PSYCH 260/BBH 203

Methods (continued)

Rick O. Gilmore

2022-01-20 07:53:20

Prelude 2:14

Prelude 1:22

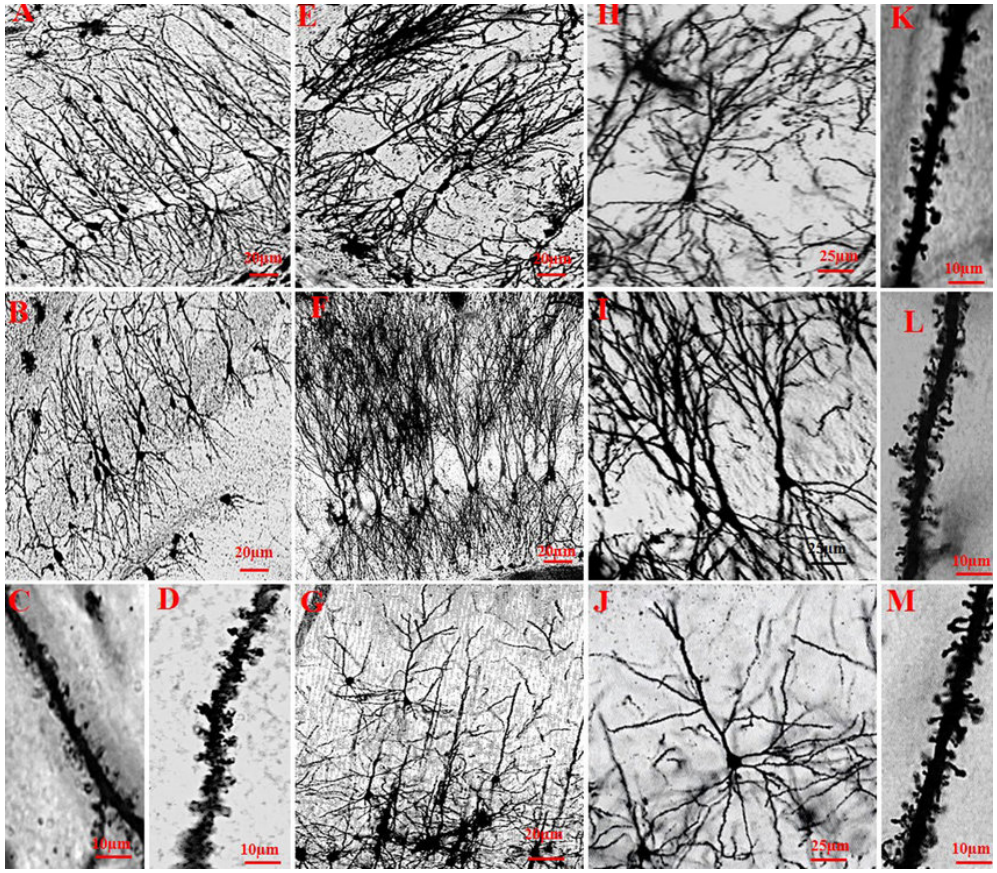
(Han et al., 2017)

Today’s topics

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

Warm-up

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



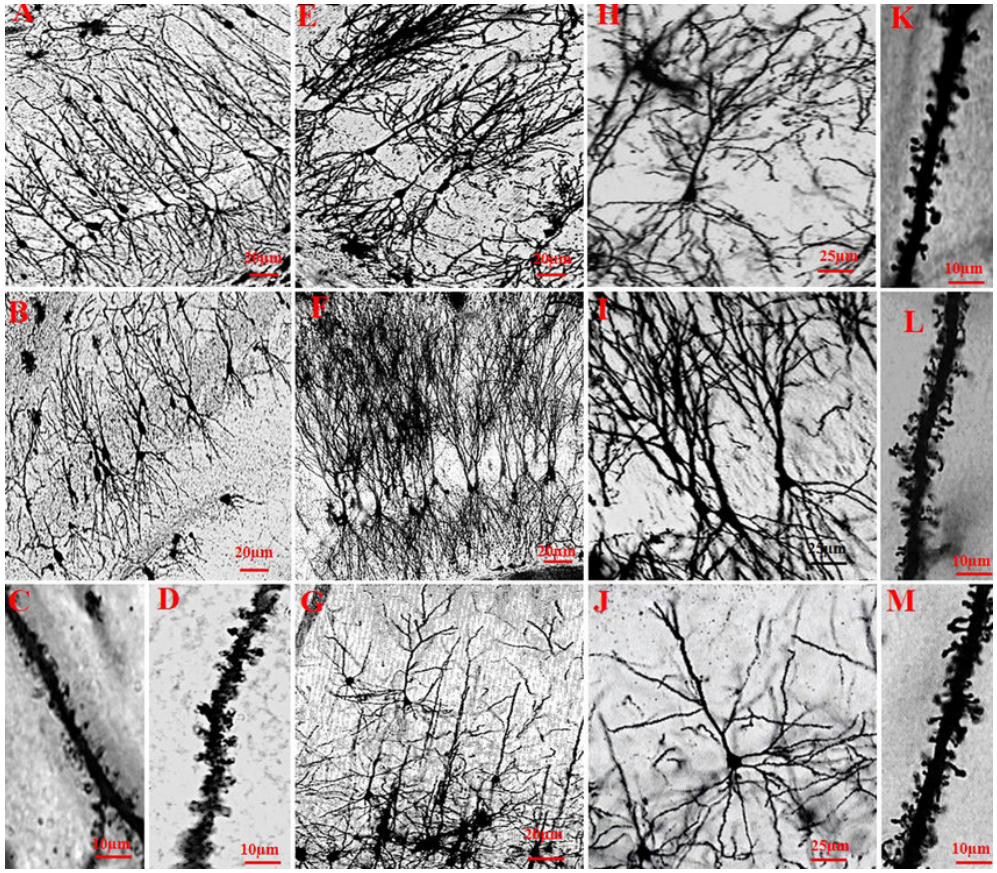
This cell-staining technique has what kind of *spatial* resolution?

