

PSYCH 260

Methods (continued)

Rick O. Gilmore

2021-09-02 09:14:54

Prelude

Scientists Programmed Lab Mice To Kill



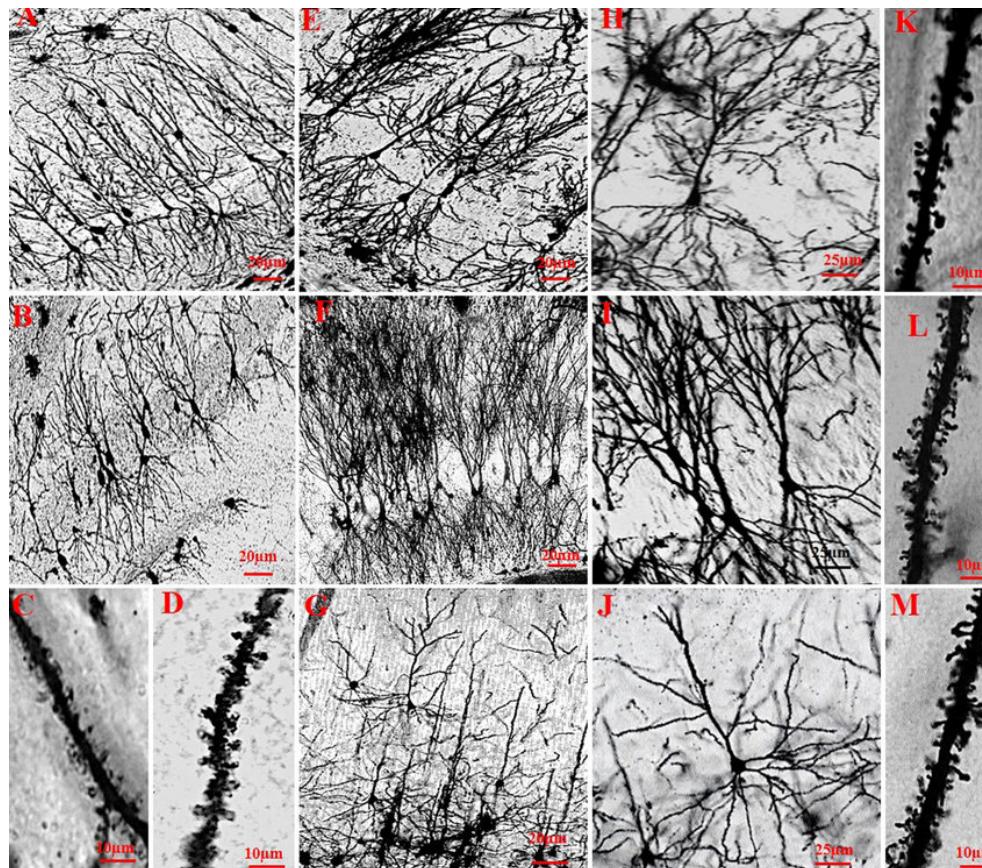
[\(Han et al., 2017\)](#)

Today's topics

- Warm-up
- Wrap-up on structural measures
- Functional measures

Warm-up

This cell-staining technique has what kind of *spatial* resolution?



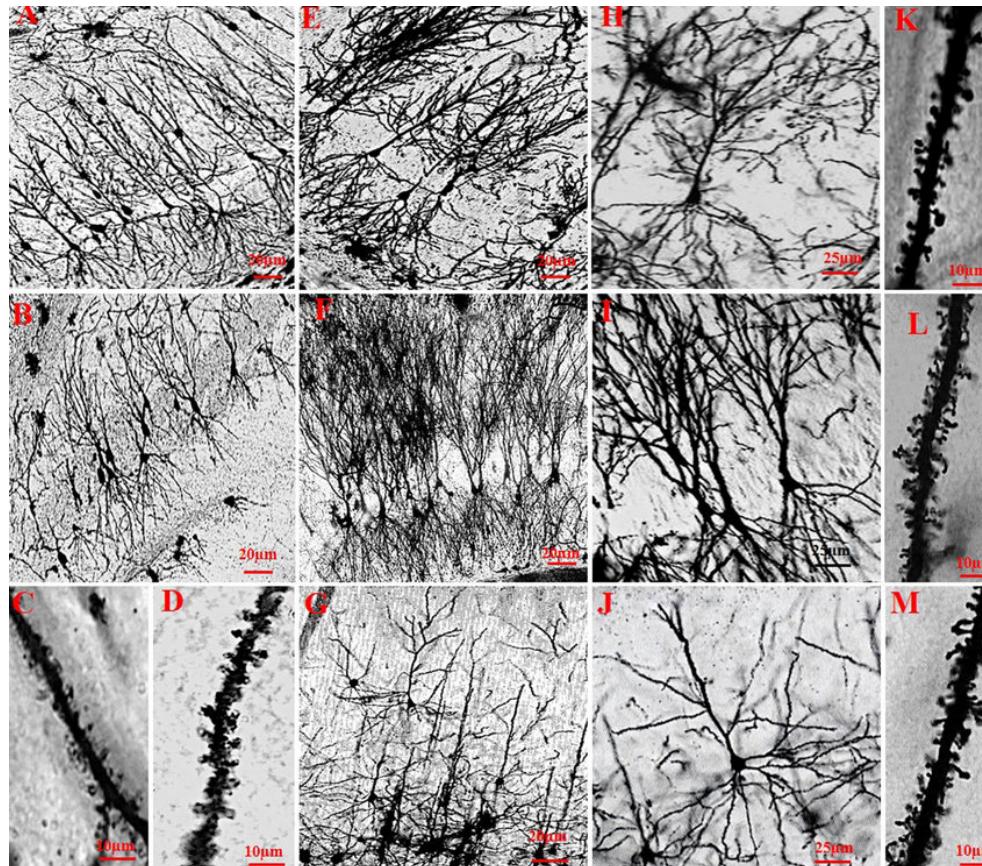
This cell-staining technique has what kind of *spatial* resolution?

- High/resolves fine details
- Low/resolves crude details

This cell-staining technique has what kind of *spatial* resolution?

- High/resolves fine details
- ~~Low/resolves crude details~~

This cell-staining technique has what kind of *temporal* resolution?



This cell-staining technique has what kind of *temporal* resolution?

- High/resolves fine details or quickly changing phenomena
- Low/resolves crude details or slowly changing phenomena

This cell-staining technique has what kind of *temporal* resolution?

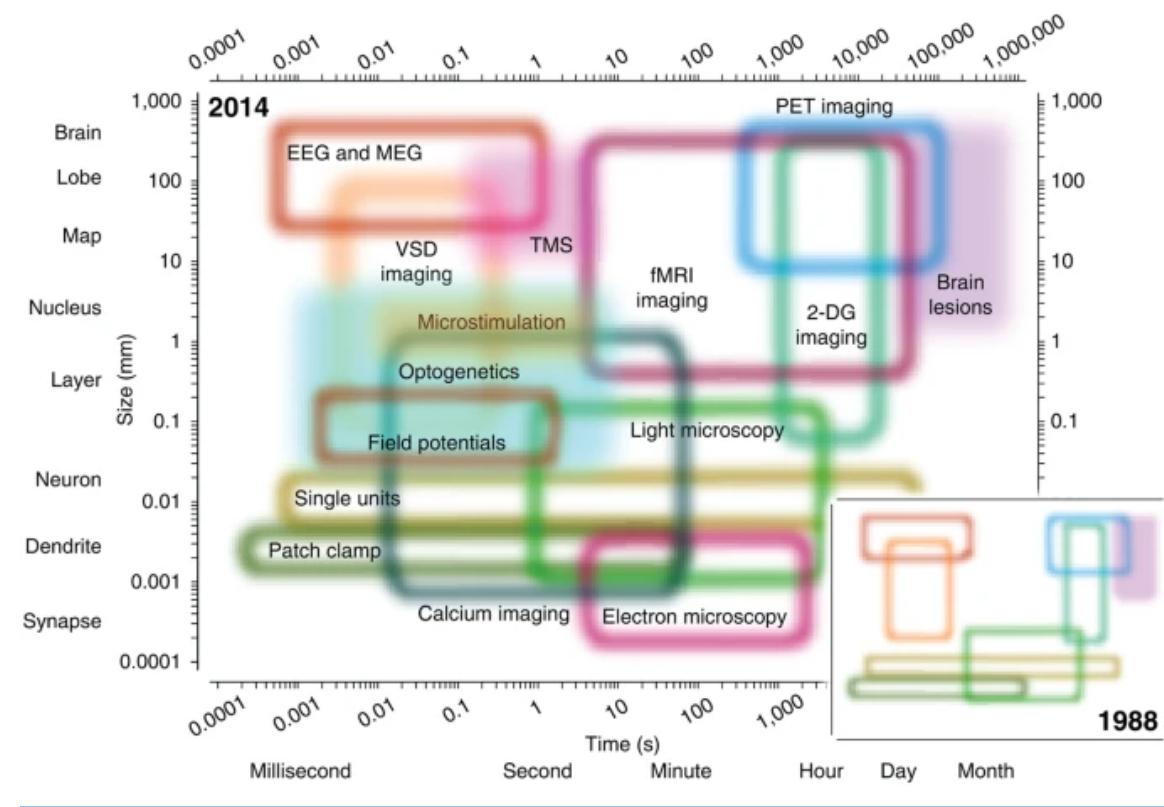
- ~~High/resolves fine details or quickly changing phenomena~~
- Low/resolves crude details or slowly changing phenomena

The cell-staining technique in question is...

- A. Nissl stain
- B. Golgi stain
- C. Cartesian stain

The cell-staining technique in question is...

