The Biology of Mind

OUTLINE OF RESOURCES

Biology, Behavior, and Mind
   Lecture/Discussion Topic: Phrenology (p. 89)

Neural Systems
   Lecture/Discussion Topic: Multiple Sclerosis and Guillain-Barré Syndrome (p. 90)
   Classroom Exercise: Modeling a Neuron and Using Dominoes to Illustrate the Action Potential (p. 90)
   PsychSim 5: Neural Messages (p. 90)
   Worth Video Anthology: The Neuron: Basic Units of Communication

Neural Communication
   Classroom Exercises: Neural Transmission (p. 91)
   Crossing the Synaptic Gap (p. 91)
   Classroom Exercise: Reaction-Time Measure of Neural Transmission and Mental Processes (p. 92)
   Worth Video Anthology: Neural Communication: Impulse Transmission Across the Synapse

Neurotransmitters and Drugs
   Lecture/Discussion Topic: Endorphins (p. 93)
   Lecture/Discussion Topic/Feature Film: Parkinson’s Disease and Awakenings (p. 93)
   Worth Video Anthology: Chemically Induced Hallucinations: Studies of Anesthetic Drugs
   The Runner’s High
   Parkinson’s Disease: A Case Study
   Treating Parkinson’s Disease: Deep Brain Electrode Implantation

The Nervous System
   Lecture/Discussion Topics: Lou Gehrig’s Disease (p. 94)
   The Autonomic Nervous System and Sexual Functioning (p. 95)
   Classroom Exercise/Critical Thinking Break: Drug Effects and the Nervous System (p. 95)
   Worth Video Anthology: The Central Nervous System: Spotlight on the Brain

The Endocrine System
   Lecture/Discussion Topics: The Endocrine System (p. 95)
   Oxytocin: The Hormone of Love, Bonding, and Generosity? (p. 96)

*Titles in the Worth Video Anthology are not described within the core resource unit. They are listed, with running times, in the Lecture Guides and described in detail in their Faculty Guide, which is available at www.worthpublishers.com/mediaroom.
The Brain

Methods of Study

Lecture/Discussion Topics: Neuroimaging Techniques (p. 97)
   A Neurosociety and Your Brain on Politics (p. 98)
   Assessing Awareness in Brain-Injured Patients (p. 98)

Worth Video Anthology: Understanding Neuroscience Methods: ERP* NEW
   Mapping the Brain Through Electrical Stimulation*
   Neuroimaging: Assessing What’s Cool*
   Brain Imaging*

Neuroanatomy

Lecture/Discussion Topic: Brain Puzzles, Models, and Molds (p. 100) UPDATED

Classroom Exercises: Building a Play-Doh Brain (p. 99)
   A Portable Brain Model (p. 99)
   Mastering Brain Structure (p. 101)
   Case Studies in Neuroanatomy (p. 101)

Student Project: The Human Brain Coloring Book (p. 102)

Worth Video Anthology: Brain Structures*

PsychSim 5: Brain and Behavior (p. 102)

Function and Behavior

Classroom Exercise/Lecture Break: Neuropsychology of Zombies (p. 102) NEW

Older Brain Structures

Lecture/Discussion Topics: Why Can’t We Tickle Ourselves? (p. 103)
   The Case of Clive Wearing (p. 103)

Classroom Exercise: Individual Differences in Physiological Functioning and Behavior (p. 104)

Worth Video Anthology: Compulsive Gambling and the Brain’s Pleasure Center*
   The Brain’s Reward Center*
   Self-Stimulation in Rats*
   Brain Transplants in Parkinson’s Patients*

The Cerebral Cortex

Lecture/Discussion Topics: Einstein’s Brain and Genius (p. 105)
   Kim Peek’s Brain (p. 106)

Classroom Exercises: Neuroscience and Moral Judgments (p. 104) UPDATED
   The Sensory Homunculus (p. 106)

Worth Video Anthology: Planning, Life Goals, and the Frontal Lobe*
   Brain and Behavior: Phineas Gage Revisited*

Language and the Brain: If you wish to discuss the brain’s role in language now, see the unit on Thinking and Language.

Brain Plasticity

Lecture/Discussion Topic: Hemispherectomy (p. 107)

Worth Video Anthology: Rewiring the Brain*
   Brain Plasticity: Rewiring the Visual Cortex*
   Language and Brain Plasticity*
   Achieving Hemispheric Balance: Improving Sports Performance*
Hemispheres and Laterization

Lecture/Discussion Topics: The Wada Sodium Amobarbital Test (p. 109)
Left-Handedness (p. 110) **UPDATED**
The Right Brain Movement (p. 112)

Classroom Exercise: Behavioral Effects of the Split-Brain Operation (p. 108)
Classroom Exercise/Student Project: The Wagner Preference Inventory (p. 108)
Student Project/Classroom Exercise: Hemispheric Specialization (p. 109)
PsychSim 5: Hemispheric Specialization (p. 108)
Worth Video Anthology: The Split Brain: Lessons on Language, Vision, and Free Will*
The Split Brain: Lessons on Cognition and the Cerebral Hemispheres*
Achieving Hemispheric Balance: Improving Sports Performance*

RESOURCES

**Biology, Behavior, and Mind**

Lecture/Discussion Topic: Phrenology

The idea that specific mental processes are located in, or associated with, discrete parts of the brain can be traced back to the early 1800s when a German physician, Franz Gall, invented phrenology. Its most important assumption was that bumps on the skull could reveal our mental abilities and character traits.

As Raymond Fancher explains, Gall was the first great comparative anatomist of brains. His careful examination of the brains of many different species led him to the conclusion that higher mental functions correlated with the size of the brain. Although the correlation is imperfect, he did demonstrate the tendency for animals with larger brains to manifest more complex, flexible, and intelligent behavior. It was this demonstration, more than any other argument, that convinced scientists that the brain was the center of all higher mental activity.

Unfortunately, because Gall embedded this contribution in the ill-fated theory of phrenology, he is now viewed as somewhat of a quack. Gall’s theory appears to have had its origin in an early childhood experience. In his autobiography, he relates how as a boy he was exasperated by fellow students who, while less intelligent than himself, received higher grades because they were better memorizers. In reflecting on his rivals, he concluded that they all had one prominent physical characteristic in common: large and protruding eyeballs. Convinced that greater intelligence was associated with larger brains, he speculated that specific parts of the brain were the seats of specific faculties or traits. People with good verbal memories might have particularly well-developed “organs of verbal memory” somewhere in their brains. Gall further surmised that this was in the region of the frontal lobes directly behind the eyes, where the pressure of the enlarged brain caused the eyes to protrude.

By observing people who exhibited particular characteristics, Gall pinpointed areas of the brain responsible for 37 different traits, including musical talent, cautiousness, faithfulness, benevolence, and hope. For example, when he asked a group of lower-class boys that he had befriended to run errands for him, he found that their attitudes toward petty theft varied greatly. Measuring the boys’ heads, he reported that the invertebrate thieves had bumps just above and in front of their ears. He hypothesized an “organ of acquisitiveness” in the brain beneath. Observation of people with strong sexual drives convinced Gall that they had well-developed neck and skull bases. This led him to localize the personality characteristic of “amativeness” in the cerebellum.

At the height of its popularity, phrenology was a parlor game played by the well-to-do in Europe. It found particularly fertile soil in the United States, where celebrities such as Edgar Allan Poe and Walt Whitman were among its adherents. Manuals for self-diagnosis were published. Phrenologists even counseled employers on screening job applicants. In 1852, Horace Greeley suggested that railroad workers be selected by the shape of their heads. Phrenology proved influential until well into the twentieth century.

Fancher suggests that among the obvious weaknesses of Gall’s theory were (1) his assumption that the shape of the skull accurately reflected the shape of the
brain, (2) his totally inadequate classification of psychological characteristics that immediately doomed any attempt to localize these in the brain, and (3) his selective and arbitrary methods of observation. With three dozen interacting traits to work with, it became easy to rationalize any apparent discrepancies in the theory. Presented with a huge organ of acquisitiveness in a generous person, Gall could argue that a larger organ of benevolence counteracted the acquisitive tendencies. Or, certain organs might temporarily be impaired by disease. In short, the theory could not be falsified. Some of Gall’s students dramatically demonstrated this pitfall. When a cast of Napoleon’s right skull predicted qualities at variance with his known personality, one phrenologist replied that his left side had been dominant, but a cast of it was (conveniently) missing. When René Descartes’ skull was found deficient in the regions for reason and reflection, phrenologists argued that the philosopher’s rationality had always been overrated. Although it’s easy to find Gall’s notions ridiculous, as Bryan Kolb notes, we are well reminded of how even now we use physical appearance to judge personality traits. For example, current research points to the presence of a strong physical-attractiveness stereotype in which we judge what is beautiful as good.


Neural Systems

Neural Structures

PsychSim 5: Neural Messages

This program explains the structure of the neuron and the transmission of neural messages. A simple neuron is drawn and students actively participate in the naming of the structures and their functions. The processes of axonal and synaptic transmission are graphically depicted, including an extremely clear picture of polarization of the axon.

