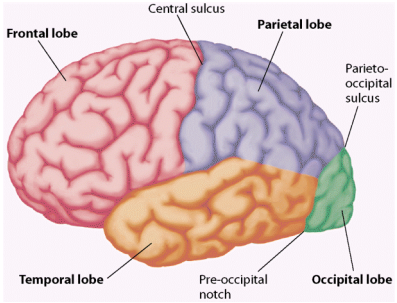
Intro to Neurocognition

PSYC 221
March 7th, 2008

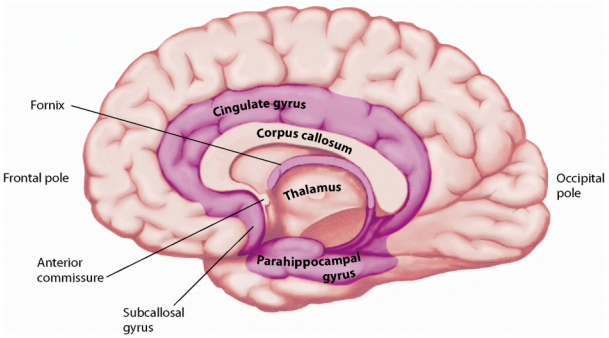
Intro to Cognitive Neuroscience

- Part I
  - Brain Basics
  - Methods
    - Lesions & neuropsychology
    - Electrical stimulation & recording
    - Structural imaging
    - Functional imaging
    - Electrophysiology (EEG/ERPs)
- Part II
  - Brain and cognition
  - Brain and language

