## Brain scans

PSY 200

Greg Francis

Lecture 04

*How to read someone's mind.*



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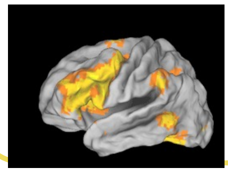
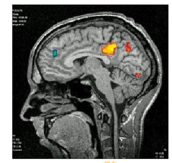
## Scanning

- 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







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## 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



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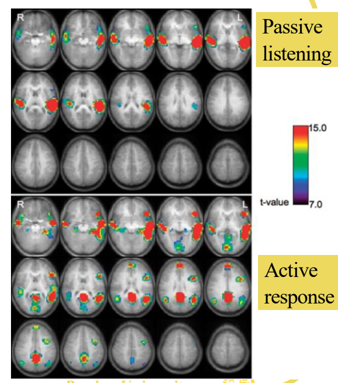
## fMRI

- 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!



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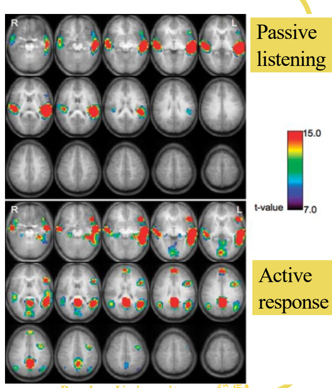
## fMRI

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



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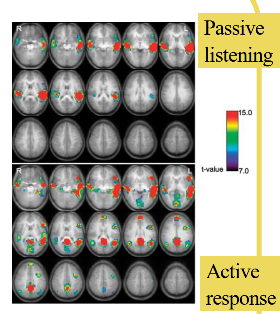
## fMRI

- 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



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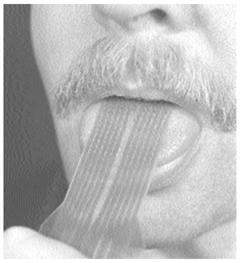
## Sensory substitution

- 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



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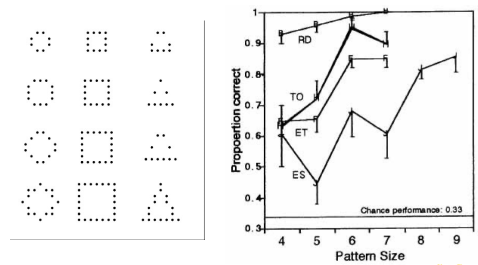
## Sensory substitution

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

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## Sensory substitution

- 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?)


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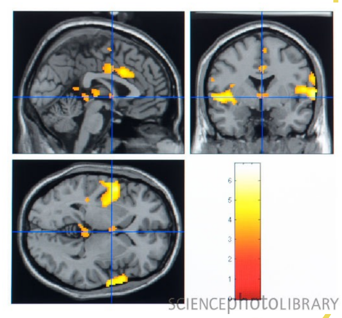
## Sensory substitution

- 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

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## 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

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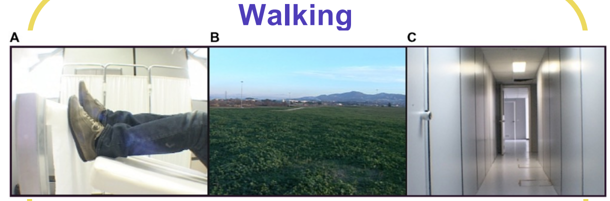
## Walking




- 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)

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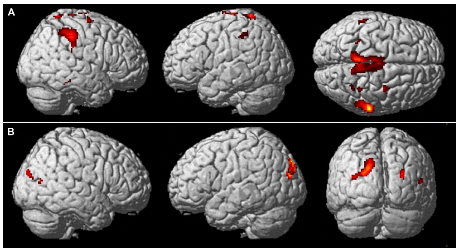
## Walking

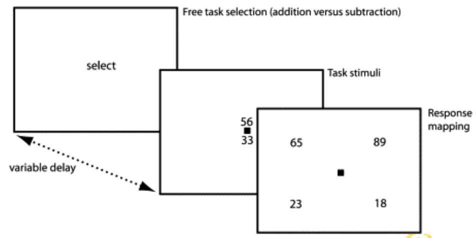



- Top: Executing or observing walking versus gray image
  - Interesting that they involve some similar brain regions
- Bottom: Hallway walking versus open field walking



