Brain scans

PSY 200

Greg Francis

Lecture 03

How to study the brain without killing someone.

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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

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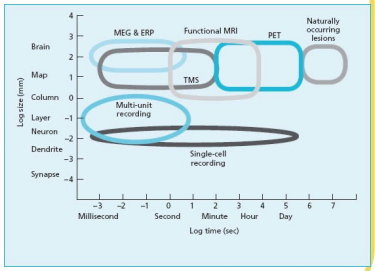
Resolution

- 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



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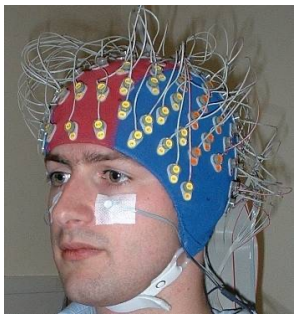
Electroencephalogram

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



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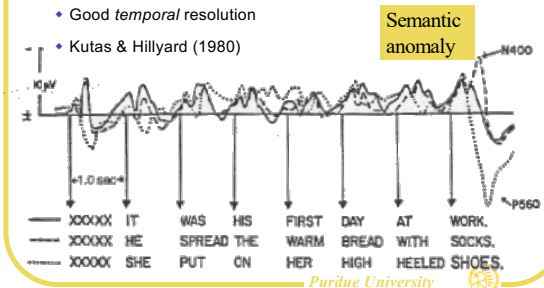
EEG

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



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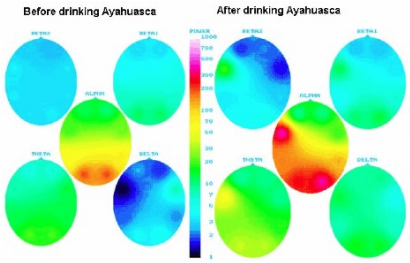
Brain maps

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



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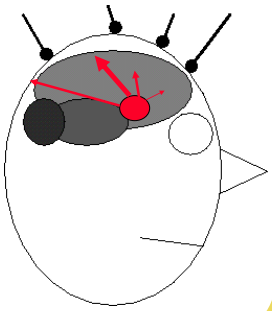
Spatial resolution

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



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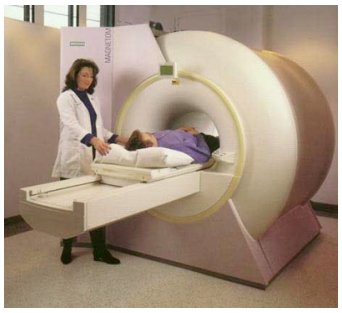
Magnetic Resonance Imaging

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



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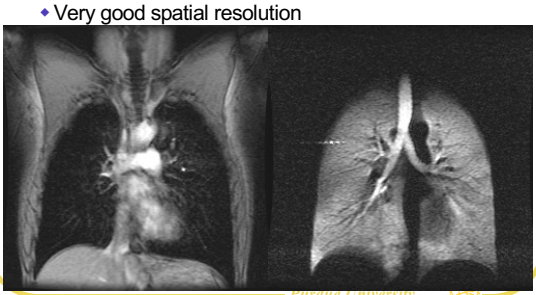
Magnetic Resonance Imaging

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



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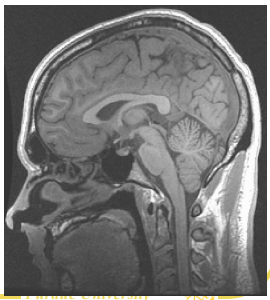
Magnetic Resonance Imaging

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



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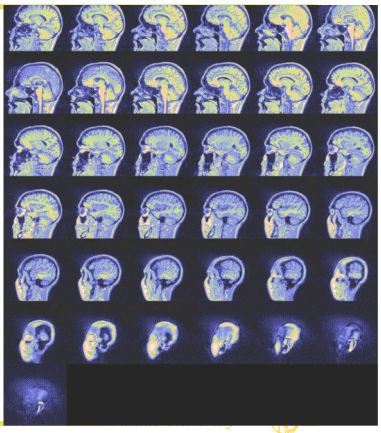
MRI Scans

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

Nobel prize winning work!



