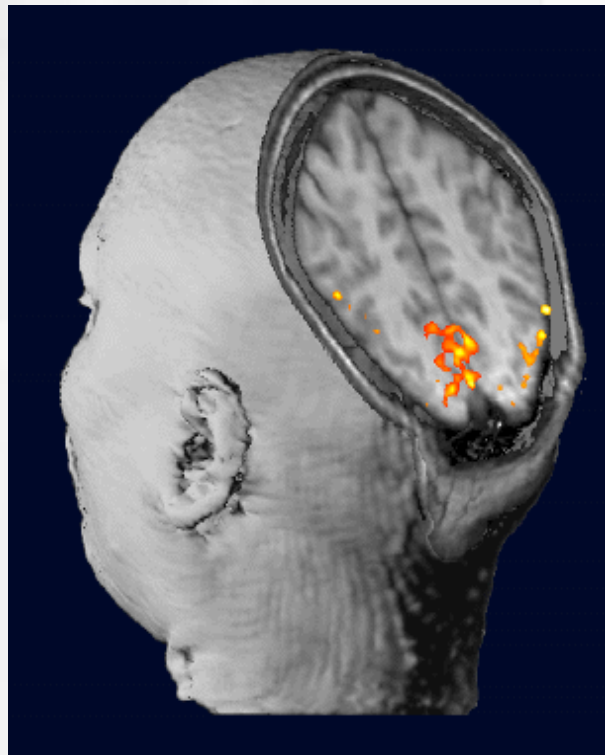
1x1x1 mm pixels
Human brain at 1.5 Tesla



0.1 x 0.1 x 0.1 mm pixels
Baboon brain at 4.7 Tesla

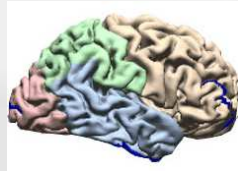
Functional MRI depends on changes in blood oxygenation that are associated with neuronal activity.

Blood Oxygenation Level Dependent (BOLD)



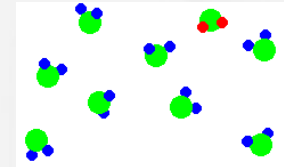
How functional MRI (fMRI) works

Brain



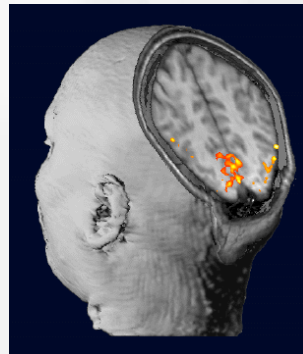
Increased brain activity produces a local increase in blood oxygenation

Physics



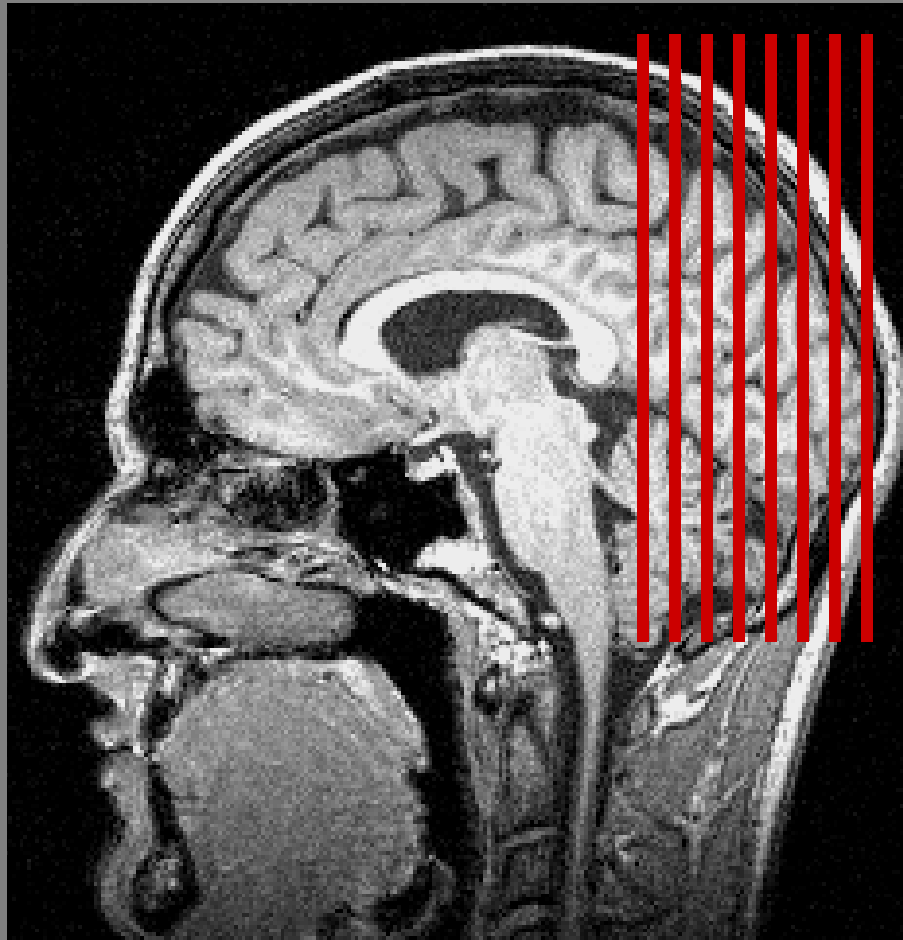
Oxygenated and Deoxygenated blood have different magnetic properties

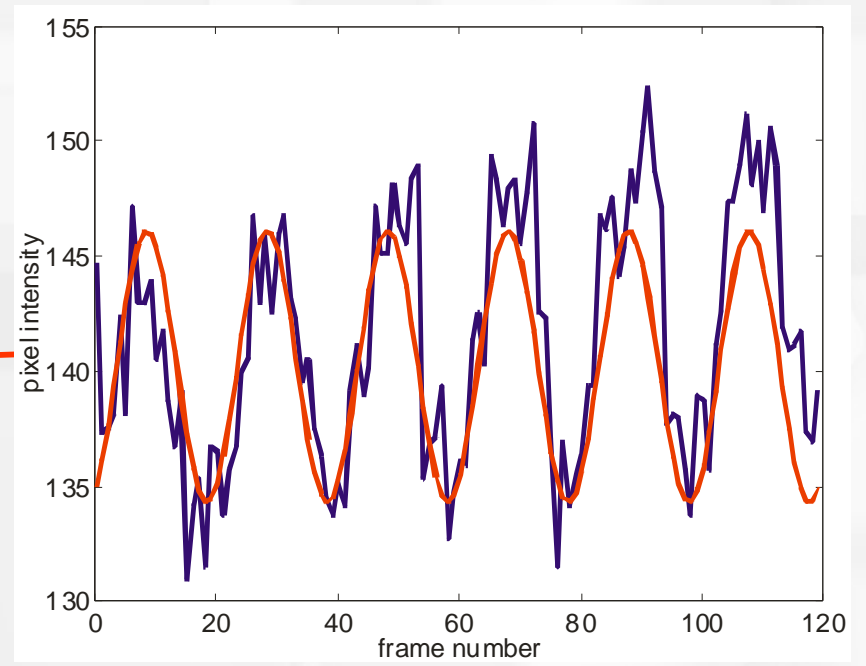
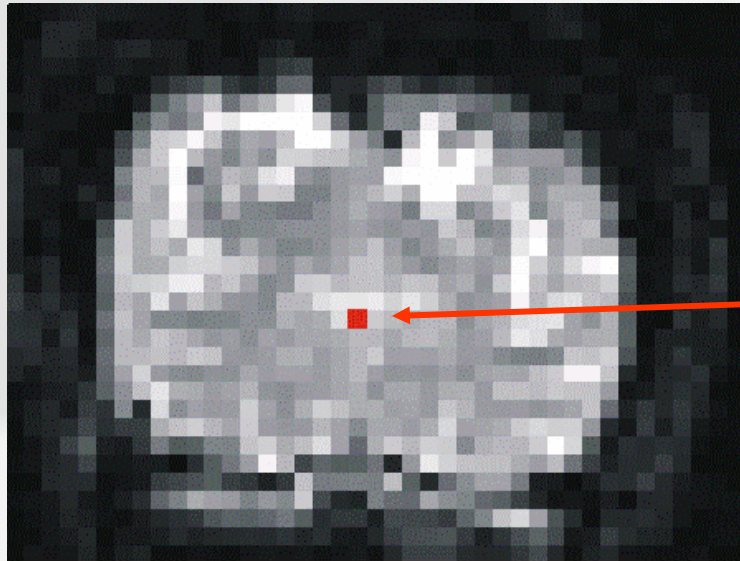
MR images are brighter where there is greater brain activity