- 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

Link to prior class notes

Functional methods

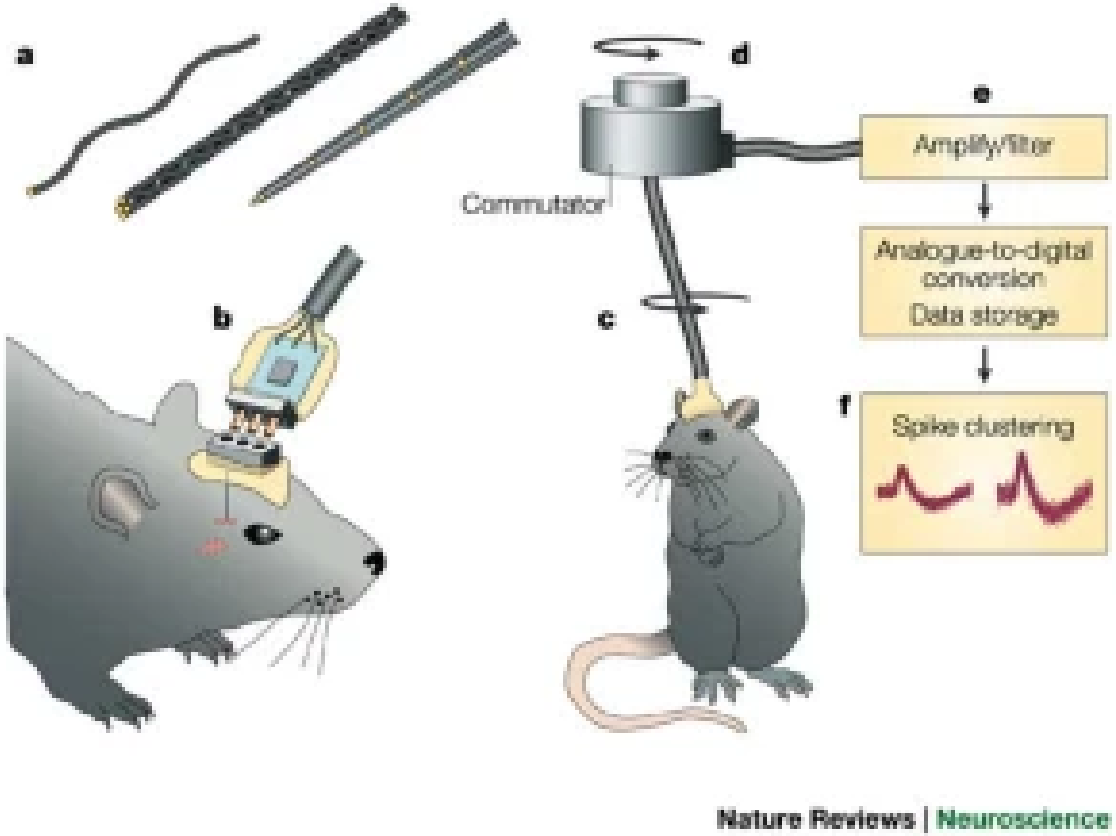
Functional methods

- 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



(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)

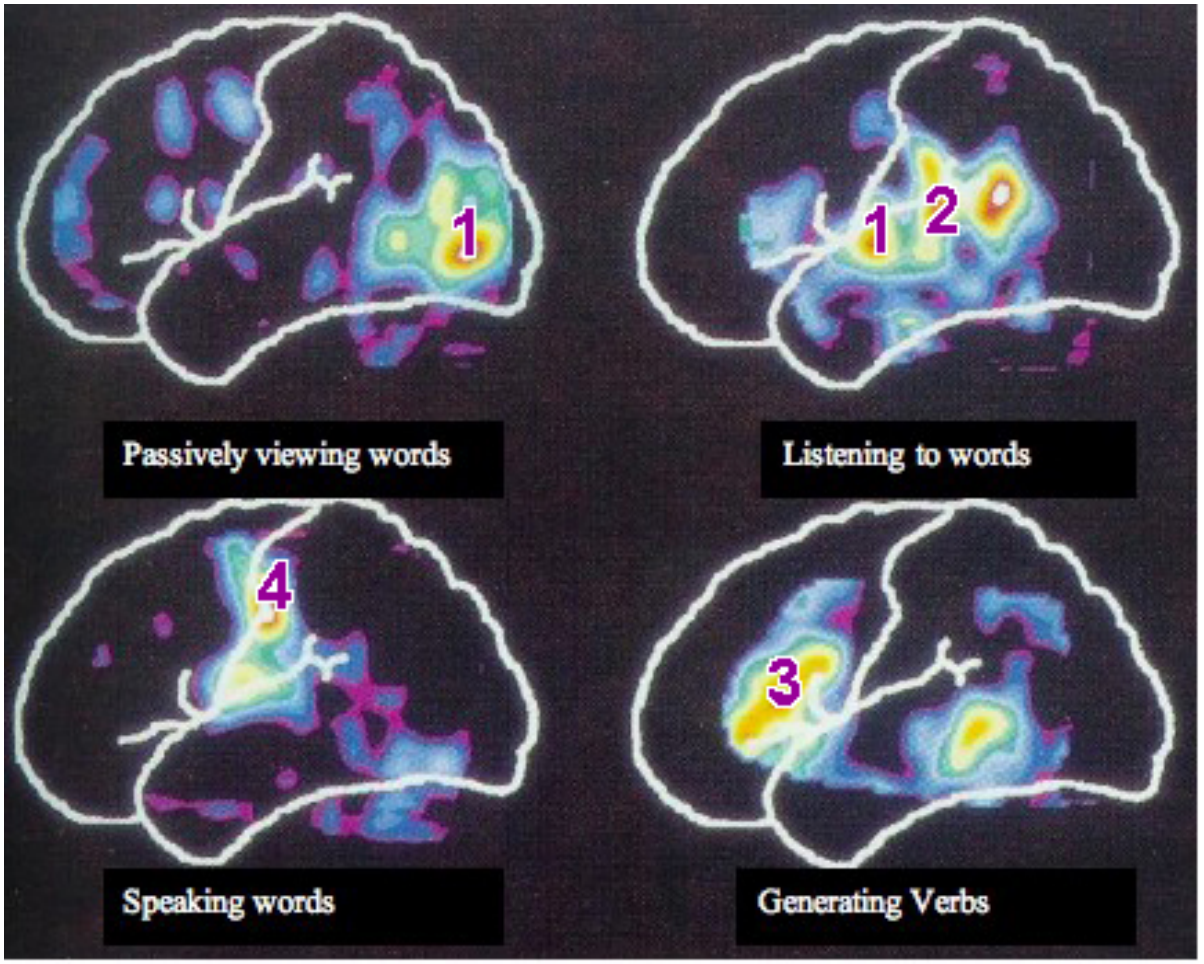
ECoG and multimodal brain imaging

https://youtu.be/gFky09ekmzw

Positron Emission Tomography (PET)

Positron Emission Tomography (PET)

