Week 1 : Background
The Development of Neuropsychology

- KW Chapter 1

Case Report : LD

- History:
  - 21 year old male
  - Fell down 5 flights of stairs, suffered CHI
  - GCS of 3
  - CT revealed bleeding and swelling on RH, then LH
  - Craniotomy to relieve pressure
  - Successful physical recovery

GCS: Glasgow Coma Scale

- 13+ "Minor"
- 8-12 "Moderate"
- 3-8 "Severe"

Score	Eyes Open	Verbal	Motor
1	no	none	none
2	to pain	sounds	extension to pain
3	to voice	words	abnormal flex to pain
4	spontaneously	confused	flex/withdraw to pain
5	..	oriented	normal resp. to pain
6	..	..	obeys commands

Case Report : LD

- Sequelae:
  - Amnesia for incident
  - NP Exam:
    - behavior : normal (?)
    - Pt and family report full recovery
    - tests:
      - impaired verbal memory
      - impaired attention
  - Unable to return to work as cook
    - can't multi-task
    - lost sense of smell and taste
  - Lost interest in socializing
  - Yet, able to play golf at expert level

Case Report : LD

- Issues:
  - Lawsuit & Settlement:
    - is he injured?
    - how can he be expert golfer but not work?
  - Rehabilitation & Recovery?
  - NP Testing shows "hidden" deficits
  - Brain imaging
    - shows diffuse bilateral damage
    - limited utility

Brain Anatomy

- Two hemispheres (Left, Right)
- Cortex ("bark")
- Gyri, Sulci
- Hand Model
- CSF
- lateral and longitudinal fissures

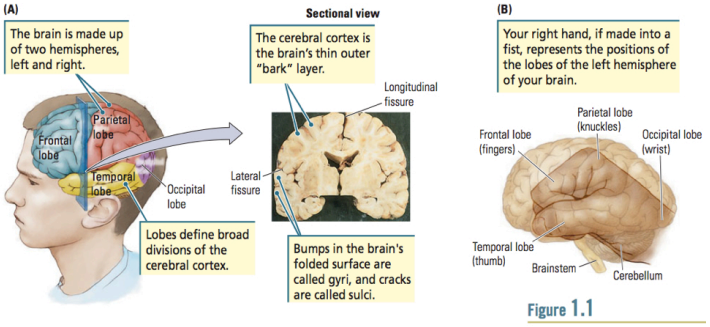
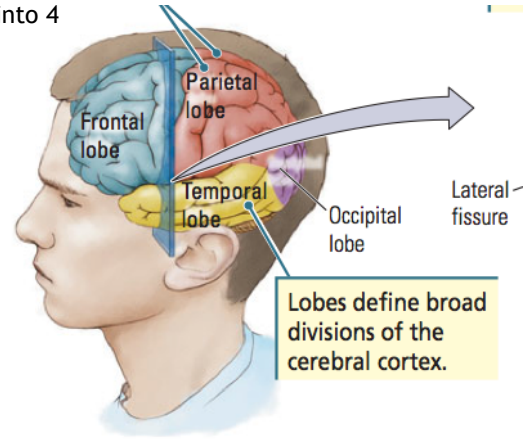


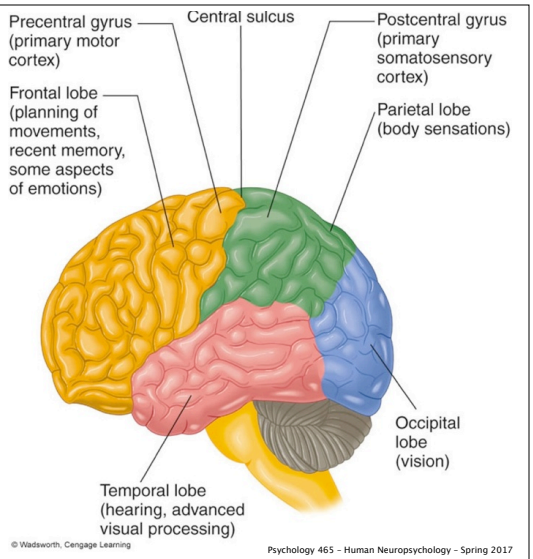
Figure 1.1

Brain Anatomy

- Cortex divided into 4 lobes
  - Frontal
  - Parietal
  - Temporal
  - Occipital