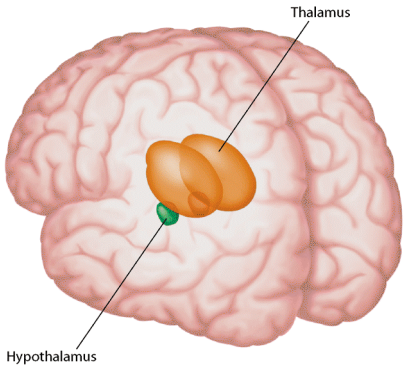
Cortical Lobes

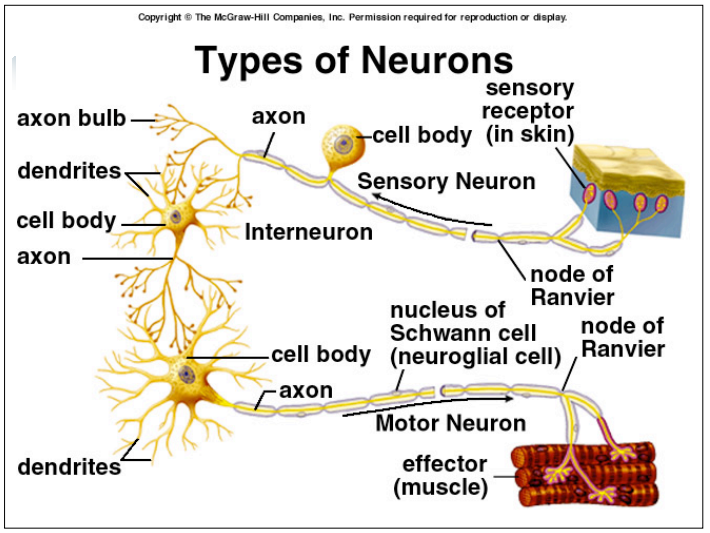


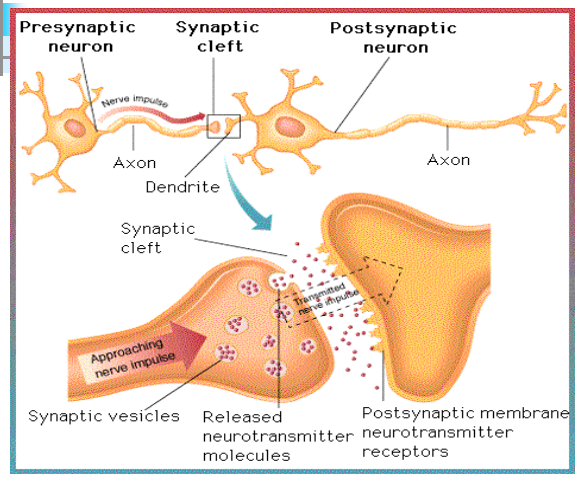
Limbic System



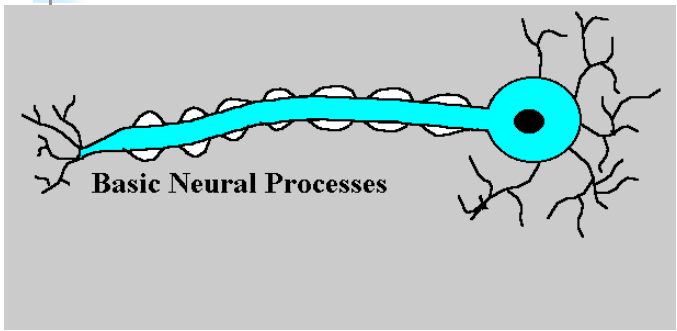
Diencephalon





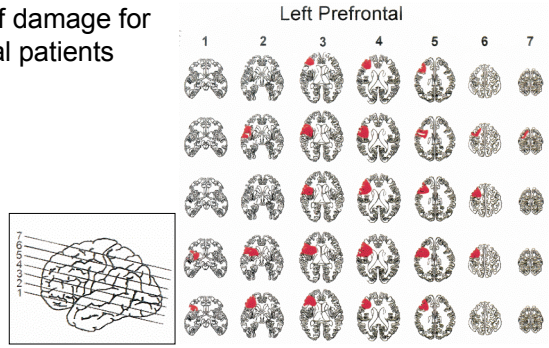


Action potential



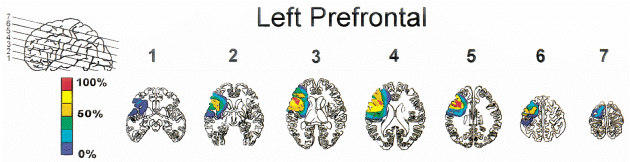
Individual vs. Group Studies

- Extent of damage for individual patients

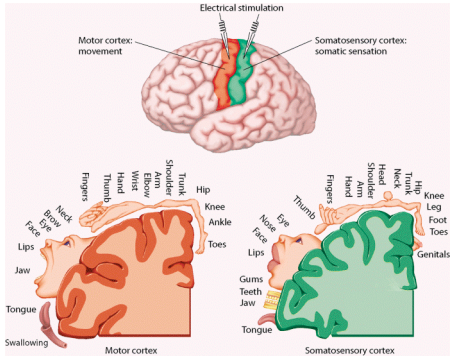


Individual vs. Group Studies

- Extent of damage for a group of patients



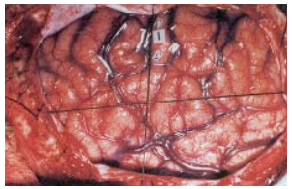
Electrical Stimulation



Adapted from Penfield & Jasper (1954)

Neurophysiology

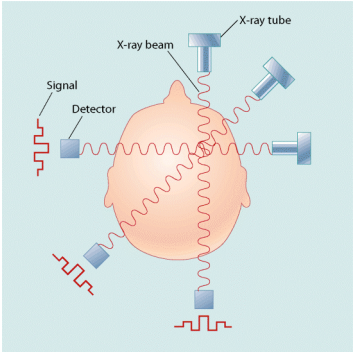
- Single-cell stimulation & recording
- Subdural, multi-electrode stimulation & recording



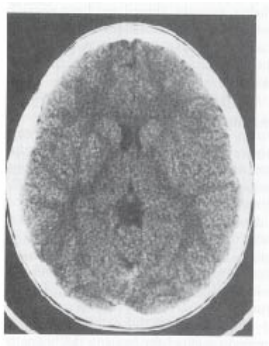
Structural Neuroimaging

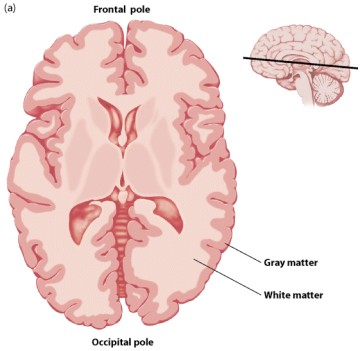
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)

CT Scans

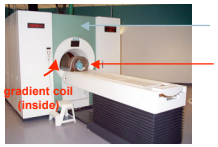


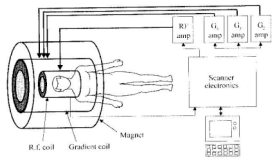
CT Scans





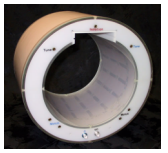
MRI





Gradient Coil

RF Coil

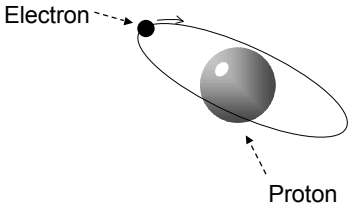


Source for Photos: Joe Gati

fMRI for Dummies

MRI

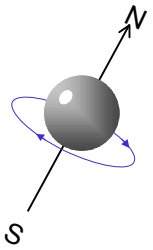
- Magnetic properties of hydrogen proton used to generate images



MRI

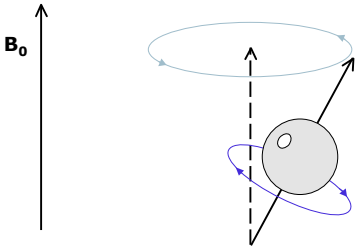
- Magnetic properties of hydrogen proton used to generate images
- Proton spins about its axis

