PSYC 3530
Cognitive Psychology

Lecture 2: The QALMRI & Cognitive Neuroscience

Class Overview

- **Introduction to the QALMRI method**
- **QALMRI activity**
- **Chapter 2: Cognitive Neuroscience (Brief Overview)**

The “QALMRI” Method

QALMRI

The QALMRI is a method for understanding and evaluating research articles. ”QALMRI” is an acronym for:

Q: Questions
A: Alternatives
L: Logic
M: Methods
R: Results
I: Inferences

Q stands for Questions

- Research begins with a question, and the point of research is to answer the question
- There are usually at least 2 levels, the big question and the specific question
- Big questions usually take many experiments to answer, small questions are usually the focus of the present

Q stands for Questions

- **Big Questio**n: Does language influence perception?

- **Specific Question:** If one language has a term for a specific color, and another language does not have that term, will the speakers of the two languages perceive that color differently?

A stands for Alternatives

- Good experiments consider at least 2 alternative answers to the specific question and explain why they are plausible
- Each possible answer is called a “hypothesis”
  - Typically, the preferred hypothesis is “THE” hypothesis, while any others are considered alternative hypotheses
- When reading a paper or proposing an experiment, you should identify the alternatives discussed by authors

A stands for Alternatives

- **H1:** Top-down processing (e.g., knowledge of color categories, labels) can influence color perception

- **H2:** Color perception is entirely driven by bottom-up properties of the visual system and impervious to top-down influences

L stands for Logic

- The logic identifies how the experiment design will allow the experimenter to distinguish between the alternatives
- IF alternative 1 (and not 2) is correct, THEN when a particular variable is manipulated, participants behavior should change in a certain way.
- There should be separate logic statements for each alternative

L stands for Logic

- ***If H1, then…***
    - ... speakers who have a term for a given color should respond differently to that color than speakers whose language contains no term for that color

- ***If H2, then...***
    - … then speakers who have a term for a given color should respond no differently to that color than speakers whose language contains no term for that color

L stands for Logic

- Ideally, the logical statements should be more specific to the experiment

- For example, perhaps one language has a name for “pink” and “red”, but another does not. The experiment could be “tell me when two shades of a color are different or the same”
  - **If H1, then…** then speakers who have a name for each should say pink and red are different, while those who do not, should say they are the same
  - **If H1, then…** then all speakers should say pink and red are different, regardless of whether they have words for them or not

M stands for Methods

- Identifies the procedures that will be used to implement the logical design
- Should state independent variable (what is manipulated) and dependent variable (what is measured)
- Describes subjects, how they were divided into groups, materials, stimuli, etc.

R stands for Results

- Identifies the *important* outcome or findings from the experiment
- Did different groups produce different means? What were they? What was the pattern of results? Were the results reliable?
- Graphs, tables, statistics used to show data

I stands for Inferences

- What did the authors infer from the results?
  - Did they draw conclusions about the hypotheses?
  - What were the implications for the big and specific questions?

- It is also important that you think critically, and draw your own conclusions:
  - **Would you draw the same conclusions given the results?**
  - **Are there potential, unaddressed limitations of the study?**
  - **Does this study spark future directions or questions?**

Making Memories: Brain Activity that Predicts How Well Visual Experience Will Be Remembered

- **Question:** What was the big question? What was the specific question?
- **Alternatives:** What were the alternatives?
- **Logic:** What was the logic of the experiment?
- **Methods:** What were the methods?
- **Results:** What were the important results?
- **Inferences:** What were the inferences? Any other thoughts?

Cognitive Neuroscience

What is cognitive neuroscience?

- The study of the physiological basis of cognition

- Involves an understanding of both the nervous system as well as the individual units that comprise that system

- The underlying physiology can be understood from many different levels
  - For example, behavior associated with ”perception” can be understood in terms of: chemical processes > neural activity > brain structures activated > groups of brain structures activated

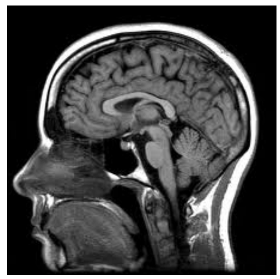
What is cognitive neuroscience?

