Brain scans

PSY 200
Greg Francis
Lecture 04

How to read someone’s mind.

Scanning

- Brain scanning techniques like fMRI provide spatial and temporal patterns of activity across the brain
- We want to analyze those patterns to discover how the brain works

fMRI

- Passive listening vs. active listening
  - Vannest et al. (2009)
  - Twenty children (ages 11-13) complete three tasks
    - Passive listening: hear a female speaker tell a 30-second story
    - Active response: hear the same speaker tell a story in 5 second segments of two sentences. Scanning occurred after the sentences (silence). Answer questions
    - Random tones: no task, just listen

The colors show the difference maps relative to listening to the tones
- Common activity (breathing, digestion, hearing machine noise,…) is subtracted out
- The colors are not brain activity!

More signals and different patterns for active listening compared to passive listening
- (Could it be otherwise?)

Does more signal for the active response mean active response listening is “better” than passive listening?
- Tested children on comprehension of stories
  - PL: 75.1% correct, SD=12.7
  - AR: 79.1% correct, SD=9.1
- No real difference in comprehension
Sensory substitution

- Some scientists look for replacements to lost perception
- For example, there is a tongue display unit that attempts to present spatial information for blind people

People can use a TDU to discriminate shapes
- Kaczmarek, Bach-y-Rita & Tyler (1998)
- Link to video on class web page

So what happens in the brain?
- Are there responses from areas typically involved in shape perception? Or in areas related to touch on the tongue? (or both or neither?)

fMRI differences suggest that using the TDU involves areas of motor cortex
- Not areas that are traditionally for visual perception
- This is the kind of question that can best be answered with brain scan technology

Walking

- There is no portable MRI machine
- But scientists are creative about how to use it to study a wide variety of activities
- Volta et al. (2015) studied walking by having participants “walk” on a cylinder outside the MRI machine

Can compare walking “indoors” versus “outdoors”
- Execution (actually “walk”) versus observation (not “walk”)
- Complicated controls
  - Press feet against cylinder
  - Still (non-moving) image
  - Gray image (no picture)
Walking

- Top: Executing or observing walking versus gray image
  - Interesting that they involve some similar brain regions
- Bottom: Hallway walking versus open field walking

Reading minds

- Long-term, the goal of fMRI research is to be able to analyze a brain scan and identify what a person is thinking
- There are several attempts to do this (Haynes et al., 2006)
  - Adding or subtracting numbers
- Based on the choice at the end, we can deduce whether the subject chose addition or subtraction for that trial
- Make an fMRI scan during the selection process
  - Whether to add or subtract numbers

Mind reading

- It is possible to build a recognition system that distinguishes (with 71% accuracy) the brain patterns for addition and subtraction
  - Depends on the place in the brain
  - Different places for intention and execution
- You can read the mind of these subjects!

Thought reconstruction

- Another research group analyzed fMRI responses to reproduce a shown image
- Performance depends on where the signals come from
  - Fewer errors for “lower” brain areas
    - Where do you stop?, the retina?, the lens of the eye?
Thought reconstruction

- These kinds of studies are mostly a demonstration of technology
  - We already know the brain represents visual information!
- Before the study was run, we knew that there were differences in the brain when we see different images
  - The percept is the brain's behavior, so there must be differences!
- These kinds of studies tell us that the neurophysiological differences between cognitive events can be measured by these brain scanning technologies
  - Failure would only indicate limits of the technology

Mind reading limits

- fMRI: If subjects decide to multiply numbers, a system trained to distinguish between subtraction and addition is clueless
- Thought reconstruction: As the number of possible images to be shown increases, it becomes harder to reconstruct the shown image
- In general, brain scans provide a very limited form of mind reading
  - People do better than this every day by watching people behave (posture, eyes, skin tone)

Problems / limitations with scanning

- So much data that it is difficult to know what to do with everything
  - Statistical analysis is complicated
  - In a small brain scan, you may have 64 x 64 voxels x 10 slices
    - 40,960 voxels overall
  - Some of those voxels will give different responses just by chance
  - Difficult to compare across subjects
    - Slightly different anatomy
  - Blurring of images is difficult to deal with (subjects move in the scanner)
    - Sometimes blur together brain areas, across a fissure, that are actually far apart on surface of cortex
  - Some cognitive events are faster than the technology can track
    - Can only measure the brain, cannot manipulate it

Statistics

- There is a significant difference in fMRI activity for some regions of the brain
  - Medial brain cavity and upper spinal column

- The "subject" in this study was a mature Atlantic salmon (sex unknown)
- The "active" regions identified by the fMRI are due to chance
- Even with purely random noise, there will be some statistically significant findings
  - The brain has lots of random noise
- These problems can be reduced but never entirely eliminated
  - They are common to many areas of psychology, not just brain scans
Neurons
- The brain cells that are responsible for cognition are neurons

A neuron
- Dendrite + input
- Soma + integrate
- Axon + output
- Myelin sheath + insulate

Myelin
- Diffusion Spectral Imaging detects properties of the myelin sheath ("white matter")
- Allows imaging of human brain connectome

A neuron
- There are many different types of neurons
- We will describe only the most common characteristics

How many neurons?
- Estimates of $10^{11}$ neurons in the human brain
  - 100,000,000,000; one hundred billion
  - estimates of 100,000 per cubic millimeter
  - (about the resolution of functional MRI)
- Millions are active at any given time

Conclusions
- Brain scans usually look at differences in brain "activity"
- Lots of technical (and ethical) issues
- The goal is to be able to look at a map (or movie) and be able to read someone’s mind
- That is many years off
  - questionable if it can even be done with these methods alone
Next time

- What is the neural activity that produces brain scans?
- How do neurons transmit information to other neurons?
- Why does (nearly) everyone like Prozac?