… and has a magnetic field



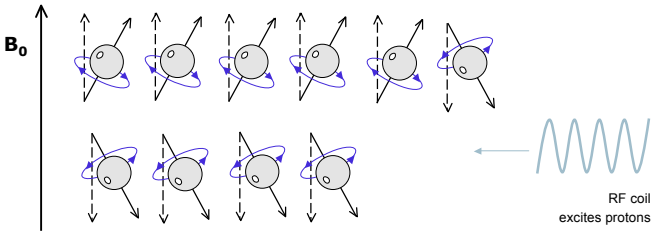
In the MRI Magnet

- Precession: proton wobbles around axis of external field



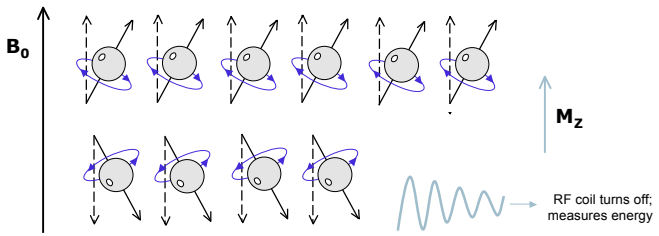
In the MRI Magnet

- When radiofrequency (RF) wave is applied at frequency of precession, photons absorb energy and precess in phase



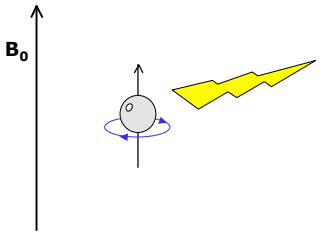
In the MRI Magnet

- When RF wave is turned off, energy is released
  - precessions dephase



In the MRI Magnet

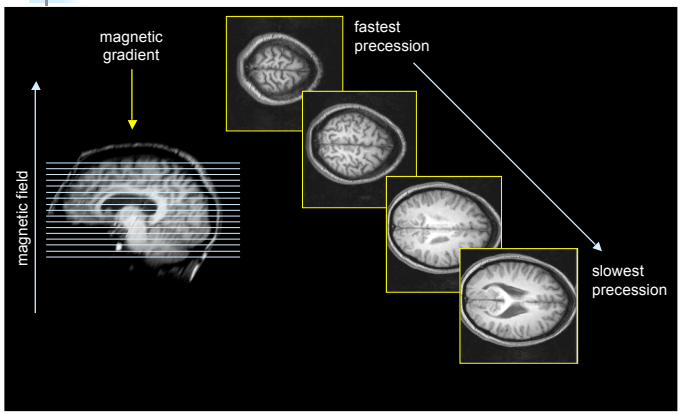
- When RF wave is turned off, RF energy is released
  - spins realign with magnetic field and release a photon



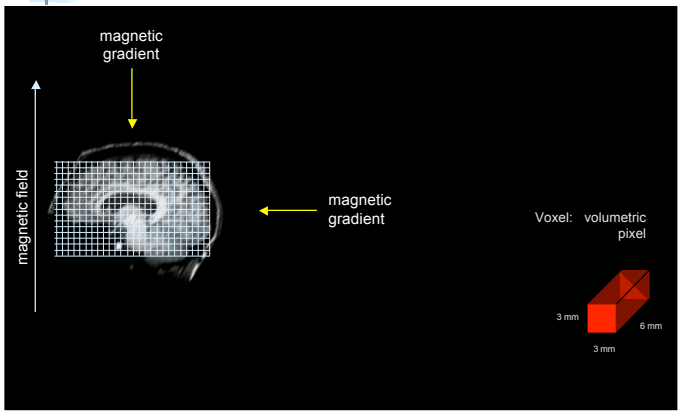
Overview of MRI

- Place person in strong external magnetic field
- Apply magnetic gradient to cause spins in different slices to precess at different frequencies
- Apply second magnetic gradient to cause spins within each slice to precess at different frequencies
- Apply excitation (RF) pulses at precession frequencies to cause protons in each voxel to jump to high-energy state
- Create image of energies released when RF pulses turned off

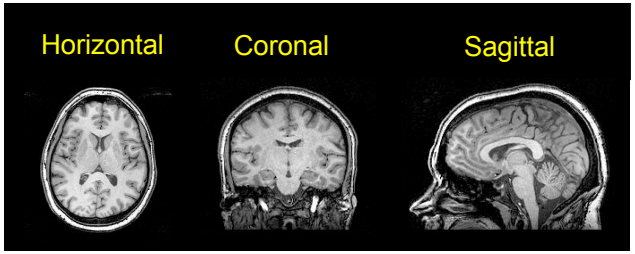
Slice Formation



Voxel Formation



MRI



MRI Safety

- Strength of magnet makes safety essential
  - Things fly – Even big things!