- A. ~~Nissl stain~~
- B. Golgi stain
- C. ~~Cartesian stain~~



Wrap-up on structural measures

Seinowski 2014

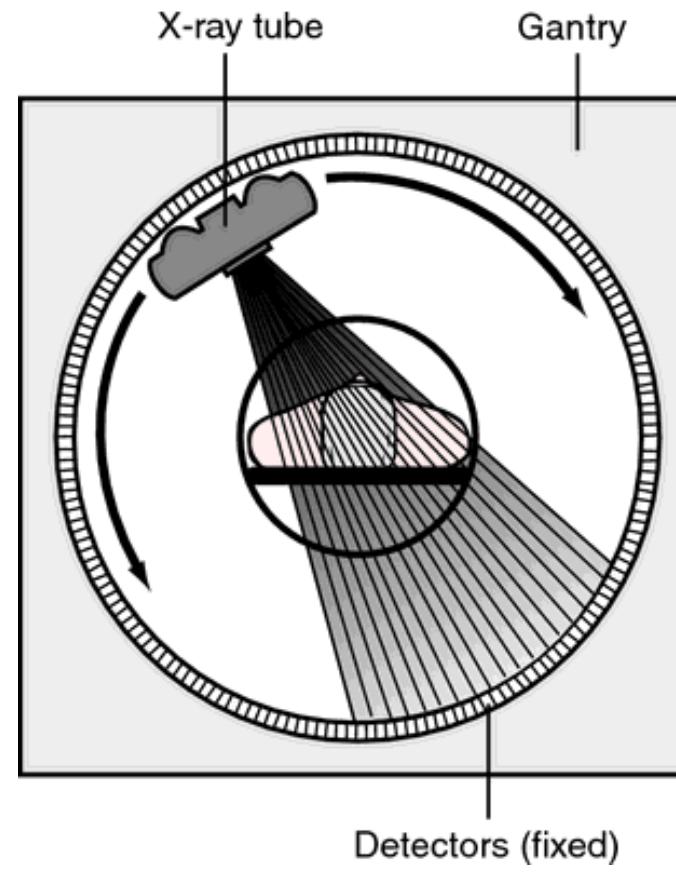
Evaluating cellular tracing techniques

- Invasive (in humans post-mortem only)
- High spatial resolution, but poor temporal resolution
 - How so?

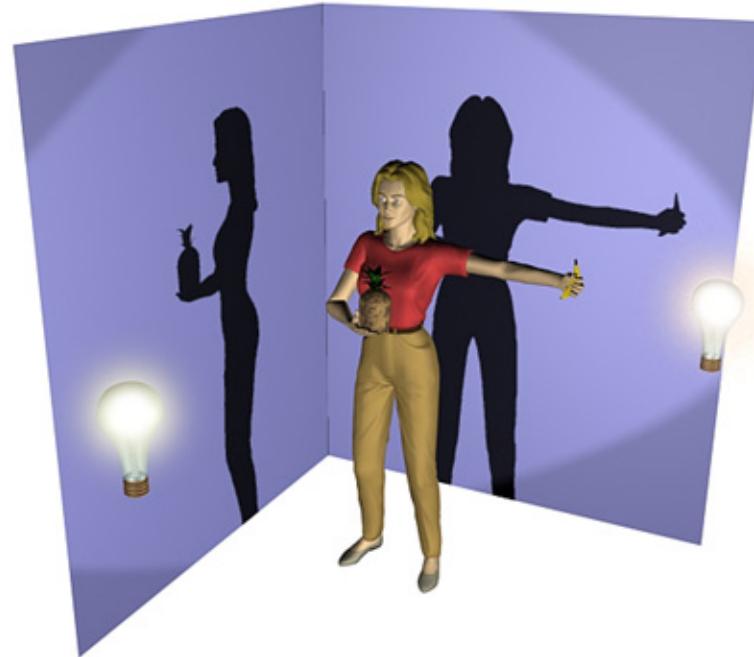
Mapping structures

- Computed axial tomography (CAT), computed tomography CT
- X-ray based

Tomography



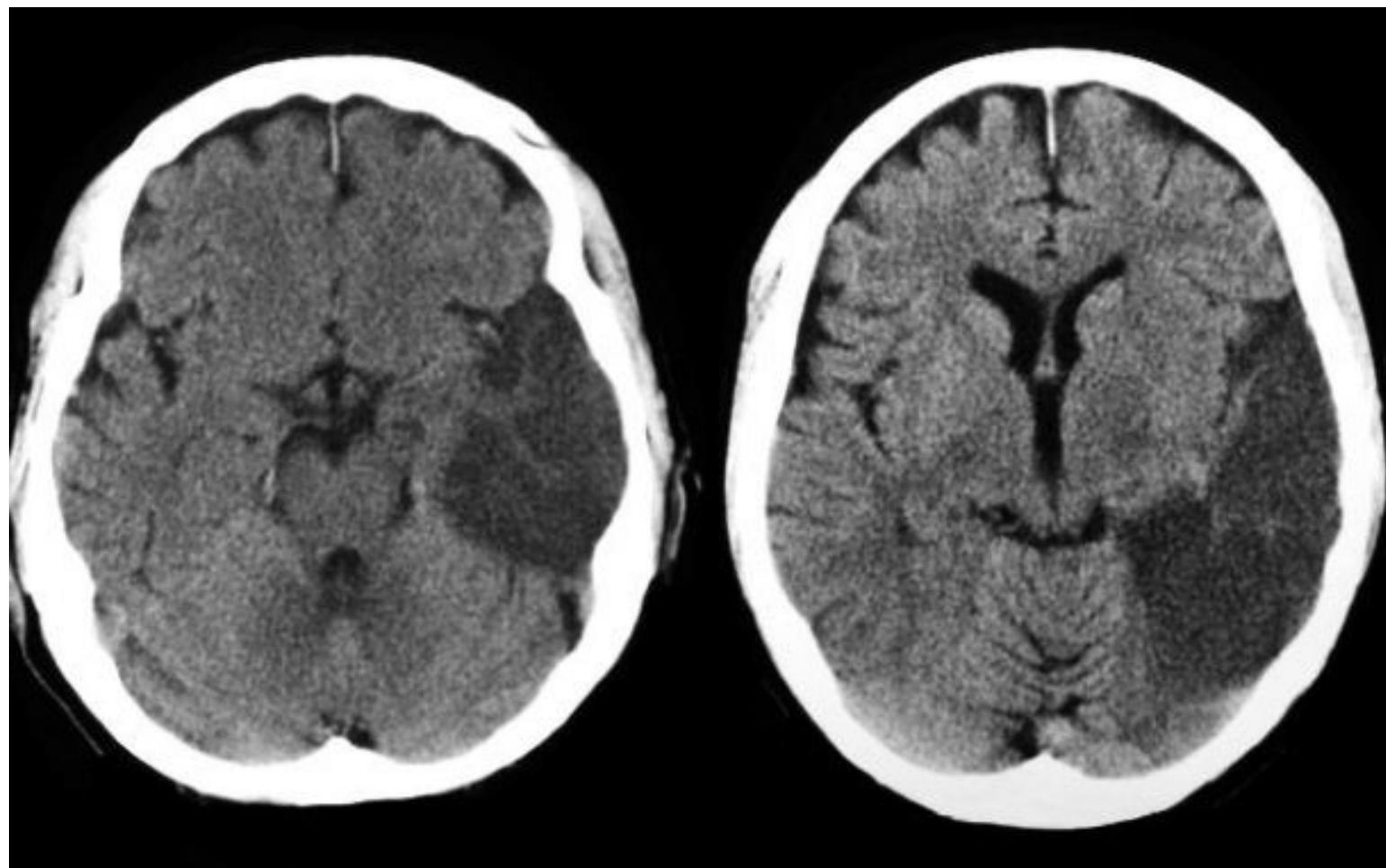
Tomography



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<https://cdn.hswstatic.com/gif/cat-scan-pineapple.jpg>

CT scan of stroke

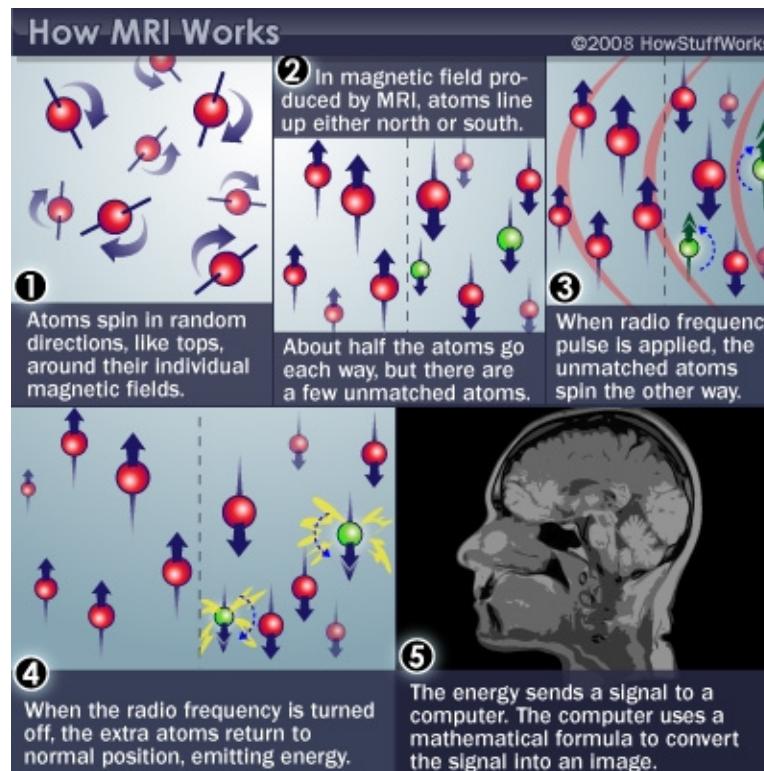


Magnetic Resonance Imaging (MRI)

- Magnetic resonance
- Some common isotopes (e.g., H) & complex molecules have a magnetic dipole
- Axes align with strong magnetic field
- When alignment perturbed by radio frequency (RF) pulse, speed of realignment varies by tissue
- Realignment emits RF signals