Classroom Exercise: Modeling a Neuron and Using Dominoes to Illustrate the Action Potential

A 5- to 7-inch plush doll in the form of a neuron is available for $8.95 from GiantMicrobes at www.giantmicrobes.com/us/products/nervecell.html. It provides a memorable model of the main elements of the nerve cell, including dendrites, cell body, axon, and terminal branches. You can use it for demonstration purposes in lecture or pass it up and down the rows of your class after students have been introduced to the structure of the neuron. It is available for purchase at the web address. Or for more information, you can call 1-(877)-MICROBE.

From Neuroscience for Kids (http://faculty.washington.edu/chudler/chmodel.html) comes a simple model of a neuron to show your class. Stretch out your arm and spread your fingers. Explain to your students that your hand represents the “cell body,” your fingers represent “dendrites” bringing information to the cell body, and your arm represents the “axon” taking information away from the cell body.

Then, to illustrate elementary concepts of neural transmission, Walter Wagor’s exercise using two sets of dominoes works well. Knocking down the first domino in a three-foot row of dominoes, spaced about one inch apart, illustrates how the action potential affects one area of the axon at a time and is sequentially passed on from one section to the next. The dominoes lying on the table illustrate the neuron’s refractory period: The axon is not immediately able to convey a new action potential. To demonstrate that more than one action potential can be traveling along the axon at the same time, have some volunteers reset the first dominoes before the last ones are knocked down. Note that there still has to be a certain amount of time between action potentials.

The all-or-none response is illustrated by the fact that the push on the first domino has to be strong enough to knock it down; pushing harder, however, does not affect the impulse’s speed. Forming a domino line that branches out illustrates axon collaterals in which the action potential affects all the branches equally. Finally, to demonstrate that myelination increases the speed of transmission, first set up a four-foot-long row of dominoes. Then, take four foot-long sticks and place one domino under each end of each stick. Line up these stick-domino groups end-to-end so that the falling dominoes of one group will hit the next group, causing it also to fall, and so on. Although both cases involve “four-foot axon collaterals,” movement down the stick-domino groups is faster. The action potential travels faster if it can “jump” from “node” to “node” rather than having to be passed on sequentially.


Lecture/Discussion Topic: Multiple Sclerosis and Guillain-Barré Syndrome

As indicated in the text, the myelin sheath is a layer of fatty cells that insulates the axons of some neurons and helps speed their impulses. Its importance for the normal transfer of information in the human nervous system is evident in the demyelinating diseases of multiple sclerosis (MS) and Guillain-Barré syndrome.

It is now clear that MS attacks the myelin sheaths of axon bundles in the brain, spinal cord, and optic nerves. (Sclerosis means “hardening” and refers to the
lesions that develop around those bundles; multiple refers to the fact that the disease attacks many sites simultaneously.) Although magnetic resonance imaging (MRI) can now detect the lesions, for years neurologists have been able to diagnose the illness by taking advantage of the fact that the myelin sheath speeds axonal conduction velocity. In one simple test, the neurologist stimulates the eye with a checkerboard pattern and then assesses the time it takes the impulse to cross the optic nerve (the electrical response is measured from the scalp over the part of the brain that is a target of the optic nerve). People with MS showed significant slowing of the conduction velocity of their optic nerve.

MS sufferers typically experience muscular weakness, lack of coordination, and impairments of vision and speech. The disease, which typically begins in early adult life, is often characterized by remissions and relapses that occur over a period of years. Its development seems to be influenced by both environmental and genetic factors. The role of environment is suggested by studies showing that people who spent their childhood in a cool climate are more likely to develop the illness. The role of genetic factors is evident from the fact that MS is rare among certain groups such as Gypsies and Asians, even when others around them show a high incidence of the disease.

Guillain-Barré syndrome is a more common demyelinating disease that attacks the myelin of the peripheral nerves that innervate muscle and skin. Often the disease develops from minor infectious illnesses or even inoculations. The illness seems to result from a faulty immune reaction in which the body attacks its own myelin as if it were a foreign substance. The symptoms come directly from the slowing of action potential conduction in the axons that innervate the muscles. The conduction deficit can be demonstrated by stimulating the peripheral nerves electrically through the skin and then assessing the time it takes to evoke a response (for example, a twitch of a muscle).

Early symptoms of Guillain-Barré syndrome include fever, malaise, and nausea. Muscular weakness often starts in the lower extremities and moves upward through the body, resulting in paralysis accompanied by abnormal sensations of tingling and numbness.


Neural Communication

Classroom Exercise: Neural Transmission

Susan Frantz of New Mexico State University (1996, September 4, personal communication) uses a brief classroom exercise to teach neural transmission. It requires only a bag of Hershey chocolate Kisses and large cards or even sheets of paper with a “+” on them. Have five volunteers who enjoy eating chocolate come to the front of class. Four will serve as dendrites and one as a cell body. Recruit five more students to serve as the axon and two or more to act as terminal fibers (each fiber should be given an unwrapped chocolate Kiss to hold onto). Assuming that you have enough students, create a similar neuron of students nearby. Begin by suggesting that you are a nearby neuron and toss Hershey Kisses (neurotransmitters) in the direction of the dendrites and cell body (that is, into the synapse). The dendrites and cell body pick up the Kisses and pass them into their mouth and immediately pick up one of several cards (positive ions) that you have previously tossed around the room near where the students are standing. Once three cards have been picked up, the neuron reaches threshold (all-or-none response) and the first person in the axon picks up a card, while the dendrites and cell body drop theirs. The next person in the axon then picks up a card while the previous person drops his or hers, and so on down the line. When the end of the axon has been reached, the terminal fibers toss their Hershey Kisses in the direction of the dendrites and cell body of the nearby neuron, repeating the process. You can extend the demonstration by wrapping a couple of sections of your axon (a couple of students) in plastic (myelin sheath) to show how the signal would be sent more quickly. You can also use Hershey Kisses with differently colored wrappers to illustrate the effects of agonistic and antagonistic drugs. (For the fall, Hershey has autumn Kisses, and Frantz uses dark red as the neurotransmitter, orange as the agonist, and silver as the antagonist.) The demo takes about 15 minutes, and one bag of Hershey Kisses is good for two classes of two neurons each.

Classroom Exercise: Crossing the Synaptic Gap

Susan J. Shapiro of Indiana University East suggests a student skit for demonstrating the process of electrochemical transmission at the level of the synapse. At the end of class, request a dozen volunteers to come 15 minutes early to the next class session. Be sure you choose volunteers who feel comfortable in front of the class because their behavior is likely to elicit a few laughs. When they arrive, assign “characters” and roles as described here and provide nametags:

1. Presynaptic membrane on the terminal button: three people in a straight line with their arms outstretched. The middle person holds hands with those on the sides.
2. Vesicle: three people holding hands in a circle behind the membrane.
3. Molecule of neurotransmitter: one person who stands inside the circle composed by the vesicle arms.
4. Dendrite: two people, each with one hand on the shoulder of the “receptor.”
5. Receptor: one person who stands between the dendrite membranes with outstretched arms.
6. Action potentials for the presynaptic and postsynaptic neurons: two people, one at the back of the classroom near one aisle and the second standing behind the barrier formed by the receptor and two dendrite membrane sections.

Then, have your volunteers rehearse the following action a couple of times (assure them that they will have assistance during class if they are not clear about their role).

The first action potential from the back of the classroom runs down the aisle (the axon) yelling “Fire! Fire!” When the action potential reaches the vesicle, it helps it over to the membrane. The vesicle opens up one grasped hand, as does the presynaptic membrane. The vesicle joins hands with the presynaptic membrane and thereby becomes part of it. The neurotransmitter exits and wanders around and eventually finds the receptor, grasping hands with the receptor for a moment. The receptor turns and tells the other parts of the membrane that something exciting has happened. The second action potential moves away from the receptor up the opposite aisle (axon). The neurotransmitter lets go and wanders around for a few more moments before returning to the presynaptic membrane. The membrane opens and the neurotransmitter moves inside.

When class begins, have your students assist in setting up the model synapse. You may want to project an image of a synapse at the front of room or suggest class members turn to the relevant text figure. When everyone is in position, ask your class what should happen first. Have the actors do what the class suggests. However, if the class directs the neurotransmitter to go through the cell membrane before the vesicle attaches to it, the vesicle membrane should remain tightly closed. That is, those making up the membrane have not been told to let go or to merge with the presynaptic membrane and thus the presynaptic membrane should not let the neurotransmitter through. Run through the process correctly three or four times.

Classroom Exercise: Reaction-Time Measure of Neural Transmission and Mental Processes

David Myers suggests an adaptation of a classroom exercise proposed by Paul Rozin and John Jonides. Not only does it illustrate an important principle about neural pathways, but it is also a lot of fun and a real loosener during the stiff first days of class.

Begin by having students stand and form a chain by putting their right hand on the shoulder of the person in front of them. There’s no problem if the chain snakes around from row to row. Stand behind the last person with a stopwatch, starting it as you squeeze his or her shoulder. This person then squeezes the shoulder of the adjacent person, and this continues through the chain. Run to the front of the chain and stop the timer when your own shoulder is squeezed. Thirty students will take about 6 seconds the first try, but with practice and a little cheerleading on your part they will bring it down to 5 seconds. They generally seem eager to beat their previous best time.

