Chapter 2

Neuroscience and Behavior

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MODULE 5: NEURONS: THE BASIC ELEMENTS OF BEHAVIOR

LEARNING OBJECTIVES

5–1: Why do psychologists study the brain and nervous system?

5–2: What are the basic elements of the nervous system?

5–3: How does the nervous system communicate electrical and chemical messages from one part to another?

Psychologists who specialize in considering the ways in which the biological structures and functions of the body affect behavior are known as **behavioral neuroscientists** (or biopsychologists).

THE STRUCTURE OF THE NEURON

Messages which enable us to think, remember, and experience emotion are passed through specialized cells called neurons. **Neurons**, or nerve cells, are the basic elements of the nervous system. Neurons have a cell body that contains a nucleus. The nucleus incorporates the hereditary material that determines how a cell will function. Neurons are physically held in place by glial cells.

A neuron has a cell body with a cluster of fibers called **dendrites** at one end. Those fibers, which look like the twisted branches of a tree, receive messages from other neurons. On the opposite side of the cell body is a long, slim, tube-like extension called an **axon**. The axon carries messages received by the dendrites to other neurons. Axons end in small bulges called **terminal buttons**, which send messages to other neurons.

The messages that travel through a neuron are electrical in nature. Although there are exceptions, those electrical messages, or impulses, generally move across neurons in one direction only. To prevent messages from short-circuiting one another, axons must be insulated in some fashion. Most axons are insulated by a **myelin sheath**, a protective coating of fat and protein that wraps around the axon. The myelin sheath also serves to increase the velocity with which electrical impulses travel through axons.

HOW NEURONS FIRE

Neurons either fire—that is, transmit an electrical impulse along the axon—or do not fire. Similarly, neurons follow an **all-or-none law**: They are either on or off, with nothing in between the on state and the off state. Before a neuron is triggered—that is, when it is in a **resting state**—it has a negative electrical charge of about 70 millivolts (a millivolt is one 1⁄1,000 of a volt).

When a message arrives at a neuron, gates along the cell membrane open briefly to allow positively charged ions to rush in at rates as high as 100 million ions per second. When the positive charge reaches a critical level, the “trigger” is pulled, and an electrical impulse, known as an action potential, travels along the axon of the neuron. The **action potential** moves from one end of the axon to the other like a flame moving along a fuse.

Speed of Transmission

These complex events can occur at dizzying speeds, although there is great variation among different neurons. The particular speed at which an action potential travels along an axon is determined by the axon’s size and the thickness of its myelin sheath.

Mirror Neurons

Mirror neurons are specialized neurons that fire not only when a person enacts a particular behavior, but also when a person simply observes another individual carrying out the same behavior.

WHERE NEURONS MEET: BRIDGING THE GAP

The **synapse** is the space between two neurons where the axon of a sending neuron communicates with the dendrites of a receiving neuron by using chemical messages. When a nerve impulse comes to the end of the axon and reaches a terminal button, the terminal button releases a chemical courier called a neurotransmitter. **Neurotransmitters** are chemicals that carry messages across the synapse to a dendrite (and sometimes the cell body) of a receiving neuron.

An **excitatory message** is a chemical message that makes it more likely that a receiving neuron will fire and an action potential will travel down its axon. An **inhibitory message**, in contrast, does just the opposite; it provides chemical information that prevents or decreases the likelihood that the receiving neuron will fire.

If neurotransmitters remained at the site of the synapse, receiving neurons would be awash in a continual chemical bath, producing constant stimulation or constant inhibition of the receiving neurons—and effective communication across the synapse would no longer be possible. To solve this problem, neurotransmitters are either deactivated by enzymes or—more commonly—reabsorbed by the terminal button in an example of chemical recycling called **reuptake**.

NEUROTRANSMITTERS: MULTITALENTED CHEMICAL COURIERS

Neurotransmitters are a particularly important link between the nervous system and behavior. Not only are they important for maintaining vital brain and body functions, a deficiency or an excess of a neurotransmitter can produce severe behavior disorders.