- How MRI works
- Also, please watch: Magnetic Resonance Imaging Explained

How MRI works

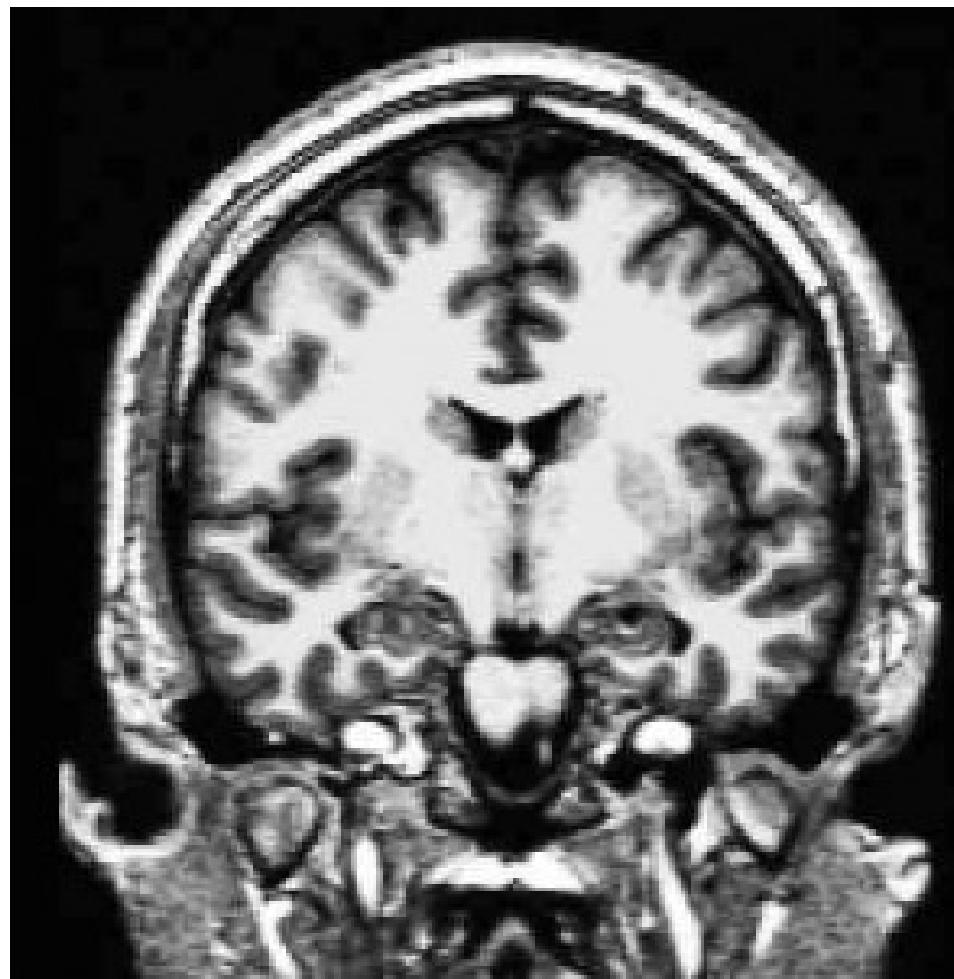


<https://cdn.hswstatic.com/gif/mri-steps.jpg>

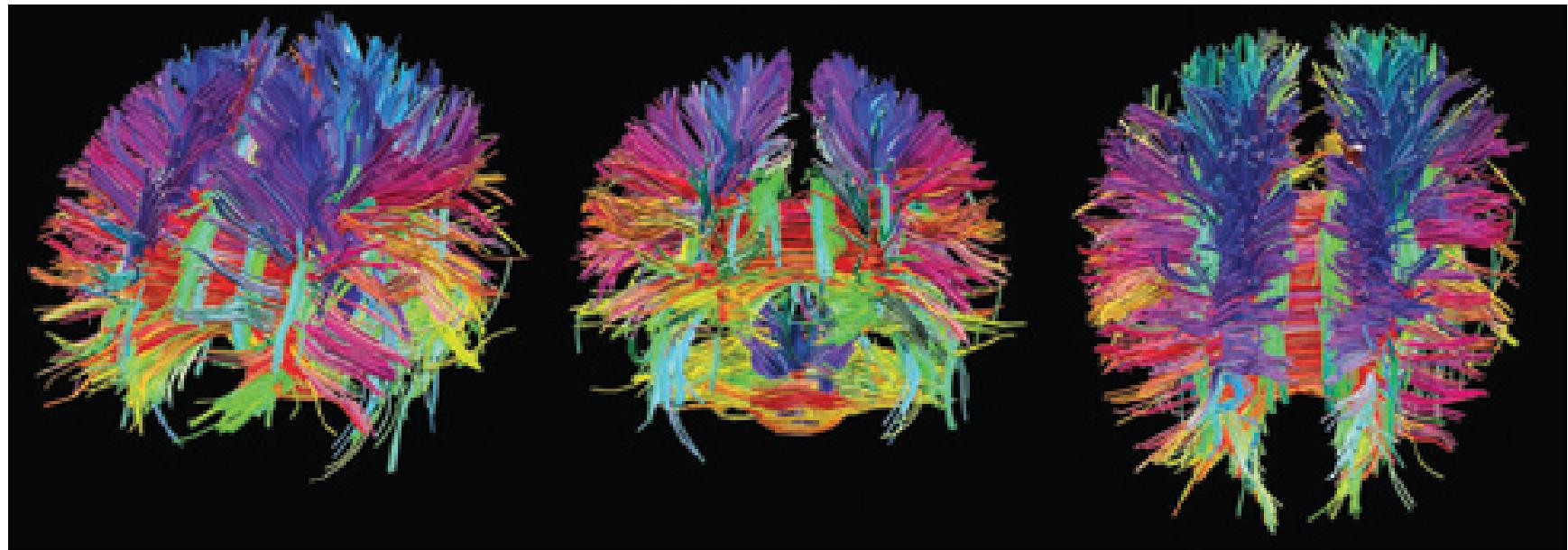
Structural MRI

- vs. Functional MRI
- Reveals tissue density/type differences
- Gray matter (neurons & dendrites & axons & glia)
vs. white matter (mostly axons)
- MR Spectroscopy (density of specific chemical substances)
- Region sizes/volumes

Structural MRI of the brain



Diffusion tensor imaging (DTI)



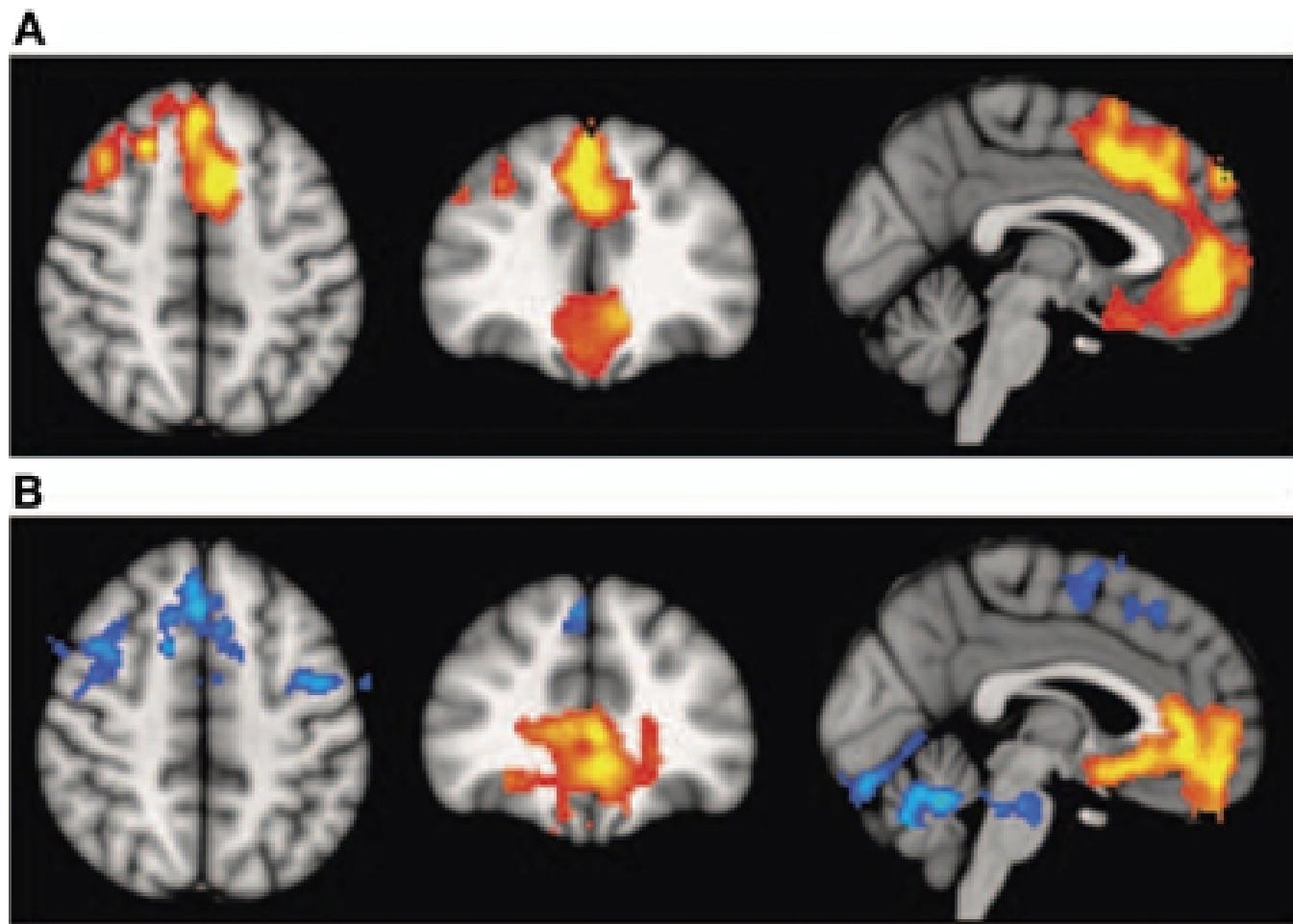
Diffusion tensor imaging (DTI)

- Type of structural MRI
- Reveals integrity/density of *axon fibers*
- Measure of connectivity between brain areas
- Measures *diffusion* pattern of H_2O molecules
- Shape of diffusion pattern captured in a *tensor*
- (Colors indicate closest-matching 'direction')

Voxel-based morphometry (VBM)

- Voxels (volume-based elements)
- Morphometry, measure (“metry”) form/morphology.
- How does brain size or thickness vary by age, disease status, etc.?