Cerebral Cortex

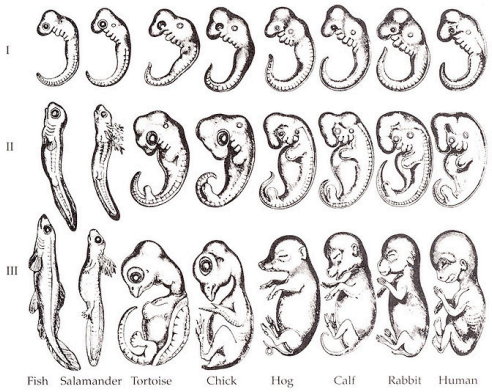


Evolution

- Phylogenetics or Phylogeny
  - study of evolutionary relationships between organism
- Ontogenesis or Ontogeny (aka morphogenesis)
  - development of organism from egg to adult

Ontogeny Recapitulates Phylogeny

- idea that an organism's development from egg to mature individual is similar to evolutionary development of species.



Brain - 3 part division

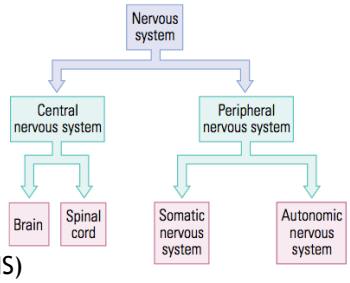
- Three divisions:
  - Forebrain
  - Brainstem
  - Spinal Cord
- These mirror phylogeny (somewhat)

Brain

- **Forebrain**
  - Cerebral Cortex
  - Limbic System
    - Hippocampus
    - Cingulate Gyrus
    - Septum
    - Amygdala
  - Basal Ganglia
    - Globus Pallidus
    - Caudate
    - Putamen
- **Brain Stem**
  - Diencephalon
    - Thalamus
    - Hypothalamus
  - Midbrain
    - RAS
  - Hindbrain
    - Pons
    - Cerebellum
    - Medulla

Nervous System

- Assumption
  - Nervous system -> Behavior
- Nervous system:
  - Central Nervous System (CNS)
    - Brain
    - Spinal Cord
  - Peripheral Nervous System (PNS)
    - Autonomic Nervous System (ANS)
      - Sympathetic
      - Parasympathetic
    - Somatic Nervous System (SNS)
- Endocrine system

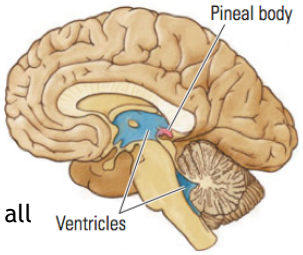


The Brain Hypothesis

- The Cardiac Hypothesis
  - Empedocles of Acragas (ca. 490–430 B.C.) : mental processes originate from heart
- The Brain is the seat of behavior
  - Hippocrates (460-377 BCE)
  - Galen (129-199 CE)
    - evidence : TBI from gladiator injuries
    - anatomy : sensory nerves go to brain

Philosophy of Mind

- Aristotle (348-322 BCE)
  - non-material *psyche* connects through heart
  - similar to "soul"
  - psyche = "mind"
- Descartes (1596-1650 CE)
  - materialist
  - dualism : mind-body problem
  - mind->body in pineal gland
  - Followers claim that animals, children, mentally ill all lack minds



- (Pineal gland is actually related to biorhythms)

Darwin, Wallace & Materialism

- Charles Darwin (1809-1892) and Alfred Russell Wallace (1823-1913)
  - studied structure and behavior of plants & animals
  - commonalities suggest relationships
  - Darwin : *common descent*

Darwin vs. Wallace : Evolution of Language

- human evolution : millions of years
- human written language : thousands of years
- How could we have language?
- Wallace : divine gift
- Darwin : … (return to this next chapter)