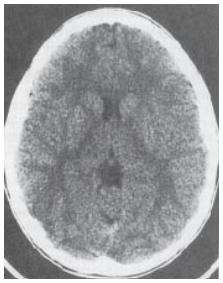
Source: www.howstuffworks.com

Source: http://www.simplyphysics.com/flying_objects.html

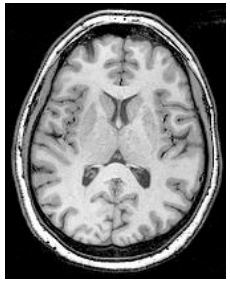
Source: Jody Culham's fMRI for Dummies web site

CT versus MRI

CT scan



MRI scan

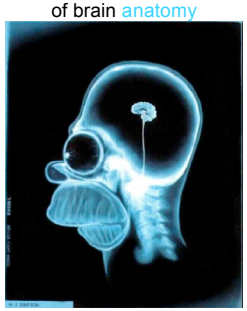


CT versus MRI

- Advantages of MRI over CT
  - Higher resolution; brain more easily visualized
  - No radiation
- Advantages of CT over MRI
  - More comfortable environment
  - No danger of foreign materials in body or MRI room

Structural vs Functional Imaging

CT & MRI provide images of brain anatomy

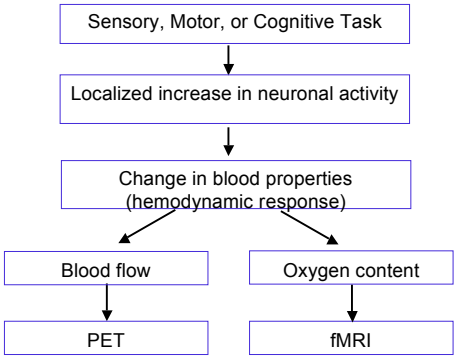


PET & fMRI provide images of brain function

Functional Neuroimaging

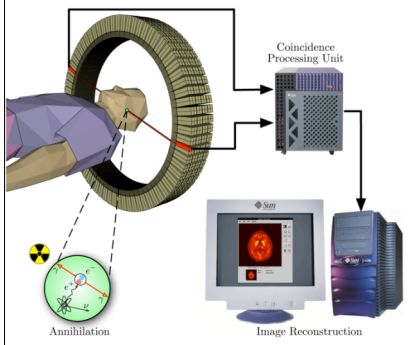
- Positron Emission Tomography (PET)
- Functional Magnetic Resonance Imaging (fMRI)

Functional Neuroimaging



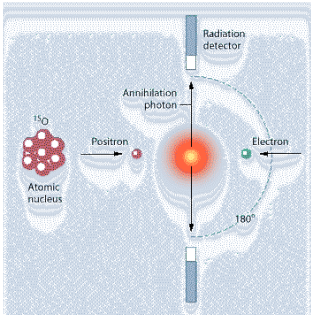
Adapted from Buckner & Logan (2001)

PET



Source: wikipedia.org

PET



fMRI

Sensory, Motor, or Cognitive Task

↓

Localized increase in neuronal activity

↓

Increased blood flow

↓

Increased ratio: oxy-HB / deoxy-HB

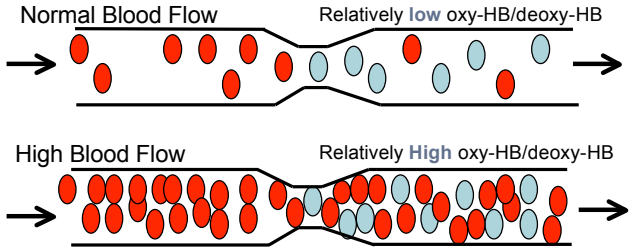
↓

Increased **BOLD** signal

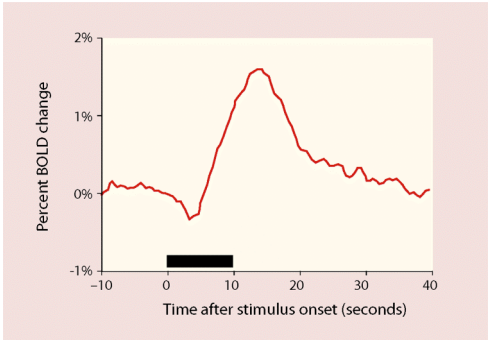
Adapted from
DeYoe et al. (1994)

