Cognitive Psychology (PSYC 363)

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Part XVI

Neuropsychology

"The prefrontal cortex is involved in higher mental functioning, like using a can opener and remembering to feed you."
A Lesson from Pinky and the Brain
Cognitive Neuroscience

Topics to Cover

• Basics of Neuro Anatomy
  – Neurons, Brain Structures
• Transduction
• Representations in the Brain
• Hemishpheric Lateralization
  – Corpus Callosum, Split Brain Patients
• Localization of Function vs. Mass Action
• Measuring Brain Activity
Cognitive Processes and Neuropsychology

• Review of topics covered
  – High and low-level processing
    • Sensation & Perception
    • Attention
    • Memory
    • Language
    • Problem Solving
  – All have biological correlates in brain

• The Amazing Brain
  – Knowledge Representation:
    • “most mysterious thing in the world”
      (William James, 1890)
Neuroscience of I-P

How is information...

1. ...acquired (sensation)?
2. ...interpreted to confer meaning (perception and recognition)?
3. ...used to ruminate (thinking and consciousness)?
4. ...to predict the future state of the environment and the consequences of action (decision making)?
5. ...to communicate (language)?
Neural Anatomy

• Neurons
  – Cell body
  – Dendrites
  – Axon
    – Terminal Buttons
  – Myelin Sheath
  – Synapse
Characteristics of Neurons

- Action Potentials
- Propagation
- Communication
  - Synapses
  - Neurotransmitters
  - Excitation and inhibition
- Long Term Potentiation (LTP)
  - “cells that fire together, wire together” (Hebb)
Excitation, Inhibition, and the Praying Mantis

• What do you know about the praying mantis?

– Females sometimes decapitate males during copulation....*what*?!

• *Why*??
What do we know so far?

• So we know how one neuron sends a signal to another.

• Where does it all start?
Sensory Transduction

SENSORY TRANSDUCTION

STIMULUS ENERGY → RECEPTOR → RECEPTOR POTENTIAL → ACTION POTENTIALS

a CAT as perceived by S
light rays
neural causes and correlates of consciousness
neural representation of a cat

a CAT as perceived by an external observer
a subject (S)
Sensory Transduction

It's not quite that straightforward
An example with visual stimuli
Visual Phototransduction

Hemispheric lateralization
Hemispheric Lateralization

How do the hemispheres communicate?
Corpus Callosum & Split-Brain
Gazzaniga's Split-Brain Studies

http://www.youtube.com/watch?v=ZMLzP1VCANo
Localization of Function

- Homunculus
Cognitive Processes and the Brain

• Localization vs. Mass Action
  – Karl Lashley, rats, engrams, and % of your brain
    • Equipotentiality
  – What does it mean to be localized?
Localization Gone Wrong!

- Anton Mesmer
- Franz Joseph Gall
- Phrenology
  - S.I. Franz quote...
BRAIN ANATOMY
(MODELS OF LOCALIZATION)
Brodmann’s Areas (Brodmann, 1909)
Major Structures: Lobes

- Cerebral Cortex
  1. Temporal
  2. Occipital
  3. Parietal
  4. Frontal
Structures in Cerebral Cortex
Broca’s Aphasia:
- Characterized by slow, laborious speech.
- Speech *production* problem.
- Comprehension is intact, can understand others.
Wernicke’s Aphasia:

- Speech *comprehension* problem.
- Not aware of speech errors.

Left Temporal Lobe
The Brain & Language

Production vs. Comprehension

http://www.youtube.com/watch?v=67HMx-TdAZI
The Brain & Memory

- Engrams?
  - Specific representations vs distributed representations
- Hippocampus
  - Semantic vs. Episodic Memory
- Amygdala
- Striatum
Hippocampus

• Damage / Removal
  – H.M.
  – Clive Wearing

• Contents
  – Episodic memory?
  – Semantic memory?
  – All LTMs?

• Consolidation
  – Long Term Potentiation
  – Reconsolidation?
Semantic Memory

• Sensory vs. Association Cortices

• Specificity of Encoding
  – Peanut vs. Banana (Thorpe, Rolls, & Maddison, 1983)
  – Steve Carell, Whoopie Goldberg, and Bill Clinton
    • Quiroga et al. (2005)
Semantic Memory

- Extrastriate Body Area (EBA)
  - Right lateral occipital cortex (Downing et al., 2001)
Medial Temporal Lobes

- H.M. (surgery) & E.P. (viral encephalitis)
  - Anterograde vs. Retrograde Amnesia
Necessity of Hippocampus

...to Semantic memory?

Moderate vs. Severe damage to MTL

- Including damage to parahippocampal and perirhinal
- Categorization using a prototype (Reed et al., 1999)

- Parahippocampal area may provide spatial context
  - Parahippocampal place area
Amygdala

- Highly arousing or emotional memories
- Fear conditioning in rats

- Located adjacent to the hippocampus and can regulate hippocampus (memory) function.
  - Stress
Emotion Expression

- Kluver-Bucy disorder (1937): Temporal Lesions
  - *psychic blindness*

  - Difficulty recognizing *fear*, anger, and surprise
  - Perceived fear as emotional, not fearful
Adolphs et al. (1994)

S.M. (Urbach-Wiethe)
Predicting the weather: Cognitive skill learning

• e.g., Knowlton, Squire, & Gluck (1994)

In this learning game you are the weather forecaster. You will learn how to predict rain or shine using a deck of four cards:

- 80% probability of sunshine
- 60% probability of sunshine
- 40% probability of sunshine
- 20% probability of sunshine

Task performance and declarative memory for the task:

CON = Controls
AMN = Amnesic subjects (hippocampus)
PD = Parkinson’s disease (striatum)
PD* = Severe Parkinson’s disease

Increased brain activation in the basal ganglia region is indicated.

