Brain scans

PSY 200
Greg Francis
Lecture 03

How to study the brain without killing someone.

Scanning

- Technology provides insight into brain processes
  - EEG recordings
  - MRI
  - Functional MRI
- Non-invasive
- Maps of brain activity
- The goal is to relate brain events to cognitive events

Resolution

- For almost every technique we have to worry about its ability to discriminate differences in
  - Space: which place is active?
  - Time: when does something happen?
  - Finer resolution is usually better
  - But can be difficult to deal with so much data

Electroencephalogram

- EEG
- The brain produces electrical activity
- Put electrodes on the head

EEG

- Watch the electrical current change through time while reading sentences (averaged across many trials)
  - Good temporal resolution
  - Kutas & Hillyard (1980)

Brain maps

- You can analyze the EEG signals in many different ways
- Compare the signal strength for different situations
- Ayahuasca is a Brazilian psychoactive tea

Ayahuasca is a Brazilian psychoactive tea
Spatial resolution

- Poor spatial resolution
- You never really know which part of the brain is making the current
  - Lots of work to improve

Magnetic Resonance Imaging

- Magnetic field forces protons in your body to line up
  - Pulses of radio into field bounce protons around
  - As they return to normal position, they emit a signal that can be decoded into a map

Magnetic Resonance Imaging

- MRI Scans: Like an x-ray machine, but can look at soft tissue (like lungs, heart...)
  - Very good spatial resolution

MRI Scans

- MRI provides a "slice" at a time
- Take multiple slices to build up full image

MRI Scans

- Can identify anatomical differences between brains
  - Alcoholic has larger ventricles and thinner corpus callosum
  - Note, comparing across brains is a bit tricky!
    - Everyone's brain is a bit different
MRI Scans

- 3-D maps
- Normal
- Ataxia:
  - loss of motor control

MRI Scans

- Non-invasive, no side effects
- Allows early detection of brain disease, tumors,…
- Fantastic spatial resolution
- But…
  - it only shows structure
  - no way to know what a brain area does

Functional MRI

- Just like MRI, but with a new analysis
  - MRI differentiates between different types of tissue (cell types)
  - Functional MRI differentiates between active and inactive neurons: concentration of oxygen
  - The measurement is called the “blood oxygen level dependent” (BOLD)
    » It roughly tracks the flow of blood in the brain
    » More active neurons recruit more blood

Functional MRI

- Color maps show strongest “responses”
  - E.g., fMRI scan of a woman after a stroke
    - Blue/green: normal blood flow
    - Red/black: abnormal blood flow

Functional MRI

- Very good spatial resolution
  - millimeters
- Pretty good temporal resolution
  - Seconds
  - (Silva, 2002)

Scanning

- Consider this fMRI scan
- It shows regional cerebral blood volume (rCBV)
- You cannot tell how/which different regions are involved in different activities
  - Breathing
  - Digestion
  - Thinking about exams
  - ….
Differences

- We have to look for differences in activity.
- Alzheimer’s patients have reduced brain activity.

A simple experiment

- Suppose you run an fMRI experiment where a person alternates between seeing a blank screen and a face.
- You take multiple fMRI scans with half recording brain activity during the blank and half recording brain activity during the face.
- Add them up pixel by pixel for each condition.

Subtraction method

- Subtract the fMRI signals produced by one condition from the fMRI signals produced by another condition.
- The difference map indicates those brain regions that are involved in the different cognitive tasks.
- It requires a sophisticated statistical analysis to avoid false positives.

Reporting

- What is usually reported is just the difference map.
- Colors mark places in the brain that are statistically different between conditions.
- Czoch et al. (2009) for rare tones vs. frequent tones.
- The map would be different if it compared rare tones versus speech.

Functional MRI

- Color maps show strongest “responses.”
- e.g., during a task that requires covert spatial attention compared to one that does not require attention.

- When moving a pointer to a target box compared to no movement.
  - “activity” in areas involved in vision, planning, and motor control.
You can use similar technology (diffusion spectral imaging) to focus on particular types of cellular material. E.g., identify axons (discussed later) that connect brain cells.

● Gives an anatomical map of how information can travel

Limitations

● Brain scans do not really tell us how the brain works
  - The scans just tell us approximately where in the brain something occurs
  - Sometimes it can tell approximately when
● Even trying to find the place may be problematic
  - Lots of cognitive abilities involve many different areas of the brain
● Most of the time theories of cognition are derived from experimental psychology
  - Brain studies explore how to implement the theories

Common misconception

● Brain scans demonstrate a physiological basis to things that were thought to be emotionally or cognitively based
  - E.g., MRI scans of stutterers
  - In fact, all behavioral traits are physiologically based

Conclusions

● Lots of research in this area
● Technology is improving in many ways
● There are many other types of scanning technologies
  - Computerized Axial Tomography (CAT)
  - Diffusion tensor imaging (DTI)
  - Single Photon Emission Computed Tomography (SPECT)
  - Near Infrared Spectroscopic Imaging (NIRSI)
  - Magnetoencephalography (MEG)
  - Positron Emission Tomography (PET)

Next time

● How do we use brain scans to study cognition?
● How good are the scans?
● What is really being measured?

How to read someone’s mind.