Blood Oxygenation Level Dependent (BOLD) Effect

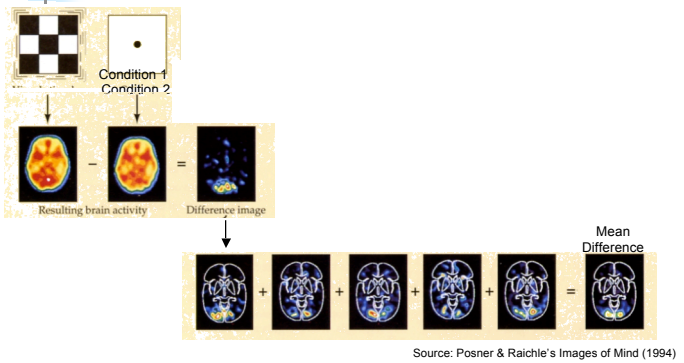
Oxyhemoglobin
Deoxyhemoglobin



fMRI



Subtraction Technique

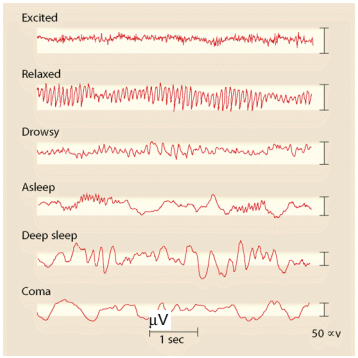


Source: Posner & Raichle's Images of Mind (1994)

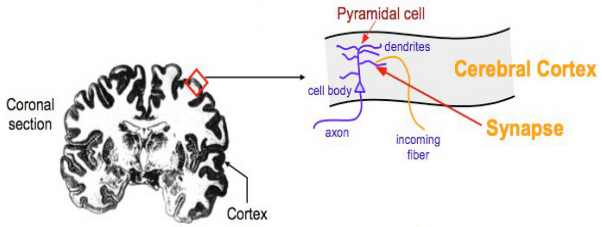
PET versus fMRI

- Advantages of MRI over PET
  - Higher spatial and temporal resolution
  - No radiation
- Advantages of PET over MRI
  - More comfortable environment
  - No danger from foreign materials in body

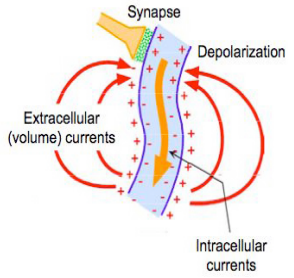
EEG



Generation of the EEG

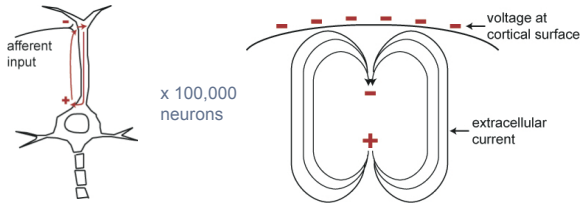


Generation of the EEG

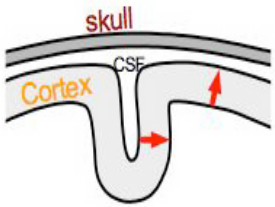


- NOT ACTION POTENTIALS!!!!
- Post-synaptic potentials in *dendrites*
  - Graded potentials

Generation of the EEG

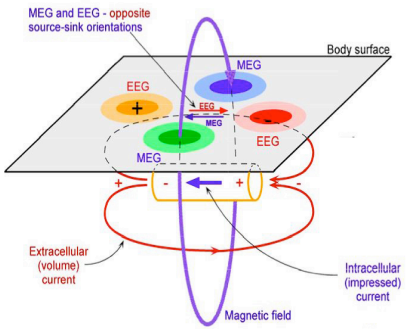


Generation of the EEG

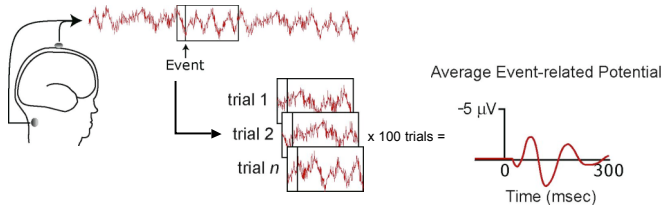


- Pyramidal neurons perpendicular to cortical surface
- Electrodes pick up activity of neurons perpendicular to scalp surface
  - Harder to pick up activity from neurons in sulci

