

Psychology 105
Chapter 2
Biopsychology - Part 2
Central Nervous System

Spring 2008

Biopsychology - Outline

Part 1: Internal communications in the body

Part 2: The Brain, Mental Processes and Behavior

- **Methods for studying the brain**
- **Major Structures and Functions of the Brain**
- **Plasticity of the Brain**
- **Hemispheric Specialization and Handedness**
- **Split Brain studies**

Part 3: Genetics and Behavior: Nature and Nurture

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The Brain

➤ *How does the brain produce behavior and mental processes?*


The brain is composed of many specialized and interconnected modules that operate in parallel and interact to produce behavior, consciousness, thought and mind.

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Studying the Brain - Research Methods

➤ **Lesions** - damage to brain tissue caused by stroke, disease, tumor or injury

- Location of lesion and nature of behavioral change gives information about what the injured part of the brain is responsible for.
- In humans, lesions are usually "naturally occurring" or a result of corrective surgery. In other animals, lesions are made deliberately to study brain function.




Phineas Gage

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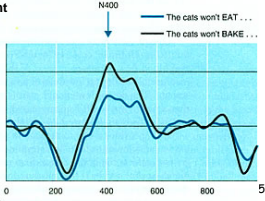
How is the Brain Studied, Cont.

➤ **EEG (ElectroEncephaloGraphy)** - Device for recording brain waves, typically from electrodes placed on the scalp

- Brain Waves - patterns of electrical activity generated by brain



➤ **ERP (Event-Related Potential)** - average of records from many EEG tracings shows timing and relationships between brain waves and event



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How is the Brain Studied, cont.

➤ **Epilepsy** - location of seizure and resulting impact on behavior points to brain function at that location

➤ **Electrical Stimulation** - Stimulating brain tissue with tiny electrodes and noting behavior or patient reports

➤ **Recording** - directly recording electrical activity with tiny electrodes stuck into brain tissue itself; done far less frequently in humans than in other animals

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How is the Brain Studied, Cont.

- **External Brain Imaging** - recording brain's electrical or chemical activity at specific sites during mental activity
- **fMRI (functional Magnetic Resonance Imaging)** - measures increased blood flow in active brain areas, in a strong magnetic field
- **PET scan (Positron Emission Tomography)** - radioactive glucose taken up by active brain cells emits positrons
- **MEG scan (MagnetoEncephaloGraphy)** - changes in magnetic field of scalp in response to electrical activity in brain

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Forebrain, Midbrain and Hindbrain Overview

Psych 105 - Chapter 2: Biopsychology <http://www.stanford.edu/group/hopes/basics/brain/ab3.html> 8

Major functions: Hindbrain

These structures operate largely outside of conscious awareness and are evolutionarily the oldest structures of the brain

- **Medulla:** respiration and heartbeat, reflexes
- **Pons:** sleep and wakefulness
- **Cerebellum:** coordinates movement, balance, posture, maintains equilibrium, involved in procedural memory

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Midbrain

- **Reticular formation (reticular activating system):** alertness, attention, screens irrelevant sensory input
- **Superior Colliculus:** Involuntary eye movements
- **Red nucleus and Substantia nigra:** Sensorimotor control

Psych 105 - Chapter 2: Biopsychology Modified from Pinel (2006), p 66. 10

Forebrain

- **Cerebral Cortex**
- **Subcortical Structures**
 - Thalamus
 - Hypothalamus
 - Limbic System (amygdala, hippocampus...)
 - Basal Ganglia
 - Corpus Callosum

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Forebrain: subcortical structures

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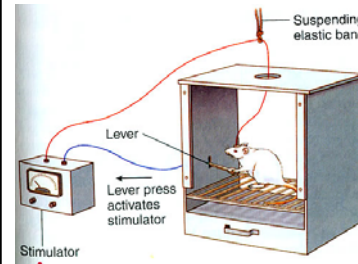
The Limbic "System"

➤ **Function:** regulation of emotional and motivated behavior

- The four Fs of motivated behavior: Fleeing, Feeding, Fighting and Mating
- Some major components:
 - **Amygdala:** Aggression, fear, rage
 - **Hippocampus:** formation of memories
 - Parts of **Hypothalamus**
 - Parts of **Thalamus?**

*there is disagreement about components of limbic system, and whether it should be called a "system"

Electrical Stimulation of Hypothalamus: Control of Motivation



An electrode is placed in rat's hypothalamus. Rat presses lever to receive electrical stimulation – thousands of times per hour (Olds and Milner, 1954)

Move electrode, and pulse electrode: rat may drink or eat excessively, or refuse to eat, or refuse to drink, depending on its placement in hypothalamus

FIGURE 15.7 A rat pressing a lever to obtain rewarding brain stimulation.