One of the most common neurotransmitters is acetylcholine (or ACh, its chemical symbol), which is found throughout the nervous system. It transmits messages relating to our skeletal muscles. Glutamate plays a role in memory. Gamma-amino butyric acid (GABA), which is found in both the brain and the spinal cord, appears to be the nervous system’s primary inhibitory neurotransmitter. It moderates a variety of behaviors, ranging from eating to aggression. Another major neurotransmitter is dopamine (DA), which is involved in movement, attention, and learning. Serotonin is associated with the regulation of sleep, eating, mood, and pain. Endorphins, another class of neurotransmitters, are a family of chemicals produced by the brain that are similar in structure to painkilling drugs such as morphine.

STUDENT ASSIGNMENTS

THE STUDY OF THE NERVOUS SYSTEM IN PSYCHOLOGY

Ask students the following questions about the study of the nervous system:

Why does a course on psychology begin by examining the structures and function of the nervous system?

Look on the Web (use Google) to find the cases of famous people who suffered from nervous system disorders. Describe the nature of their disorder and how it affected their behavior when alive as well as whether it caused them to die prematurely.

What is your interpretation of the quote “The brain is wider than the sky”?

THE NEURON AND THE SYNAPSE

Ask students the following questions:

Are medications for psychological disorders overprescribed (also can be used as a discussion question in class)?

What are the implications of the fact that neurons communicate across synapses rather than being directly hard-wired?

What are the advantages in the nervous system of having neurons fire according to the all-or-none law?

LECTURE IDEAS

PARTS OF THE NEURON

There is both a concept clip and an Interactivity available through CONNECT that demonstrate the structure of the neuron.

HELPFUL HINTS FOR STUDENTS:

Here are some ways to make it easier for students to remember the parts of the neuron. Students will groan but like all of these hints, they will come in handy!

Dendrites: These structures resemble the branches of a tree (the word “tree” can be made out of “dendrite”).

Axon: The length of this structure can vary greatly; although most are several millimeters in length, some can be as long as 3 feet (as a hint, tell students that an “ax” can be used to cut a “tree branch” – i.e. dendrite).

Cell Body: This structure is similar to parts of all other cells in the body (i.e., CELLS in BODY)

Terminal Buttons: These are small bulges that actually look like buttons (i.e., BUTTONS that are TERMINAL)

Myelin Sheath: This is a protective coating of fat and protein (like a dress is also a SHEATH). The thicker it is the faster the speed of transmission down the axon.

ALL-OR-NONE LAW

Discuss the implications of the all-or-none law, in that intense stimuli do not result in higher peaks but more frequent impulses. It is especially important to point out the significance of the fact that the synapse is not a hard-wired connection between neurons. This means that neurons can be more flexible, but it also means that more can “go wrong” in the nervous system, such as if there is too much neurotransmitter present in the synapse (as is true when cocaine stimulates dopamine receptors), too little (as is true with dopamine in Parkinson’s disease), or too much activity of reuptake enzymes (as is the case with serotonin and psychological disorders such as depression and anxiety). Emphasize the importance of the receptor sites on the postsynaptic surface. Talk about the variety of neurotransmitters and the functions they serve in the nervous system, and the fact that some neurotransmitters can have different effects (excitatory vs. inhibitory) depending on the area of the nervous system in which they are acting.

USING THE SLIDES:

There are several figures integrated into the powerpoint slides which you may find helpful in demonstrating the neuron, synapse, and action potential.

- Figure 1: Primary Components of the Neuron
- Figure 2: Movement of an Action Potential Along an Axon
- Figure 3: Changes in the Voltage in a Neuron during the Passage of an Action Potential
- Figure 4: A Synapse is the Junction Between an Axon and a Dendrite

MODULE 6: THE NERVOUS SYSTEM AND THE ENDOCRINE SYSTEM: COMMUNICATING WITHIN THE BODY

LEARNING OBJECTIVES

6–1: How are the structures of the nervous system linked together?

6–2: How does the endocrine system affect behavior?

THE NERVOUS SYSTEM: LINKING NEURONS

Central and Peripheral Nervous Systems

The **central nervous system** (CNS) is composed of the brain and spinal cord. The **spinal cord**, which is about the thickness of a pencil, contains a bundle of neurons that leaves the brain and runs down the length of the back. A **reflex** is an automatic, involuntary response to an incoming stimulus.