## 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

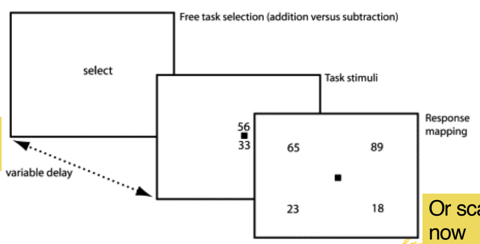





## Reading minds

- 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

Scan now

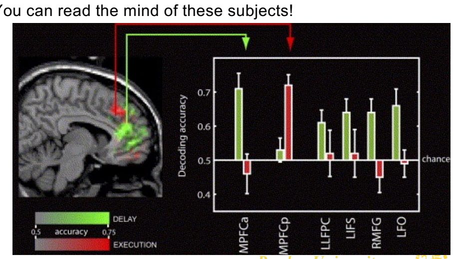



Or scan now



## Mind reading

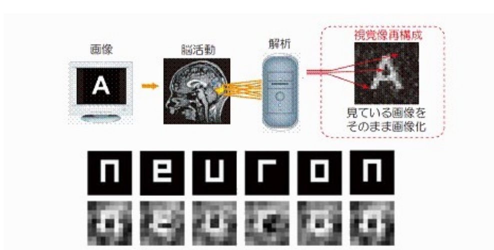
- It is possible to build a recognition system that distinguishes (with 71% accuracy) the brain patterns for addition and subtraction
  - Depends on the place in the brain
  - Different places for intention and execution
- You can read the mind of these subjects!






## Thought reconstruction

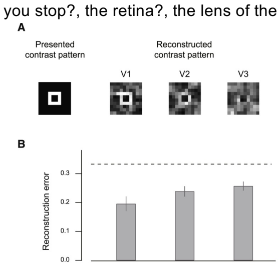
- Another research group analyzed fMRI responses to *reproduce* a shown image






## Thought reconstruction

- 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



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## 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)



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## 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



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## Statistics

- It is easy to do the statistics incorrectly (it has taken a while for the field to sort this out)
- Bennett et al. (2010) ran a study where the subject was shown a series of photographs depicting people in social situations with a specified emotional valence, either socially *inclusive* or socially *exclusive*. The subject was asked to determine which emotion the individual in the photo must have been experiencing.
- fMRI contrasts were computed between the scans for the two types of emotional valence



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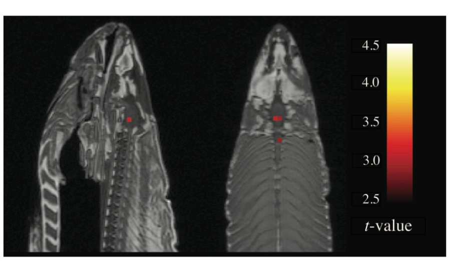
## Statistics

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



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## Statistics

- 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



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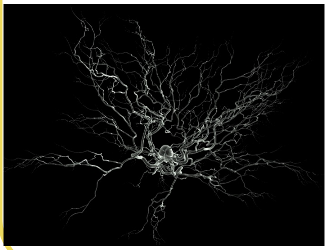
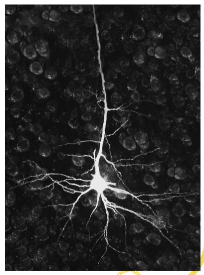
## Neurons

- The brain cells that are responsible for cognition are neurons

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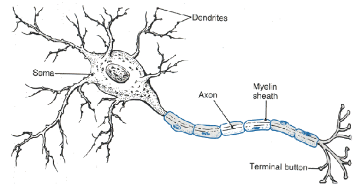
## A neuron

- Dendrite
  - input
- Soma
  - integrate
- Axon
  - output
- Myelin sheath
  - insulate

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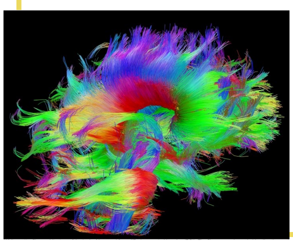
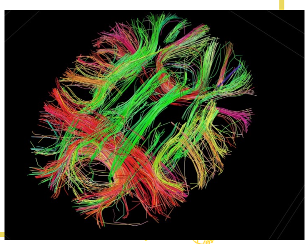
## Myelin

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

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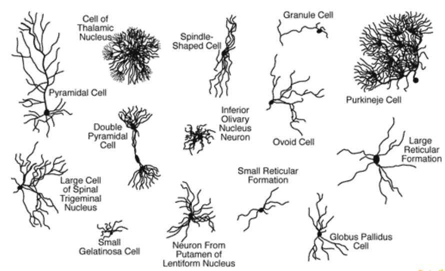
## A neuron

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

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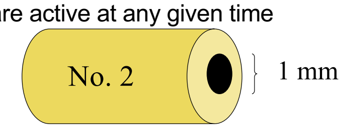
## How many neurons?

- 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




https://www.youtube.com/watch?v=2qTuZlMvFgY
(time 2:55)

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## 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

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## 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?*

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