Figure showing percentage correct over trials for different groups.
MEASURING BRAIN ACTIVITY
Historical Neuroscience

• Historical vs. Modern Approaches
  – Direct Observation
    • Case Studies (e.g., HM, NA, Clive Wearing)
    • Lesion/ablation
    • Single cell recording, microelectrodes
How do we measure the brain?

Case Studies

Henry Molaison (HM) (1926-2008)

Clive Wearing (1938 - )

Hippocampus Damaged by Herpes Simplex Encephalitis
Slice it out and see what happens!

Lesion / Ablation

Watch a Lesion Procedure
Do we need to slice it out?

- Transcranial Magnetic Stimulation (TMS)

Magnetic pulse to ease depression

A non-invasive procedure to help fight depression called transcranial magnetic stimulation, or TMS, uses a magnetic pulse to stimulate brain cells that control mood.

- Limbic system structures thought to control emotional and behavioral patterns.
- The pulses trigger electrical changes, causing neurons to become active.
Do we need to slice it out?

• We can deactivate it with temperature or chemicals.

Visual short-term memory deficit from hypothermia of frontal cortex

(Bauer & Guster, 1974; 1976)

Role of norepinephrine in mediating stress hormone regulation of long-term memory storage: A critical involvement of the amygdala

(Ferry, Roozendaal, & McGaugh, 1999)
How about in autopsy?

Dr. Lucy Rorke-Adams
(former caretaker of Einstein’s brain)

Watch Brain Slicing!

Dissection of H.M.’s Brain at UCSD (2008)

The frozen block of gelatin and brain was sectioned on a heavy-duty microtome for 53 hours straight. Five blades were used in the process.
Measuring Brain Juice

Microelectrodes & Measuring Neurotransmitters

Stereotaxic Surgery
Computerized Axial Tomography

- Indirect Observation
  - CT or CAT (Computerized Axial Tomography)
  - Electroencephalography (EEG)
  - Magnetoencephalography (MEG)
  - Positron Emission Tomography
  - fMRI (functional Magnetic Resonance Imaging)

*NOT a CAT scan*
Computerized Axial Tomography

Anatomy of a CT scan
CT scanners give doctors a 3-D view of the body. The images are exquisitely detailed but require a dose of radiation that can be 100 times that of a standard X-ray.

Computed tomography scans are made by rotating an X-ray beam around the patient, imaging the body in a series of slices that a computer stitches together.
Electroencephalography

• Electroencephalography (EEG)
  – Procedure
  – What are we measuring?
  – Advantages and Drawbacks
Electroencephalography

Signal Detection Theory

Signal : Noise
Magnetoencephalography

- Magnetoencephalography (MEG)
  - Procedure
    - Magnetically Shielded Room
  - What are we measuring?
  - Advantages and Drawbacks

Signal Detection Theory

Signal : Noise
Magnetoencephalography

Magnetoencephalogram (MEG)
• **EEG**
  - Electrical signal (can be distorted and very small, about 1 million times weaker than household batteries)
  - Measures sulci & gyri (top)
    - Broader sensitivity

• **MEG**
  - Magnetic field (less prone to distortion but very small, < 100 million times weaker than Earth’s)
    - Greater spatial mapping
  - Measures sulci only
Positron Emission Tomography (PET)

- Procedure
- What are we measuring?
- Advantages and Drawbacks
Magnetic Resonance Imaging

- Magnetic Resonance Imaging
  - Procedure
  - What are we measuring?
  - Advantages and Drawbacks
  - What makes it fMRI?
    - (i.e., functional)

Clark-Foos: MR Image (4.13.2007)
Magnetic Resonance Imaging

Magnetic Resonance Imager (MRI)
Uses of fMRI

• Lie Detection (e.g., Langleben et al., 2005)
Uses of fMRI

• Sleep and Memory Consolidation
  – Emotional Memory? (Payne & Kensinger, 2011)

Diekelmann & Born, 2010
Uses of fMRI

• Seeing the future?
  – Episodic memory (Schacter, Addis, & Buckner, 2007)

Box 1 | The typical paradigm for probing past and future events

I remember taking a daytrip last summer and walking on the beach.
I imagine picking out a puppy at the pet shop next year.

Brain regions involved:
- Precuneus/retrosplenial cortex
- Medial prefrontal cortex
- Lateral parietal cortex
- Medial temporal lobe
- Lateral temporal cortex
The DANGER of Using Magnetic Resonance Imaging
Summary

- Biological correlates in brain
- Neurons and their interactions
- Brain areas and localization
- Different ways to measure activity in brain