Three kinds of neurons are involved in reflexes. **Sensory (afferent) neurons** transmit information from the perimeter of the body to the central nervous system. **Motor (efferent) neurons** communicate information from the nervous system to muscles and glands. **Interneurons** connect sensory and motor neurons, carrying messages between the two.

The **peripheral nervous system** branches out from the spinal cord and brain and reaches the extremities of the body. Made up of neurons with long axons and dendrites, the peripheral nervous system encompasses all the parts of the nervous system other than the brain and spinal cord. There are two major divisions—the somatic division and the autonomic division. The **somatic division** specializes in the control of voluntary movements—such as the motion of the eyes to read this sentence or those of the hand to turn this page—and the communication of information to and from the sense organs. The **autonomic division** controls the parts of the body that keep us alive—the heart, blood vessels, glands, lungs, and other organs that function involuntarily without our awareness.

Activating the Divisions of the Autonomic Nervous System

The autonomic division plays a particularly crucial role during emergencies. The **sympathetic division** is the part of the autonomic division of the nervous system that acts to prepare the body for action in stressful situations, engaging all the organism's resources to respond to a threat. In contrast, the **parasympathetic division** acts to calm the body after the emergency has ended. The sympathetic and parasympathetic divisions work together to regulate many functions of the body. The sympathetic and parasympathetic divisions also are involved in a number of disorders.

THE EVOLUTIONARY FOUNDATIONS OF THE NERVOUS SYSTEM

The forerunner of the human nervous system is found in the earliest simple organisms to have a spinal cord. Over millions of years, the spinal cord became more specialized, and organisms became capable of distinguishing between different kinds of stimuli and responding appropriately to them. Ultimately, a portion of the spinal cord evolved into what we would consider a primitive brain. Today, the nervous system is hierarchically organized, meaning that relatively newer (from an evolutionary point of view) and more sophisticated regions of the brain regulate the older, and more primitive, parts of the nervous system.

Evolutionary psychology is the branch of psychology that seeks to identify how behavior is influenced and produced by our genetic inheritance from our ancestors. Evolutionary psychologists argue that the course of evolution is reflected in the structure and functioning of the nervous system and that evolutionary factors consequently have a significant influence on our everyday behavior. **Behavioral genetics** is the study of the effects of heredity on behavior.

THE ENDOCRINE SYSTEM: OF CHEMICALS AND GLANDS

The **endocrine system** is a chemical communication network that sends messages throughout the body via the bloodstream. Its job is to secrete **hormones**, chemicals that circulate through the blood and regulate the functioning or growth of the body.

As chemical messengers, hormones are like neurotransmitters, although their speed and mode of transmission are quite different. Whereas neural messages are measured in thousandths of a second, hormonal communications may take minutes to reach their destination.

A key component of the endocrine system is the tiny **pituitary gland**, which is found near—and regulated by—the hypothalamus in the brain. The pituitary gland has sometimes been called the "master gland" because it controls the functioning of the rest of the endocrine system. Although hormones are produced naturally by the endocrine system, the ingestion of artificial hormones has proved to be both beneficial and potentially dangerous.

STUDENT ASSIGNMENTS

PARTS OF THE NERVOUS SYSTEM

Have students complete Handout 3–1 on the parts of the nervous system.

BEHAVIORAL GENETICS

Instruct students to visit the Human Genome Project Web site. An excellent resource and background can be found at http://web.ornl.gov/sci/techresources/Human_Genome/index.shtml

Have them locate and describe three genes related to psychological functioning.

THE ENDOCRINE SYSTEM

Have students complete Handout 3–2 on the parts of the endocrine system.

HOW THE ENDOCRINE SYSTEM FUNCTIONS

Ask students to answer these questions:

What is meant by "negative feedback"? How does the endocrine system ensure that hormones do not reach too high a level in our bodies?

What do you think the significance is that the hypothalamus is a structure in both the nervous and endocrine systems?

In times of stress, how do the endocrine and autonomic nervous systems work together?

LECTURE IDEAS

There is a concept clip found on CONNECT which illustrates the parts of the nervous system.

FUNCTIONAL DIVISIONS OF THE NERVOUS SYSTEM

The powerpoint slides include a figure (Figure 1: A Schematic Diagram of the Relationship of the parts of the Nervous System) which can be used to summarize the parts of the nervous system.