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


1
Passively viewing words
1
2
Listening to words
4
Speaking words
3
Generating Verbs

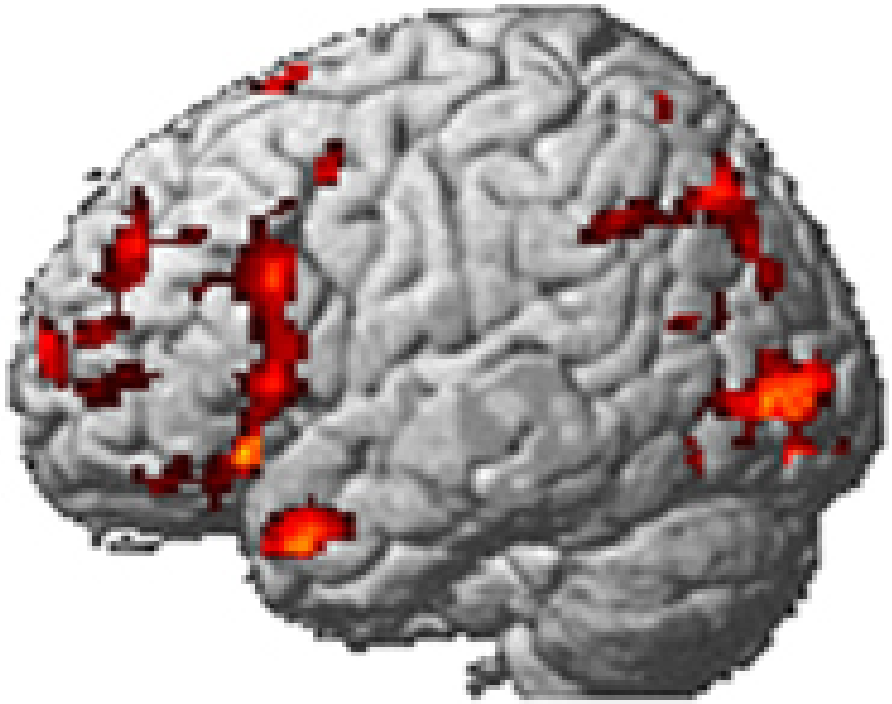
Evaluating PET

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

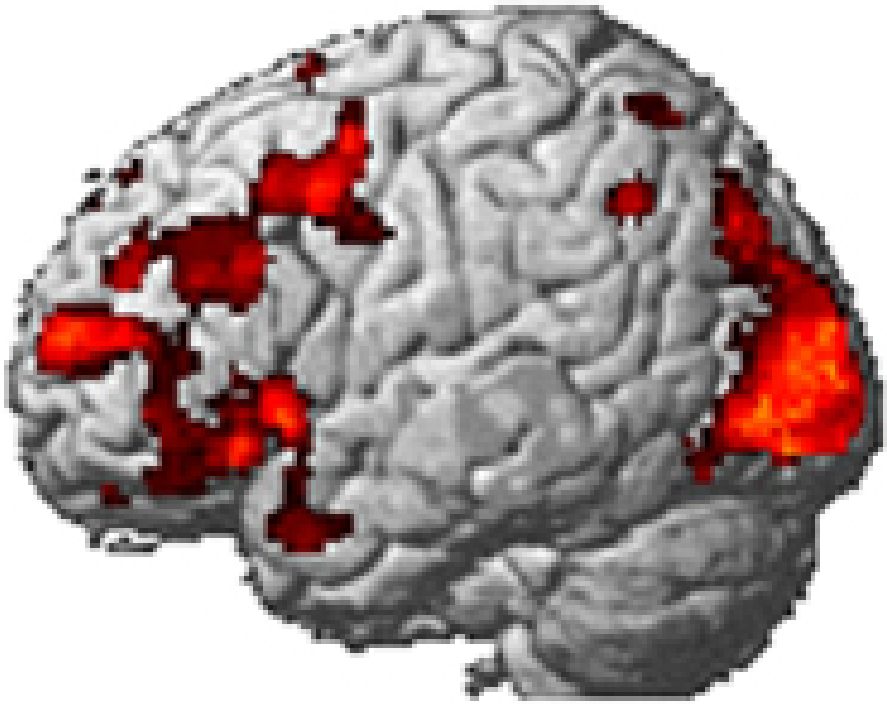
Functional Magnetic Resonance Imaging (fMRI)