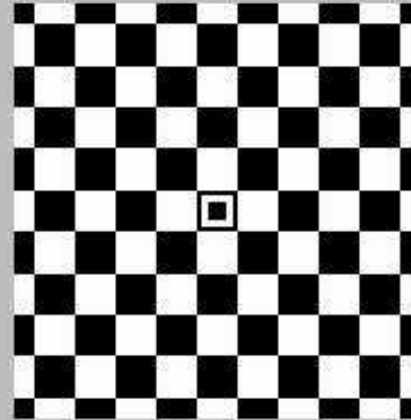
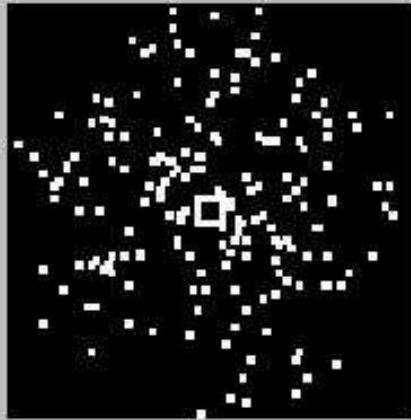


fMRI 'activity map'



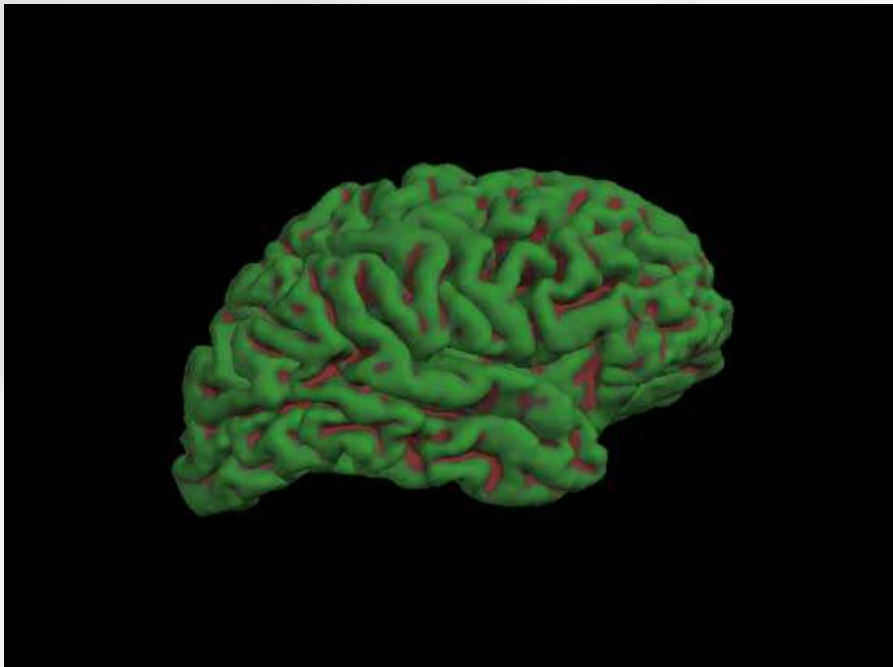
Motion

Flicker

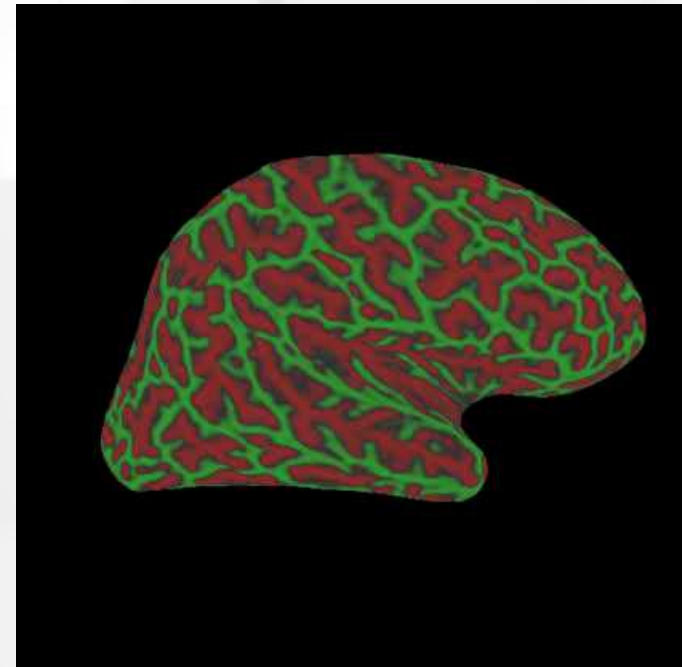


Viewing fMRI data on 'flattened' cortex

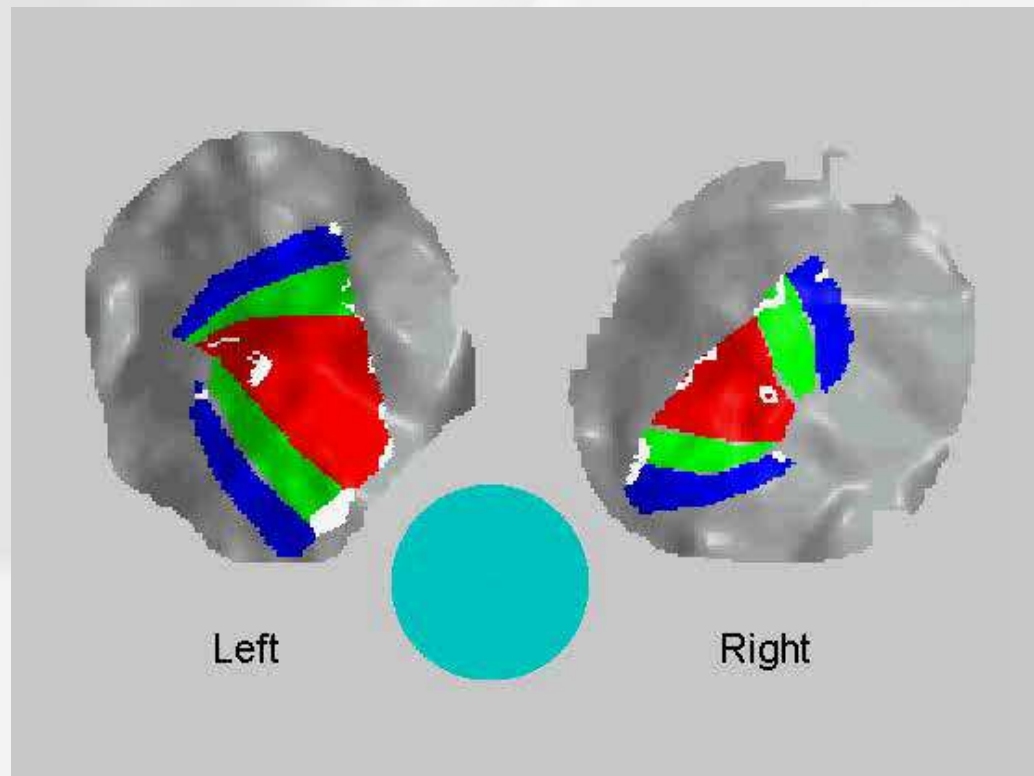
Inflate



Flatten

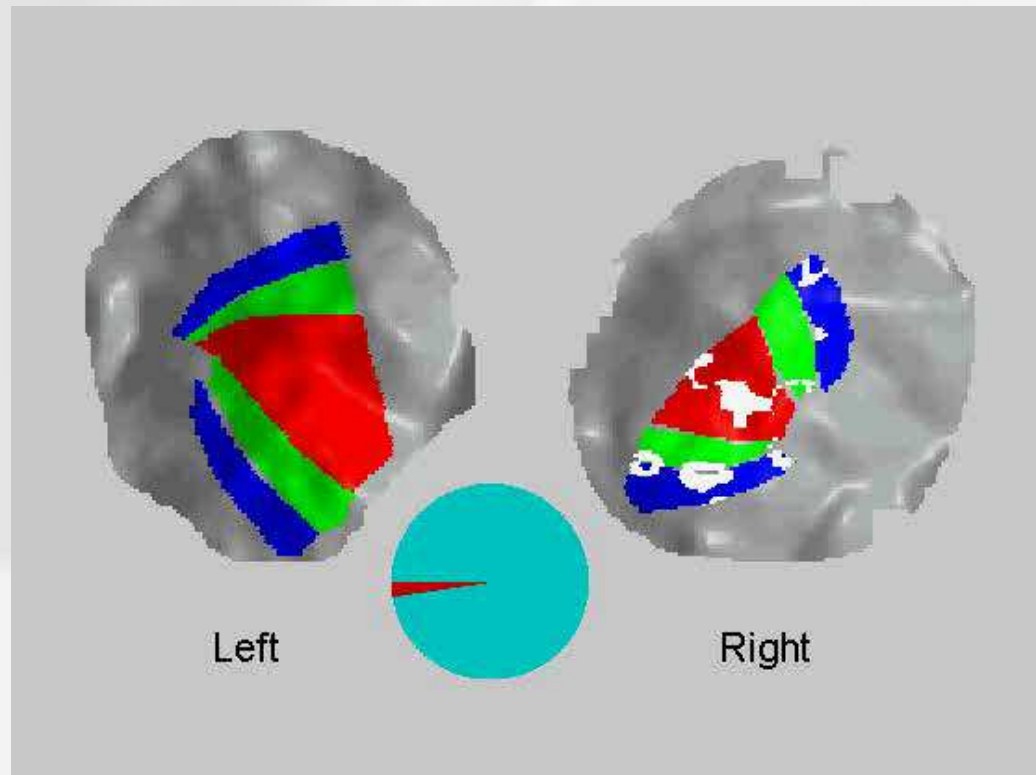


Mapping Retinotopic Visual Areas: Response to Expanding Ring

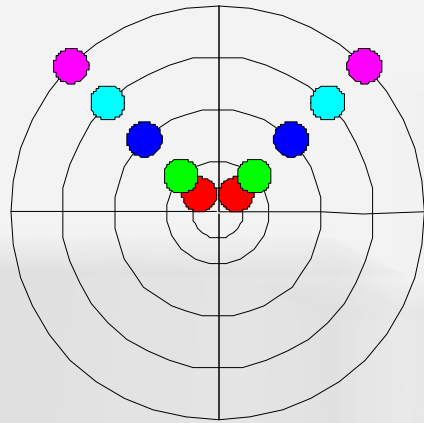


- V1**
- V2**
- V3**

Mapping Retinotopic Visual Areas: Response to Rotating Wedge

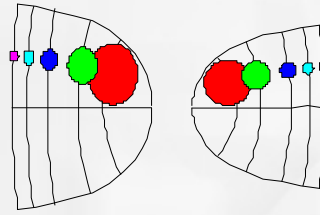


Cortex

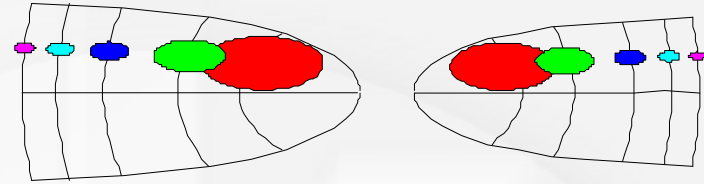


Visual space

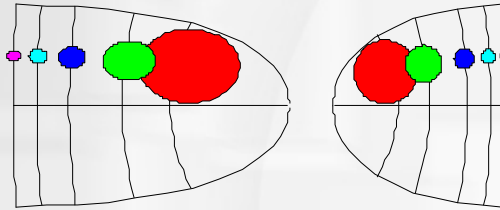
az



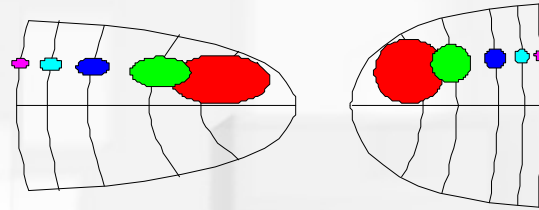
bdb



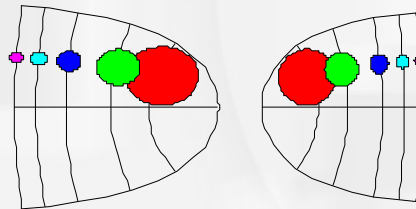
bja



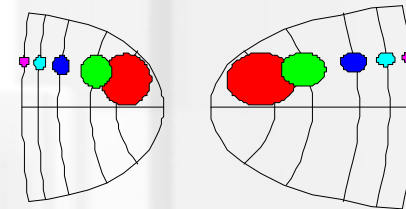
cdc



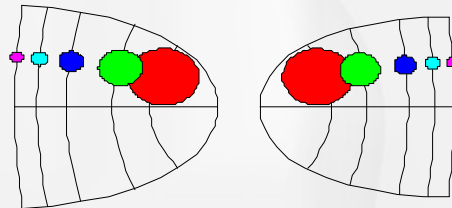
mlo