Next, have your students sit down and consider whether they would expect a faster, slower, or similar time if instead they squeezed the ankle of the adjacent person. From the chapter’s discussion of neural pathways, most are able to reason that it should take longer to feel the squeeze, because the sensory input has to travel farther (from the ankle versus the shoulder). Try it and indeed it will take about 7 or 8 seconds to get through 30 students. Again repeat the experiment once or twice to demonstrate variation. This provides a rough measure of the speed with which neural transmission occurs.

Finally, have students stand again and this time grab both shoulders of the person in front of them. Each student squeezes the same shoulder squeezed by the student behind him or her (this takes 8 or 9 minutes to get around a group of 30). This illustrates how a simple reaction-time measure can assess the speed of cognitive processing. Finally, ask for a bit more demanding mental processing: “Squeeze the shoulder opposite to whichever shoulder was squeezed—if your right shoulder was squeezed, then squeeze the left shoulder of the person in front of you.” Obviously, reaction speed provides an index to the complexity of the information processing.

John Fisher suggests another simple demonstration of differences in the complexity and thus speed of neural transmission that pairs of students can try in class or as a project on their own. A dollar bill is held at one end between the middle finger and thumb of your dominant hand. At the same time, the index finger and thumb of your other hand are placed on either side of the note at its center, as close as possible without actually touching it. If the bill is now released, you will have no problem catching it, even though you do not

move any part of the “catching” hand until you have released the dollar bill. Next hold the note as before, but instruct a second person to position his or her own finger and thumb as you did earlier for the catching. Emphasize that he or she must not move until you release the bill. Drop it and surprisingly his or her fingers will close on thin air. What you found to be the simplest of tasks, the other person will find impossible. The explanation, of course, is that your brain can send the message “catch” to one hand at exactly the same moment it sends “let go” to the other. However, for the second person a message has to be sent from the eyes as they register the release of the bill before the brain can transmit the “catch” signal to the fingers. Slightly more time is necessary for this more complex neural transmission, and thus the bill slips through the fingers.


Neurotransmitters and Drugs

Lecture/Discussion Topic: Endorphins

The word endorphin was coined from “endogenous morphine” and refers to the brain’s natural painkillers (opiates). After Candace Pert and Solomon Snyder identified “opiate receptors” in brain areas linked with pain, the race to identify the brain’s natural painkillers was on. The discovery of the endorphins grew out of the curiosity of two British pharmacologists, Hans Kosterlitz and John Hughes, who in 1975 isolated a substance from the brains of pigs that had the same actions as morphine; they named it enkephalin. Subsequently, other brain opioids were discovered. The group as a whole was named endorphins, and research has now indicated that these natural opiates are produced by the brain, the pituitary gland, and other tissues in response to pain, stress, and even vigorous exercise.

While pain is necessary to warn us of danger to our physical well-being, constant intense pain would eventually incapacitate us, and so endorphins help our bodies to control the degree of pain. Studies of laboratory rats have demonstrated that not only shock but even its anticipation can produce an increase in brain endorphins. For example, when rats were placed in a chamber where they had been shocked a week earlier, the level of the brain’s natural opiates immediately increased.

Other investigators have shown that psychological stress also triggers the production of endorphins. In one study, pain was induced by a shock to the person’s foot. The degree of pain was not determined by measuring the reflex actions of the leg muscles, a test that has proved reliable in other studies. The experimenters, instead, induced stress by sounding a warning signal two minutes before a shock might or might not be delivered. The participants were tested under three conditions. Some were given an injection of a painkiller, such as morphine; a second group was given an injection of naloxone (a drug that suppresses endorphin activity in the brain); and a third group was given nothing at all. Initial pain sensitivity was identical in all three conditions. Results showed that with repeated stress, pain sensitivity decreased in both the no-injection and painkiller-injection conditions. This suggested that the participants in the no-injection group had indeed produced natural opiates. Proof of this came from the fact that men and women who received the endorphin suppressor actually showed more sensitivity to pain and stress as testing proceeded.

Strenuous exercise also triggers the release of endorphins. Studies of seasoned runners, for example, show that during a long, difficult workout the nervous system can dip into its endorphin reserve and not only block pain messages but also produce the so-called runner's high (see The Runner's High in the Worth Video Anthology). Perhaps of greatest interest to students will be some applications of this research. The endorphin system can be brought into action by neurostimulation therapy. In this pain-reducing technique, wires are pasted to the skin near an injury, and a slight electric current is delivered through electrodes. Low-frequency, high-intensity impulses stimulate endorphin release. Olympic athletes have used this method to ease various aches and pains. Steve Maslek reportedly played much of his final year of high school basketball with a battery-powered neurostimulator under his uniform (he later played for the University of Pittsburgh). The device helped the 6-foot-8-inch center participate despite a stress fracture in his backbone. In February 2010, champion skier Lindsey Vonn competed in the Olympic downhill with an extremely painful shin injury. Despite the pain, she won a gold medal.


Lecture/Discussion Topic/Feature Film: Parkinson’s Disease and Awakenings

You can readily extend your discussion of neurotransmitter research by describing disorders that are based in some neurotransmitter deficiency. Parkinson’s disease provides one familiar example.

The disease is named after James Parkinson, a London physician who first described its “involuntary tremulous motion” in 1817. For more than a century, the disease was thought to be an illness of the spinal
cord, the muscles, and the motor regions of the cerebral cortex. In the early twentieth century, some suspected that a chemical deficiency was the root cause and that Parkinson’s might be alleviated by replacing the chemical. In the 1960s, neuroscientists concluded that the tremors of Parkinson’s disease result from the death of nerve cells that produce dopamine, and thus the affliction became the first illness attributed to a neurotransmitter deficiency. Hoping to treat the disorder by giving their patients dopamine, physicians quickly learned that it would not cross the blood-brain barrier. In 1967, pharmacologists found that l-dopa would cross the barrier and that the brain would then convert it to dopamine.

In his 1973 book *Awakenings*, Oliver Sacks presents the heartwarming story of how the new treatment miraculously transformed the lives of a number of victims of a sleeping-sickness pandemic that swept the world between 1916 and 1927. The disease killed millions and left millions more in a severe Parkinsonian-like state. Some of Sacks’ patients had spent 50 years in a zombielike state, staring blankly into space and speaking little, if at all. When treated with l-dopa, they began to speak, walk without assistance, and express all the normal human emotions.

Before the treatment, one patient moved his arm so slowly it was virtually undetectable. He would start the day with his hand on his knee, by noon it would be halfway to his face, and by evening at his nose. After administering l-dopa, Sacks asked the patient about his frozen poses. “What do you mean, ‘frozen poses’?” he replied. “I was merely wiping my nose.” Sacks assembled 30 photos taken of the patient in one day, converted them to movie film, and ran the film at 16 frames per second. The patient was right; wiping his nose was simply taking 10,000 times as long as normal.

Unfortunately, the massive doses of l-dopa required to alleviate the symptoms eventually produced extremely unpleasant and unpredictable side effects. Sacks writes that “yo-yo reactions began occurring in a majority of my patients; and along with these, there increasingly occurred an extreme and ever-increasing sensitivity to l-dopa; and extraordinary (and unpredictable) sensitivity to all sorts of conditions and circumstances which would normally have little or no disturbing effects.” One patient reported, “I feel completely normal . . . but I’ve become oversensitive, and the moment I overexert myself or overexcite myself, or if I am worried, or get tired, all the side-effects immediately come back. . . . I’m perfect when everything is going smoothly, but I feel like I’m on a tightrope, or like a pin trying to balance on its point.” Symptoms included nausea, anxiety, irritability, hyperactivity, dangerous clumsiness, and, in some cases, uncontrollable movement and even frightening hallucinations. Sacks points out that patients with ordinary Parkinson’s disease can expect the longest periods of unclouded response and milder “side effects” such as nausea, loss of appetite, and restlessness. Most important, Sacks’ case study shows how it may be possible to correct a brain disorder by replenishing the supply of a missing neurotransmitter.

*Awakenings* was made into a wonderful feature film, starring Robin Williams and Robert De Niro. It is worth showing in connection with this specific topic or even as a general introduction to biology and behavior. Three specific clips are highly recommended. The dramatic symptoms are seen in the following clips:

1. From 11:21 minutes into the film until 15:27 minutes (from Lucy’s first appearance in a wheelchair until the physician removes the ball from Lucy’s upraised arm).
2. From 18:15 minutes until 22:19 minutes (from when the physician checks his chart and sees Lucy apparently walking toward the drinking fountain until the physician leaves the hospital’s parking lot).
3. From 38:40 minutes until 52:50 minutes (from when the physician asks the nurse if she has heard of l-dopa until Leonard introduces himself to a male orderly). This relatively long clip shows the discovery and use of l-dopa on Leonard.