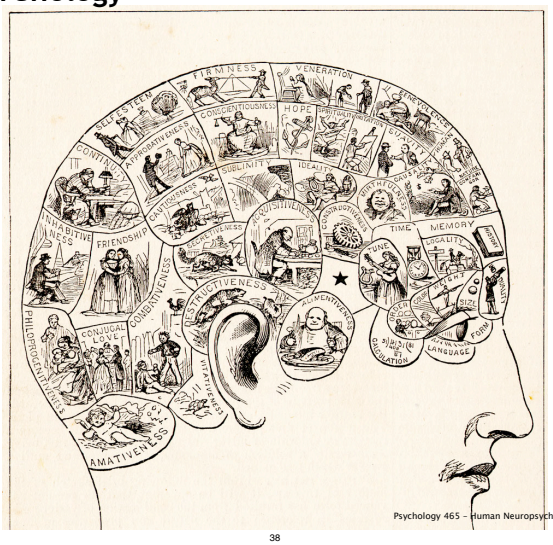
Localization of Function

- Franz Josef Gall (1758-1828) / Phrenology
  - Cortex is functional (not just covering for the pineal gland as per Descartes)
  - ignored data from clinical cases
  - good idea, poor execution
- Paul Broca - Broca's Area
  - data based on clinical patients

Phrenology

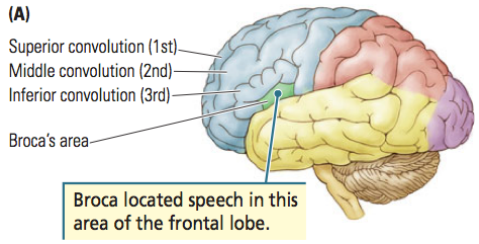
- A now discredited "science" from 1749 thru mid 1800s
- Theory:
  - Brain controls behavior
  - Brain areas are modular
  - Cranial bone (skull) conforms to shape of brain
  - Therefore, measuring skull shape --> cognitive and emotional abilities
- Data:
  - Data came from animal and human skulls
  - Human skulls : primarily of criminals
  - tended to ignore good data (data from brain damage)

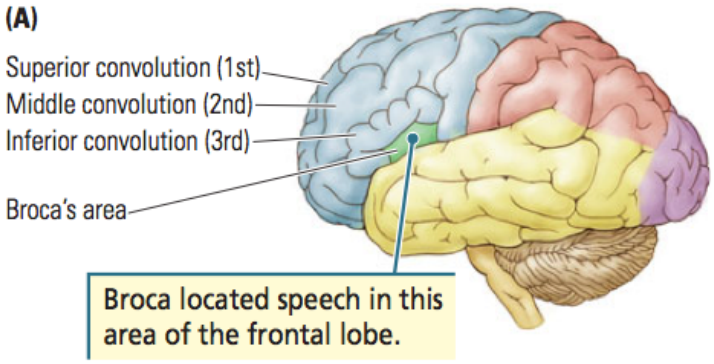
Phrenology



Broca's Aphasia

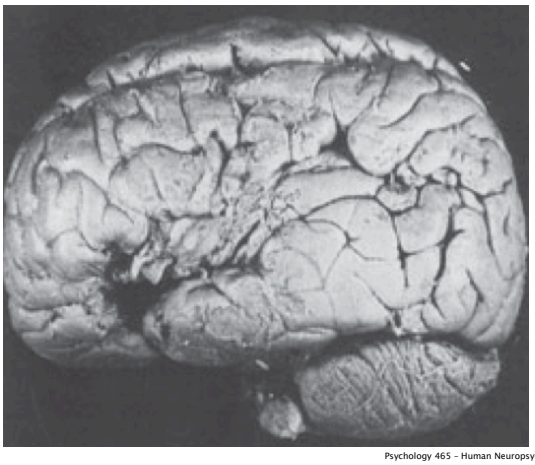
- Patient ML
  - lost expressive speech, except to say "tan" and swear
    - "aphasia"
  - paralyzed on right side
  - could understand spoken speech
  - autopsy showed brain damage in LH