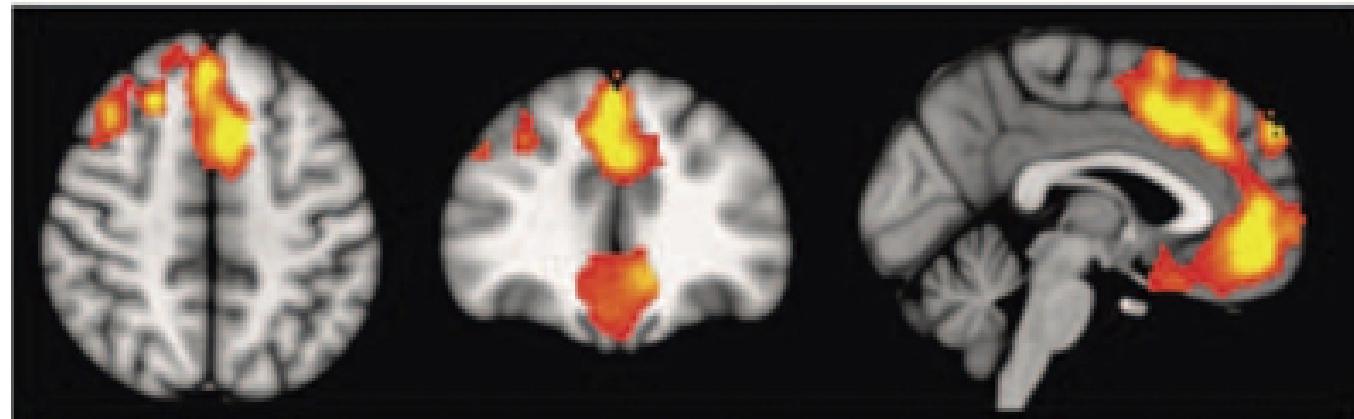
Voxel-based morphometry



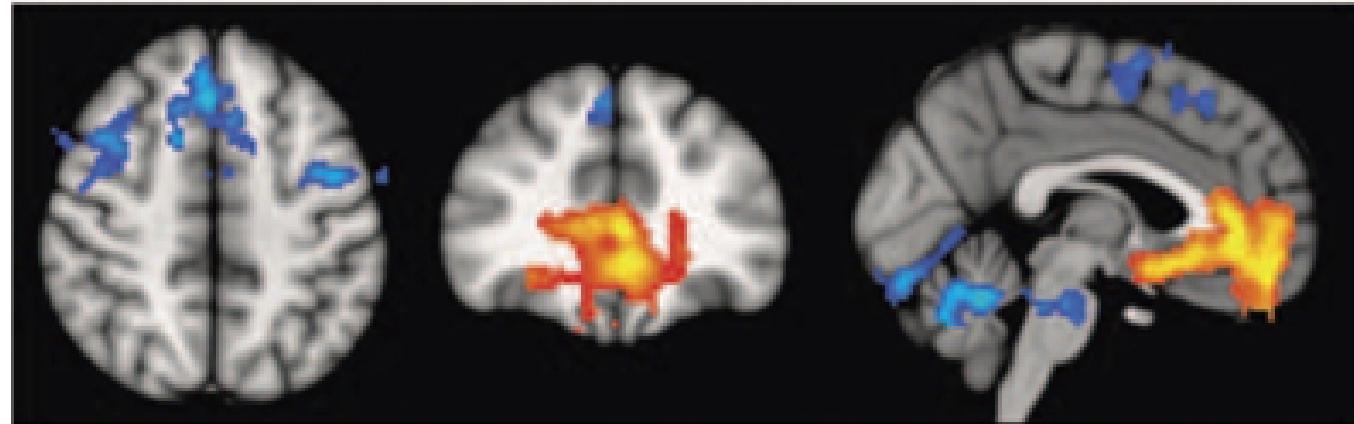
https://www.frontiersin.org/files/Articles/18691/fnhum-06-00184-HTML/image_m/fnhum-06-00184-g003.jpg

Colors mean *size* differences, not activity

A



B



Functional methods

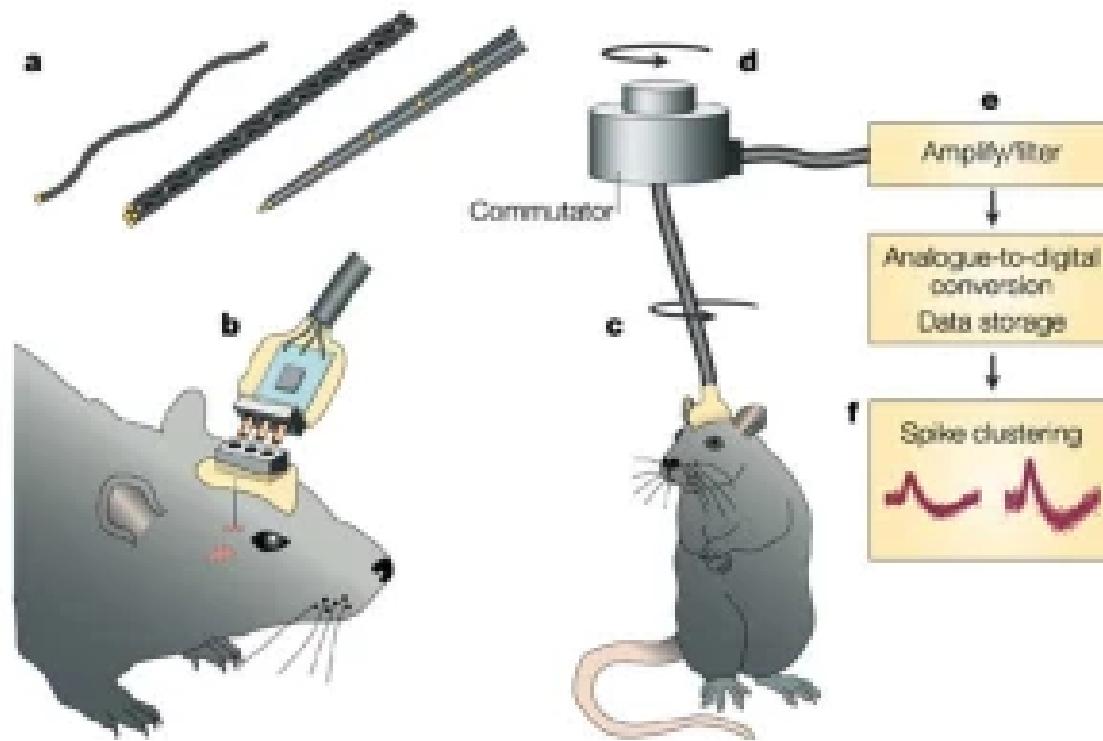
Functional methods

- Recording from the brain
- Interfering with the brain
- Stimulating the brain
- Simulating the brain

Recording from the brain

- Single/multi unit recording
 - Microelectrodes
 - Units -> Small numbers of nerve cells

Single/multi-unit Recording



Nature Reviews | Neuroscience

(Maren & Quirk, 2004)

Single/multi-unit recording

- What does neuron X respond to?
- High temporal (ms) & spatial resolution (um)
- Invasive
- Rarely suitable for humans, but...

Electrocorticography (ECoG)



ECoG and multimodal brain imaging

<https://youtu.be/gFky09ekmzw>

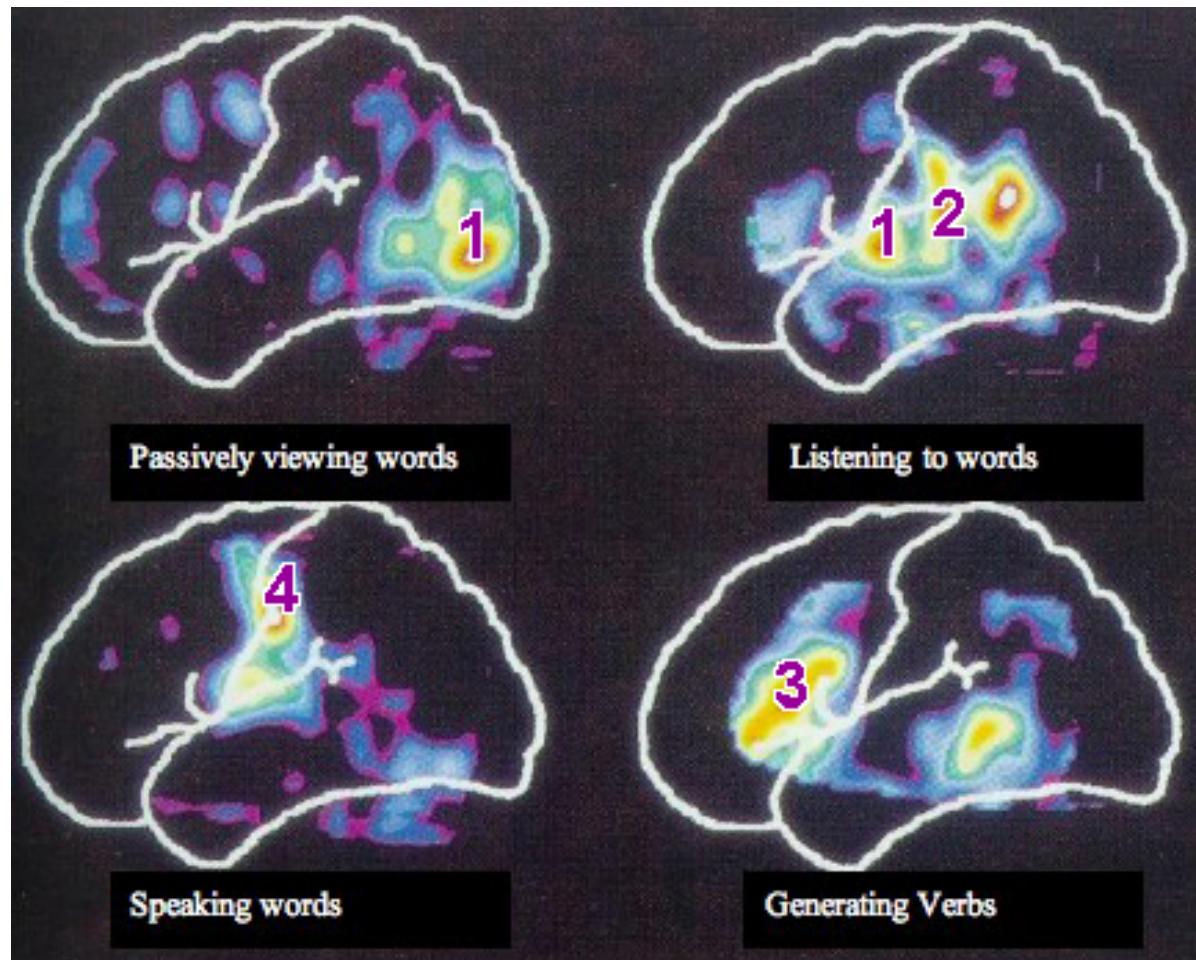
Positron Emission Tomography (PET)

How Does a PET Scan Work?