### The Nervous System

**Lecture/Discussion Topic: Lou Gehrig’s Disease**

Lou Gehrig, the “Pride” and “Iron Horse” of the New York Yankees, played baseball from 1923 until 1939. He was a member of many World Series championship teams and set numerous individual records, including playing in 2130 consecutive games (a record that held until Cal Ripken Jr. played his 2131st consecutive game in 1995).

In 1938, Gehrig started to lose strength. As Detroit Tiger pitcher Eldon Auker described it, “Lou seemed to be losing his power. His walking and running appeared to slow. His swing was not as strong as it had been in past years.” Gehrig was suffering from amyotrophic lateral sclerosis (ALS for short), which was first described by Jean-Martin Charcot in 1869. The disease has come to be known as Lou Gehrig’s disease after he developed it. Lou died in 1941 at the age of 38.

ALS strikes about 6 in every 100,000 people, usually between the ages of 60 and 75. Death is usually within five years of diagnosis. It begins with general weakness, first in the throat or upper chest, then progressing to the arms and legs. Walking becomes difficult, and victims typically struggle with swallowing and speaking. The disease generally does not affect any of
the sensory systems, cognitive functions, bowel or bladder control, or even sexual function.

ALS is caused by the death of motor neurons that connect the rest of the nervous system to muscles enabling movement. Neurons in the brain that connect primarily with motor neurons can also be affected. Amyotrophic means “muscle weakness” and lateral sclerosis refers to “hardening of the lateral spinal cord” where motor neurons are located. Motor neurons may suddenly die because of the death of microtubules that carry proteins down the motor-neuron axons because of a buildup of toxic chemicals within the motor neurons, or as a result of toxic chemicals released from other neurons. Presently, there is no cure for ALS, although some new drugs appear to slow its progression.


**Classroom Exercise/Critical Thinking Break: Drug Effects and the Nervous System**

Many people are aware of the many recreational drugs and therapeutic medicines that are available today on the open market and in the underground market. But how many people know how these drugs work, or why they have the effects they do? This exercise is designed to get students thinking about drugs and medications; it is a simple, two-part activity that can be done in class as a lecture break or as a more elaborate homework assignment. The goal is to get students to integrate what they have learned about the central and peripheral nervous systems and what they have learned about the actions of neurotransmitters.

The activity is to be conducted using problem-based learning pedagogy in which students must figure out what they know and what they do not know (yet) in order to complete the exercise. If your class is small enough, you can have students work on this individually, but it is more effective if they work in small groups. This exercise can be completed in as little as 15 to 20 minutes if you assign only the first portion. If you assign any of the optional questions, the exercise will take more time. Handout 1a includes the questions students should answer for the basic exercise. Handout 1b is an alternative version of (a), containing some additional questions that you can include, perhaps for a subsequent homework assignment.

**Lecture/Discussion Topic: The Autonomic Nervous System and Sexual Functioning**

Most of the time, the sympathetic and parasympathetic nervous systems work in opposition to each other to keep the body’s activities balanced. The sympathetic system “gears up” the body for action and “turns off” the digestive (enteric) system, while the parasympathetic system “slows down” the body and “turns on” the digestive system. This is why they are referred to as the “fight-or-flight” and “rest-and-digest” systems, respectively. However, in the case of sexual intercourse, the sympathetic and parasympathetic nervous systems actually work in concert, affecting external genitalia in a way that enables the full process of sexual arousal and orgasm. While the parasympathetic system is responsible for changes in bloodflow to produce erection and stimulation in both the male (penis) and female (clitoris), the sympathetic system controls subsequent ejaculation and orgasm. This intimate balance can be disrupted by both physiological and psychological factors. For example, anxiety, conflict, excessive arousal (e.g., from too much caffeine), or other physiological issues can increase sympathetic nervous system activation when a couple initially comes together, and all of these things can impede the appropriate parasympathetic activity to generate sexual stimulation. Likewise, if sympathetic activity is disrupted prior to ejaculation, this can be an obstacle to the completion of orgasm. Thus, normal healthy sexual functioning really can be affected if a man or woman isn’t in the “right mood” at the right time(s)!

If your students are mature enough, you might want to begin an objective discussion of sexual arousal and sexual functioning. You can help them generate a list of psychosocial and physiological factors that might affect sexual functioning. The list should be limited to factors that a therapist would want to work on with clients who have difficulties with sexual functioning or with achieving satisfactory sexual intimacy with their partners.


**The Endocrine System**

**Lecture/Discussion Topic: The Endocrine System**

*Exocrine* glands secrete substances outside the body. Examples include salivary glands, tear glands, and sweat glands. *Endocrine* means “within”: endocrine glands secrete from within the body into the bloodstream. The *hormone receptor molecule* is the key to understanding the operation of the endocrine system. That is, hormone actions are typically very specific because only certain cells in the body can respond and, often, only at limited times. For example, oxytocin is released by the posterior pituitary and carried through the bloodstream to all the tissues and cells in the body. Yet, it acts on only two tissues: the breasts and uterus in the female. Furthermore, it acts only under certain conditions. It causes breast tissue to eject milk only if the female has recently given birth and is nursing. Oxytocin also causes uterine contractions at the end of
pregnancy. (See the next Lecture/Discussion Topic for more information on oxytocin.)

Richard Thompson provides a specific and clear example of how the endocrine system works, which you might mention in class. Under stressful conditions, the hypothalamus produces a hormone called corticotrophin-releasing hormone (CRH) that travels to cells in the anterior pituitary, causing it to release adrenocorticotropic hormone (ACTH) into the bloodstream. ACTH acts on the adrenal gland, causing its cells to release cortisol, a stress hormone that mobilizes the body. The increased blood level of cortisol eventually acts back on the hypothalamus and pituitary to decrease their release of CRH and ACTH. This general sequence is true for all endocrine-gland action; it is comparable to a thermostat’s regulation of temperature. As the hormone level goes up, the “thermostats” in the hypothalamus and pituitary are turned off. As it goes down, they are turned on.

You might also want to use the text figure to identify in class some of the important hormones and their principal effects. Note that the hypothalamus’ various releasing hormones regulate the pituitary. As such, the hypothalamus is the control center of the endocrine system. The hormones of the adrenal glands are described in the text. Others are described here:

1. The anterior pituitary secretes growth hormone. Too little produces dwarfism; too much results in gigantism.
2. The posterior pituitary secretes vasopressin (in addition to oxytocin), which constricts blood vessels and raises blood pressure.
3. The thyroid releases thyroxine and triiodothyronine, which increase metabolic rate, growth, and maturation.
4. Attached to the thyroid, the parathyroids release parathyroid hormone (parathormone), which increases blood calcium and decreases potassium.
5. The pancreas secretes insulin, which regulates the level of sugar in the bloodstream by increasing entry of glucose to cells (see also Motivation).
6. The ovary secretes estrogen, which promotes ovulation and female sexual characteristics.
7. The testes release the androgens, which promote sperm production and male sexual characteristics.


Lecture/Discussion Topic: Oxytocin: The Hormone of Love, Bonding, and Generosity?
Class discussion of the role of a specific hormone may help students appreciate the nature and functions of the endocrine system, as well as its interaction with the nervous system. Students will be fascinated by research on oxytocin, sometimes referred to as “the hormone of love and bonding.”

Ruth Feldman and her colleagues at Israel’s Bar-Ilan University studied the relationship between oxytocin and attachment of mother and child. First, they measured plasma oxytocin from a sample of 62 pregnant women during their first trimester, third trimester, and the first postpartum month. Then, to assess the level of attachment (or bonding), the researchers observed mother-child interaction along four dimensions, including gaze, affect, touch, and vocalization. For example, stronger attachment would be suggested by the mother focusing her gaze mostly on the child, showing a positive energy toward the child, maintaining constant affectionate and stimulating touch with the child, and using “motherese” speech with the child.

The researchers found that oxytocin had a definite relationship to bonding. Mothers with a high level of the hormone in the first trimester engaged in more attachment behaviors after birth. In addition, mothers who had higher levels of oxytocin across the pregnancy and the postpartum month reported more behaviors that support the formation of an exclusive relationship with the child, for example, singing a special song to the infant or bathing and feeding in a special, affectionate way. The mothers were also more committed to checking on their infants’ safety when they were apart and to securing the infants’ future.

In another study, Paul Zak of Clarement Graduate University reported that participants who were given synthetic oxytocin gave significantly more money to a stranger than those who were given a placebo. The results also suggested that the person doing the giving has to feel some bond with the other person.

The investigation included two tests of how male students would split $10 between themselves and a person assigned to them by a computer. In the first test, participants decided whether they wanted to give any to the person with whom they were paired by computer. In the second test, participants again had to decide how to split $10. However, this time neither person got anything if the partner rejected the offer. That stipulation required donors to think about the feelings of the other person. Results showed that in the first test both the oxytocin group and the placebo group gave the same amount (about $2 on average). In the second test, the oxytocin group gave $4.86, which was about 80 cents more on average than the amount given by the placebo group. Both groups gave more than what they themselves identified as the minimum they would personally accept—about $1.70. “Oxytocin is a social glue that holds us all together and makes us care about other people,” concludes Zak.
Shelley Taylor, director of the University of California, Los Angeles, Social Neuroscience Lab, urges caution in labeling oxytocin the “love” or “trust” hormone. One-time administrations of oxytocin may not reflect natural physiological processes. In addition, the hormone may be involved in the response to social separation and the associated stress. Taylor and her colleagues have found that women who reported more gaps in their interpersonal relationships and less positive relationships with their primary partners had higher levels of oxytocin and the stress hormone cortisol than those reporting better relationships. Taylor suggests that high oxytocin in times of social stress or pain may “lead people to seek out more and better social relationships.”