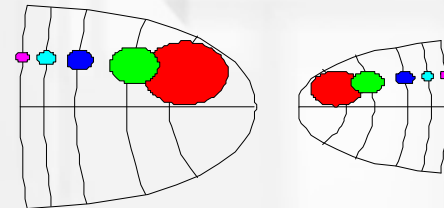
psk



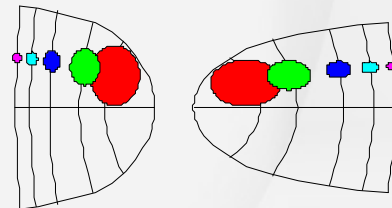
rod



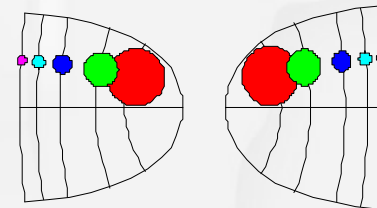
rsk



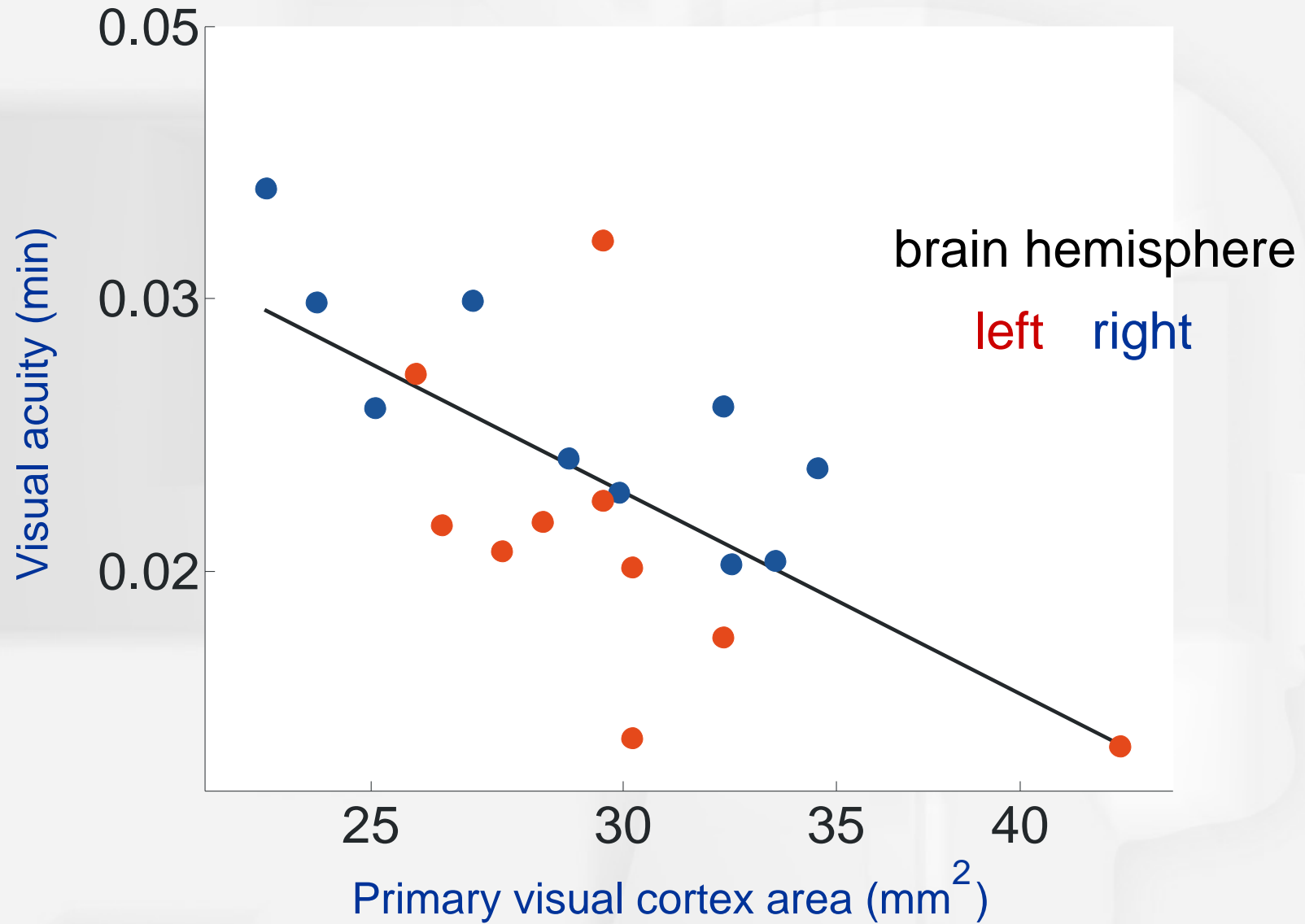
sc



ver



Cortical area correlates with visual acuity



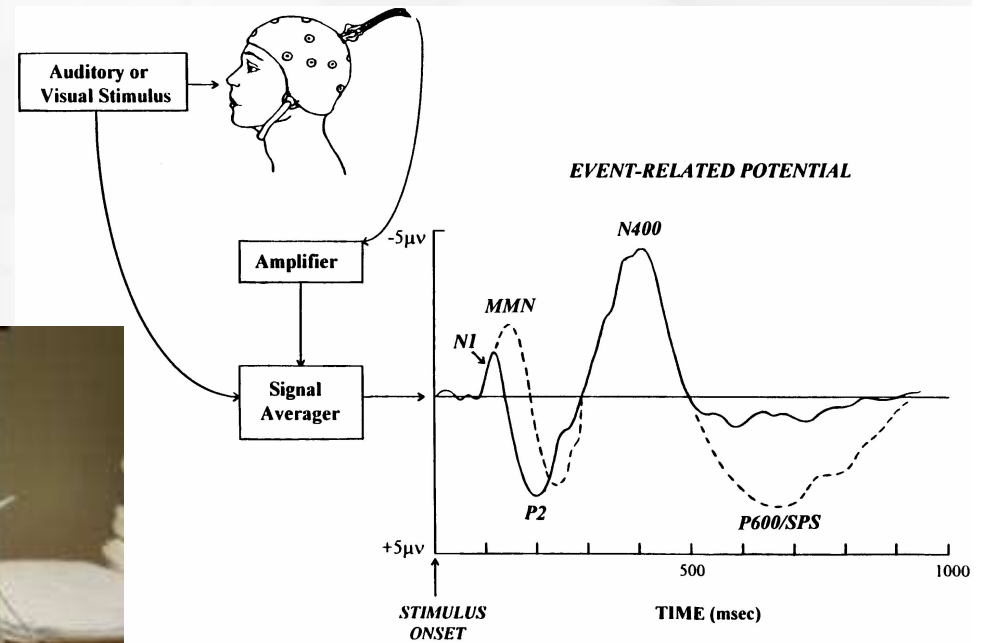
Other Brain Imaging Techniques

- **Positron emission tomography (PET)**
 - Person is injected with a radioactive tracer
 - Tracer moves through bloodstream
 - Monitoring the radioactivity measures blood flow
 - Changes in blood flow show changes in brain activity



Electroencephalography (EEG)

Measures changes in electrical potentials on the surface of the head.
Very fast temporal resolution, poor spatial resolution



Magnetoencephalography (MEG)

Measures changes in the magnetic field on the surface of the head. Very fast temporal resolution, poor spatial resolution but better than EEG (but more expensive)