Positron Emission Tomography (PET)

- Radioactive tracers (glucose, oxygen)
- Positron decay
- Experimental condition - control
- Average across individuals



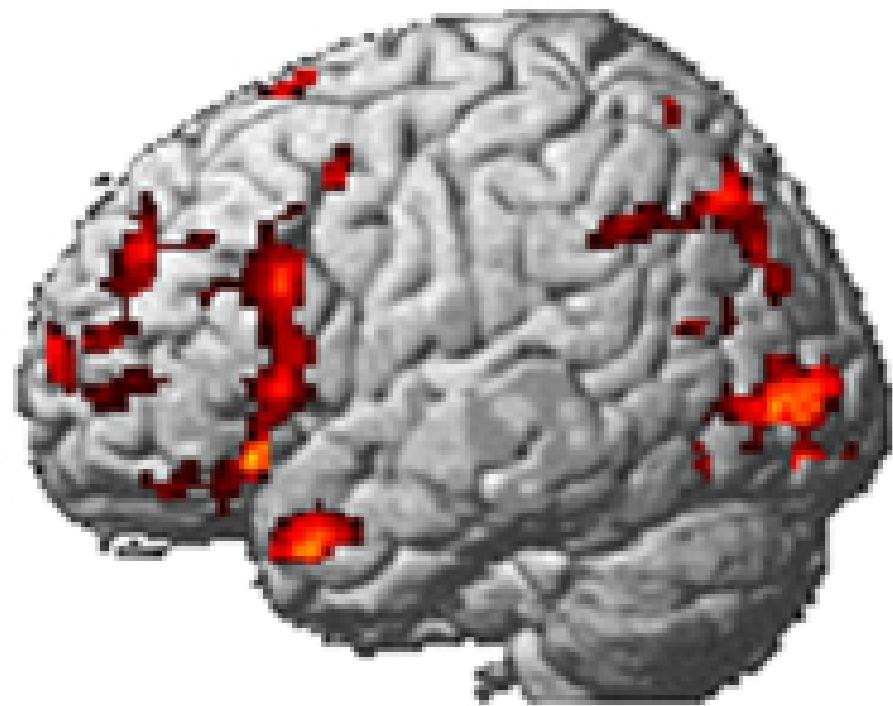
Evaluating PET

- Temporal (~ s) and spatial (mm-cm) resolution *worse* than fMRI
- Radioactive exposures + mildly invasive
- Dose < airline crew exposure in 1 yr

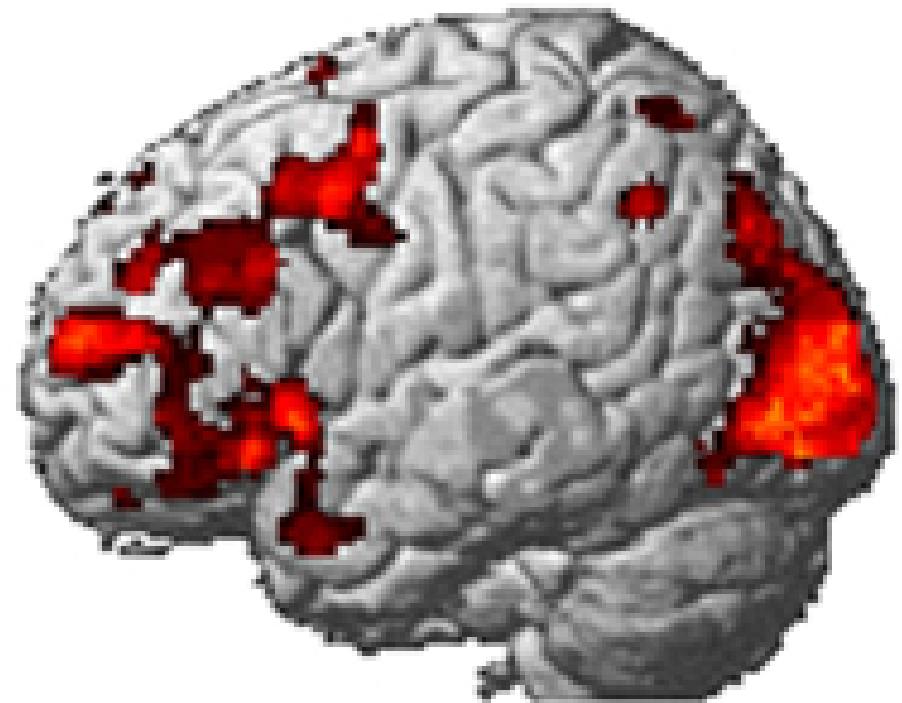
Functional Magnetic Resonance Imaging (fMRI)

- Neural activity -> local O_2 consumption increase
- *Blood Oxygen Level Dependent (BOLD) response*
 - Oxygenated vs. deoxygenated hemoglobin creates magnetic contrast
 - Do regional blood O_2 volumes (and flow) vary with behavior X?

fMRI

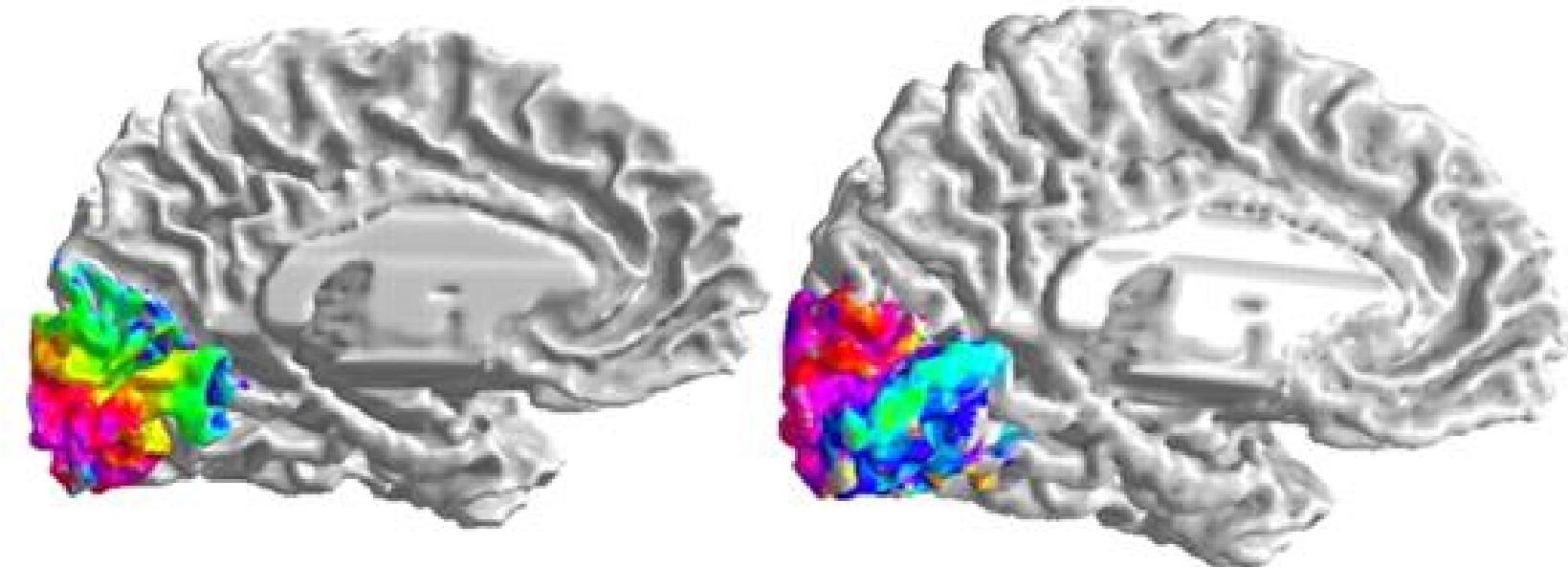
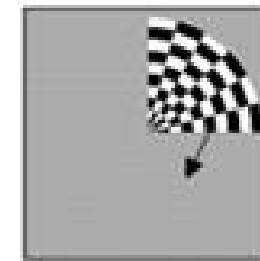
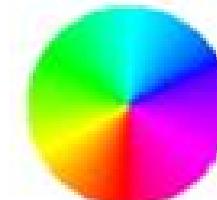
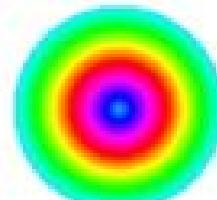
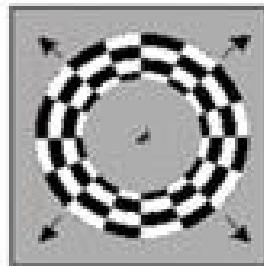


HAPPY



SAD

fMRI (Dougherty et al., 2003)



Retinotopy task -- Wedge-Clockwise run



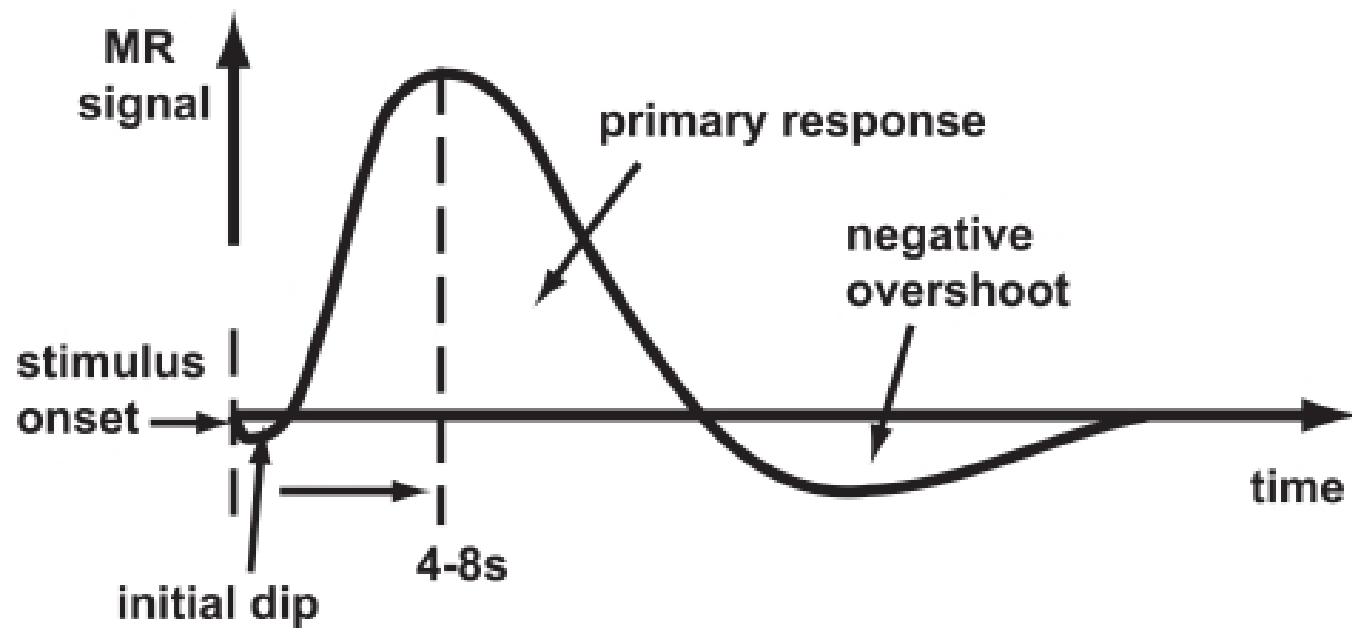
Retinotopy task -- Ring-Expanding run



Evaluating fMRI

- Non-invasive, but expensive
- Moderate but improving (mm) spatial, temporal (~sec) resolution
- Indirect measure of brain activity
- Hemodynamic Response Function (HRF)
 - 1s delay plus 3-6 s 'initial-dip'