The Brain

Methods of Study

Lecture/Discussion Topic: Neuroimaging Techniques

Every year scientists announce new discoveries and also generate new interpretations of old discoveries. Although scientists have long been able to map basic functions such as memory, language, and musical ability, some brain mappers are now testing the ability of the neuroimaging techniques to unravel the more complex mysteries of consciousness, morality, and empathy. For example, in one study researchers scanned the brains of participants as they reflected on a variety of moral dilemmas. Using earlier data about where emotions are processed, the researchers found that even when people think they are making strictly rational judgments, they also seem to be employing emotion, because both emotion and reasoning areas are highlighted. (See Classroom Exercise: Neuroscience and Moral Judgments on p. 104.)

As the text notes repeatedly, everything psychological is also biological. Marcus Raichle, a professor of radiology and neurology at Washington University in St. Louis, is trying to learn something of the sense of “self.” How might the brain generate the sense that “you’re you and I’m me and we know that”? He hypothesizes that some of the brain’s frenetic “resting” activity—it consumes about 20 percent of the body’s entire energy budget even when not engaged in any particular task—might be supporting self-awareness. In scans of people undertaking challenges that seem to lie outside the self, such as math problems, baseline resting activity dropped off in a portion of the brain’s frontal cortex, a couple of inches behind the center of the forehead. Raichle’s team then compared brain activity in situations that were identical, except in the self-involvement they required. In one case, the participants had to say whether pictures of mundane objects, say picnic scenes or kittens, belong indoors or outdoors. This task, which demanded that participants step outside themselves, caused activity in the prefrontal areas to decrease. In the other case, they were asked to consider whether the same pictures had pleasant or unpleasant associations. As the viewers considered their own responses to the pictures, activity in the possible “self” networks surged. The research team concluded that at least part of our sense of self depends on knots of neurons elaborately interconnected in the frontal cortex.

Other researchers are looking for the basis of “other,” that is, our ability to put ourselves in other people’s shoes and imagine their beliefs and desires. Charles Frith and his colleagues at University College, London, asked participants to think about the following event: A burglar robs a shop, walks down the street, and unknowingly drops his glove. A police officer coming from behind stops him to tell him about the glove. The burglar turns around and surrenders. Why does he do this?

The answer requires thinking about the “other”—the burglar thinks the police officer is about to arrest him. The neural circuits in the participants’ brains that light up at this moment of empathy paralleled the ones that typically light up when thinking about one’s self. “Thinking about yourself in a situation may be the way you think about other people,” suggests Frith.

Researchers are quick to acknowledge the limits of their methodology. For example, Dartmouth’s Michael Gazzaniga notes that the fMRI traces brain activity by tracking bloodflow, which rises whenever there is a surge in metabolism. Elements of some tasks, he suggests, “may be so automatic that they require no increase in metabolism,” thus allowing active brain regions to slip past the technique undetected. Eric Kandel of Columbia University College of Physicians and Surgeons adds, “If a number of areas show activation, we don’t know whether they are causally involved or going along for the ride.” Certainly, no one claims
that research will identify a single brain area as the site of morality or consciousness. “Everything that happens in the brain is based on the work of systems, like music in an orchestra performed from a score,” says Antonio Damasio of University of Iowa. “It all sounds like one thing, but it’s coming from 100 or more individual parts. What we’re doing is finding out those little parts.”


Lecture/Discussion Topic: A Neurosociety and Your Brain on Politics

Neurologist Richard Restak predicts the emergence of a neurosociety in which we will have to come to terms with advancements in brain imaging that include

- tests that reveal certain thoughts and inclinations that we might prefer to keep private.
- brain scans that assess our suitability for certain jobs.
- assessments that explain why we are romantically attracted to some people but not to others.
- brain-imaging studies that predict the products we are likely to purchase.
- brain response patterns that reveal the emotions elicited in us by television programs and movies.
- brain-imaging profiles that assess which political candidates we are most likely to vote for.

Neuroscientist Marco Iacoboni and his colleagues at the Brain Research Institute at University of California, Los Angeles, have used functional magnetic resonance imaging to “read” the brains of swing voters as they responded to the 2008 presidential candidates. The 20 research participants had indicated they were open to choosing a candidate from either party in the 2008 election. While their brains were scanned, they viewed still photos of each candidate as well as video excerpts from their campaign speeches. The participants rated the favorability of the candidates on “before” and “after” questionnaires. The researchers’ intriguing conclusions included the following:

- Activity in the amygdala when participants’ viewed the words Democrat, Republican, and Independent suggested high levels of anxiety. Men who viewed Republican showed high activity in both the amygdala and the insular cortex indicating both anxiety and disgust.
- Of all the candidates’ speech excerpts, Mitt Romney’s prompted the greatest activity in the amygdala (indicating high voter anxiety). However, as the participants continued to listen, their anxiety subsided. The researchers suggested that perhaps voters would become more comfortable with Mr. Romney as they saw more of him.
- In swing voters who gave John Edwards lower ratings, photos of him elicited activity in the insular cortex, a brain area associated with disgust and other negative feelings. Swing voters who had given him higher ratings showed significant activation of the mirror neurons, brain cells activated when people feel empathy. Conclusion? Mr. Edwards elicits a strong effect on swing voters—both those who like him and those who don’t.
- Voters who rated Hillary Clinton unfavorably showed significant activity in the anterior cingulate cortex, an emotional center of the brain that is aroused when a person feels compelled to act in two different ways but must choose one. The researchers suggested this finding might indicate unacknowledged impulses to like Mrs. Clinton. In contrast, those swing voters who rated her favorably showed very little activity in this brain area when viewing pictures of her.

After the researchers published their Op-Ed piece in the New York Times, another team of cognitive neuroscientists voiced concern. They challenged the idea that it is possible to definitively read the minds of potential voters by looking at their brain activity while viewing presidential candidates. Brain regions, the critics claimed, are typically engaged by many mental states and thus a one-to-one mapping is difficult. For example, the amygdala is activated by positive emotions as well as by anxiety. Careful experimental design and peer review is crucial, they argued, to drawing sound conclusions. Nonetheless, the critics voiced excitement about the potential of using brain-imaging techniques to better understand the psychology of political decisions.


Lecture/Discussion Topic: Assessing Awareness in Brain-Injured Patients

Nicholas Schiff and his colleagues’ work with “minimally conscious” patients provides an excellent...
example of how neuroimaging technology provides important insights into the living brain. The results of their work suggest that brain-damaged people who are unable to respond and thus have often been treated as though they are unaware may actually be hearing and registering what is happening in their environment.

Using fMRI scans, the researchers compared the brain activity of men determined to be minimally conscious with that of healthy men and women. In terms of overall brain activity, the two groups were very different, with the brains of the minimally conscious men showing less than half the activity of the brains of healthy adults.

However, when the researchers played an audiocassette in which a relative or loved one reminisced, telling familiar stories and recalling shared experiences, the sound of the voice prompted a pattern of brain activity in the minimally conscious that was similar to that of the healthy participants. In fact, the brain-injured persons showed near-normal patterns in the language processing areas of their brains. This suggests, argues Schiff, that some neural networks “could be perfectly preserved under some conditions.”

In one case, a minimally conscious man heard his sister recount his toast at her wedding, as well as times they played together as children. Although his eyes were closed, the researchers found that the visual areas of his brain were active, suggesting that he might be producing images.

Mental states change over time. Some patients have recovered function almost completely after being thought vegetative. Neuroimaging provides one way to assess these changes and even link them to treatment efforts. “The most consequential thing about this is that we have opened a door, we have found an objective voice for these patients, which tells us that they have some cognitive ability in a way they cannot tell us themselves,” concludes Joy Hirsch, a member of the research team. The patients, she added, “are more human than we imagined in the past, and it is unconscionable not to aggressively pursue research efforts to evaluate them and develop therapeutic techniques.”

About 6 million Americans live with the consequences of serious brain injuries. An estimated 100,000 to 300,000 are in a minimally conscious state, that is, bedridden and unable to communicate or feed and care for themselves, but typically breathing on their own.


**Neuroanatomy**

*Classroom Exercise: Building a Play-Doh Brain*

Laura Valvatne of Shasta College passes along a delightful classroom exercise in which small groups build a human brain out of Play-Doh. Before the activity, tell students to read carefully the text section on the human brain, paying special attention to the illustrations. Ask each student to choose the five most important structures and to explain in writing why each was selected.