- 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

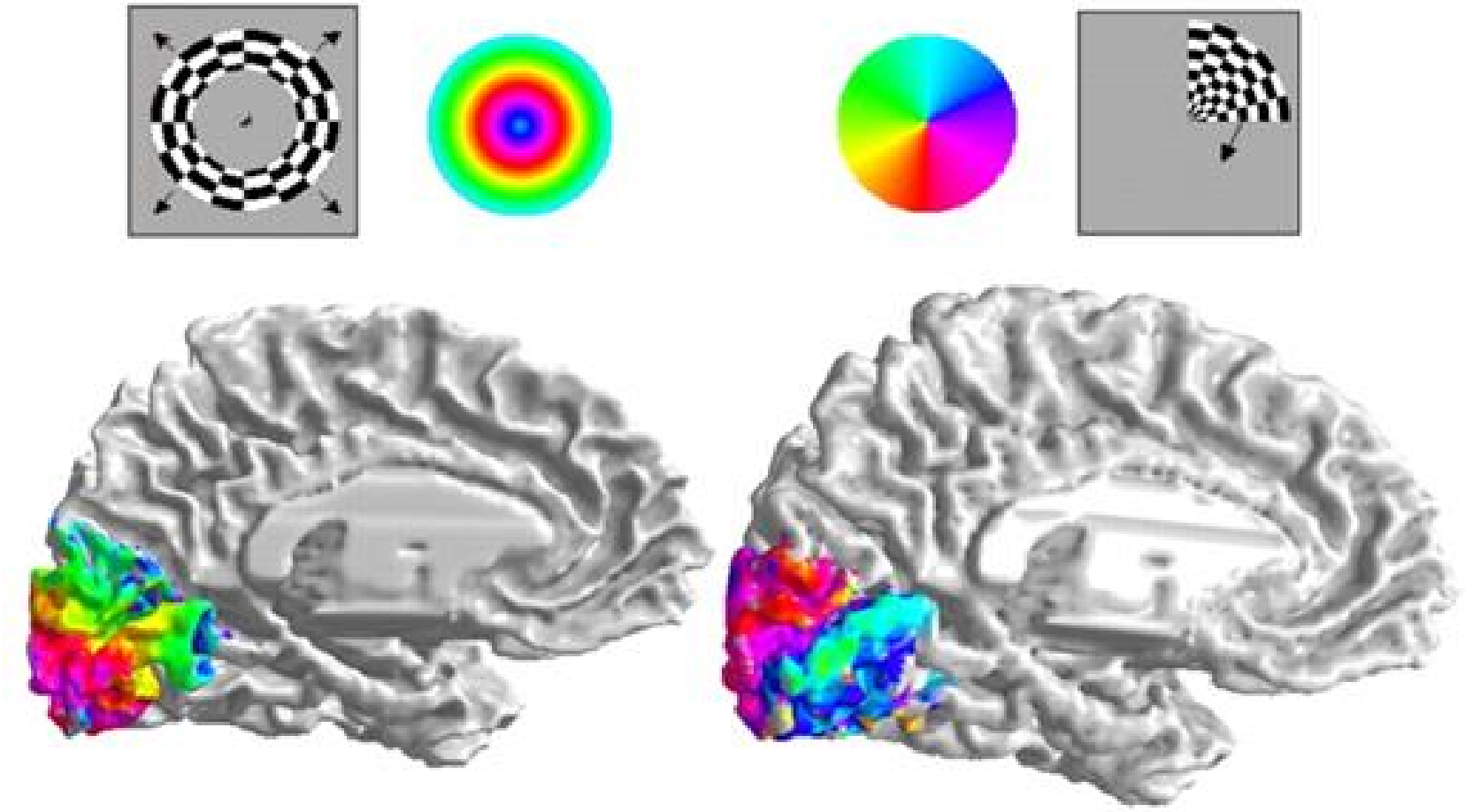


HAPPY



SAD

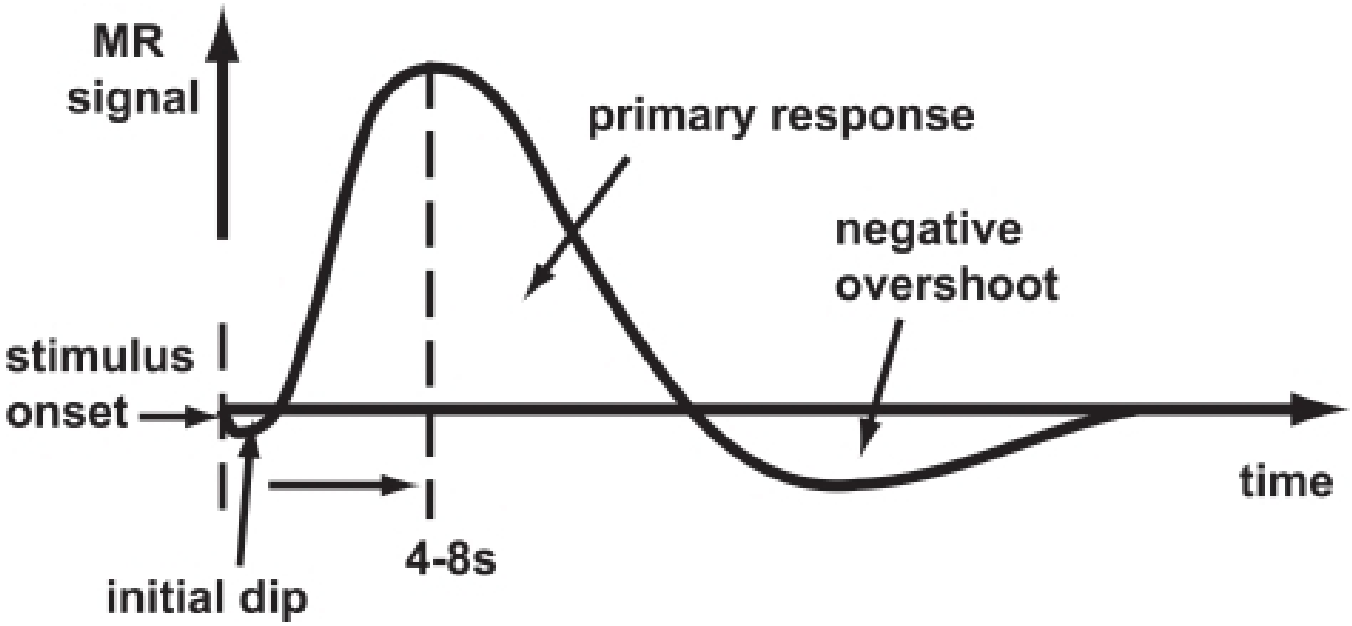
fMRI (Dougherty et al., 2003)