Hemodynamic Response Function (HRF)

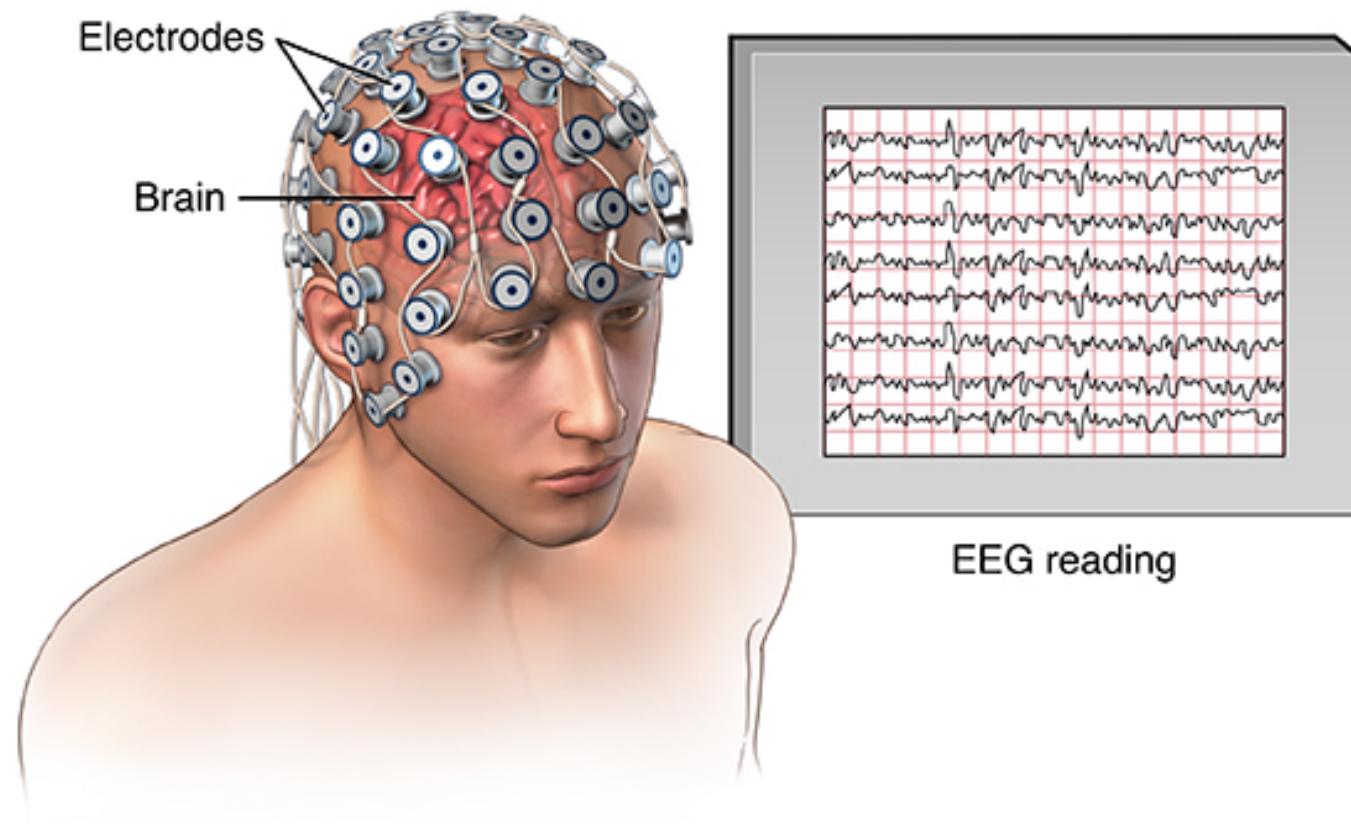


Electroencephalography (EEG)

- How does it work?
 - Electrodes on scalp or brain surface
- What do we measure?
 - Combined activity of huge # of neurons

EEG

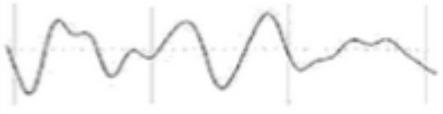
Electroencephalogram (EEG)



EEG

- High/fine temporal resolution but poor spatial resolution
- Analyze frequency bands
 - LOW: deep sleep
 - MIDDLE: Quiet, alert state
 - HIGH: "Binding" information across senses

EEG Frequency

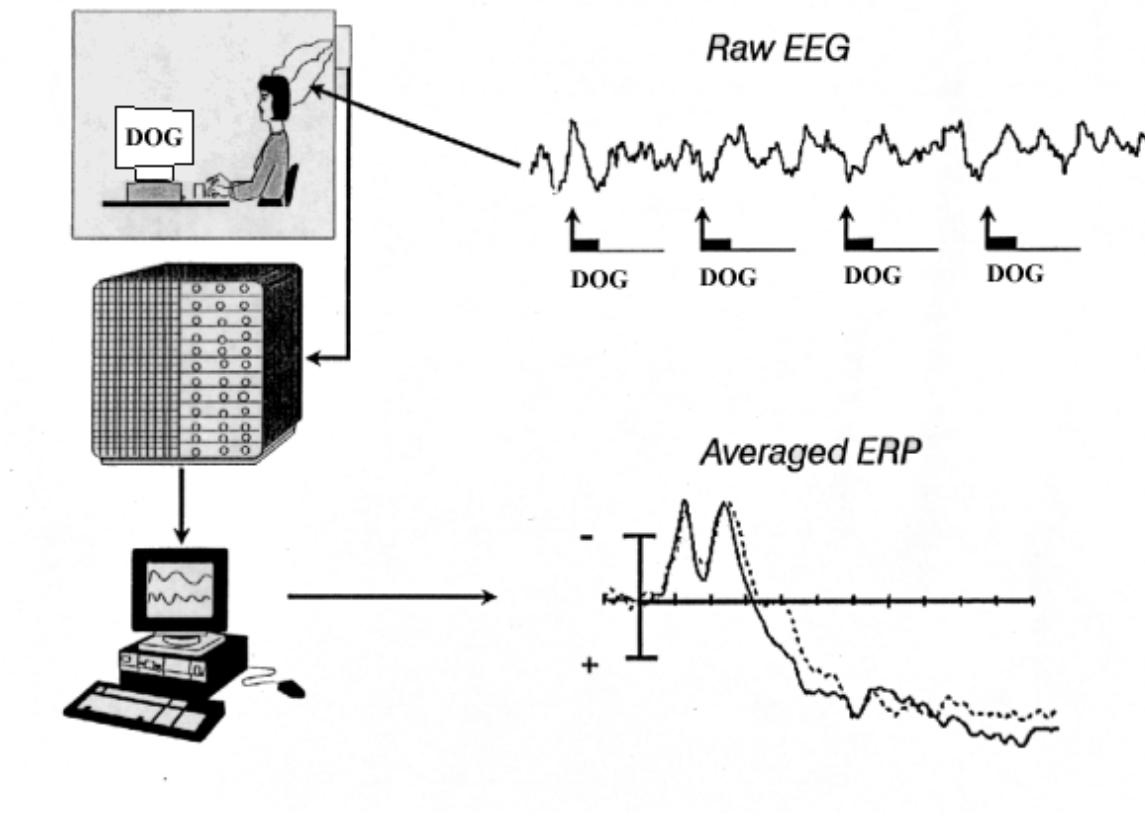
Frequency Band Name	Frequency Bandwidth	State Associated with Bandwidth	Example of Filtered Bandwidth
Raw EEG	0–45 Hz	Awake	
Delta	0.5–3.5 Hz	Deep Sleep	
Theta	4–7.5 Hz	Drowsy	
Alpha	8–12 Hz	Relaxed	
Beta	13–35 Hz	Engaged	

Event-related potentials (ERPs)

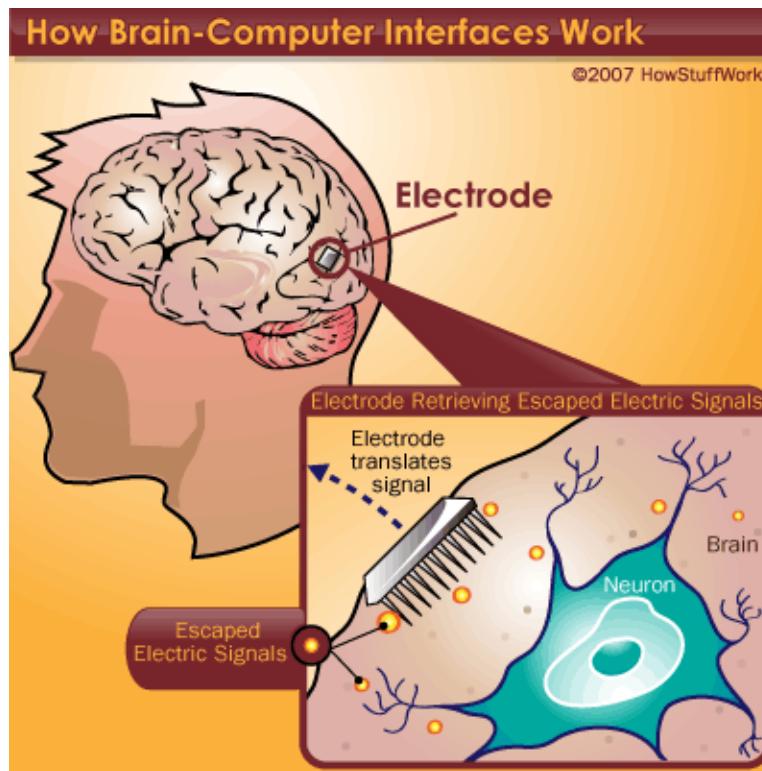
- EEGs time-locked to some event
- Averaged over many trials

ERPs

Event-Related Potential Technique



Brain Computer Interface (BCI)