In preparation for the working session, obtain enough Play-Doh for each group of four to build a brain. Then provide each group with five different colors as well as 10 toothpicks and 10 sticky notes. Each student should describe to his or her group the five structures he or she chose as most important and explain why. The group should then decide on a minimum of five structures to build into their Play-Doh brain, with at least one brain structure contributed by each student. In putting the brain together (they can decide whether it should be 3-D or a cross section), they should write the name of each structure on a sticky note and together decide what to say about its function on the opposite side.

The groups will produce widely varied products. When they are done, have them set the brains on a piece of paper to display at the front of class. Have everyone vote for the “best” brain. Before they leave, encourage them to take the Play-Doh home to give to neighborhood kids, siblings, children, or relatives.

Valvatne, L. (2000, October 14). Class demonstration suggestions (PSYCHTEACHER@list.kennesaw.edu).

*Classroom Exercise: A Portable Brain Model*

Susan J. Shapiro of Indiana University East suggests using students’ hands as a three-dimensional model of the human brain. The strategy can provide a very helpful starting point for students who are still attempting to grasp the basic vocabulary of brain structure. It is also a model they can take with them into a test! Shapiro uses a projected diagram of the brain in introducing the model in class. What follows are a few highlights. See the original description (reference at the end of the exercise) for a more detailed model.

Begin by having students hold their hands in front of them with palms outward. The skin on the hands represents the cortex, or “gray matter,” which controls much of our behavior and thought. Muscles in the hands represent the white matter and carry information from one part of the brain to another. Because the brain model could not fit inside the skull, we must curl the fingers down and bring the thumbs close in to our hands to make fists. Many brain structures are C-shaped because the brain tissue has been curled to fit inside the skull. Even when curled, however, there is still too much cortex and so we must pinch the skin on the back of the hands. This creates wrinkles—the cortex is both curled and wrinkled to fit inside the skull.

Now have students cross their fists to reflect the two brain hemispheres. Have them place their hands next to each other, outer edges touching, thumbs on the outside. The right hand (on the left side) represents the left hemisphere and the left hand represents the right hemisphere. (This helps students to remember that the left and right hemispheres control movement and sensation on the opposite sides of the body). The wrists represent the brainstem.

Continue by having them look at their right fist (the left hemisphere). The fingers of the right fist form the frontal lobe, which is responsible for such complex and abstract abilities as making plans and forming judgments. To move a finger, the student needs to move muscles at the base of the fingers. At about this location, just before the knuckles, is the motor cortex that controls most of the voluntary movement of the body. The area from the knuckles to halfway back on the hand represents the parietal lobe, which is responsible for combining sensory information. At about the knuckles, just behind the motor cortex and in the parietal lobe, is the sensory cortex. It registers and processes body sensations.

The lower part of the back of the hand constitutes the occipital lobe, which is involved in vision. Obviously, the thumb can lift away from the rest of the brain model but is attached at the base. This is similar to the temporal lobe; although it is connected to the parietal and occipital lobes, its front section can be lifted away from the rest of the brain. The hand side of the thumb represents the area of the brain cortex that is responsible for hearing. Around this area in the parietal lobe are cells responsible for different aspects of language.

Inside both temporal lobes (the thumbs) are the hippocampus and amygdala. The former is involved in memory; the latter is linked to emotional reactions such as fear and anger. Inside the brainstem (the wrists) is the medulla, which is responsible for heartbeat and breathing, and the reticular formation, which is responsible for general arousal. If you picked up a cluster of marbles and held them in your closed hand, they would be in the same location as the basal ganglia, thalamus, and hypothalamus. The basal ganglia are involved in initiating movement and in controlling fine movements. The thalamus is a relay station for messages between the lower brain centers and the cerebral cortex. The hypothalamus directs maintenance activities such as eating, drinking, and body temperature. It helps govern the endocrine system via the pituitary gland, and it is linked to emotion.


Lecture/Discussion Topic: Brain Puzzles, Models, and Molds

A variety of items are available for use in discussing brain structure and function. Following are a few that have worked well.

For great fun, either before or after students read the text discussion of the brain, distribute a brain pop to each member of your class. These are organic, gluten-free lollipops, shaped in the form of a brain. They are available from CandyWarehouse (www.candywarehouse.com). Order online or call 310-343-4099. A bag of 12 pops is $29.40.

Various brain models useful for lecturing on brain structure are available from Ward’s Natural Science (www.wardsci.com), 5100 West Henrietta Road, P.O. Box 92912, Rochester, NY 14692-9012, telephone 1-800-962-2660. One of the simplest and least expensive is the Introductory Brain for $113. It is bisected to show major structures both internally and externally. It is painted and numbered to distinguish the various components. Larger and more detailed models—for example, one that allows you to dissect the brain into eight parts and even shows the intricate details of the limbic system—are available for $217 or more.

3B Scientific’s (www.3bscientific.com) numerous brain models, from the relatively simple and inexpensive to the more elaborate, are available for purchase. You can view detailed descriptions and pictures of the models at the website.

For something simple and inexpensive, yet sure to capture students’ attention, consider The Zombie Brain Gelatin Mold, which enables you to make and bring a brain to class. Perhaps, as Gerald Peterson suggests, you might be able to implant some fruit to represent certain brain structures, such as the limbic system. The plastic mold actually provides the left hemisphere of a jiggly brain that’s about $7 1/2" \times 6 1/2"$. It is available for $7.95 from McPhee (www.mcphie.com), telephone 425-349-3009.

Finally, introduce the cerebral cortex by noting that the deeply convoluted surface of the brain is most strongly linked to intelligence. Because of its wrinkled appearance in humans, only about one-third of it is visible on the surface. Illustrate by taping together two 11.5” \times 17” sheets of paper (large size copy paper) and saying to the class before crumpling it into a ball: “This sheet represents the approximate surface area of that thin sheet of neural tissue that we call the cerebral cortex. So how can we fit it inside a skull (a skull small enough to be vaginally delivered)? Nature’s answer: Crumple it up.”
Classroom Exercise: Mastering Brain Structure

You can use the following exercise, suggested by Tom Pusateri of Florida Atlantic University, to engage students as you introduce the various brain structures. To combat the myth that we use only 10 percent of our brain's capacity, Pusateri suggests distributing Handout 2 before you discuss brain function. As you introduce each structure, ask students to jot down a few notes regarding its activity while driving a car. Suggest that some brain structures may be more active under certain driving conditions, while others may be active regardless of conditions. After you have covered all the important brain structures, you might have students form small groups to compare their responses before reporting to the full class.

The following are sample responses for each brain structure:

- **Cerebellum:** Coordinates left and right hand movements on the steering wheel.
- **Medulla:** Regulates breathing and heart rate while we concentrate on driving.
- **Pons:** Assists in the coordination of driving motions and in alertness.
- **Reticular formation:** Regulates our alertness or drowsiness as we drive. Ask students what actions they take to keep alert at the wheel (e.g., open windows, play music, drink caffeinated beverages).
- **Thalamus:** Relays visual and auditory cues to areas of the cerebrum.
- **Hypothalamus:** Makes us aware when we are too hot or too cold (to adjust the temperature controls), or too hungry, thirsty, or in need of a restroom stop.
- **Amygdala:** May be active during "road rage" (e.g., when another driver behaves recklessly).
- **Hippocampus:** Contributes to the formation of memories of road hazards for future trips.
- **Corpus callosum:** Shares sensory and motor driving information from both hemispheres.
- **Frontal lobe:** Helps us in planning our routes (e.g., if we notice a hazard or detour).
  - **Motor cortex:** Initiates driving actions (e.g., moves the right foot to the gas or brake pedals). Ask students to trace the pathway from the motor cortex to the right foot.
  - **Frontal cortex:** Involved in muscle movements and in making plans and judgments.
- **Parietal lobe:** Helps us determine if our car may fit into a parking space (right parietal lobe).
- **Sensory cortex:** Registers the pressure of the right foot on the gas pedal or brake. Ask students to trace the pathway from the right foot to the sensory cortex.
- **Occipital lobe**
- **Visual cortex:** Processes the visual road signals (e.g., stop lights, speed limit signs).
- **Temporal lobe**
- **Auditory cortex:** Processes the sounds of other vehicles (e.g., sirens, horns, passing vehicles).

You might conclude by asking students which 90 percent of their brain would they like removed while driving.


Classroom Exercise: Case Studies in Neuroanatomy

Jane Sheldon uses an effective small-group exercise that challenges students to apply their knowledge of neuroanatomy mastered from the text and your classroom presentation. Divide the class into groups of four to six students and ask them to analyze the case studies in Handout 3.

Using what they have learned about anatomy and the workings of the human brain, students should describe the brain areas activated in each situation and how such brain stimulation relates to the behavior in the scenario. Although many brain structures are obviously operating simply because the people in the cases are conscious and active, students should focus on the brain areas activated more than usual in these cases. They may use their notes and the textbook. Each group should record its answer to use for later class interaction (as well as for later studying).

