Week 4.1

Brain and EEG method

9/17/2018
Roadmap

• More about brain regions and their major associated functions
• EEG method
• Some examples of ERP
• EEG vs. ERP
• EEG vs. fMRI
• A quick review
More about forebrain

• Cerebral cortex
  ➢ Four lobes

Mid sagittal view
Forebrain: Cerebral cortex

• Frontal lobe

Forebrain: Cerebral cortex

- Temporal lobe - auditory and language

Forebrain: Cerebral cortex

• Occipital lobe

Lateralization

- Left and right hemisphere
- Connected by corpus callosum
Forebrain: Limbic system

- **Thalamus**
  - Relaying info to cerebral cortex

- **Hypothalamus**
  - Thirst
  - Hunger
  - Desire
  - Temperature control
Forebrain: Limbic system

- Amygdala
  - Emotion

(Arnal et al. 2015; source: https://www.pbs.org/newshour/science/brains-love-hate-screams)
Lateralization

- Split-brain research
  - Disrupt connections between the two hemispheres
  - Presumably causing significantly negative effect
  - No obvious effect in daily behavior
How do we investigate the time course of cognitive processes?

- Behavioral method?
  - Reaction time?
  - Eye-tracking?
How do we investigate the time course of cognitive processes?

• Why fMRI not a good choice
Electroencephalography (EEG)

• EEG: scalp recording of electrical activities emitted from neural transmission
• Non-invasive
• Non-radioactive
A typical setup of an EEG system

- Computer for EEG recording
- EEG Amplifier
- Computer for stimuli presentation
Sample EEG raw data

Use one word to describe EEG raw data: MESSY
How to get ERPs?

1. Participants do a task (e.g., press a button while reading a sentence) while wearing an EEG cap

2. The stimulus presentation computer sends a marker to the EEG recording machine to mark the beginning of each sentence on the EEG raw waveform. (Assume there are 50 sentences, then there will be 50 markers that mark the beginning of each sentence. These 50 sentences are also the 50 “events”)

3. The waveforms of those 50 events are averaged
ERP

• Event-related potential (ERP): An EEG waveform (usually averaged) time locked to an event/stimulus
SOME COMMONLY SEEN ERPS

• N200: Perceptual mismatch
• Mismatch Negativity (MMN): detection of one stand-out (oddball) stimulus from the context
• P300: Cognitive demand
• N400: Semantic anomaly (e.g., “I’m drinking a chair.”)
• P600: Syntactic anomaly (e.g., “He throw a ball.”)
ERP naming conventions

• A letter P or N followed by a number
  ➢ P: Positive
  ➢ N: Negative
  ➢ Number: either the latency (the duration from the stimulus onset to the peak of the ERP) or the peak order
Some examples of ERP

- **N400**: A negative-going ERP peaking at about 400 ms from stimulus onset

Some examples of ERP

- P300: A positive-going ERP peaking at about 300 ms from stimulus onset (which is also usually the 3rd positive ERP from stimulus onset, so it’s also called P3.)
Some examples of ERP

- N200: A negative-going ERP peaking at about 200 ms from stimulus onset (which is also usually the 2nd negative ERP from stimulus onset, so it’s also called N2.)
Some examples of ERP

- Mismatch Negativity (MMN): detection of one stand-out (oddball) stimulus from the context

Nagai et al. 2013
## A quick comparison between EEG and fMRI

<table>
<thead>
<tr>
<th></th>
<th>EEG</th>
<th>fMRI</th>
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<tbody>
<tr>
<td><strong>Measurement</strong></td>
<td>Electrical activities from neural transmission</td>
<td>Blood oxygen level dependent (BOLD) signal</td>
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<tr>
<td><strong>Temporal resolution</strong></td>
<td>Good (~50 ms)</td>
<td>Bad (~6 seconds)</td>
</tr>
<tr>
<td>(i.e., the time course of input processing)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Spatial resolution</strong></td>
<td>Bad</td>
<td>Good</td>
</tr>
<tr>
<td>(i.e., the location where the processing occurs)</td>
<td></td>
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<tr>
<td><strong>Equipment cost</strong></td>
<td>Relatively low (~USD$28K for a 32-ch system)</td>
<td>High (~USD$3 million for a 3-Tesla scanner)</td>
</tr>
<tr>
<td><strong>Data collection cost</strong></td>
<td>Subject compensation + consumables (gel, syringes, spare sensors, etc.)</td>
<td>Subject compensation + hourly usage charge (USD$600/hr at U of R.)</td>
</tr>
<tr>
<td><strong>Pre-experiment preparation</strong></td>
<td>40-60 mins (depending on the system and subject’s scalp condition)</td>
<td>10 minutes</td>
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<tr>
<td><strong>Post-session clean-up</strong></td>
<td>20 minutes</td>
<td>2 minutes</td>
</tr>
<tr>
<td><strong>Skills required for analysis</strong></td>
<td>Some programming experience in MATLAB</td>
<td>Basic analyses can all be done in graphic user interface (GUI)</td>
</tr>
</tbody>
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Things that EEG can tell us

• Processing time course: pre-lexical, post-lexical, decision making, responses, etc.
  o Perception
  o Reading
  o Attention
  o Cognitive demand

• Covert measurement of processing
  o Infant research
THINGS THAT EEG CANNOT TELL US

• The exact location where the processing occurs.
• Anatomical details of the brain
• Connections among different brain regions
• Mental processes that do not have distinct ERPs
Which of the following questions could be answered by fMRI?

A. Do we first process visual or sound information while reading a word?
B. Which parts of our brain are involved in face recognition?
C. How do infants respond to oddball stimuli?
D. Do bilinguals have one or two mental lexicons?
Which of the following questions could be answered by EEG?

A. Do we first process visual or sound information while reading a word?
B. The time it takes to recognize a word
C. IQ
D. Individual differences
Is IQ measurable using neuroimaging techniques?

- Possibly
  - ERP waveforms: amplitude and latency
  - Brain size
  - fMRI studies of memory
  - Connections
A quick review

• What is cognitive science about?
• -isms

• Different approaches to the study of cognition
  o Experimental
  o Connectionism/Artificial Intelligence
  o Information processing
  o Ecological
  o Observational
  o Evolutionary

• Localization of brain function
• Basic brain anatomy (terms covered in the lecture)
• fMRI vs. EEG method