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

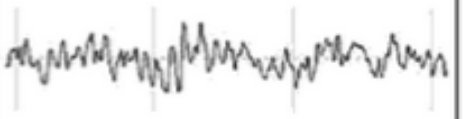
EEG

https://upload.wikimedia.org/wikipedia/commons/2/26/Spike-waves.png

EEG

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

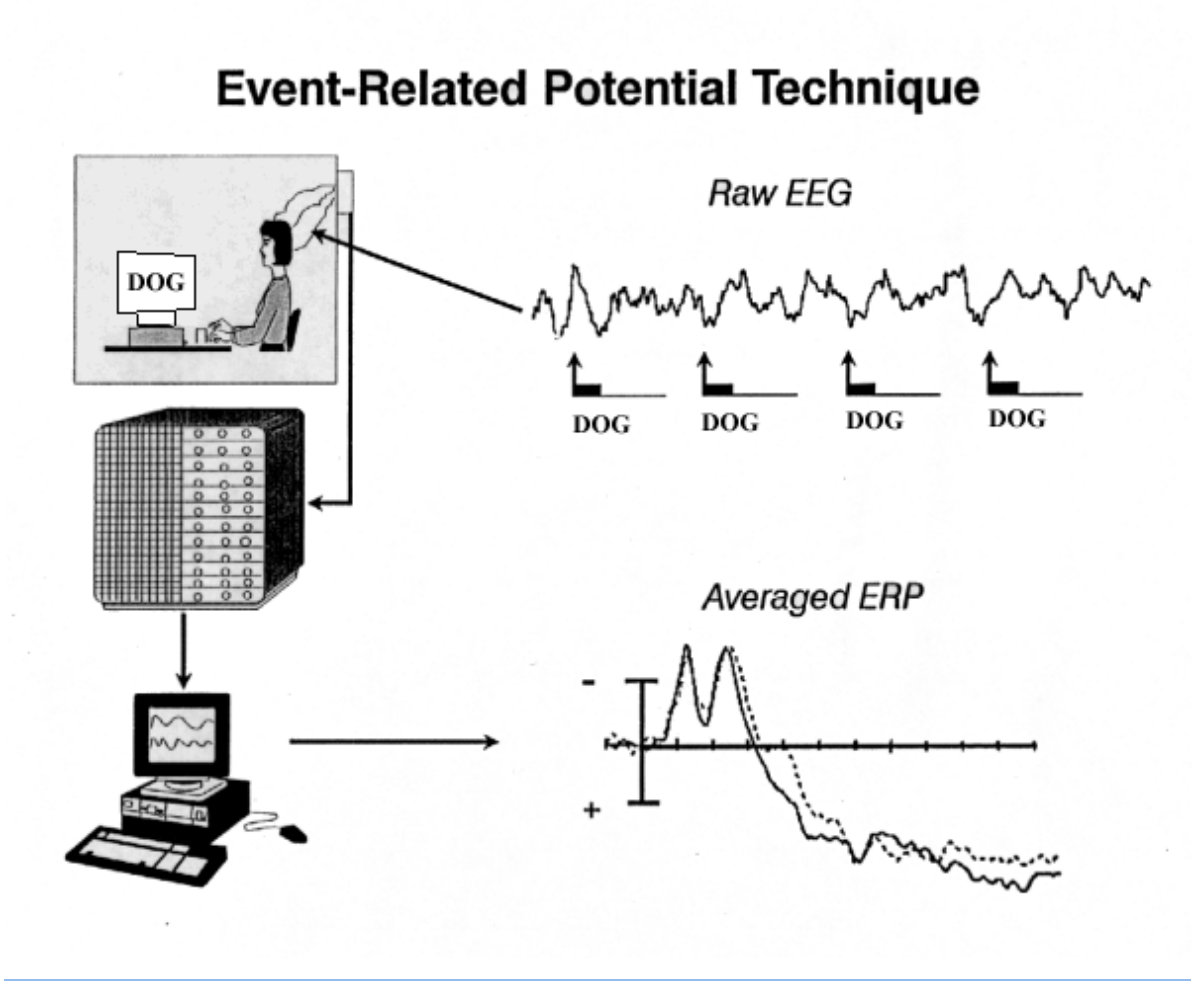
EEG Frequency

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	

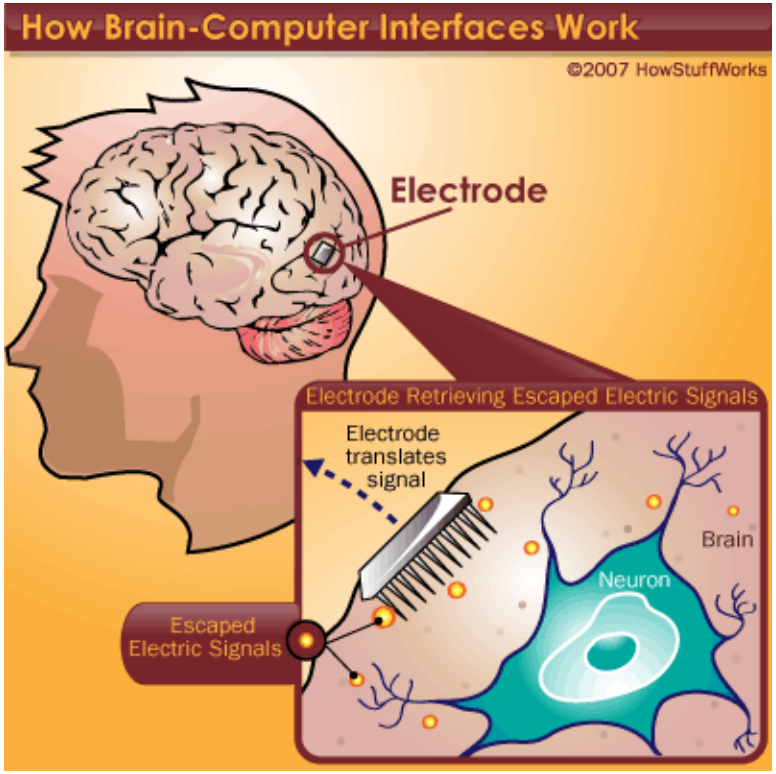
Event-related potentials (ERPs)

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

ERPs


Event-Related Potential Technique
DOG
Raw EEG
DOG
DOG
DOG
DOG
Averaged ERP
-
+

Brain Computer Interface (BCI)



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

Magneto-encephalography (MEG)

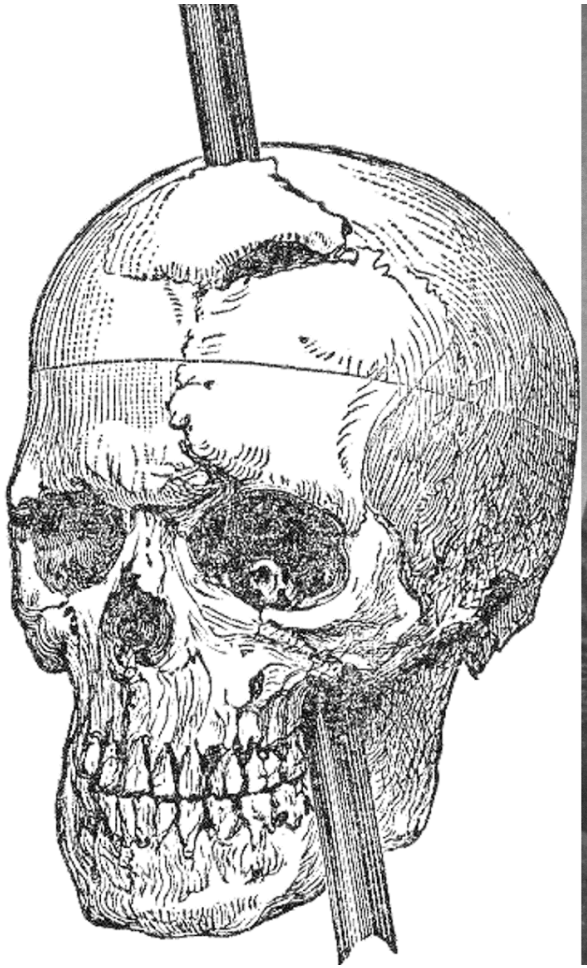
- Like EEG, but measuring magnetic fields
- High temporal resolution, low spatial resolution
- Magnetic field propagates w/o distortion

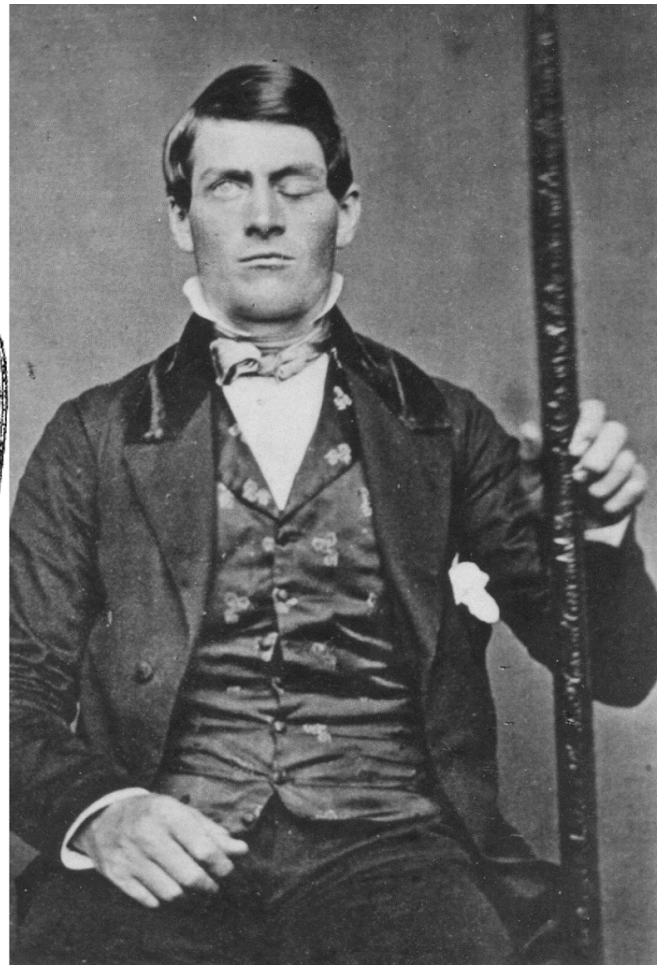
MEG

Manipulating the brain

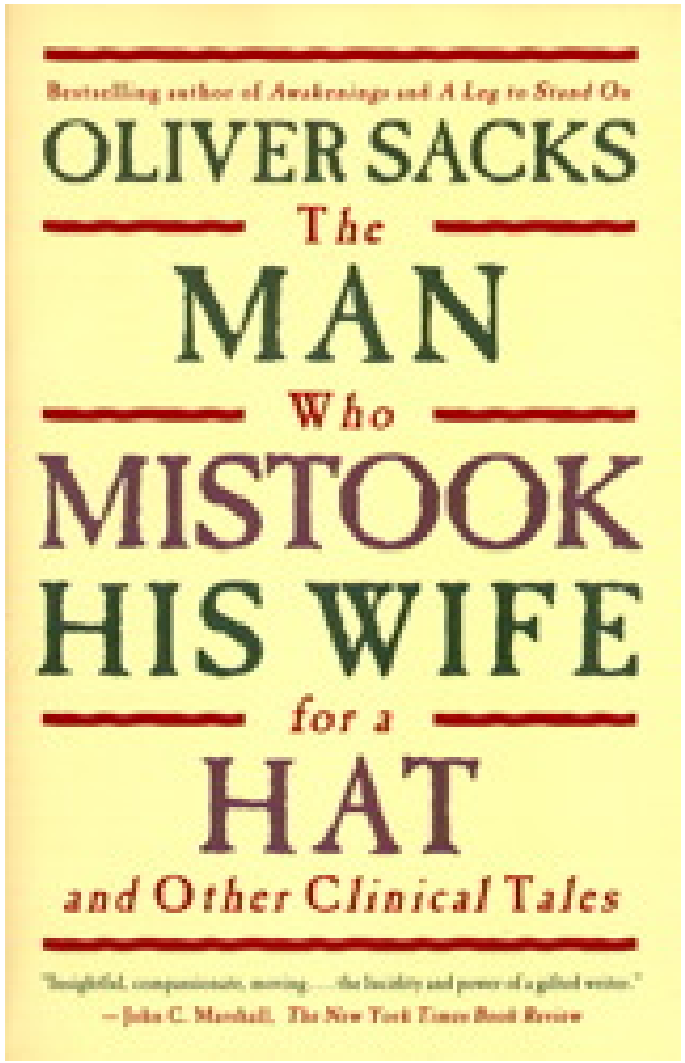
- Nature's "experiments"
  - Stroke, head injury, tumor
  - Neuropsychology
- If damage to X impairs performance on Y -> X critical for/controls Y
- Poor spatial/temporal resolution, limited experimental control