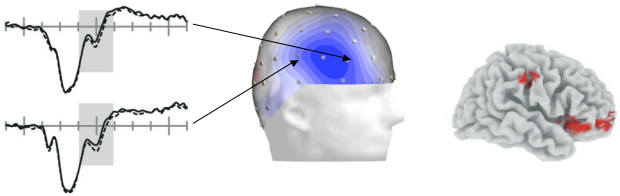
EEG vs. MEG



From EEG to ERPs

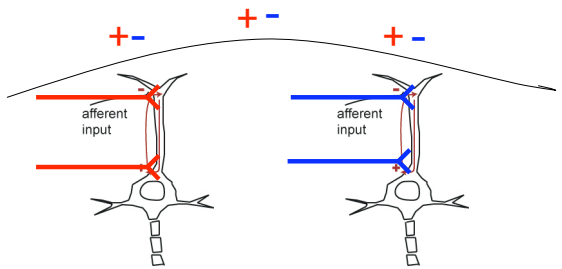


ERP Analysis



Interpretation

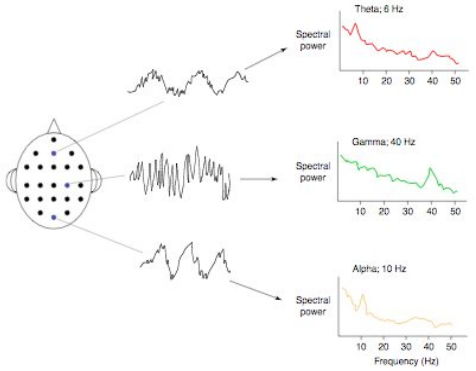
- Polarity of EEG/ERPs
  - Positive voltage does NOT mean an increase in activity
  - Negative voltage does NOT mean a decrease in activity



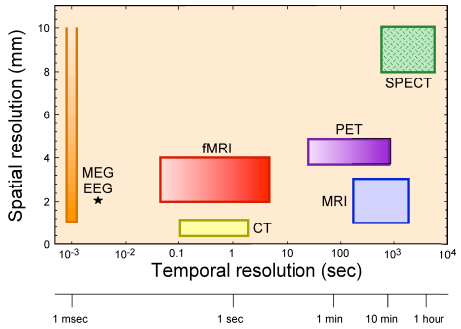
Beyond Averaging

- EEG made up of oscillations
- Oscillations linked to specific cognitive operations
  - Theta (4-7 Hz)
  - Alpha (8-14 Hz)
  - Gamma (30+ Hz)
- Can localize oscillations and examine synchronization

EEG Oscillations

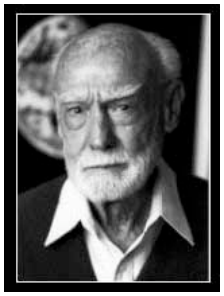


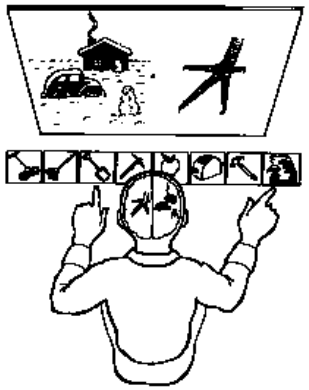
Spatial and Temporal Resolution of Common Methods



Split Brain Studies

- Roger Sperry





Split Brain Studies

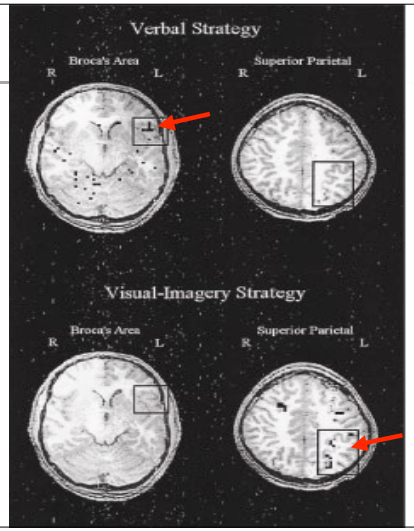
- objects presented briefly in the right visual field could be named readily, but objects presented in the left visual field could not be named

Hemispheric Specialization

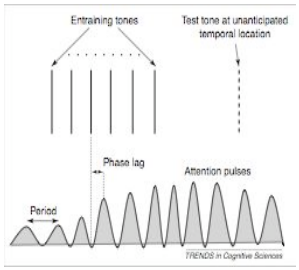
- Left side predominantly used for language and arithmetic (verbal)
- Right side predominantly used for spatial tasks and music (nonverbal)

Reichle, Carpenter & Just (2000)

- 12 participants
- measured verbal and spatial ability
- Sentence-picture verification task (plus above star)
- had participants do some blocks of trials using verbal strategy and others using visual-imagery strategy

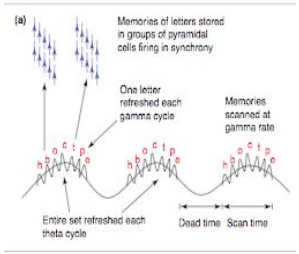


Oscillations & Cognition



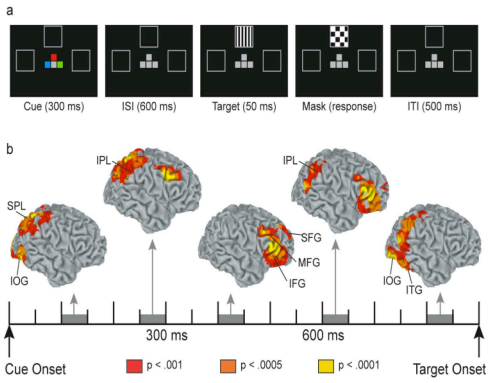
- Brain oscillations can entrain to external stimuli
- Anticipate (attend) to onset of stimulus based on phase of oscillation