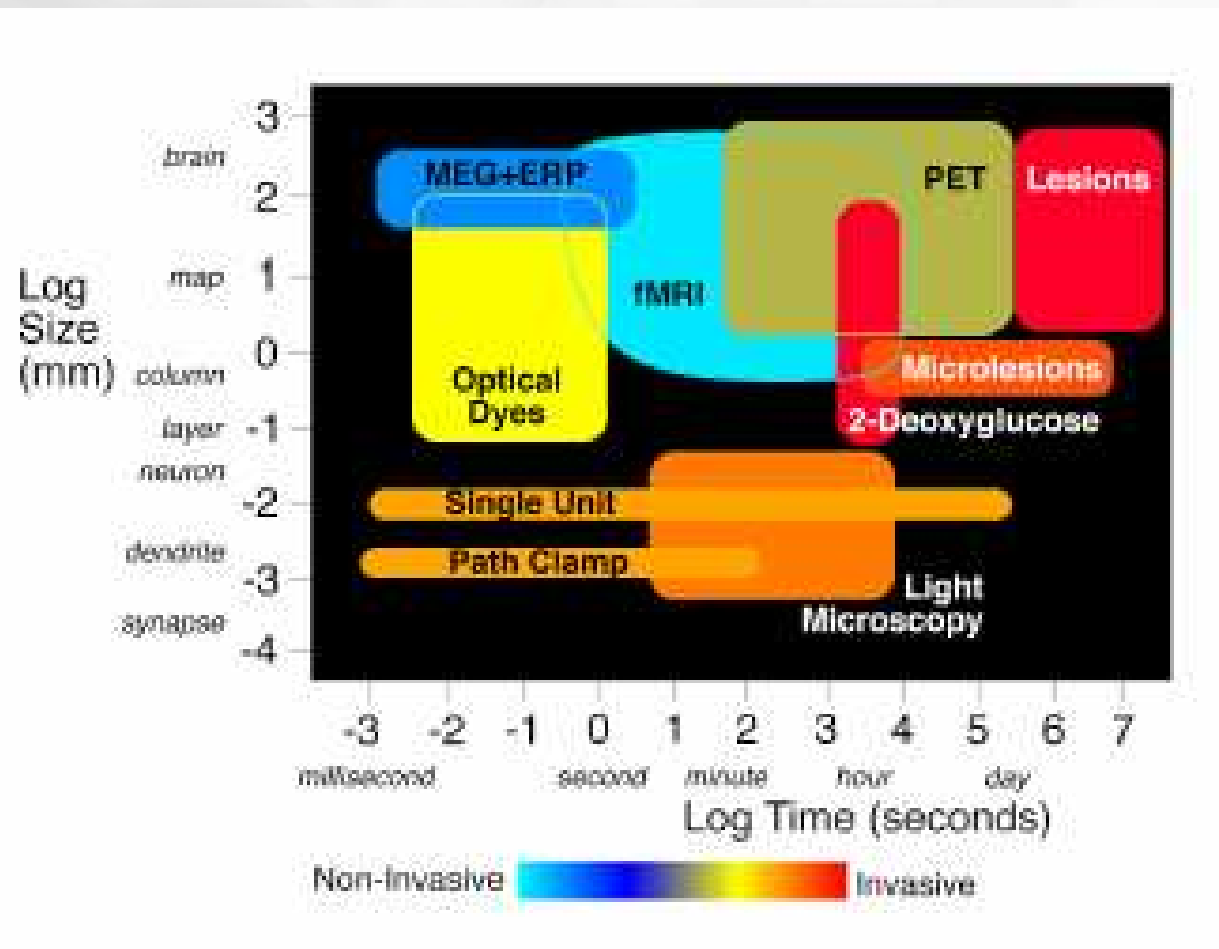


Transcranial Magnetic Stimulation (TMS)

Pulse of magnetic field change induces localized brain responses!