HELPFUL HINTS FOR STUDENTS:

As you go through this figure, here are some hints to give students to help them remember the terms:

Autonomic nervous system: Think of “automatic.” This part of the nervous system controls actions that we do not think about and that happen without our control.

Sympathetic nervous system: Think of “sympathetic.” When we get emotional (“sympathetic”), we experience arousal and stimulation, exactly the actions of this part of the autonomic nervous system.

Parasympathetic nervous system: Think of “pear.” When your parasympathetic nervous system is aroused, you can eat food, like a pear.

Somatic nervous system: Soma stands for “body.” The somatic nervous system is the “bodily” nervous system, meaning that it translates information received through the bodily senses and gives instructions to the muscles and glands (a long explanation, but if they remember “body,” it will help them to remember the term).

NEGATIVE FEEDBACK IN THE ENDOCRINE SYSTEM

Describe the process of hormone secretion in terms of a negative feedback loop. The hypothalamus-pituitary axis regulates hormone production in the other glands in the endocrine system when blood levels of a hormone become too low or when the hypothalamus is triggered to release a hormone that in turn will increase the production of hormones by other glands. The pancreas operates on a separate dimension that regulates glucose metabolism.

HORMONAL SUPPLEMENTS

Ask students what they think of hormonal supplements such as steroids for body builders and athletes (many recent examples of this, unfortunately!) and estrogen for women going through the menopause. Some aging "baby boomers" are turning to growth hormones as the key to maintaining their youthful vitality. However, all of these strategies carry risks. Are the dangers of steroid replacement and supplement worth possible harmful effects?

MODULE 7: THE BRAIN

LEARNING OBJECTIVES

7–1: How do researchers identify the major parts and functions of the brain?

7–2: What are the major parts of the brain, and for what behaviors is each part responsible?

7-3: How do the halves of the brain operate interdependently?

7–4: How can an understanding of the nervous system help us find ways to alleviate disease and pain?

STUDYING THE BRAIN'S STRUCTURE AND FUNCTIONS: SPYING ON THE BRAIN

The brain has posed a continual challenge to those who would study it. For most of history, its examination was possible only after an individual had died.

The electroencephalogram (EEG) records electrical activity in the brain through electrodes placed on the outside of the skull. Functional magnetic resonance imaging (fMRI) scans provide a detailed, three-dimensional computer-generated image of brain structures and activity by aiming a powerful magnetic field at the body. Positron emission tomography (PET) scans show biochemical activity within the brain at a given moment. Transcranial magnetic stimulation (TMS) is one of the newest types of scan. By exposing a tiny region of the brain to a strong magnetic field, TMS causes a momentary interruption of electrical activity. The enormous advantage of TMS, of course, is that the virtual cut is only temporary.

THE CENTRAL CORE: OUR "OLD BRAIN"

A portion of the brain known as the **central core** is quite similar in all vertebrates (species with backbones). The central core is sometimes referred to as the "old brain," because its evolution can be traced back some 500 million years to primitive structures found in nonhuman species.

The first part of the central core of the brain that can be seen is the hindbrain which contains the medulla, pons, and cerebellum. The medulla controls a number of critical body functions, the most important of which are breathing and heartbeat. The pons is a bridge in the hindbrain.
The **cerebellum** extends from the rear of the hindbrain. Without the help of the cerebellum we would be unable to walk a straight line without staggering and lurching forward, for it is the job of the cerebellum to control bodily balance.

The **reticular formation** extends from the medulla through the pons, passing through the middle section of the brain—or midbrain—and into the front-most part of the brain, called the forebrain.
Hidden within the forebrain, the **thalamus** acts primarily as a relay station for information about the senses.
The **hypothalamus** is located just below the thalamus. One of its major functions is to maintain homeostasis, a steady internal environment for the body. The hypothalamus helps provide a constant body temperature and monitors the amount of nutrients stored in the cells.

THE LIMBIC SYSTEM: BEYOND THE CENTRAL CORE

The brain has pleasure centers in several areas, including some in the **limbic system**. Consisting of a series of doughnut-shaped structures that include the amygdala and hippocampus, the limbic system borders the top of the central core and has connections with the cerebral cortex The limbic system is involved in several important functions, including self-preservation, learning, memory, and the experience of pleasure. Injury to the limbic system can produce striking changes in behavior.

