260-2017-01-18-methods-II

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Prelude

(Han et al. 2017)

Spatial and Temporal Resolution

(Sejnowski, Churchland, and Movshon 2014)

Which of the following statements about the brain imaging technique used in this figure is FALSE?

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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.

Which of the following statements about the brain imaging technique used in this figure is FALSE?

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- **C. It provides information about rapid (millisecond-level) changes in brain activity.**
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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)

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 (~ 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
  - 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 (~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

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