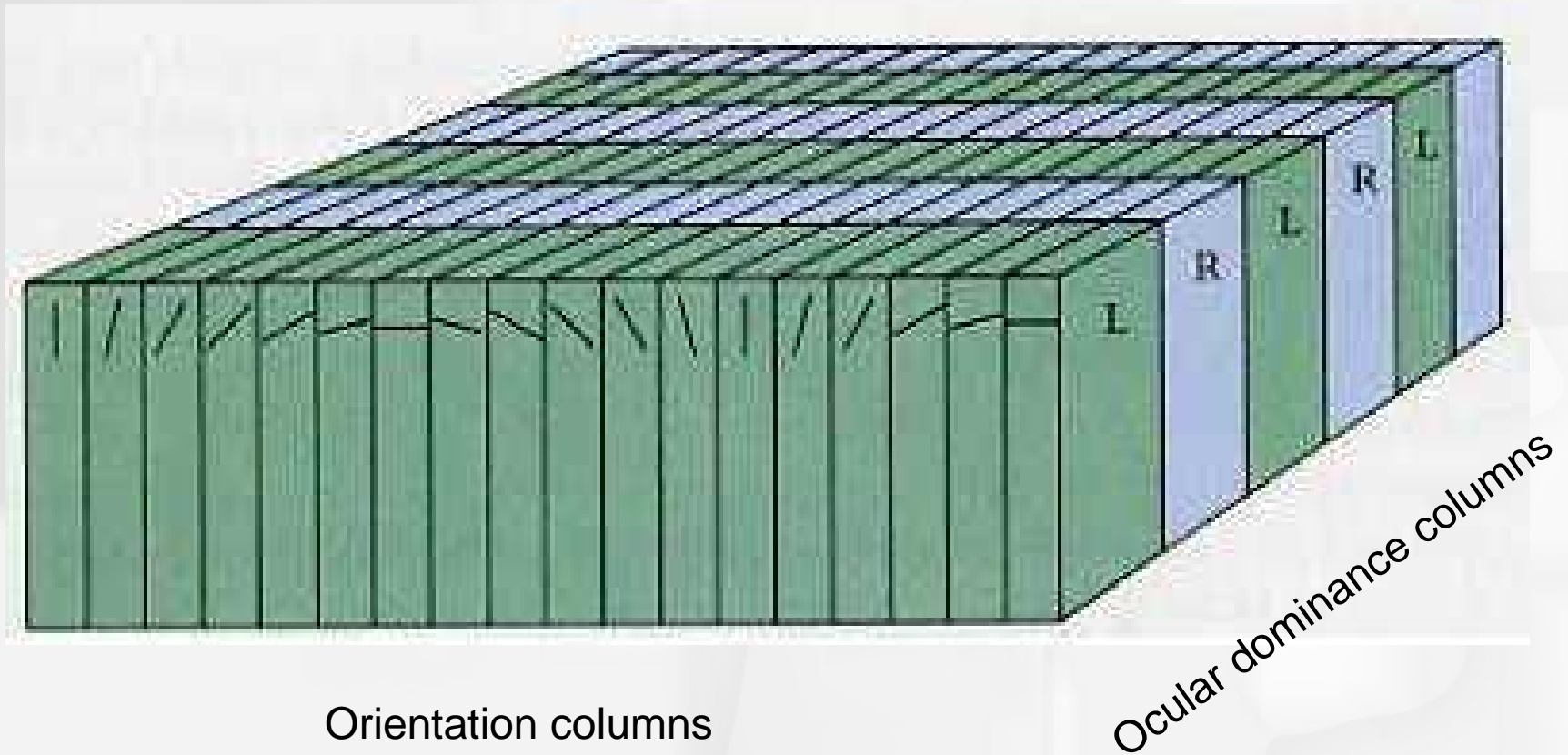


Spatial and Temporal resolution of neuroscience methods



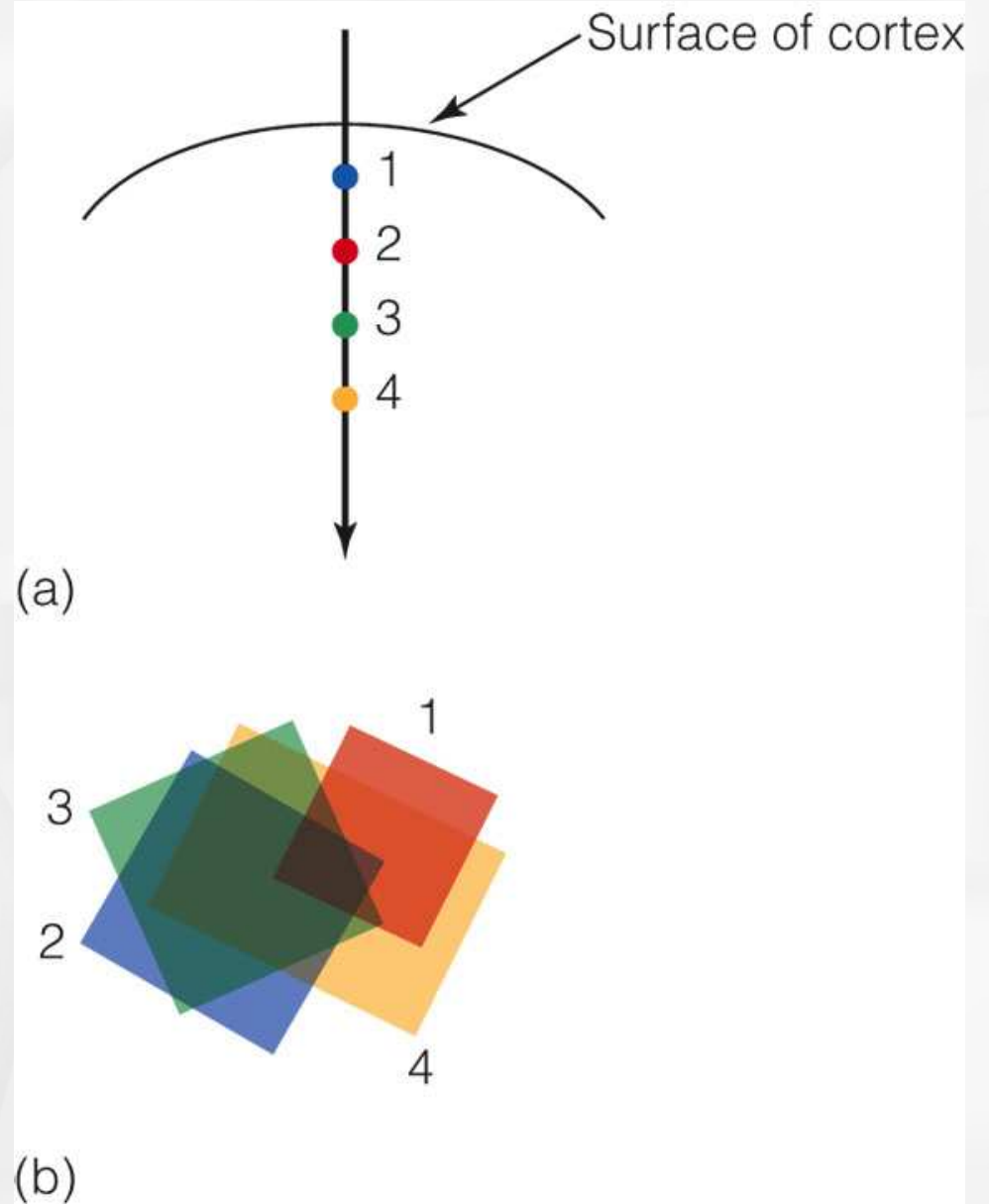
The Primary Visual Cortex:

Hubel and Wiesel's '**Cube Model**' for the representation of orientation and ocular dominance.



Organization of 'Columns' in V1

- Visual cortex shows:
 - Orientation columns