Oscillations & Cognition



- Coupling of oscillations
- e.g. 7 +/- 2 memory items
  - Gamma/theta coupling

Oscillations & Cognition

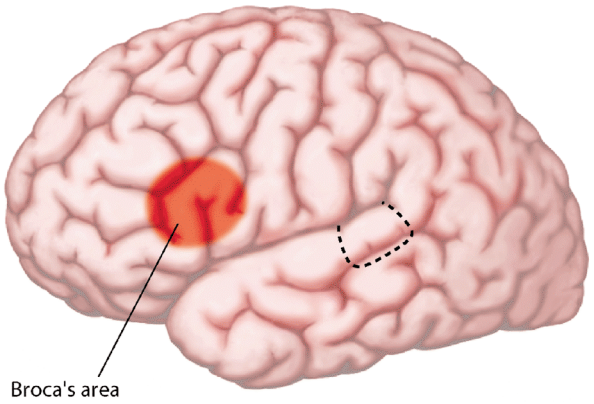


Broca's Aphasia

- Problem with speech production

- **M.E.** *Cinderella...poor...um 'dopted her...scrubbed floor, um, tidy...poor, um...'dopted...Si-sisters and mother...ball. Ball, prince um, shoe...*
- **Examiner** *Keep going.*
- **M.E.** *Scrubbed and uh washed and un...tidy, uh, sisters and mother, prince, no, prince, yes. Cinderella hooked prince. (Laughs.) Um, um, shoes, um, twelve o'clock ball, finished.*
- **Examiner** *So what happened in the end?*
- **M.E.** *Married.*
- **Examiner** *How does he find her?*
- **M.E.** *Um, Prince, um, happen to, um...Prince, and Cinderalla meet, um met um met.*
- **Examiner** *What happened at the ball? They didn't get married at the ball.*
- **M.E.** *No, um, no...I don't know. Shoe, um found shoe...*

Broca's Aphasia



Wernicke's Aphasia

Problem with speech comprehension

Examiner: *What brings you to the hospital?*

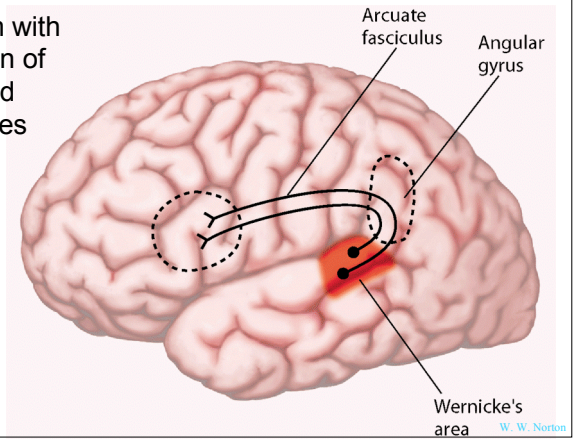
Patient: *Boy, I'm sweating, I'm awful nervous, you know, once in a while I get caught up, I can't mention the tarrripoi, a month ago, quite a little, I've done a lot well, I impose a lot, while, on the other hand, you know what I mean, I have to run around, look it over, trebbin and all that sort of stuff.*

Examiner: *Thank you, Mr. Grogan. I want to ask you a few –*

Patient: *Oh, sure, go ahead, any old think you want. If I could I would. Oh, I'm taking the word the wrong way to say, all of the barbers here whenever they stop you it's going around and around, if you know what I mean, that is tying and tying for repucer, recuperation, well, we were trying the best that we could while another time it was with the beds over there the same thing*

Conduction Aphasia

Problem with repetition of word and sentences



Peterson, Fox, Posner, Mintun & Raichle (1989)