Broca's Aphasia

- Autopsy picture : ML - showing damage to Broca's area

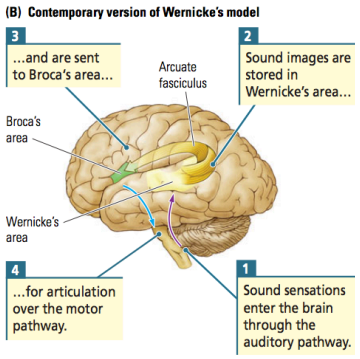


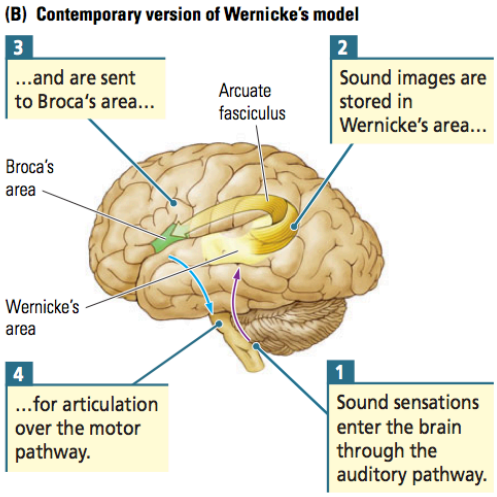
Broca's aphasia

- Established two principles:
  - Localization
  - Lateralization

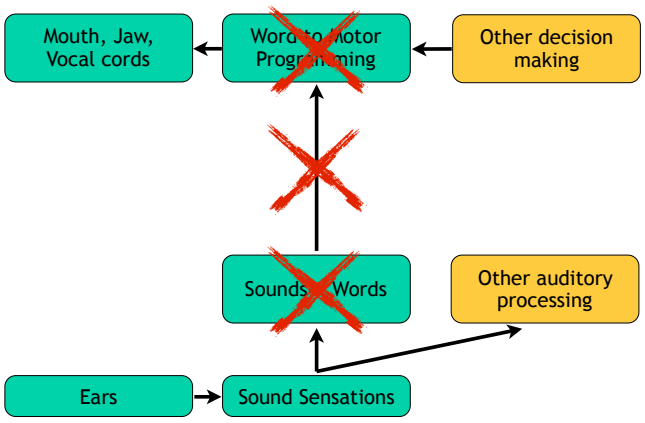
Wernicke's Aphasia

- Symptoms
  - can speak, but nonsense
  - can not understand or repeat spoken speech
  - hearing is fine
  - no paralysis





Block Model of Aphasia (Wernicke-Geshwind model)



Sequential Programming & Disconnection

- Some abilities require multiple brain areas
- Areas operate in sequence
- Possible to damage the **connections** between areas w/o damaging areas
- "Disconnection" Syndromes

The three Aphasias

	Broca	Wernicke	Conduction
Understand Speech?	✔	✘	✔
Repeat Speech?	✘	✘	✘
Speak	✘	✔ (nonsense)	✔ (error-prone)

Patients Misbehaving

- In the following videos, are any of the patients showing "pure" symptoms, or are we seeing a mix of symptoms?

Evidence against Localization

- Pierre Flourens
  - Animal experiments
  - removed portions of cortex
  - behavior initially reduced
  - followed by partial recovery
- Conclusion:
  - cortex is generalized, not localized

Hierarchical Organization and Distributed Systems

- John Hughlings-Jackson (Neurologist, 1835-1911)
  - brain has hierarchy
    - forebrain, brainstem, spinal cord
  - higher levels of function depend on lower levels
  - damage to higher levels --> *dissolution* of behavior (opposite of *evolution*)

The Split Brain Studies

- Joseph Bogen and Phillip Vogel, neurosurgeons
- Cut corpus callosum to reduce seizures

- Patients: in many ways, normal
- Experiments showed:
  - both hemispheres operate somewhat independently
  - LH and RH different modes, strengths
  - LH
    - spoken language
    - analytic, sequential, details
  - RH
    - visual, spatial
    - holistic, gestalt

Conclusions re: localization

- "Distributed Hierarchy"

- Distributed
  - cognitive functions localized in more than one place
  - multiple systems interact

- Hierarchy
  - Higher level behavior is made up of lower level parts
  - parts are often relatively independent

- Dissociation (see next slide)

