

# 260-2017-01-18-methods-II

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## Prelude

(Han et al. 2017)

## Spatial and Temporal Resolution

(Sejnowski, Churchland, and Movshon 2014)

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- A. It is non-invasive.
- B. It provides information about brain structures.
- C. It provides information about rapid (millisecond-level) changes in brain activity.
- D. It cannot resolve details about individual neurons.

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## Today's topics

- Functional methods

## Functional methods

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

## Recording from the brain

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

## Single/multi-unit Recording

<http://www.nature.com/nrn/journal/v5/n11/images/nrn1535-i1.jpg>

## Single/multi-unit recording

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

## Electrocorticography (ECoG)

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Story about child who underwent ECoG surgery.

## Positron Emission Tomography (PET)

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

## PET

- Evaluating PET
  - Temporal ( $\sim$  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  $\rightarrow$  local  $O^2$  consumption increase
- Blood Oxygen Level Dependent (BOLD) response
  - Oxygenated vs. deoxygenated hemoglobin
  - Do regional blood  $O^2$  levels (and flow) vary with behavior X?

## fMRI

## fMRI (Dougherty et al. 2003)

## fMRI

- Evaluating
  - Non-invasive, but expensive
  - Moderate but improving (mm) spatial, temporal ( $\sim$ sec) resolution
  - **Indirect** measure of brain activity

- Hemodynamic Response Function (HRF)
  - 1s delay plus 3-6 s ramp-up

## 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

## EEG

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

## EEG Frequency

## Event-related potentials (ERPs)

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

## ERPs

## Brain Computer Interface (BCI)

<http://s.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
  - Remember Galen?
- Logic: damage impairs performance = region critical for behavior

- Poor spatial/temporal resolution, limited experimental control

## **Phineas Gage**

### **Stimulating the brain**

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

### **tDCS**

(Dayan et al. 2013)

### **TMS**

(Dayan et al. 2013)

### **Optogenetic stimulation**

### **Evaluating stimulation methods**

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

### **Deep brain stimulation**

#### **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, and Movshon 2014)](<http://doi.org/10.1038/nn.3839>)

### **Next time...**

- Neuroanatomy

## References

- Dayan, Eran, Nitzan Censor, Ethan R. Buch, Marco Sandrini, and Leonardo G. Cohen. 2013. “Noninvasive Brain Stimulation: From Physiology to Network Dynamics and Back.” *Nature Neuroscience* 16 (7): 838–44. doi:10.1038/nn.3422.
- Dougherty, R. F., V. M. Koch, A. A. Brewer, B. Fischer, J. Modersitzki, and B. A. Wandell. 2003. “Visual Field Representations and Locations of Visual Areas V1/2/3 in Human Visual Cortex.” *Journal of Vision* 3 (10): 1–1. doi:10.1167/3.10.1.
- Han, Wenfei, Luis A. Tellez, Miguel J. Rangel, Simone C. Motta, Xiaobing Zhang, Isaac O. Perez, Newton S. Canteras, Sara J. Shammah-Lagnado, Anthony N. van den Pol, and Ivan E. de Araujo. 2017. “Integrated Control of Predatory Hunting by the Central Nucleus of the Amygdala.” *Cell* 168 (1): 311–324.e18. doi:10.1016/j.cell.2016.12.027.
- Sejnowski, Terrence J, Patricia S Churchland, and J Anthony Movshon. 2014. “Putting Big Data to Good Use in Neuroscience.” *Nature Neuroscience* 17 (11). Nature Publishing Group: 1440–1. doi:10.1038/nn.3839.