Phineas Gage





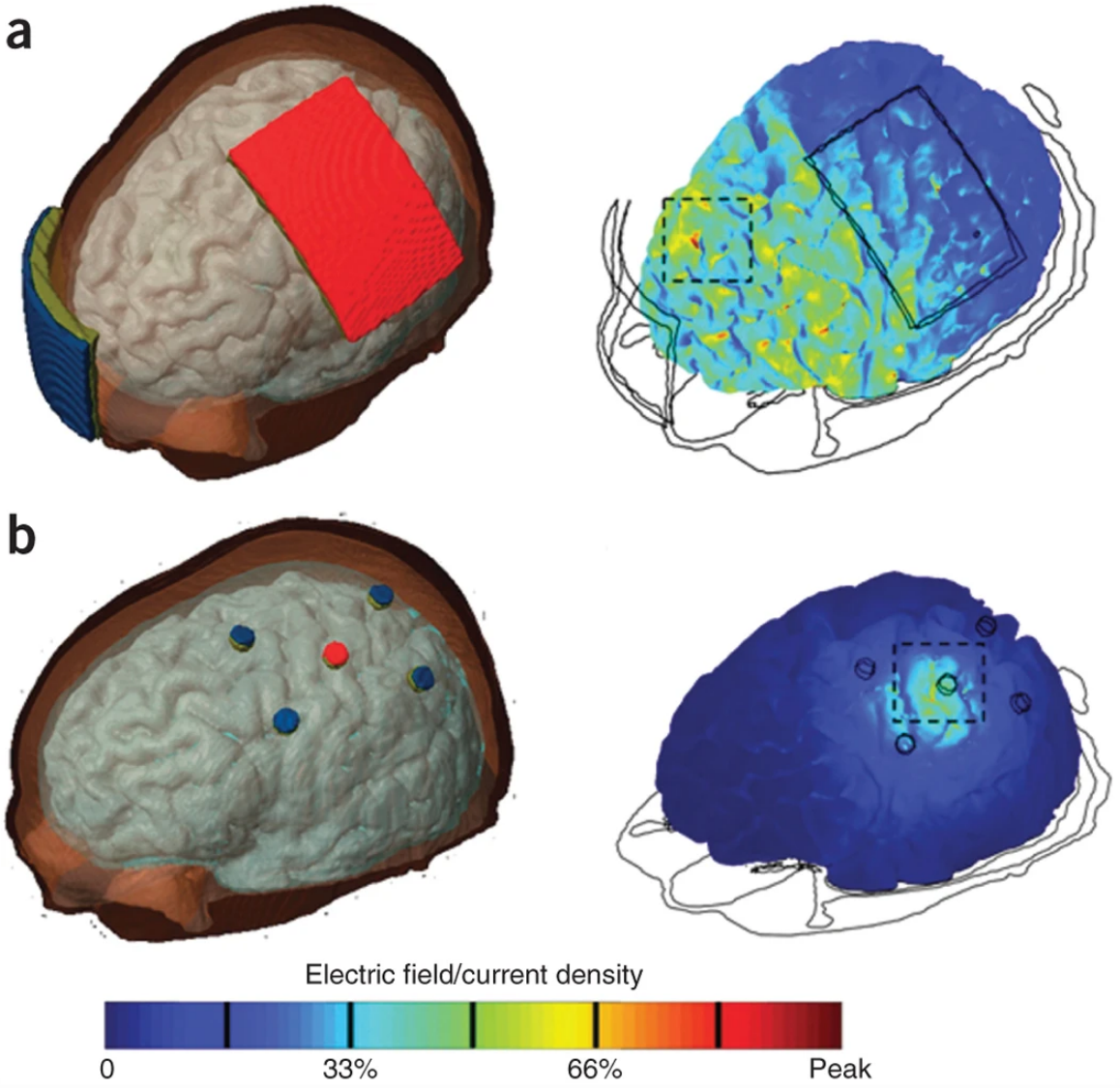
http://www.doctorsimpossible.com/the-curious-case-of-phineas-gage/


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

Stimulating the brain

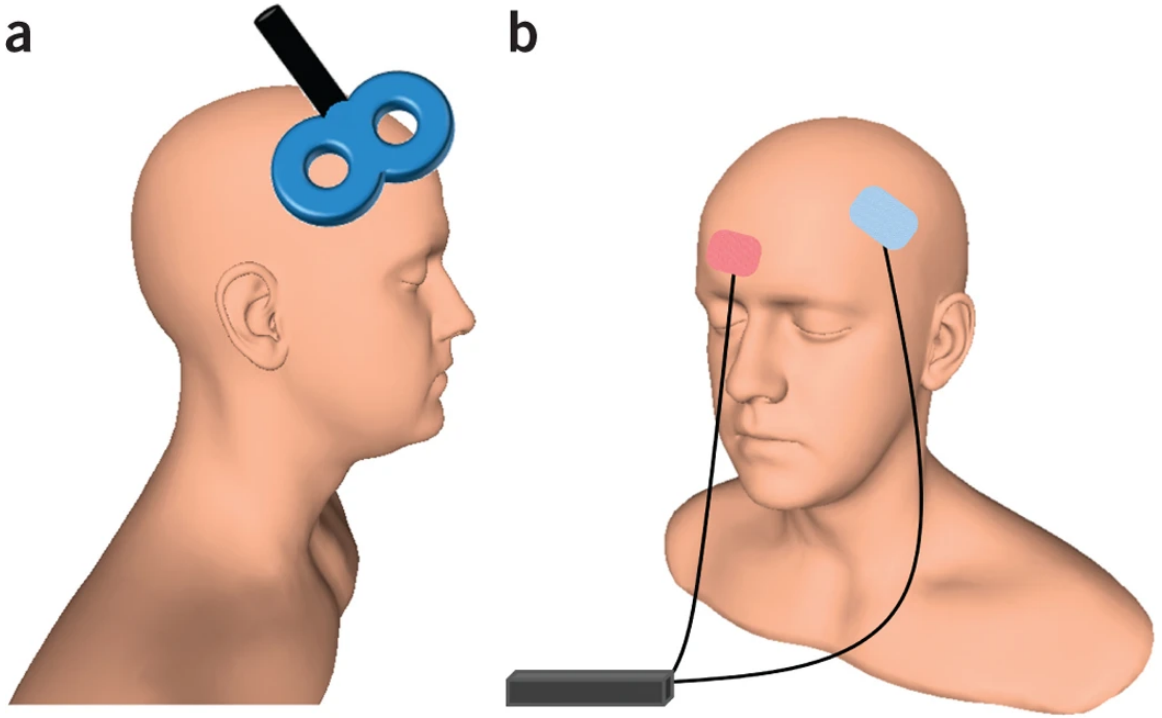
- Pharmacological
- Electrical (transcranial Direct Current Stimulation - tDCS)
- Magnetic (Transcranial magnetic stimulation - *TMS*)
- Optically (optogenetics)