THE CEREBRAL CORTEX: OUR “NEW BRAIN”

The **cerebral cortex** is the “new brain” responsible for the most sophisticated information processing in the brain. The cortex has four major sections called **lobes**. If we take a side view of the brain, the frontal lobes lie at the front center of the cortex and the parietal lobes lie behind them. The temporal lobes are found in the lower-center portion of the cortex, with the occipital lobes lying behind them. These four sets of lobes are physically separated by deep grooves called sulci.

The Motor Area of the Cortex

The **motor area** is the part of the cortex that is largely responsible for the body’s voluntary movement. The motor area of the cortex provides a guide to the degree of complexity and the importance of the motor capabilities of specific parts of the body. In fact, it may do even more: Increasing evidence shows that not only does the motor cortex control different parts of the body, but it may also direct body parts into complex postures.

The Sensory Area of the Cortex

The **sensory area** of the cortex includes three regions: one that corresponds primarily to body sensations (including touch and pressure), one relating to sight, and a third relating to sound. The somatosensory area in the parietal lobe encompasses specific locations associated with the ability to perceive touch and pressure in a particular area of the body. As with the motor area, the amount of brain tissue related to a particular location on the body determines the degree of sensitivity of that location: The greater the area devoted to a specific area of the body within the cortex, the more sensitive is that area of the body.

The senses of sound and sight are also represented in specific areas of the cerebral cortex. An auditory area located in the temporal lobe is responsible for the sense of hearing. If the auditory area is stimulated electrically, a person will hear sounds such as clicks or hums. The visual area in the cortex, located in the occipital lobe, responds in the same way to electrical stimulation. Stimulation by electrodes produces the experience of flashes of light or colors, suggesting that the raw sensory input of images from the eyes is received in this area of the brain and transformed into meaningful stimuli.

The Association Areas of the Cortex

The **association areas** generally are considered to be the site of higher mental processes such as thinking, language, memory, and speech.

Injuries to the association areas of the brain can produce aphasia, problems with language. In Broca's aphasia, speech becomes halting, laborious, and often ungrammatical, and a speaker is unable to find the right words. In contrast, Wernicke's aphasia produces difficulties both in understanding others' speech and in the production of language.

NEUROPLASTICITY AND THE BRAIN

Neuroplasticity refers to changes in the brain that occur throughout the life span relating to the addition of new neurons, new interconnections between neurons, and the reorganization of information-processing areas. **Neurogenesis** is the creation of new neurons. The ability of neurons to renew themselves during adulthood has significant implications for the potential treatment of disorders of the nervous system.

THE SPECIALIZATION OF THE HEMISPHERES: TWO BRAINS OR ONE?

Because of the way nerves in the brain are connected to the rest of the body, the two symmetrical left and right mirror-image halves of the brain, called **hemispheres** , control motion in—and receive sensation from—the side of the body opposite their location. The dominance of one hemisphere of the brain in specific functions, such as language, is known as **lateralization**.

Exploring Diversity

Human Diversity and the Brain

The interplay of biology and environment in behavior is especially clear when we consider evidence suggesting that even in brain structure and function there are both sex and cultural differences. With regard to sex differences, young girls show earlier development in the frontal lobes, which control aggressiveness and language development. On the other hand, boys' brains develop faster in the visual region that facilitates visual and spatial tasks such as geometry. Most males tend to show greater lateralization of language in the left hemisphere. For them, language is clearly relegated largely to the left side of the brain. In contrast, women display less lateralization, with language abilities apt to be more evenly divided between the two hemispheres.

Culture also gives rise to differences in brain lateralization. Native speakers of Japanese seem to process information regarding vowel sounds primarily in the brain's left hemisphere. In contrast, North and South Americans, Europeans, and individuals of Japanese ancestry who learn Japanese later in life handle vowel sounds principally in the right hemisphere.