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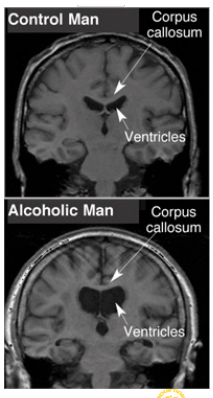
MRI Scans

- 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



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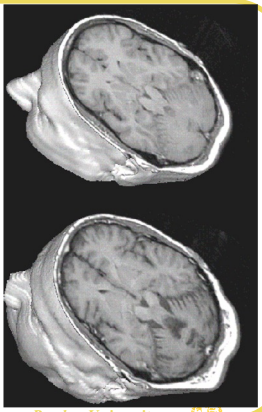
MRI Scans

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



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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*

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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

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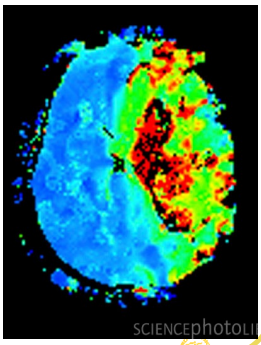
Functional MRI

- 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



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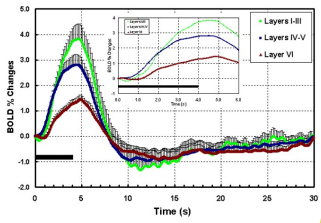
Functional MRI

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



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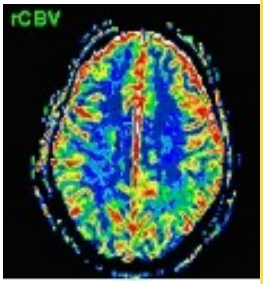
Scanning

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



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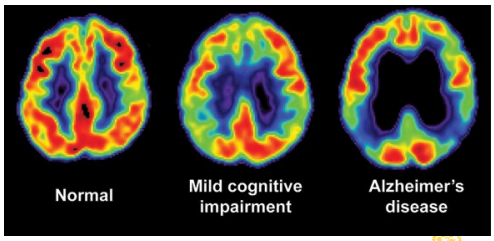
Differences

- We have to look for *differences* in activity
- Alzheimer's patients have reduced brain activity



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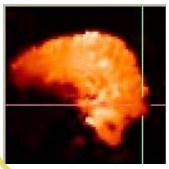
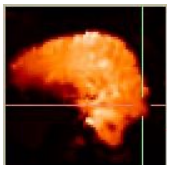
A simple experiment

- 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

Viewing blank



Viewing face



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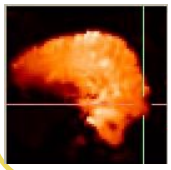
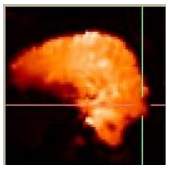
Subtraction method

- 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!

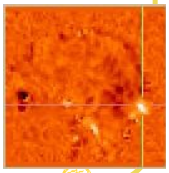
Viewing blank



Viewing face



Difference map



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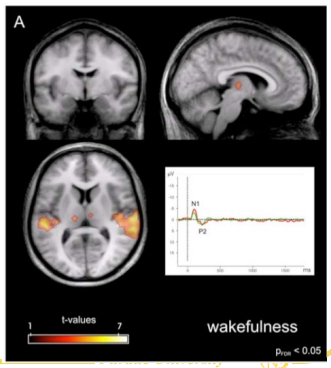
Reporting

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



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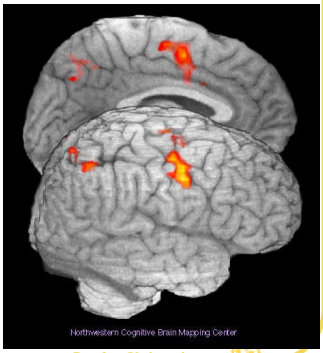
Functional MRI

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



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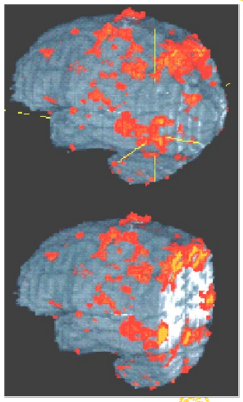
Functional MRI

- When moving a pointer to a target box compared to no movement
  - "activity" in areas involved in vision, planning, and motor control



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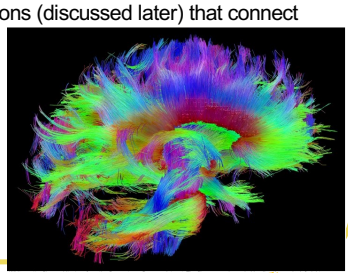
Connectome

- 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



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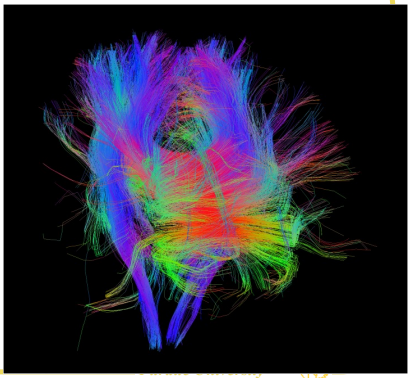
Connectome

- Gives an anatomical map of how information can travel



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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 *theories* of cognition are derived from experimental psychology
  - Brain studies explore how to implement the theories

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Common misconception

- Brain scans *demonstrate* a physiological basis to things that were thought to be emotionally or cognitively based
  - e.g., MRI scans of stutters
  - in fact, *all* behavioral traits are physiologically based

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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)

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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.*

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