 - Neurons within columns fire maximally to the same orientation of stimuli
 - Adjacent columns change preference in an orderly fashion
 - 1 millimeter across the cortex represents entire range of orientation



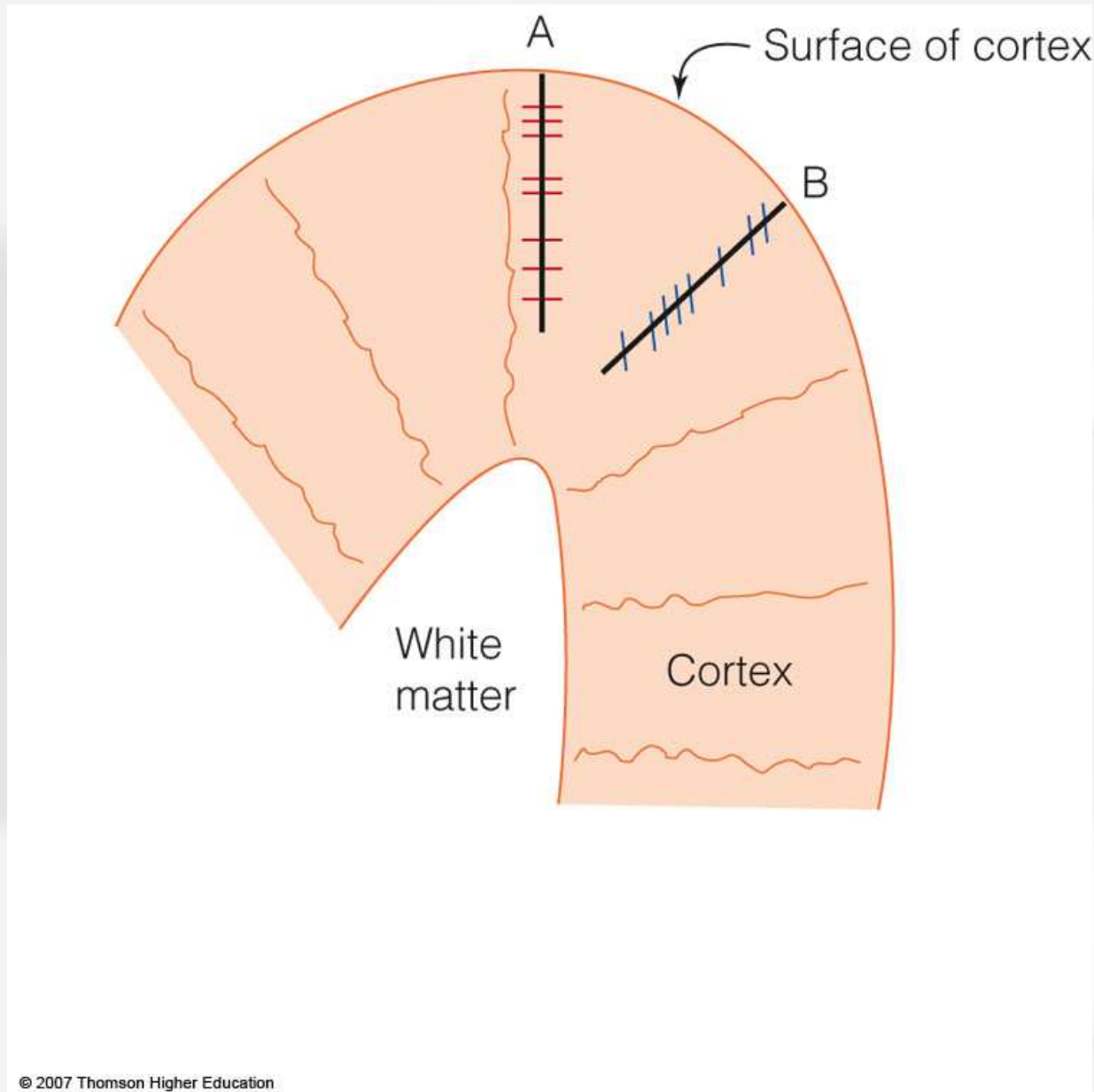
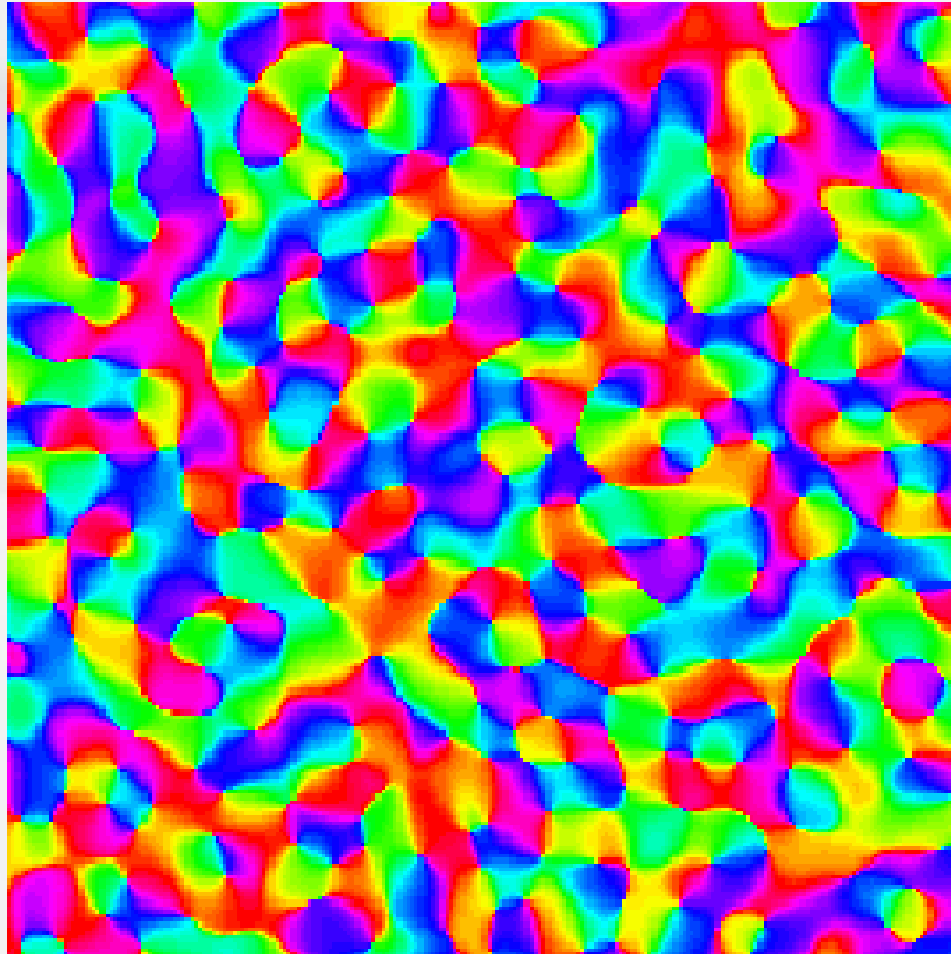
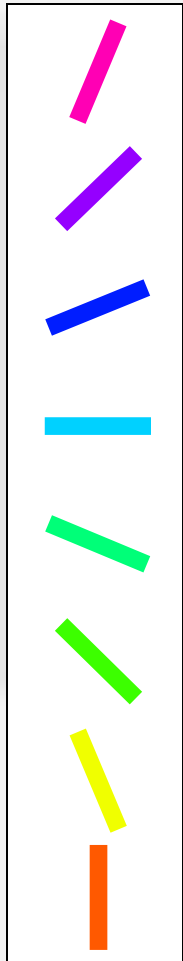