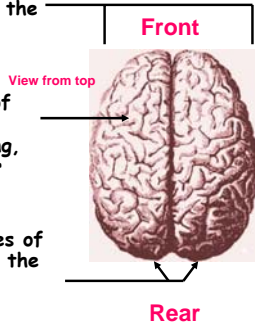
(Pinel, J., 2006, p. 387, based on research by Olds and Milner in 1954)
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The Cerebrum: Higher Cognitive Functions

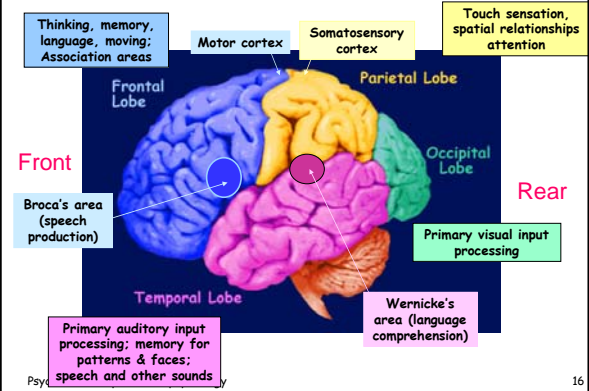
Cerebrum – Topmost layer of the brain; the bulbous cap over the limbic system

Cerebral cortex – Thin gray-matter covering of the cerebrum, wrinkled and folded; carries out perceiving, thinking and voluntary motor control

Cerebral hemispheres – The two walnut shaped halves of the cerebrum, connected by the *corpus callosum*



Lobes of the Cerebrum



The Triune Brain Hypothesis (McClean)

Older brain structures are overlaid with newer ones, but old structures and functions remain in place in mammals that evolved later

➤ **Reptilian brain** (primitive brain)

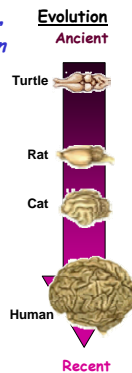
- Drive vital functions, such as heart rate, breathing, digestion, movement

➤ **Limbic system** (old mammalian brain)

- Adds emotions, complex motives, increased memory abilities

➤ **Cerebrum and Neocortex** (new mammalian brain)

- Cerebrum and neocortex: Enables cognitive skills: perception, reasoning, planning, creating, problem solving, decision making, imagining, language



Localization and Distribution of Function

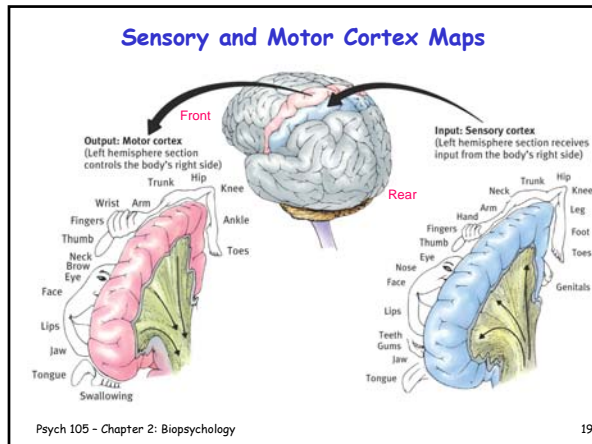
➤ **Localization of Function** – neurons with similar functions are grouped together

- Stimulating one brain region can trigger a sensation, thought or behavior; stimulating a different brain region triggers a different sensation, thought or behavior

▪ Examples:

- **Broca's Area and Wernicke's Areas:** production of speech and understanding of speech
- **Inferotemporal cortex** – pattern recognition, form perception, facial recognition
- **Medial temporal cortex** – movement perception
- **Motor cortex** – control of voluntary movement

➤ **Distribution of function** – many complex behaviors involve more than one area of the brain, often both halves of the brain



Association Cortex

➤ *Association cortex* - combines information from many other parts of the brain

- **Majority** of cerebral cortex consists of association areas
- **Planning, Anticipating, Judging, Making decisions**
- **Solving Problems, Thinking, Recognizing patterns**
- **Emotional control, Logic, Reasoning, Sense of Self**

fMRI used to predict addition vs subtraction

After training 40 min, changes in medial prefrontal cortex could be used to predict whether participant intended to add or subtract two numbers with 70% accuracy

Haynes, et. al. (2007) *Current Biology*, 17 (4).