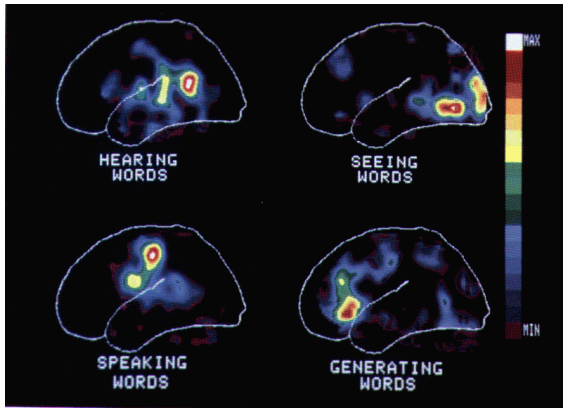
Experimental Conditions

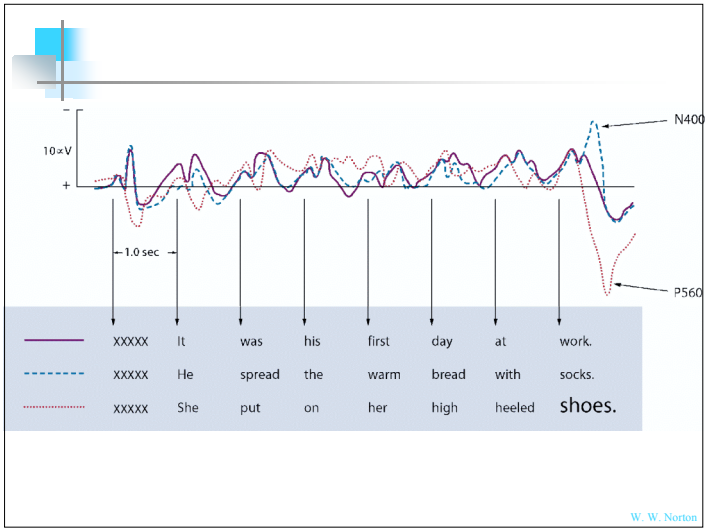
1. **The subjects stared at a crosshair on a computer monitor while their brain activity was monitored via PET imaging.**
2. **Common English nouns appeared on the screen (visual), or were heard over earphones (auditory). The presentation rate was 40 words a minute.**
3. **The subjects were asked to speak the words that they saw or heard.**
4. **The subjects were asked to say aloud a use appropriate for the noun they either viewed or heard. e.g., if the word was 'hammer' an appropriate response would be 'hit'**

The PET scans for the different aspects of the tasks were constructed as follows:

Hearing Words2(auditory)-1
Seeing Words2(visual)-1
Speaking Words3-2
Generating Words4-3

Peterson, Fox, Posner, Mintun & Raichle (1989)





Bilingualism

- Different regions for different languages?

fMRI Evidence:

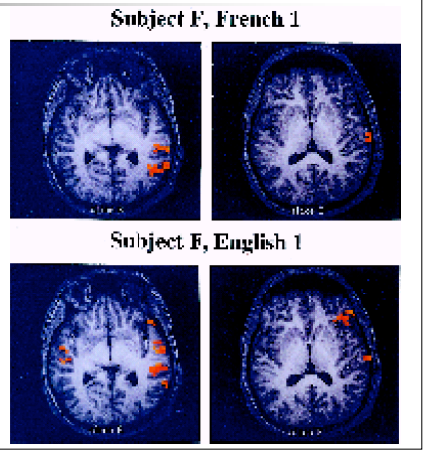
- Dehaene et al (1997)
- Kim et al (1997)
- Wagner et al (1999)

Dehaene et al (1997)

- N = 8
- Listen to stories:
  - Native (French)
  - Second (English) - after age 7
- Found:
  - Native = activation in Broca's
  - Second = activation spread through frontal regions

Dehaene et al (1997)

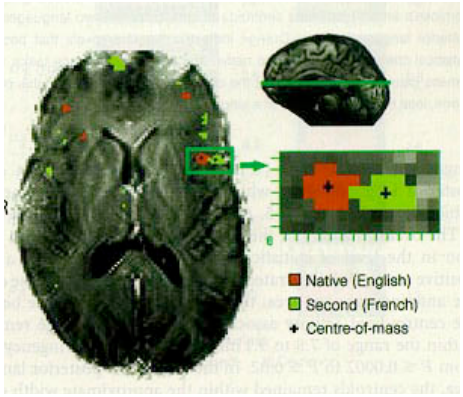
- Conclude:
- separate centers for 2 langs



Kim et al (1997)

- N = 6
- Silent word reading:
  - Native (English)
  - Second (French) - after age 11
- Found:
  - Native = left activation
  - Second = left activation
    - 2 centers = 7.9 mm apart

Kim et al., 1997



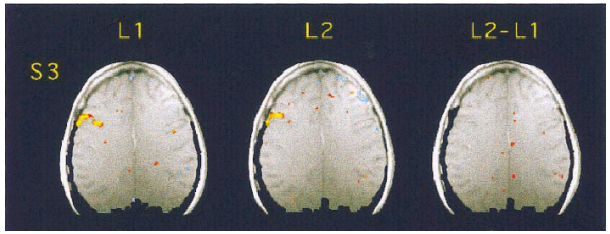
•Conclude: separate - but close centers

Wagner et al (1999)

N = 8

- Decide if words in upper/lower case:
  - Native (Spanish/English)
  - Second (Spanish/English) - after age 10
- Found:
  - Native = left activation
  - Second = left activation

Wagner et al (1999)



•Conclude: same location

One location or 2? Or 3? Or?

- Differences in procedure/task
  - Listening, Reading, Deciding
- Differences in languages
  - English, French, Spanish
- Small sample sizes