<https://cdn.hswstatic.com/gif/brain-computer-interface-3.gif>

Magneto-encephalography (MEG)

- Like EEG, but measuring magnetic fields
- High temporal resolution, low spatial resolution
- Magnetic field propagates w/o distortion

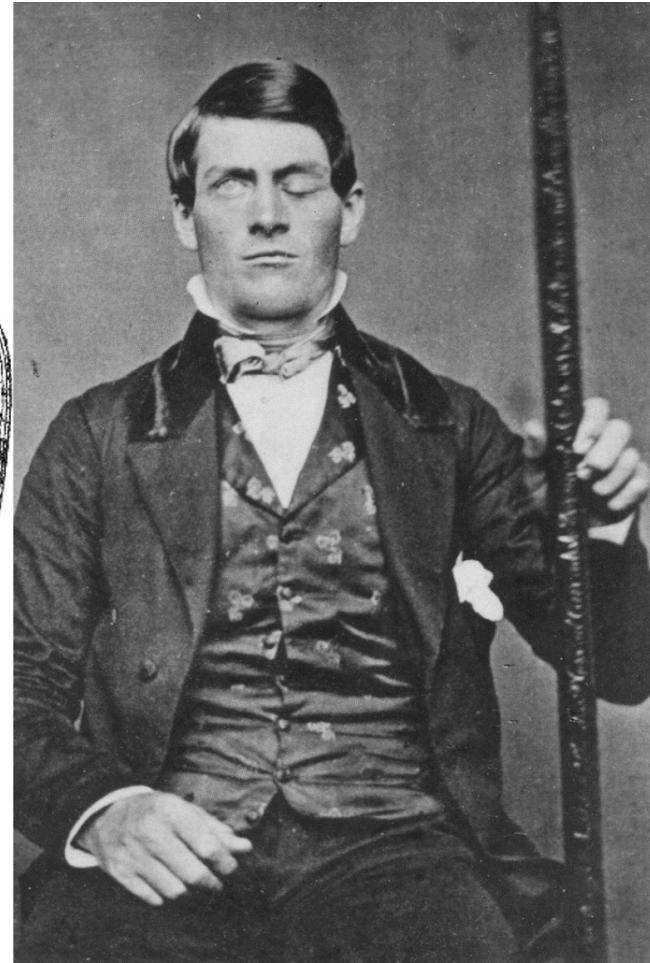
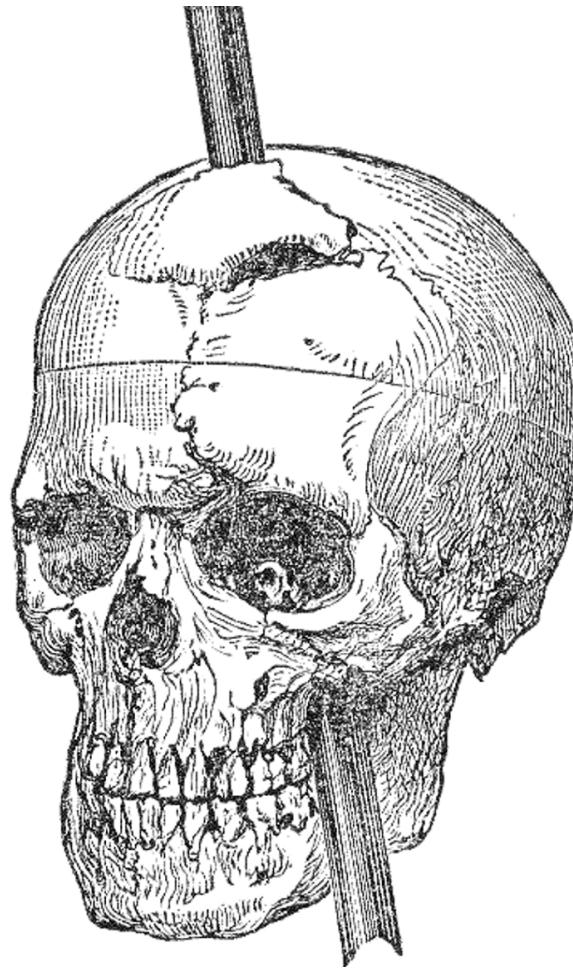
MEG



Manipulating the brain

- Nature's "experiments"
 - Stroke, head injury, tumor
 - Neuropsychology
- If damage to X impairs performance on Y -> X critical for/controls Y
- Poor spatial/temporal resolution, limited experimental control

Phineas Gage



<http://www.doctorsimpossible.com/the-curious-case-of-phineas-gage/>

Bestselling author of *Awakenings* and *A Leg to Stand On*

OLIVER SACKS

The

MAN

Who

**MISTOOK
HIS WIFE**

for a

HAT

and Other Clinical Tales

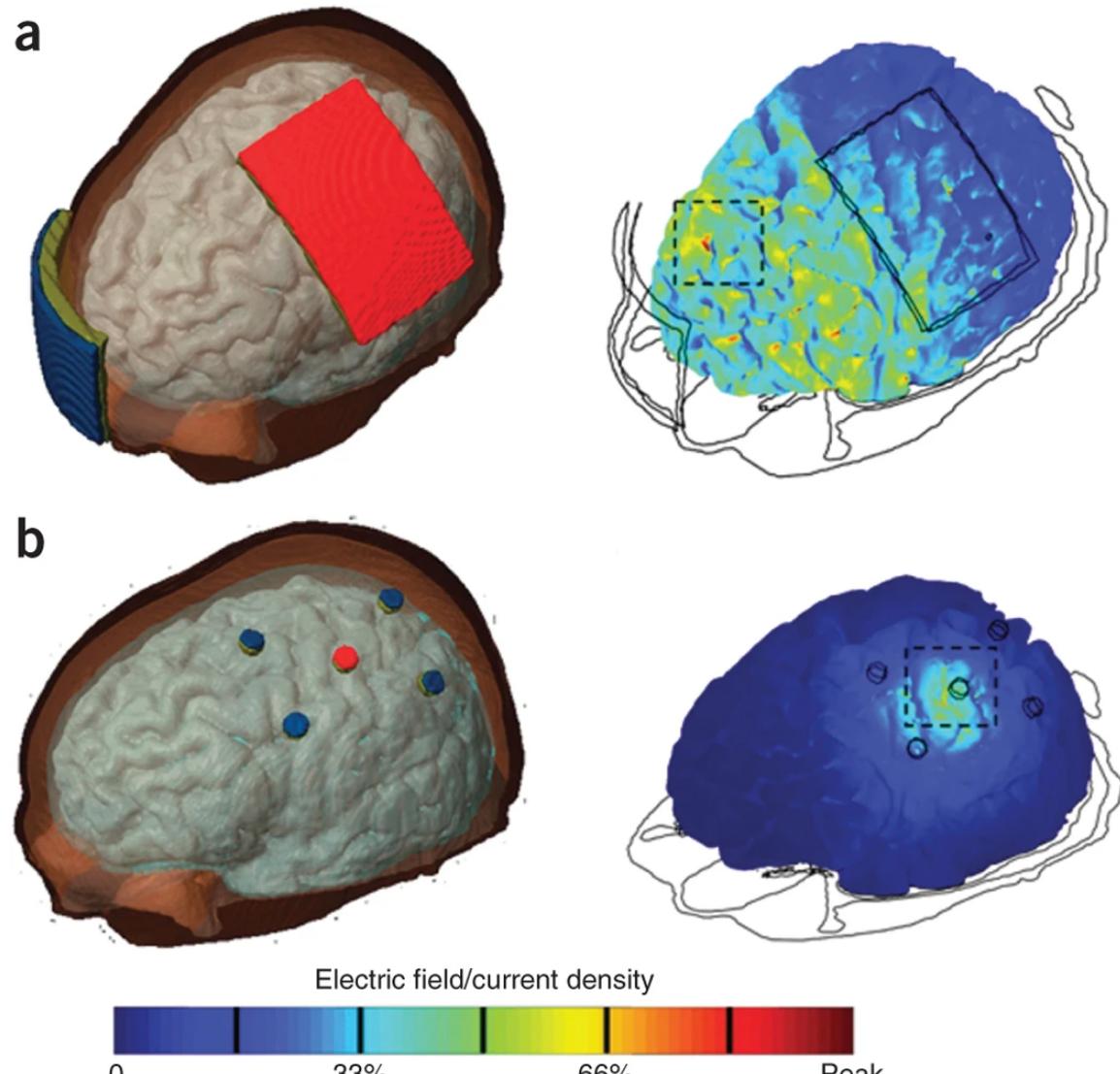
"Beguiling, compassionate, moving....the lucidity and power of a gifted writer."

—John C. Marshall, *The New York Times Book Review*

Stimulating the brain

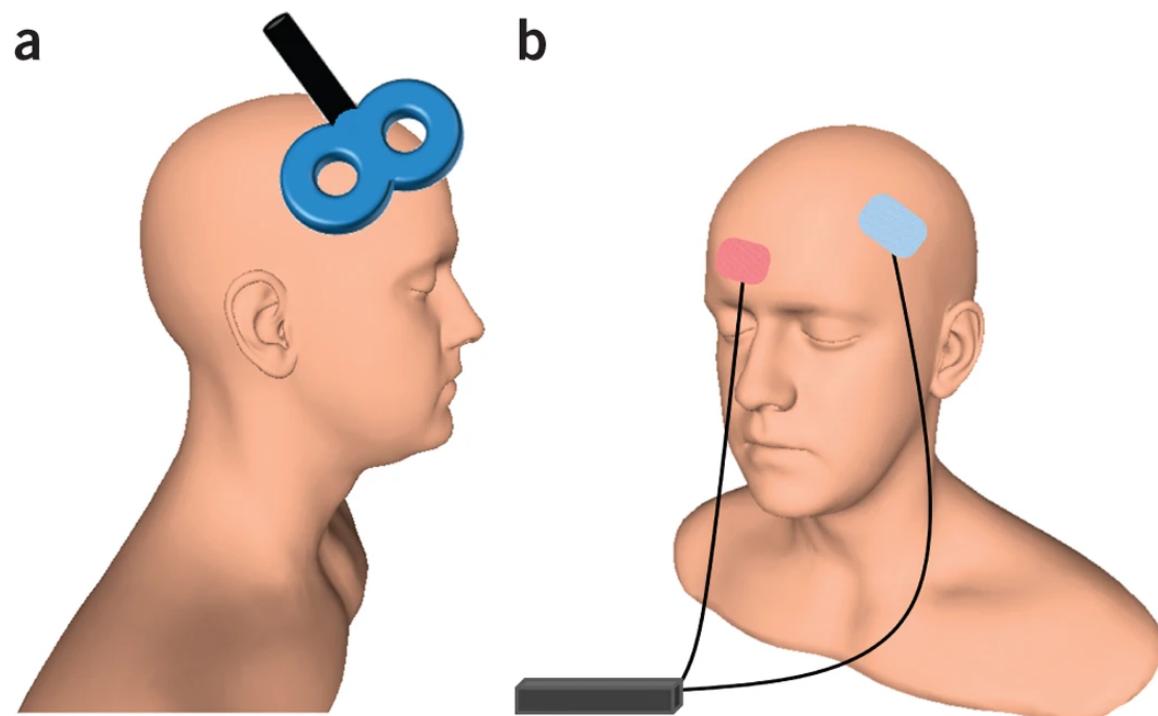
- Pharmacological
- Electrical (transcranial Direct Current Stimulation - tDCS)
- Magnetic (Transcranial magnetic stimulation - *TMS*)
- Optically (optogenetics)

tDCS



[\(Dayan, Censor, Buch, Sandrini, & Cohen, 2013\)](#)