- Although we may think of cognitive neuroscience as only studying the physiology underlying cognition…
  - “What is the neural representation of visual objects?”
  - “What brain regions are associated with language production versus comprehension?”
- Cognitive psychologists also use neuroscience tools and techniques to investigate cognitive theories and better understand mental processes
  - For example, if semantic and episodic memory systems are in fact separate memory systems, we could use these neuroscience tools to determine whether they are physiologically independent

Cognitive Neuroscience Methods

Structural Magnetic Resonance Imaging (MRI)

- Uses strong a strong magnetic field and radio waves to form images of brain structures



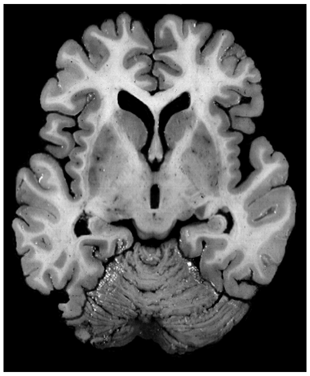
Cognitive Neuroscience Methods

Structural Magnetic Resonance Imaging (MRI)

- Most human tissue is water based
  - Amount of water in different tissues vary (gray matter, white matter)
  - Water molecules have two protons in them
  - Protons have weak magnetic fields
  - Because tissues have different amounts of water/protons/magnetic properties, MRI can be used to make an image of the different tissues

Cognitive Neuroscience Methods

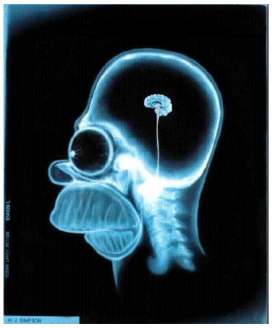
- Real photograph (left)
- MRI (right)



Cognitive Neuroscience Methods

- Anatomy vs. Function

Brain Anatomy
CT, MRI



Brain Function
PET, EEG, fMRI

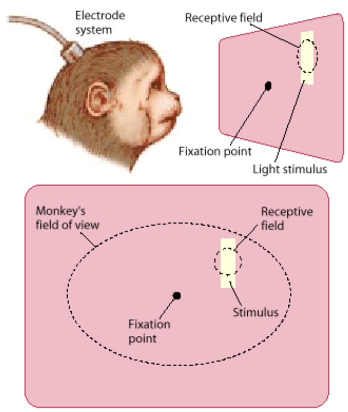
Cognitive Neuroscience Methods

What do we need to consider when choosing a functional technique?

- Spatial resolution
  - Minimum distance to tell two structures apart
- Temporal resolution
  - Minimum time to tell to events apart
- Invasiveness
  - Is equipment located internally or externally

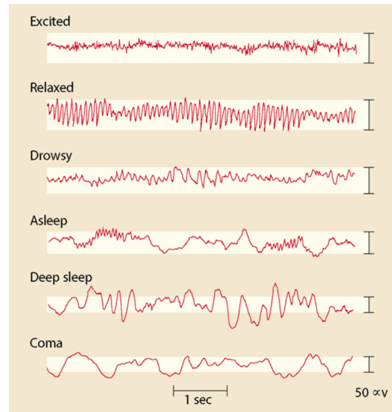
Single-Unit Recordings

- Invasive
- Correlational
- Very high spatial resolution
- Very high temporal resolution



Electroencephalograph (EEG / ERP)