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Neuroplasticity

Plasticity - Changes in brain organization in response to experience and/or injury:

- **Learning** → formation of new connections and new synapses between neurons
- **Traumatic experience** → changes in hippocampus, amygdala (e.g.)
- **Injury** → regrowth of cells (limited), formation of new connections, reorganization of functions
 - Regrowth most likely in infants and children; less likely in adults, but occurs in some brain areas
 - Reorganization of function illustrated in **phantom limb*** phenomenon

***Phantom limb** - the perception that a limb that has been amputated is still in place and responding to stimuli; sometimes pain is perceived in a missing limb, and sometimes touching unrelated body parts evokes a sensation that is felt in the missing limb

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Hemispheric Specializations - of most right-handed people

Function	Left hemisphere specialization	Right hemisphere specialization
Vision	Words, letters	Faces, geometric patterns, emotional expressions
Hearing	Language sounds	Nonlanguage sounds, music
Touch		Tactile patterns, Braille
Movement	Complex movement	Movement in patterns
Memory	Verbal memory, meaning in memories	Nonverbal memory, perceptual memory
Language	Speech, reading, writing, arithmetic	Emotional content, nuances, intonation
Spatial ability		Mental rotation, geometry, distance, direction

(after Pinel, 2006, p 405)

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Note: these are **tendencies**, not absolute divisions of function

Handedness and Hemispheric Specialization

- About 90% of population is right-handed
- Previous chart describes about 95% of right-handers; in remainder, language function is in right hemisphere or split between hemispheres
- Of left-handers:
 - About 70% have language functions in left hemisphere
 - About 15% have language in right hemisphere
 - Remainder have language split between hemispheres
- Both halves of brain cooperate in most tasks
 - Both are capable of analytic and holistic processing (a strong left-brained vs right-brained distinction is psychobabble)
 - R and L hemispheres communicate frequently and rapidly
 - Both contribute to emotional, memory, cognitive, communication functions

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Crossover of function

The biggest hemispheric specialization of all:

- **Sensory input:**
 - input from **right** side of body goes to **left** side of brain (mostly)
 - input from **left** side of body goes to **right** side of brain (mostly)
- **Motor control:**
 - **Right** side of brain controls movement of **left** half of body
 - **Left** side of brain controls movement of **right** half of body.
- Two halves of brain are connected by and communicate with each other via large bundles of neurons
 - largest called the **corpus callosum**.

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Split Brain

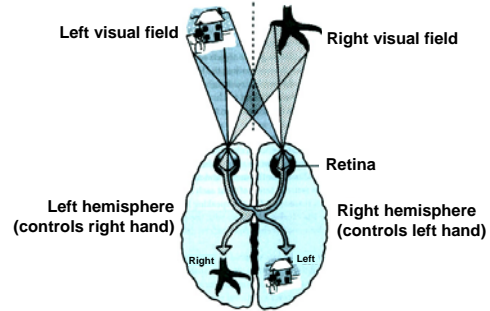
Research on Split Brain patients demonstrates some hemispheric specializations

➤ **Split brain surgery:** Corpus callosum is severed in order to relieve severe epilepsy, removing most communication between the two halves of the brain

➤ **Result:**

- **Dual Consciousness:** Separate consciousness experienced in each hemisphere
- **Function:** Normal, except on tasks where they need to integrate information from the two halves of their brains (Sperry and Gazzaniga)

Split Brain Experiment



➤ From Blackmore, S. (2005). *Consciousness: A Very Short Introduction*, p 71. New York: Oxford University Press.

Another Split Brain experiment

"HEART" is flashed on split screen

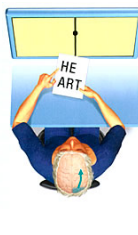


(adapted from Freberg, 2006, 279)

"What word did you see?"



"Point with your left hand at the word you saw."



Summary - 1

- Body, behavior and mind are interdependent
- Nervous system is composed of neurons
- Neurons transmit information via electrical impulses
- Neural information is passed from one neuron to the next at the synapse, via neurotransmitters
- Neurotransmitters are vital to control of behavior, mood and experience
- The brain is composed of billions of neurons with trillions of connections among them
- The brain is organized into areas responsible for control of different functions, which are highly integrated with each other

Summary - 2

- The old brain is responsible for basic control of heart beat and respiration
- The limbic system is responsible for emotional and motivational control and homeostasis
- The cerebral cortex is responsible for sensory, motor, and higher cognitive functions such as language
- Much of the cortex is association cortex, which is responsible for things such as planning, judgment, and complex social and emotional understanding and response.

Summary - 3

- Plasticity of the brain - the ability to change and reorganize - enables us to respond to change throughout our lives
- One or the other half of the brain is (mostly) responsible for some brain functions (lateralization).
- The left side of the brain receives input from and controls the right side of the body, and vice versa (crossover of function).
- Splitting the brain results in dual consciousness but no change of personality or intellect

Summary - 4

➤ **The endocrine system is a slower means of communication and control via hormones, and is largely controlled by the hypothalamus and pituitary in the brain.**