THE SPLIT BRAIN: EXPLORING THE TWO HEMISPHERES

It is clear from experiments that the right and left hemispheres of the brain specialize in handling different sorts of information. At the same time, it is important to realize that both hemispheres are capable of understanding, knowing, and being aware of the world, in somewhat different ways. The two hemispheres, then, should be regarded as different in terms of the efficiency with which they process certain kinds of information, rather than as two entirely separate brains. The hemispheres work interdependently to allow the full range and richness of thought of which humans are capable.

Becoming an Informed Consumer of Psychology

Learning to Control Your Heart—and Mind—Through Biofeedback

Biofeedback is a procedure in which a person learns to control through conscious thought internal physiological processes such as blood pressure, heart and respiration rate, skin temperature, sweating, and the constriction of particular muscles.

STUDENT ASSIGNMENTS

There are several CONNECT activities (concept clips and Interactivities) which address concepts relevant to this module.

PARTS OF THE BRAIN

Handouts 3–3 and 3–4 contain assignments on the parts of the brain.

GENERAL QUESTIONS ABOUT THE BRAIN

Ask students the following questions:

Can machines ever be designed that would "read our minds"? Why or why not?

What might be the importance of the fact that the amygdala and the hippocampus, the centers for emotion and memory, are located close together and are both part of the "old brain"?

How might the findings on neuroplasticity be applied to issues such as retraining older workers or helping brain-injured individuals recover lost functions?

LEFT-RIGHT BRAIN QUESTIONNAIRE

Have students complete Handout 3–5 on whether they are “right brained” or “left brained.”

LECTURE IDEAS:

USING THE SLIDES:

There are several slides which offer figures useful in teaching the various parts of the brain:

- Figure 2 - The Major Divisions of the Brain
- Figure 4 - The Limbic System

Medulla	Controls critical body functions, including breathing and heartbeat.
Pons	Transmits motor information. Coordinates muscles and integrates movement between the right and left halves of the body. Involved in the control of sleep.
Cerebellum	Helps maintain balance by monitoring feedback from the muscles to coordinate their placement, movement, and tension. Also involved in some cognitive functions.
Reticular formation	Activates other parts of the brain to produce general bodily arousal. During sleep, filters out background stimuli.
Thalamus	Relay station for information concerning the senses. Integrates information from higher parts of the brain to send to the cerebellum and medulla.

Hypothalamus	Maintains a steady internal environment for the body. Produces and regulates behavior critical to the survival of the species, such as eating, self-protection, and sex.
Limbic system (amygdala, hippocampus, fornix)	Serves basic functions relating to emotions and self-preservation, such as eating, aggression, and reproduction. Plays an important role in learning and memory.

Visual cortex	Raw sensory input of images from the eyes is received in this area of the brain and transformed into meaningful stimuli.
Primary auditory cortex	Responsible for the sense of hearing. Stimulation of this area results in the experience of sounds such as clicks or hums.
Primary somatic sensory cortex	Specific locations associated with the ability to perceive touch and pressure in a particular area of the body.
Primary motor cortex	Responsible for the body's voluntary movement.
Broca's area	Responsible for production of speech.
Wernicke's area	Responsible for comprehension of speech.
Frontal lobe	Responsible for planning and judgment.

HELPFUL HINTS FOR STUDENTS

Here are some hints to give students to help them remember the terms (Spoiler alert: the puns here are really bad – but effective!):

Medulla: Without breathing, you would be very "dull."

Pons: Ponds hand cream is something you put on your hands and it could help your muscles move.

Cerebellum: You need this for balance—Cere-bal (ance)-um

Reticular formation: Like a military formation, sends messages up and down within the brain.

Thalamus: You would throw a ball during a relay race. The thalamus is a relay station.

Hypothalamus: Sounds like "homeostasis," the state of stability in the body's internal environment.

Limbic system: When you dance the limbo, you feel happy (emotion function), and later you remember having a good time (memory function).

Hippocampus: You would remember if you saw a hippo while you were camping out in the woods.

Broca's area: Think of Tom Brokaw, the newscaster. Without speech, he would not be able to announce the news.

Wernicke's area: Not Broca's area.