tDCS



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

TMS



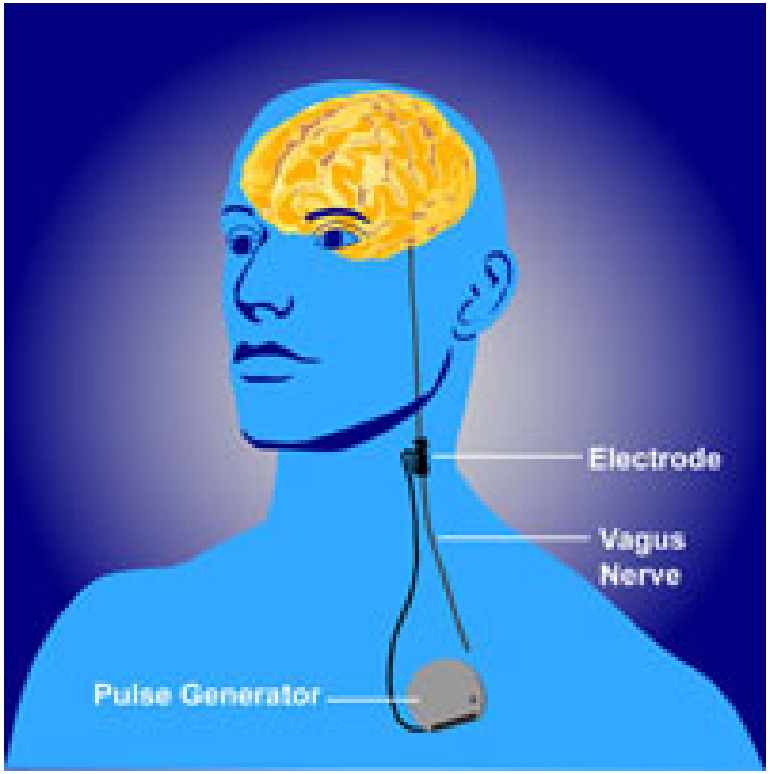
(Dayan, Censor, Buch, Sandrini, & Cohen, 2013)

Optogenetic stimulation

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

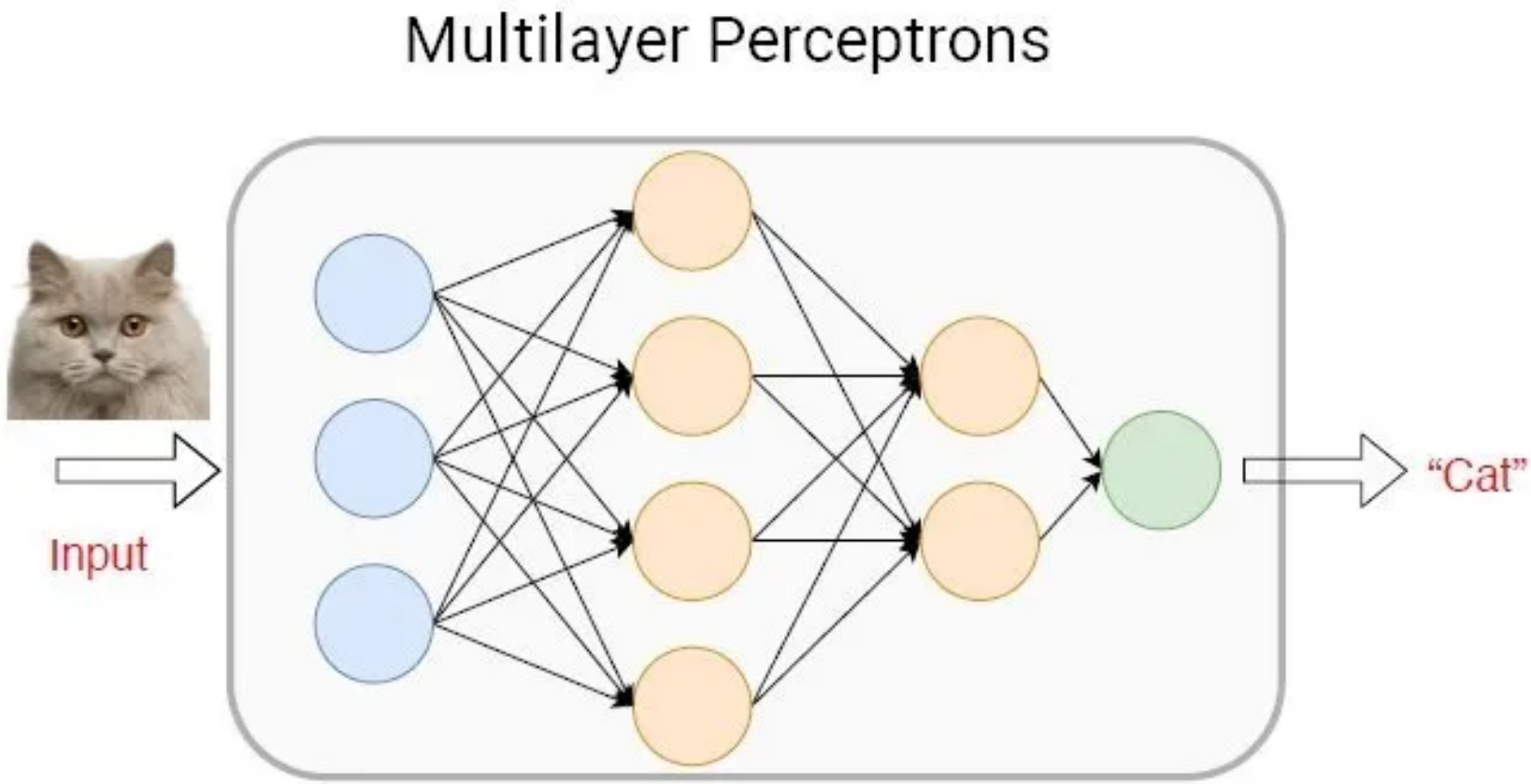


https://www.nimh.nih.gov/health/topics/brain-stimulation-therapies/brain-stimulation-therapies