Reconvene the class and call on each group to give one interpretation. As necessary, ask the class to expand (or even correct) the answer given by a group. For example, a group may indicate that Anne’s motor cortex is operating as she moves her arm to paint. You might ask the class whether the left or right motor cortex is operating as the artist moves her right arm. You might also ask the class to indicate the lobe in which the motor cortex is located. Rarely does one group produce all possible answers, so the exercise enables them to teach one another. Neuroanatomy structures and related functions for each of the cases are given on the next page.
<table>
<thead>
<tr>
<th>Neuroanatomy structure</th>
<th>Related function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anne</td>
<td></td>
</tr>
<tr>
<td>Left motor cortex</td>
<td>Controls right hand</td>
</tr>
<tr>
<td>Left frontal lobe</td>
<td>Contains motor cortex</td>
</tr>
<tr>
<td>Visual cortex</td>
<td>Used for vision</td>
</tr>
<tr>
<td>Both occipital lobes</td>
<td>Contain visual cortexes</td>
</tr>
<tr>
<td>Auditory cortexes</td>
<td>Used for hearing music</td>
</tr>
<tr>
<td>Both temporal lobes</td>
<td>Contain auditory cortexes</td>
</tr>
<tr>
<td>Right hemisphere</td>
<td>Spatial ability for painting</td>
</tr>
<tr>
<td>Thalamus</td>
<td>Relays sensory information</td>
</tr>
<tr>
<td>Frontal lobes</td>
<td>Deciding what to paint</td>
</tr>
<tr>
<td>Left sensory cortex</td>
<td>Feeling the paintbrush</td>
</tr>
<tr>
<td>Left parietal lobe</td>
<td>Contains sensory cortex</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>Coordinates moving arm</td>
</tr>
<tr>
<td>Eddie</td>
<td>Move muscles</td>
</tr>
<tr>
<td>Both motor cortexes</td>
<td>Contain motor cortexes</td>
</tr>
<tr>
<td>Frontal lobes</td>
<td>Needed for sense of touch</td>
</tr>
<tr>
<td>Both sensory cortexes</td>
<td>Contain sensory cortexes</td>
</tr>
<tr>
<td>Parietal lobes</td>
<td>Used for vision</td>
</tr>
<tr>
<td>Visual cortexes</td>
<td>Contain visual cortexes</td>
</tr>
<tr>
<td>Both occipital lobes</td>
<td>Spatial ability for wrestling</td>
</tr>
<tr>
<td>Thalamus</td>
<td>Sensory relay</td>
</tr>
<tr>
<td>Frontal lobes</td>
<td>Decision making and attention</td>
</tr>
<tr>
<td>Medulla</td>
<td>Regulates heart and breathing</td>
</tr>
<tr>
<td>Amygdala</td>
<td>Aggression and fear</td>
</tr>
<tr>
<td>Reticular formation</td>
<td>Controls arousal</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>Balance and coordination</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Regulates temperature</td>
</tr>
<tr>
<td>Hippocampus</td>
<td>Memory for moves</td>
</tr>
<tr>
<td>Jill</td>
<td>Remembering and learning</td>
</tr>
<tr>
<td>Hippocampus</td>
<td>Anger and fear about cases</td>
</tr>
<tr>
<td>Amygdala</td>
<td>Decision making and attention</td>
</tr>
<tr>
<td>Frontal lobes</td>
<td>Regulates hunger and thirst</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Needed for reading</td>
</tr>
<tr>
<td>Angular gyrus</td>
<td></td>
</tr>
</tbody>
</table>

Source: TEACHING OF PSYCHOLOGY by Sheldon. Copyright 2000 by Taylor & Francis Informa UK ltd. - Journals Reproduced by permission of Taylor & Francis Informa UK Ltd. Journals in the format Other Book via Copyright Clearance Center.

**PsychSim 5: Brain and Behavior**

This activity reviews the major divisions of the brain, the structures within them, and their functions. The student takes a tour of the brain, discovering the functions of each region or area.

**Student Project: The Human Brain Coloring Book**

In A Colorful Introduction to the Anatomy of the Human Brain: A Brain and Psychology Coloring Book, psychologists John P. J. Pinel and Maggie E. Edwards introduce brain structures and their important psychological functions. The book promotes active learning by encouraging close attention through coloring. Students assess their progress through the use of a cover flap that conceals labels while they review. Each chapter ends with an extensive series of review exercises. Intended for those who have no background in neuroscience, the book is a particularly useful supplement for the introductory psychology course.


**Function and Behavior**

**Lecture Break: Neuropsychology of Zombies**

Harvard child psychiatrist Dr. Steven Schlozman has garnered a lot of media attention lately, but not for his work with clients or for scholarly research appearing in professional journals. Instead, he’s earned the interest and adoration of sci-fi fans worldwide with his new


Older Brain Structures

Lecture/Discussion Topic: Why Can’t We Tickles Ourselves?

The text reports that one function of the cerebellum, the “little brain” attached to the rear of the brainstem, is to help coordinate movement output and balance. Research indicates that part of the cerebellum’s function is to tell the brain what to expect from the body’s own movements. In this way, the brain can ignore expected pressure on the soles of the feet while walking and attend to more important sensations such as stubbing a toe.

Sarah-Jayne Blakemore and her colleagues at University College, London, have addressed the interesting question, “Why can’t we tickle ourselves?” For their study, the researchers had six volunteers lie in a brain-scanning machine with their eyes closed. A plastic rod with a piece of soft foam attached to it moved up and down, tickling the participants’ left palms. The experimenter and the volunteers took turns moving the rod, so the volunteers were either tickling themselves or were being tickled. In a third condition, the foam was secretly removed, so the volunteers moved the rod but felt nothing.

Throughout this process, the researchers used functional MRI scans to compare activity in different parts of the brain. On the basis of the results, they concluded that during self-tickling, one part of the brain tells another: “It’s just you. Don’t get excited.” The cerebellum is involved in predicting the specific sensory consequences of movement. It provides the signal that is used to cancel the sensory response to self-generated stimulation. In short, it tells the sensory cortex what sensation to expect and this dampens the tickling sensation.


Lecture/Discussion Topic: The Case of Clive Wearing

The text notes that the hippocampus processes memory. When animals or people lose their hippocampus to surgery, illness, or injury, they become unable to lay...
down new memories of facts and experiences. The unit on Memory in these resources describes the remarkable case of Clive Wearing, who, when afflicted by encephalitis, experienced total destruction of the hippocampus, as well as damage to other brain structures. His story illustrates the devastating effects of his memory loss. You may choose to discuss it now.

Classroom Exercise: Individual Differences in Physiological Functioning and Behavior

Research on individual differences in physiological functioning provides another opportunity to drive home the importance of the biological perspective. Eysenck’s work on introversion–extraversion (see Handout 3, p. 647, in the unit on Motivation and Work, the last six items of which assess extraversion) and Zuckerman's research on sensation-seeking (see Handout 5, p. 713, in the unit on Emotion) are excellent examples.

Eysenck has suggested that differences in introversion–extraversion are closely linked to the cortical arousal of the brain’s ascending reticular activating system (reticular formation). Extraverts seem to have higher sensory thresholds and less-arousable cortices. They must constantly seek stimulation to maintain their brain activity levels and avoid boredom. In contrast, introverts typically operate at an above-optimal cortical arousal level. They are so easily aroused that they tend to avoid external stimulation, seeking solitude and nonstimulating environments in an attempt to keep their arousal level from becoming too aversive. They avoid the noisy parties that extraverts seek.

Eysenck’s famous “lemon-juice” demonstration illustrates this arousal difference. Ask your students how strongly they salivate to lemon juice. Their personality type is likely to be a good predictor of their reaction, or vice versa. “Under conditions of equal stimulation,” predicted Eysenck, “effector output will be greater for introverts.” Research findings confirm that introverts do salivate more when pure lemon juice is placed on their tongues. Other studies have indicated that when exposed to the same level of various stimuli, introverts become more physiologically aroused than extraverts. Given their choice of an optimal level of stimulation, extraverts also choose higher levels. And, they are less likely to be inhibited by punishment and actually seem to experience less pain than introverts.

Zuckerman’s concept of sensation-seeking is discussed in the Emotion unit in these resources. Levels of sensation-seeking have been related not only to a wide range of cognitive and behavioral variables but also to differences in physiological functioning. For example, in response to new stimuli, as well as to changes in such stimulation, high sensation seekers demonstrate greater electrical activity in the brain than low sensation seekers. They also show a rise in sex hormones and lower levels of monoamine oxidase (MAO), an enzyme in the brain and most other tissues that controls neurotransmitters. Zuckerman observes that as testosterone levels peak in men during their late teens and early 20s (and then tapers down), so does sensation-seeking. MAO seems to serve some dampening or regulatory role, since drugs inhibiting its action can produce euphoria, excitement, and even hallucinations. Some researchers believe that the lower MAO level of high sensation seekers explains their greater activity level and sociability.

Work by neuroscientist Brian W. Haas and his colleagues on how personality traits may be linked with specific brain responses suggests that extraverts exhibit different brain responses to positive and negative words. That is, while processing a positive word such as lucky, the extravert’s brain shows increased activation in the anterior cingulate. In fact, Haas claims he can assess a person’s tendency toward extraversion by merely observing (through fMRI) his or her anterior cingulate’s response to positive and negative words. It seems that the extravert’s brain is attracted to positive words and lingers on them a few milliseconds longer.

