Foundations (cont.)

- Complexity
- Testing explanations in psychology
- Cognitive Neuroscience

Complexity is key

- The amazing thing about thought is that everything is too complicated for us to do
  - Yet, we manage to get around the world.
- What do we mean by complexity?
  - There are always many possibilities
  - Only a few of them are relevant
  - How do we decide which ones are correct?

Example

- How can you get to Dallas from here?
- Possibilities
  - Drive
  - Take a bus
  - Take a plane
  - Walk?

There are many other options too

- Unlikely routes
  - Drive via Peru
- Unlikely modes of transportation
  - Scooter
- Impossible actions
  - Magical transportation devices
- Unlikely time scales
  - 3 minutes; 275 years
- If we considered all of these possibilities, how would we ever decide what to do?

Complexity

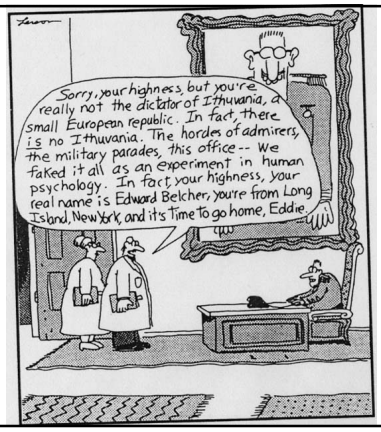
- Somehow we manage to solve these problems
- What must happen?
  - We must limit the options we consider
  - We must think quickly enough to consider a reasonable number of options
- How does this happen?

Constraints

- A central theme this semester is constraints
- The cognitive system has many ways of focusing on what is relevant
  - Constraints promote information likely to be relevant
  - Some possibilities may be missed
- Constraints determine what is easy or hard to do.
  - Theories suggest possible sets of constraints
  - Experiments test whether people use those constraints.

Ways of testing theories

- Return to levels of explanation
- Theories may describe constraints at different levels of explanation
  - Computational level
  - Algorithmic level
  - Implementational level
- Different kinds of data will be relevant to each type of explanation.



Computational level explanations

- Computational level explanations specify input/output relationships
- Studies must explore these relationships
- Given a particular situation or stimulus
  - What is the output?
  - Does that output differ from what is optimal
    - That is, the best that could happen?
      - Example: Psychophysics
  - What possibilities are considered?
    - Are some possibilities excluded?
      - Example: Parsing language

Methods

- Ratings and judgments
  - Similarity, typicality, grammaticality
- Problem-solving studies
- Classification and Learning
- Memory tests
  - Recognition
  - Recall

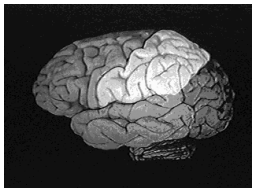
Algorithmic level explanations

- Specify representations and processes
  - Often suggests what will be easy and hard to do.
- Tests must distinguish between types of representations and processes
- Response time
  - A measure of what is easy and hard
    - Example: Mental rotation
- Think-aloud protocols
  - Speaking aloud the inner voice
    - Example: Self-explanation effects

Implementational level explanations

- Specifies how thought is implemented
  - Human thought occurs in the brain
- We cannot open up people's brains in general
- Cognitive neuroscience
  - Using natural experiments
    - Disorders and lesions (from events like strokes and war)
  - Non-invasive brain imaging
    - PET, fMRI, and ERP
  - Let's focus on these a bit more.

This is your brain

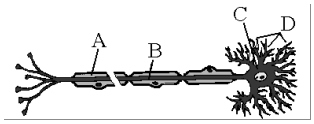


Four lobes
- Frontal
- Parietal
- Temporal
- Occipital

It is not this color of course...

Neurons and activity

- The active cells in the brain are neurons
- They send signals (called action potentials)
  - These signals influence neighboring cells
  - Signals are electrical
- The combined activity of neurons carries activation.



What, When, and where?

- There are three key aspects to studying people's brains.
- What functions are performed?
- Where are they performed?
- When does the activity occur?

Lesion Studies

- Studying brain damage can tell us something about what areas of the brain affect particular functions
  - If an area has a lesion, and the person shows a specific deficit, then that area probably has *something* to do with that function.
    - Pretty vague conclusion…
- Example: Memory disorders
  - Lesions of the hippocampus and memory

Brain imaging

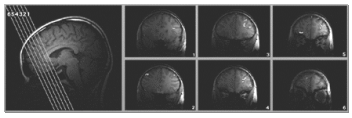
- We want to know where the activity is happening
  - Spatial resolution
- We want to know when it occurs
  - Temporal resolution
- Different techniques have different strengths.

ERP

- Event Related Potentials
- Electrodes are placed at the scalp
  - Measure small changes in voltage after presentation of some stimulus
- Poor spatial resolution
  - Current must pass through scalp
- Excellent temporal resolution

fMRI

- Functional Magnetic Resonance Imaging
- Measures cerebral blood flow
  - Probably related to neural activity
- Excellent spatial resolution
- Poor temporal resolution



PET

- Positron Emission Tomography
- Also a measure of brain activity
  - Traces path of radioactive substance put in blood
  - Often measures glucose uptake
  - More invasive than fMRI
    - Not used as often as fMRI any more.
- Good spatial resolution
- Poor temporal resolution

EROS

- Event-Related Optical Signals
- Shine an infra-red light into the skull
  - Measure how it is reflected back from the brain
- Gives a measure of activity on the cortex
  - Good temporal resolution
  - Good spatial resolution
- Cannot give information about sub-cortical (internal) structures in the brain
  - Can be used in conjunction with fMRI

Summary

- Much remains to be learned about the brain
- We will touch on evidence from cognitive neuroscience this semester.
- There may be limits on what we can learn from the brain.
  - It is not necessary that the way my brain does something is the same as the way your brain does the same thing.