*Sim*ulating the brain

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

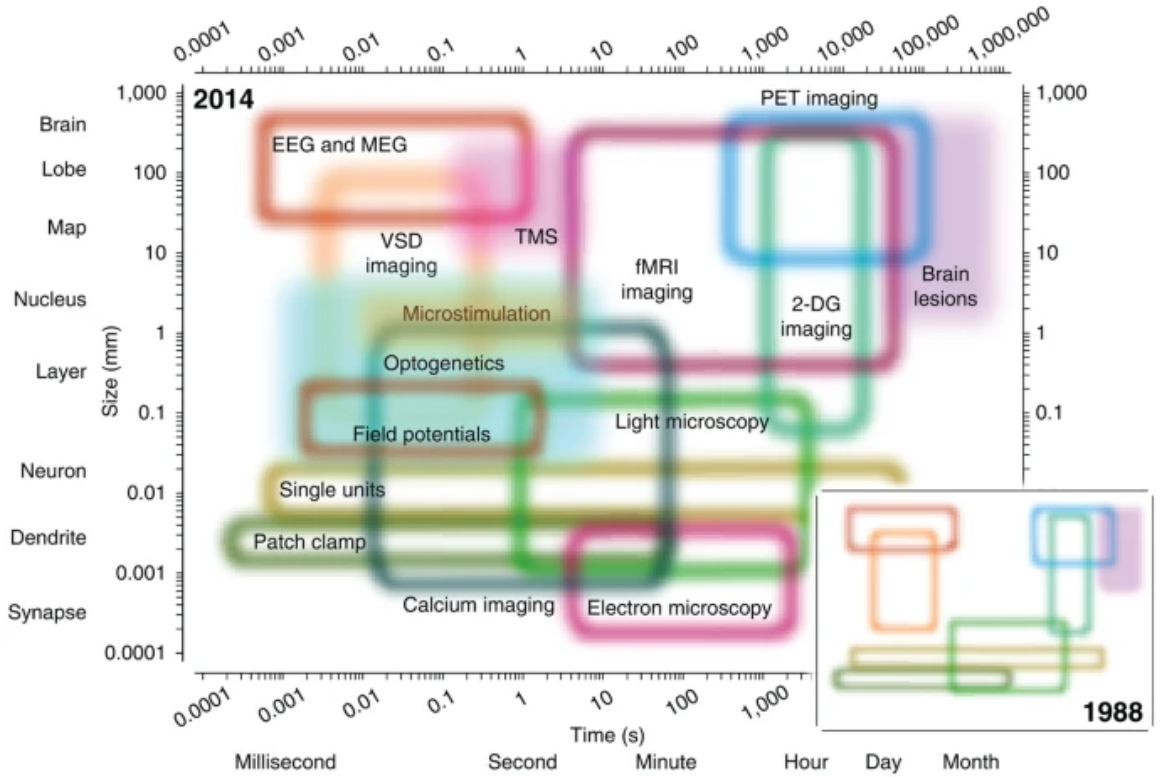
Application: AI



https://viso.ai/deep-learning/deep-neural-network-three-popular-types/

(Redmon, 2018)

Spatial and Temporal Resolution

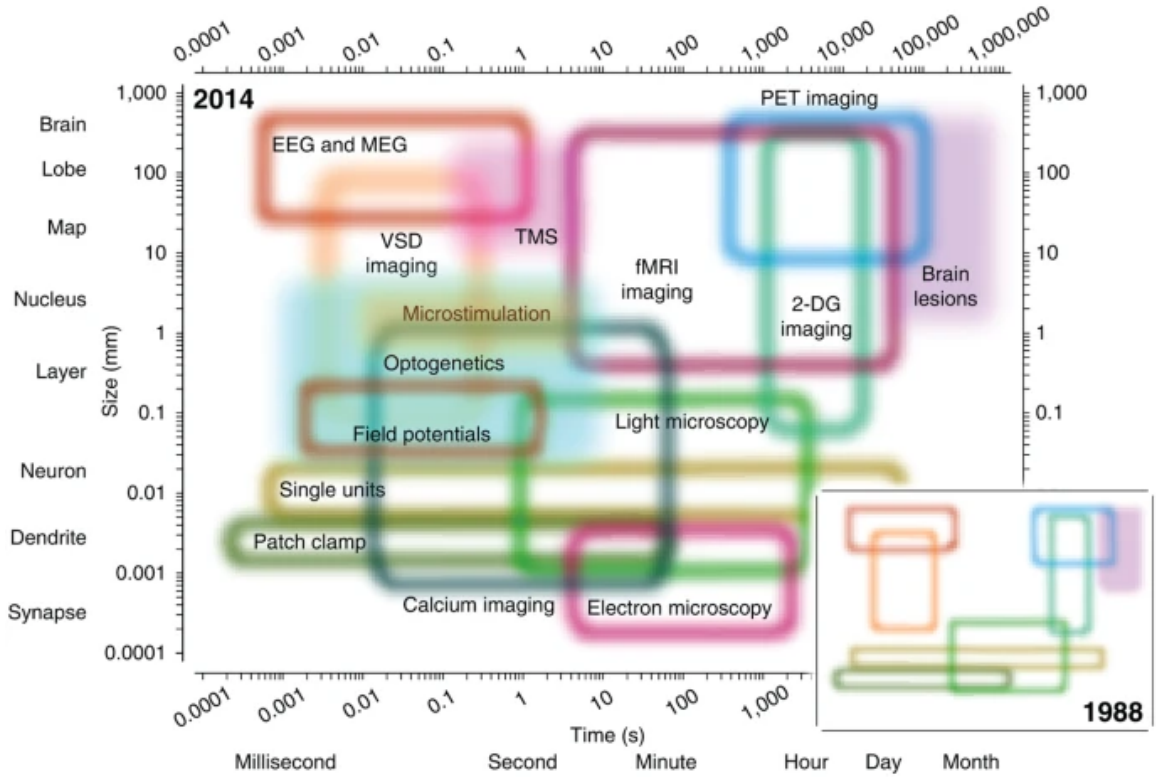


(Sejnowski, Churchland, & Movshon, 2014)

Bottom line…

- Neuroscientists…
  - need to use many tools
  - seek converging evidence

Spatial and Temporal Resolution



(Sejnowski, Churchland, & Movshon, 2014)

Next time…

- Brain anatomy (through song & dance)

References

Dayan, E., Censor, N., Buch, E. R., Sandrini, M., & Cohen, L. G. (2013). Noninvasive brain stimulation: From physiology to network dynamics and back. *Nature Neuroscience*, *16*(7), 838–844. https://doi.org/10.1038/nn.3422

Dougherty, R. F., Koch, V. M., Brewer, A. A., Fischer, B., Modersitzki, J., & Wandell, B. A. (2003). Visual field representations and locations of visual areas V1/2/3 in human visual cortex. *Journal of Vision*, *3*(10), 1–1. https://doi.org/10.1167/3.10.1

Han, W., Tellez, L. A., Rangel, M. J., Motta, S. C., Zhang, X., Perez, I. O., … Araujo, I. E. de. (2017). Integrated Control of Predatory Hunting by the Central Nucleus of the Amygdala. *Cell*, *168*(1), 311–324.e18. https://doi.org/10.1016/j.cell.2016.12.027

Maren, S., & Quirk, G. J. (2004). Neuronal signalling of fear memory. *Nature Reviews. Neuroscience*, *5*(11), 844–852. https://doi.org/10.1038/nrn1535

Redmon, J. (2018, March). YOLOv3. Youtube. Retrieved from https://www.youtube.com/watch?v=MPU2HistivI

Sejnowski, T. J., Churchland, P. S., & Movshon, J. A. (2014). Putting big data to good use in neuroscience. *Nature Neuroscience*, *17*(11), 1440–1441. https://doi.org/10.1038/nn.3839