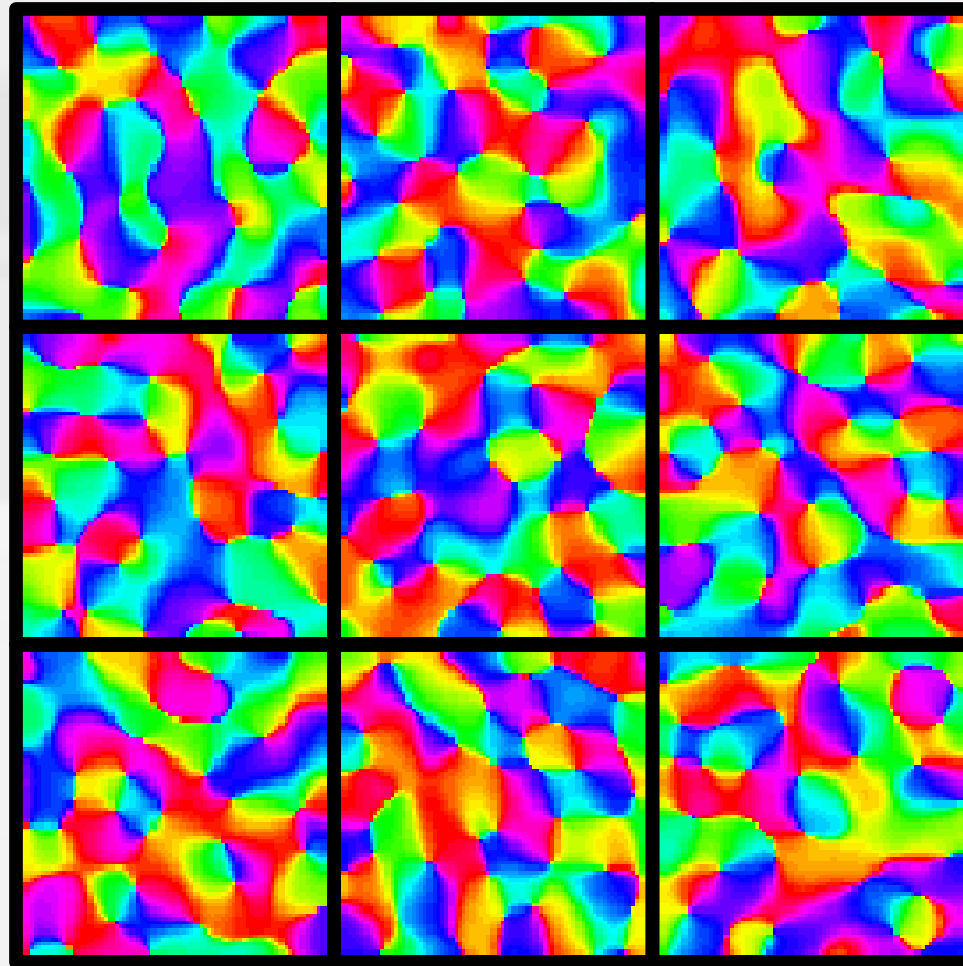
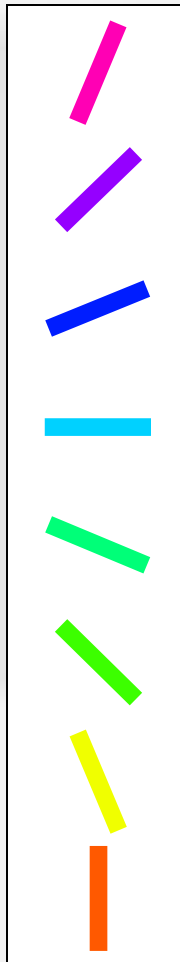
Figure 4.10 All of the cortical neurons encountered along track A respond best to horizontal bars (indicated by the red] lines cutting across the electrode track.) All of the neurons along track B respond best to bars oriented at 45 degrees.