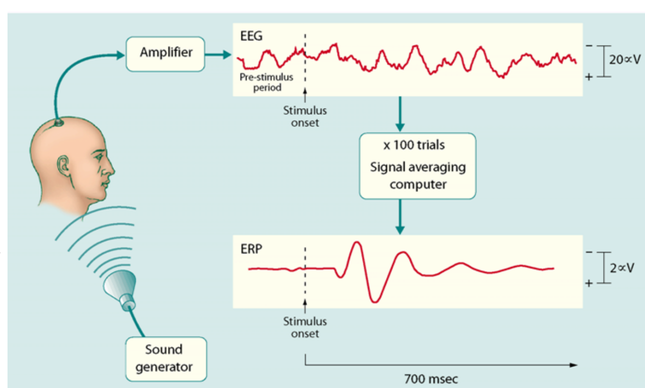
- Measures electrical activity along the scalp = sum of activity of millions of neurons



Electroencephalograph (EEG / ERP)

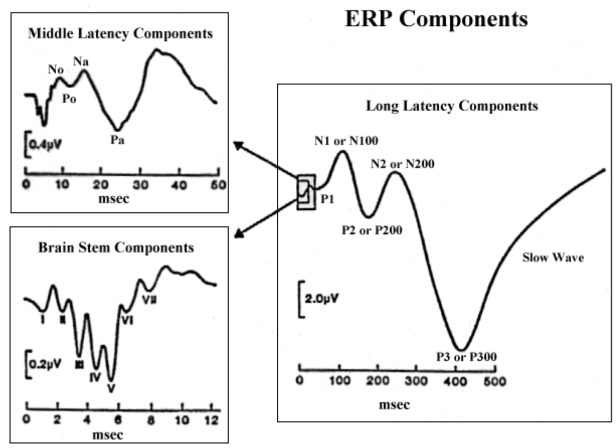
Event-related potentials (ERP)

- ERPs are a special case of EEG
- Average EEG trace from a large number of trials
- Align signal to onset of a stimulus or response – hence event-related potential (ERP)



Electroencephalograph (EEG / ERP)

- Correlational
- Low spatial resolution
- High temporal resolution



Functional Magnetic Resonance Imaging (fMRI)

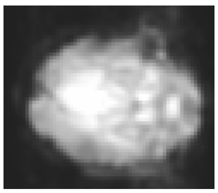
- Blood Oxygenation Level Dependent (BOLD) signal
  - Indirect measure of neural activity

- fMRI is sensitive to the ratio of oxygenated to deoxygenated hemoglobin in the blood
  - There is more oxygenated hemoglobin in vessels surrounding active tissue (neural activity = oxygenated hemoglobin)
  - The difference in magnetic susceptibility between oxyhemoglobin and deoxyhemoglobin, leads to magnetic signal variation which can be detected using an MRI scanner

Functional Magnetic Resonance Imaging (fMRI)

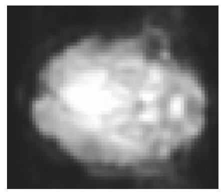
- Relies on a subtraction method
- Which is superimposed on an anatomical image

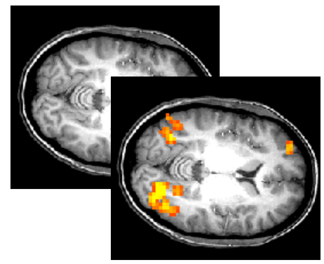
Condition 1



minus

Condition 2





- IMPORTANT
  - The activity you see on the image is not the only activity. It's how much MORE activity in those areas as compared to some control

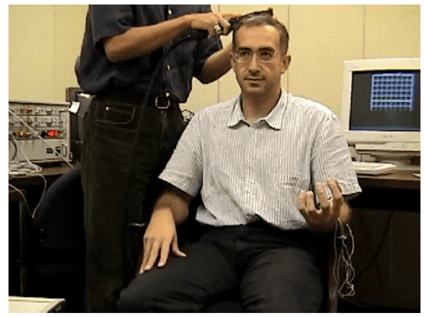
Functional Magnetic Resonance Imaging (fMRI)