TMS



(Dayan, Censor, Buch, Sandrini, & Cohen, 2013)

Optogenetic stimulation

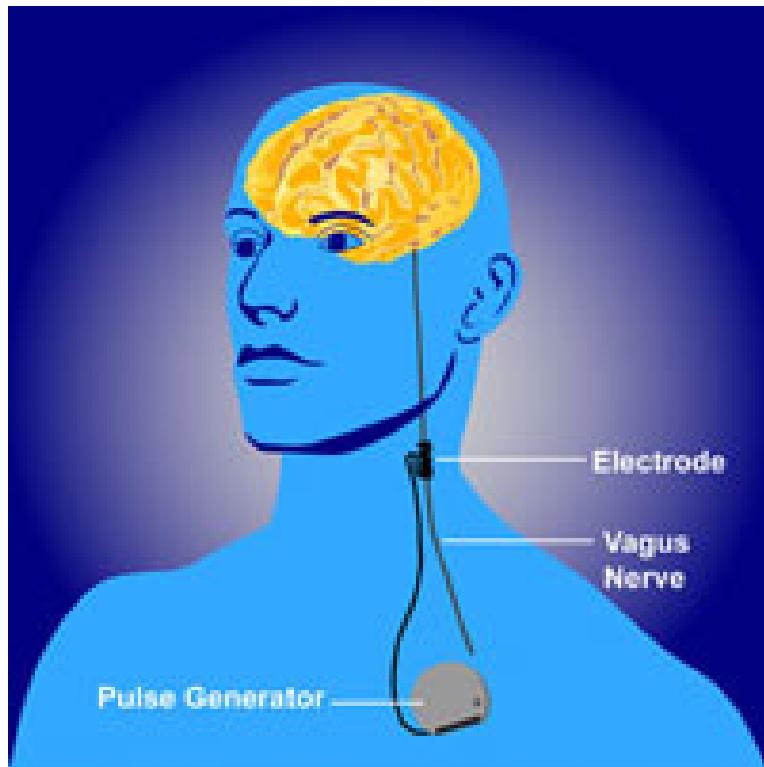
Method of the Year 2010: Optogenetics - by Nature Video



Evaluating stimulation methods

- Spatial/temporal resolution?
 - Does stimulation mimic natural activity?
 - Optogenetic stimulation highly similar, others less so
- Deep brain stimulation as therapy
 - Parkinson's Disease
 - Depression
 - Epilepsy

Deep brain stimulation



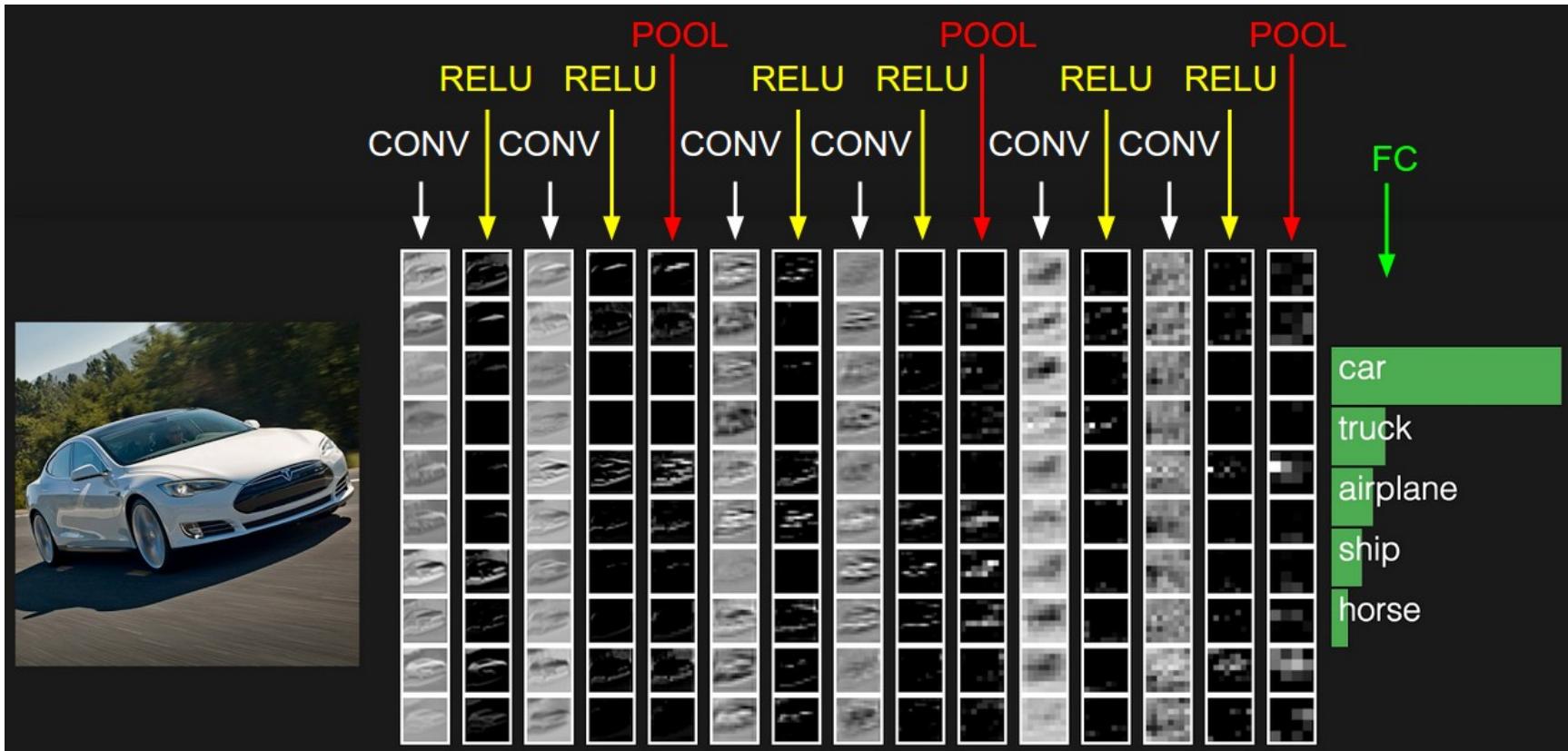
<https://www.nimh.nih.gov/health/topics/brain-stimulation-therapies/brain-stimulation-therapies>

Parkinson's Disease

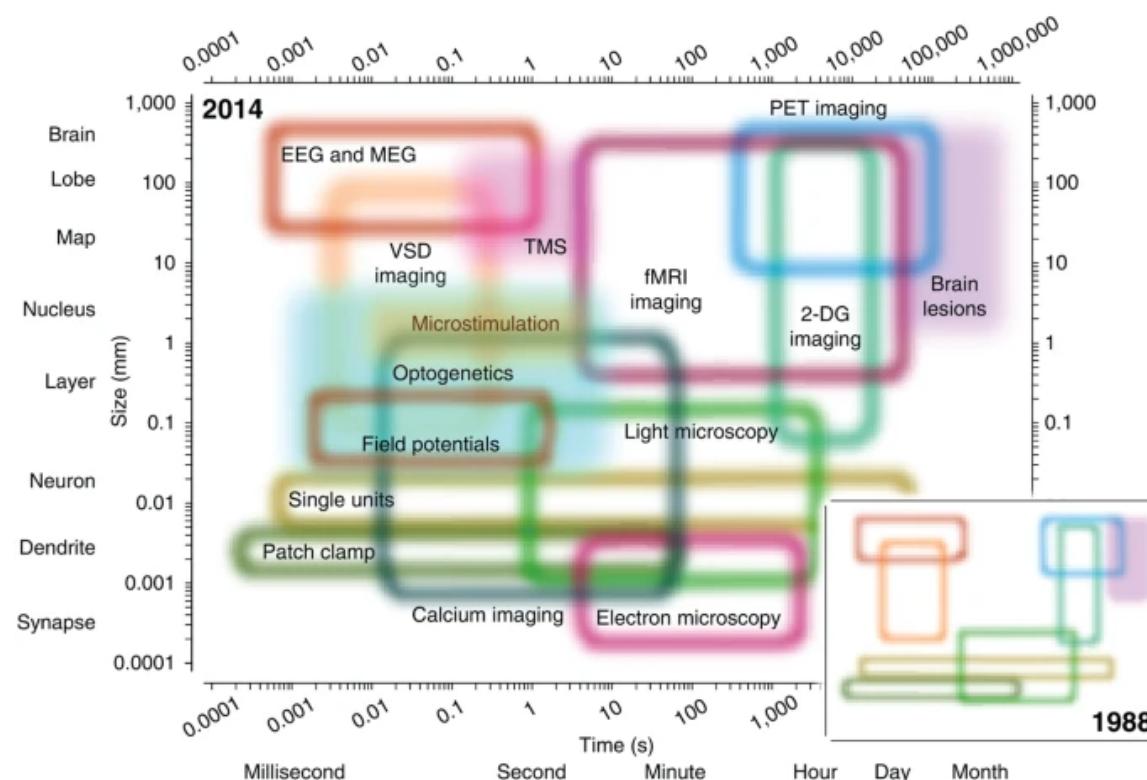


Simulating the brain

- Computer/mathematical models of brain function
- Example: neural networks
- Cheap, noninvasive, can be stimulated or “lesioned”



Spatial and Temporal Resolution



(Sejnowski, Churchland, & Movshon, 2014)

Next time...

- Brain anatomy (through song & dance)

References

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