Dissociation

- Single or simple dissociation:
  - Lesion to brain area L1 causes behavior problem B1
  - Lesion to other area L2 does not cause B1

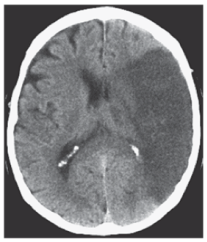
- Double Dissociation:
  - Lesion to brain area L1 causes B1 but not B2
  - Lesion to other area L2 causes B2 but not B1

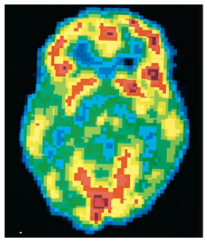
The Neuron Hypothesis

- Anatomical observations
- Electrical stimulation
  - led to behavior
- Connections between neurons
  - created to store information
- Neurotransmitters
  - chemicals which convey impulse from neuron to another

Neuroimaging

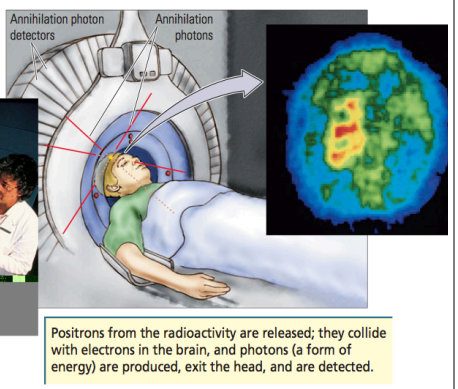
- Visualizing the brain *in vivo*
- CT : Computed Tomography
  - xray
  - cheap(er), quick
  - low resolution
- PET : Positron Emission Tomography
  - radioactive injection
  - tag chemicals to image





PET Scanner

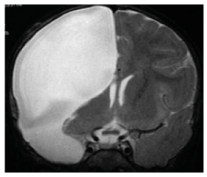
A small amount of radioactively labeled water is injected into a subject. Active areas of the brain use more blood and thus have more radioactive labels.



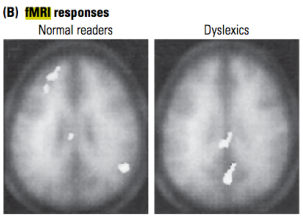
Positrons from the radioactivity are released; they collide with electrons in the brain, and photons (a form of energy) are produced, exit the head, and are detected.

Neuroimaging

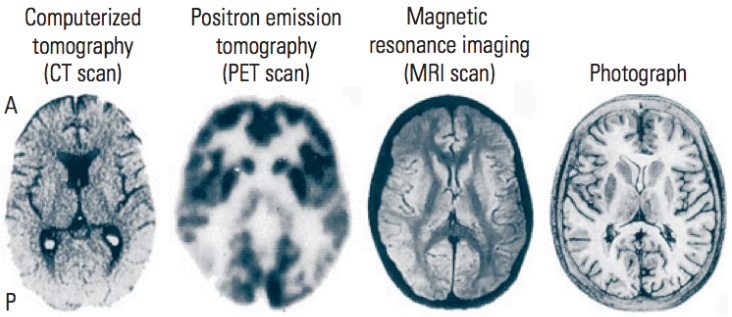
- MRI : Magnetic Resonance Imaging
  - magnetic fields
  - detailed
  - expensive



- fMRI : Functional MRI
  - metabolism in real time



Comparison of Neuroimaging images



Neuropsychology and related fields

- MS/MA
- Ph.D.
  - Experimental
    - Neuroscience
    - Cognitive Science
    - Psychology
      - Biopsychology, Cognitive, Developmental, Educational, Forensic, Personality, Social...
  - Counseling
  - Clinical
    - **Neuropsychology**
- M.D.
  - Neurology
  - Psychiatry

Clinical Neuropsychology

- Old School
  - localize site of lesion by way of behavioral testing
  - "Well, your brain is broken!"

- New School
  - diagnose disease by behavioral testing
  - provide clinical guidance re: ADLs, vocational
  - track recovery & rehabilitation
  - uses neuroimaging for finding lesions
  - forensic
  - research : behavioral testing
    - drug research
    - TBI
    - etc...