Orientation Maps



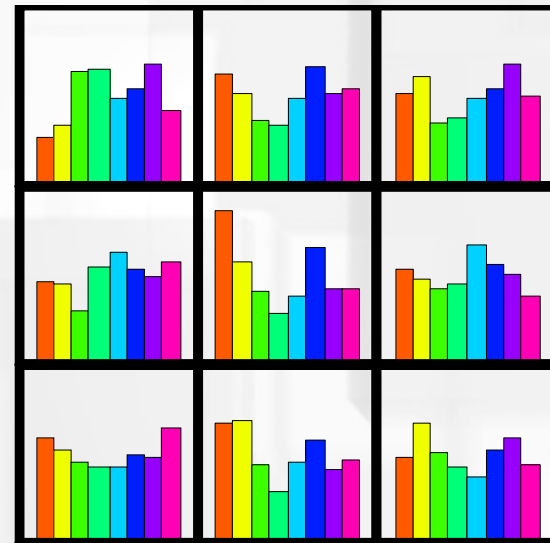
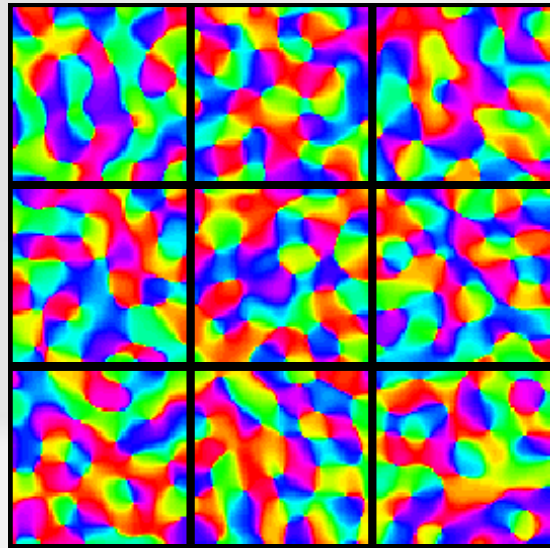
Can we measure orientation maps with fMRI?

Not quite.



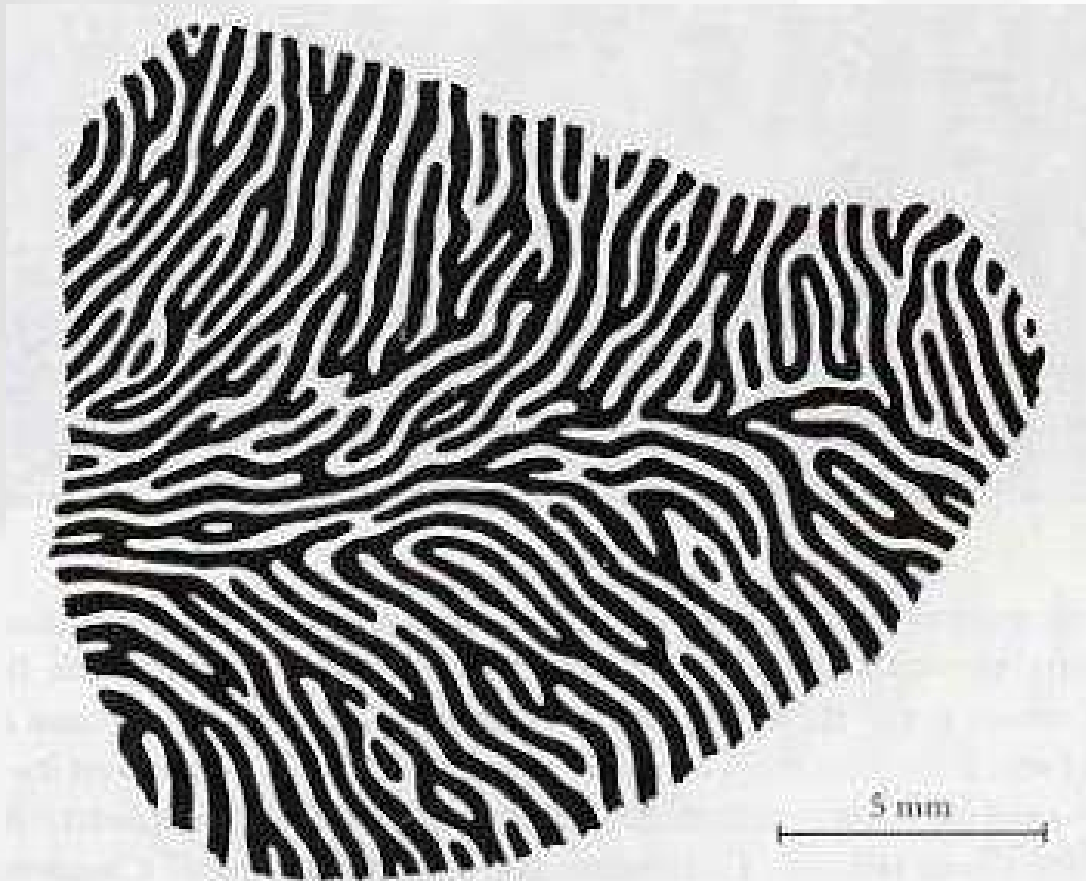
3mm (typical pixel size for fMRI)

But we can come close – the pattern of fMRI responses varies as we change the orientation of the stimulus.



Ocular dominance columns

- Neurons in the cortex respond preferentially to one eye
- Neurons with the same preference are organized into columns
- The columns alternate in a left-right pattern every .25 to .50 mm across the cortex

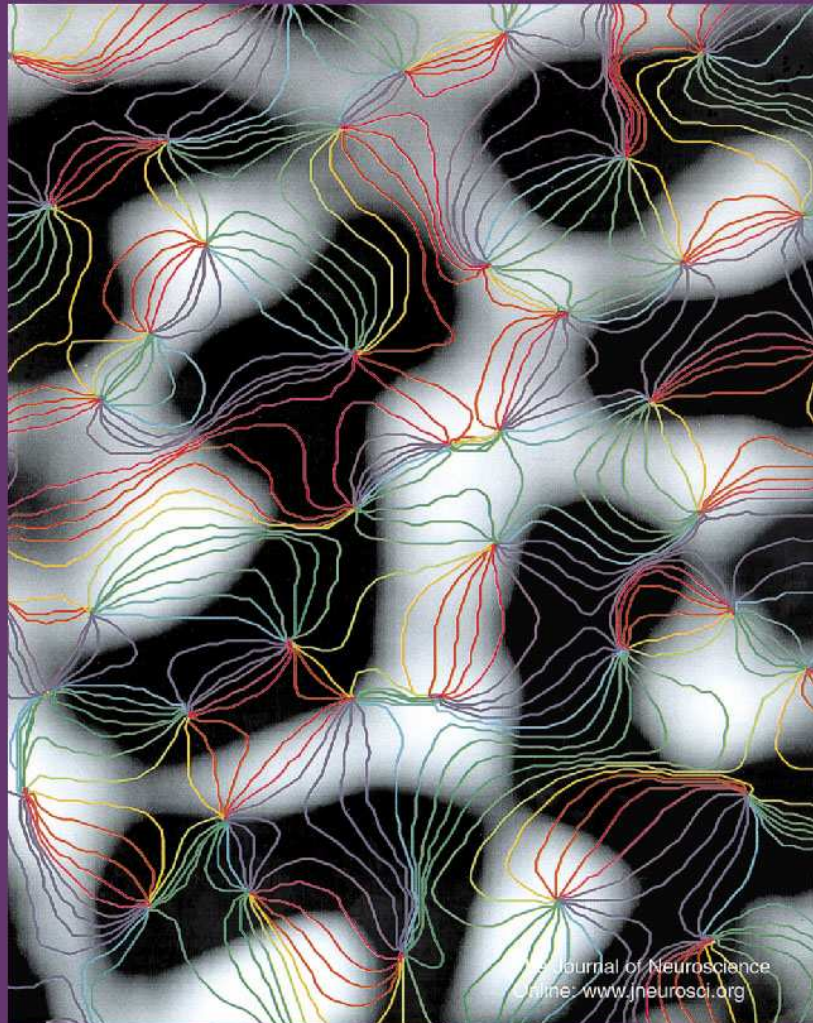


Overlay of ocular dominance columns and orientation maps on the surface of V1.

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