- fMRI – Measures ratio of oxygenated and deoxygenated hemoglobin

- Correlational
- Overlays functional activation over structural images
- Relatively high spatial (not as high as MRI)
- Medium temporal resolution (not as high as EEG)

Transcranial Magnetic Stimulation (TMS)

- TMS uses magnetic pulses to transiently disrupt brain function
- Experimentally induced lesion, therefore causal, not correlational
- Variable spatial resolution
- Variable temporal resolution (single-pulse vs. rapid-rate)



transcranial Direct Current Stimulation (tDCS)

- tDCS: applies constant, low current electrical stimulation to the scalp
- Thought to alter membrane potential – excitation & inhibition
- Experimentally, therefore causal, not correlational
- Poor spatial resolution
- Poor temporal resolution – after effects

Converging Evidence

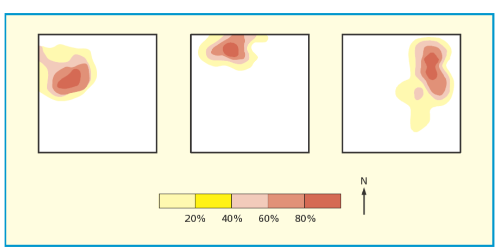
- One way to gain further and more powerful information about cognitive processes is to combine different techniques to study the same cognitive process

- Provides supporting evidence
- Addresses problems with associated techniques
- Addresses new issues

Memory for Space: Does the Hippocampus Contain a Spatial Map?

Single-Unit Recording Evidence

- Place cells respond maximally when animal in certain location



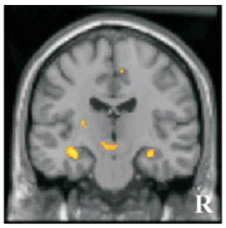
- Collection of place cells could serve as a spatial map

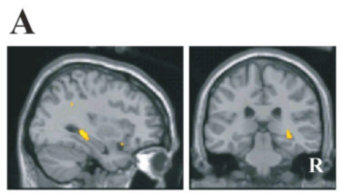
Memory for Space: Does the Hippocampus Contain a Spatial Map?

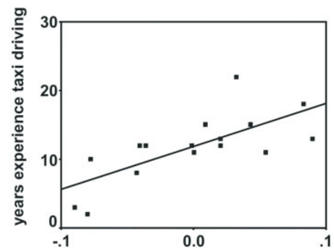
Structural MRI evidence

- Expert navigators have greater posterior hippocampal volume (taxi drivers)
- Correlated with experience

Taxi > Bus



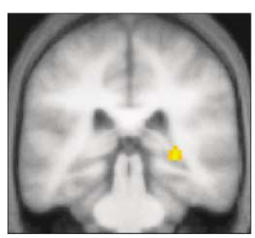




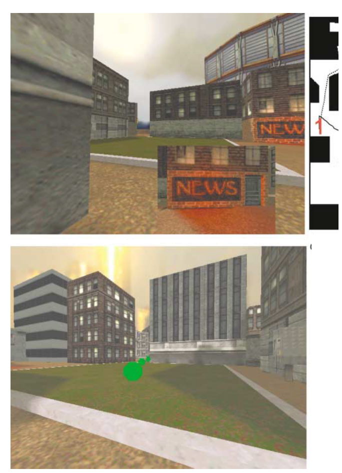
Memory for Space: Does the Hippocampus Contain a Spatial Map?

fMRI evidence

- Navigating in virtual reality
- Accurate wayfinding using a well-learned route resulted in greater R. Hippocampal activity



R. Hippocampus
Accurate > Inaccurate
wayfinding



Take Home Messages

- By understanding the brain, we may understand how cognition operates

- Techniques in neuroscience allow physical measurement of cognitive processes
  - Techniques vary in terms of:
    - Spatial resolution
    - Temporal resolution
    - Invasiveness
    - Correlational vs. Causal
    - Direct vs. Indirect Measures