BIOGRAPHY OF ROGER SPERRY (FROM PETTIJOHN'S CONNECTEXT)

Roger Sperry was born August 20, 1913, in Hartford, Connecticut. He was awarded a Nobel Prize in Physiology or Medicine in 1981 for his more than 40 years of research on the brain. The prize was given specifically for his work on the "split-brain," in which he discovered that the two cerebral hemispheres of the brain had distinct functions. The left, usually the dominant side, is involved in reasoning, language, writing, and reading, whereas the right, or less dominant side, is more involved in nonverbal processes, such as art, music, and creative behavior.

In one of his most important studies, Sperry asked subjects who had undergone split-brain surgery to focus on the center of a divided display screen. The word "key" was flashed on the left side of the screen, while the word "ring" was projected on the right side. When asked what they saw, the split-brain patients answered "ring" but denied that any other word was also projected onto the screen. Only the word "ring" went to the speech center in the left hemisphere. Although the right hemisphere cannot verbalize the information (the word "key") that was projected on the left side of the screen, subjects are able to identify the information nonverbally. Sperry asked subjects to pick up the object just named without looking at it. If subjects were told to use their left hand, they could easily identify a key. However, if asked what they had just touched, they would respond “ring.”

Sperry received his PhD from the University of Chicago in 1941. He did his early research at the Yerkes Laboratories of Primate Biology and the National Institute of Health before joining the staff of the California Institute of Technology in 1954 as Hixon Professor of Psychobiology. He originally studied cats, and found that the corpus callosum, or nerve bundle, connecting the two cerebral hemispheres, was necessary for the transfer of information from one side of the brain to the other.

Sperry next began to study epileptic patients whose corpus callosum had been severed to prevent seizures. His research on the “syndrome of hemisphere deconnection” has contributed valuable information to the treatment of various brain disorders.

Sperry continued to be an active researcher until his death in 1994.

BACKGROUND ON SPLIT BRAIN

Go to http://www.macalester.edu/psychology/whathap/UBNRP/Split_Brain/Split_Brain_Consciousness.html, which documents various aspects of the split-brain phenomenon including procedures for testing patients with split brains.

ONLINE LEARNING CENTER: AROUND THE GLOBE

The Brain's EEG Response to Language

Learning a language is an important milestone for a baby. It can change a baby's world, and the baby's brain. Psychologists have learned that people who do not hear certain sounds when they are young have problems learning to tell the difference between them. For example, many Japanese speakers cannot tell apart American English's R and L, which are not used in the Japanese language. Buchwald et al. (1994) decided to see if there was a physical difference in the way that the brains of Japanese natives and Americans react to the sounds of R and L. The researchers took electroencephalogram (EEG) recordings from English-speaking Japanese and American adults. The subjects listened to pairs of similar words beginning with R and L, like rip and lip, and also pairs of sounds that began with other letters, like ba and pa. The Americans showed a strong increase in brain electrical activity 250 milliseconds after they heard all words; the Japanese did too, but not for R and L words. Otherwise, the EEGs looked the same. In spite of years of exposure to English, the Japanese speakers' brains still did not react to sounds that do not occur in Japanese.

MEDIA PRESENTATION IDEAS:

There are several places online where video and interactive activites may be found:

- PBS Discovering Psychology series: http://www.learner.org/series/discoveringpsychology/
- Youtube.com
- Scientific American: http://www.scientificamerican.com/
- National Geographic: http://www.nationalgeographic.com/
- Brain Games: http://braingames.nationalgeographic.com/episode/0/
- BBC: Science: Human body: http://www.bbc.co.uk/science/humanbody/

POPULAR MOVIES

The Limbic System:

A very funny scene that students will enjoy is the medulla oblongata scene from the movie *The Waterboy*, when the protagonist argues with his professor about the role of the brain in behavior. This is a short scene that will definitely lighten the lecture. It is also a good scene to show because it is actually incorrect—when they discuss the "medulla oblongata" as having a role in aggression and happiness, they are actually referring to the amygdala!

Coping with Brain Damage:

Other older movies illustrating people who must cope with brain damage are *Regarding Henry* and *Rocky V*.

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Need specific chapters? Create a book that contains only the chapters you want, in the order you want. Create will even re-number the pages for you! Feldman, *Understanding Psychology*, offers five additional modules on the following topic areas:

- Diversity and Culture
- Forensic Psychology
- Industrial/Organizational Psychology
- Sustainability/Environmental Psychology
- Statistics