The relationships between physiological functioning and personality types or traits are intriguing. However, much of the research is correlational and thus open to alternative interpretation. Questions of cause and effect and of possible third mediating factors must still be answered.


The Cerebral Cortex

Classroom Exercise: Neuroscience and Moral Judgments

When Joshua Greene was at Princeton University (he is now at Harvard), he and his research team began their study of the neural correlates of moral judgments. Their fascinating findings provide important insight into the interplay between emotion and reason in resolving moral dilemmas.

Pose to your students the following dilemma that the Princeton research team uses.

It’s wartime and you are hiding in the basement with a group of townspeople. Enemy soldiers are outside. Your baby starts to cry loudly; if nothing is done, the soldiers will find you and kill everyone including the baby. The only way to prevent this loss of life is to cover the baby’s
way to save the five people is to push this man off the bridge and into the path of the trolley. Is that morally permissible?

In this case, the majority of respondents say no. The much stronger emotion associated with the VMPFC conflicts with a purely utilitarian judgment. Interestingly, however, Koenigs and his research team reported that those with damage to the VMPFC were much more likely to say that it is okay to push a man in front of a moving trolley. Presumably, with less emotion aroused, they gave a cooler, cognitive response.


Lecture/Discussion Topic: Einstein’s Brain and Genius

When Albert Einstein died of a ruptured abdominal aneurysm in 1955, pathologist Dr. Thomas Harvey removed his brain and, with the family’s consent, kept the organ for scientific study. At the time, Harvey reported that from all appearances Einstein’s brain was well within the normal range. For example, it was no larger or heavier than anyone else’s.

From time to time, Harvey has provided samples for other researchers to study. In 1996, Dr. Sandra F. Witelson and her colleagues at McMaster University obtained photos of Einstein’s brain before it had been sectioned, as well as a significant portion of brain tissue itself. For comparative purposes, Witelson maintains a Brain Bank of normal, undiseased brains that have been donated by people whose intelligence has been carefully assessed before death. The Brain Bank enabled researchers to compare Einstein’s brain with those of men close to his age.

Witelson, Debra Kigar, and Harvey have reported that while the overall size of Einstein’s brain was average, the region called the inferior parietal lobe was 15 percent wider than normal. “Visual-spatial cognition, mathematical thought, and imagery of movement,” reported the researchers, “are strongly dependent on this region.” Einstein’s brilliant insights were often the result of visual images that he translated into the language of mathematics. For example, his special theory of relativity was based on his reflections of what it would be like to ride through space on a beam of light.
The researchers also reported that a feature known as the sylvian fissure (a groove that normally runs through the brain tissue) was shorter than average. This meant that the brain cells were packed more closely together, permitting more interconnections and thus more cross-referencing of information and ideas. Although other researchers studying Einstein’s brain have reported differences such as more glial cells and more densely populated neurons, Witelson suggested that these findings are compelling because “the differences occur in the region that supports psychological functions of which Einstein was master.”

Critics have observed that while Einstein’s brain may well be different, the cause-effect relationship is unanswered. As Michael Lemonick concludes, the differences may be the result of strenuous mental exercise, not the cause of genius. “Bottom line,” writes Lemonick, “we still don’t know whether Einstein was born with an extraordinary mind or whether he earned it, one brilliant idea at a time.”


Lecture/Discussion Topic: Kim Peek’s Brain

Perhaps even more intriguing than the study of Einstein’s brain are brain scans of Kim Peek, who was the inspiration for Rain Man, the 1988 film about an autistic savant with astounding mathematical skills.

Kim Peek was born November 11, 1951, and died December 22, 2009. He was not autistic, but he did have a lot in common with Rain Man. He had the ability to memorize telephone directories at lightning speed and had total recall of 9000 books. Researchers have discovered that each of his eyes could read a separate page simultaneously, taking in every word. In 10 seconds, he read a page that takes most people 3 minutes. Moreover, he never forgot what he read.

Peek was a megasavant. While most savants have expertise in one or two subjects, Kim was an expert in at least 15 different subjects, including history, sports, space, music, and geography. In fact, no one in the world is thought to possess a brain as extraordinary as Peek’s was.

Known as Kimputer to many, his knowledge-library included world and American history, geography (roads and highways in the United States and Canada), professional sports (baseball, basketball, football, Kentucky Derby winners), the space program, movies, the Bible, and calendar calculations (he can tell the day of the week of any person’s birth, day of the week of his or her present year’s birthday, and year and day of the week the person will turn 65). When asked, he could also name the highways that lead into a person’s small town, the county, the area code and zip code, the television stations available in the town, and to whom telephone bills must be paid, and he could describe any historical events that may have occurred in the area. Kim’s musical abilities were similarly phenomenal. Having heard a symphonic work once as a boy, he never forgot it. If there was a mistake in the playing, he would observe, for example, “The second trombone player came in a few moments late.”

At the same time, Kim was developmentally disabled. He did not walk until he was 4 and continued to have severe motor deficiencies. Kim needed help bathing and brushing his teeth. Often, his father, Fran, needed to redress him in the morning because he put his shirt on backward. Fran took care of his son full time and rarely had a moment to himself. In fact, he would check on him two or three times each night.

Fran explains that from birth his son was different: “Physically, he was unusual. His head was a third larger than normal.” Across the back of his head, he had an encephalocele—a blister into which part of the brain protrudes. The blister retracted when Kim was 3, pulling a nodule into his cerebellum and destroying half of it. In 1983, Kim had his first brain scan, which indicated that his brain was highly unusual. It was not divided into separate hemispheres and it had no corpus callosum, the connecting tissue that normally connects the left and right hemispheres. There was no anterior commissure, and there was damage to the cerebellum. In fact, an MRI indicated that the right half of Kim’s cerebellum had exploded into eight or nine small pieces, likely caused by pressure when the blister retracted into his brain. Only a thin layer of skull covered the area of the previous encephalocele.

Although NASA scientist Richard Boyle cannot fully explain Kim’s capabilities, he suggests that “Because he has no corpus callosum, there are theories about the right brain being freed from the dominance of the left. So instead of having the two sides of the brain competing, you have one megacomputer. But this is just a theory. Usually when someone has that condition, there are other conditions that are more detrimental to the individual.”


Classroom Exercise: The Sensory Homunculus

Each nerve fiber carries a message about the location and intensity of touch to the sensory cortex, so that together the nerve fibers form a spatial “map” of the body skin surface in the cortex that is called the “sensory homunculus.” James Motiff provides a classroom demonstration that shows students how the amount of sensory cortex devoted to specific areas is closely
related to the area’s touch sensitivity. The largest portions are devoted to areas having the greatest sensitivity, for example, the lips, tongue, and hands (see the text figure).

The children’s game of identifying the number of fingers on a person’s back provides the basis for this exercise. Ask for a volunteer to come to the front of the room. Have the volunteer close his or her eyes and report the number of fingers you press on the skin. Randomly press from one to four digits lightly on the back or on the hand and inform the class of the correct number after the volunteer’s guess. Greater accuracy for touch to the hand will be obvious. Far more cortex is devoted to the hand than to the back and this explains the difference in sensitivity. (You could do this same exercise by having students work in pairs.)

Douglas Chute and Philip Schatz suggest a related classroom exercise or student project. It involves touching toes. (If you use this demonstration in class, you will want to obtain informed consent from your student volunteers.) Ask the volunteer to remove his or her shoe and sock. After a blindfold is in place, touch the second, third, or fourth toes gently with a pen or stylus. It is most effective to touch slightly to the left or right midline of each toe. Chute and Schatz report that student accuracy in identifying the toe being touched is only 80 or 90 percent. Less cortex is devoted to the toes than to, say, the fingers. At the same time, with feedback on accuracy, participants are 98 percent correct after as few as 10 trials. Performance, however, returns to baseline in a few days. Chute and Schatz suggest that “the toe-touching phenomenon shows that the nervous system does not come with sensory relationships prewired but that these relationships can be learned and forgotten.”


**Brain Plasticity**

*Lecture/Discussion Topic: Hemispherectomy*

The hemispherectomy provides a vivid example of brain plasticity. Dating back to 1928, the hemispherectomy was devised as a treatment for malignant brain tumors. However, not only did it fail to cure the patients, but it was also associated with high mortality and morbidity. The surgery was used again in the 1940s and 1960s as a treatment for seizure disorders, but each time it fell into disfavor because of postoperative complications.

A number of medical advancements have contributed to its current success. In 1997, a Johns Hopkins medical team followed up on the 58 child hemispherectomies they had performed and were “awed” by how well the children retained their memory, personality, and humor after removal of either hemisphere. Jason Brandt, a Johns Hopkins neurologist, concluded, “That a child with half a brain can indeed be a whole person speaks to the malleability of both the human brain and human spirit. It’s amazing, it’s wonderful. I’m at a loss to describe it.”

In a follow-up study, Hopkins researchers contacted many of the families of the 58 children who participated in the 1997 study as well as those of 53 other children who had a hemispherectomy more recently. They found that 65 percent of the patients were seizure-free; 21 percent had occasional, nonhandicapping seizures; and 14 percent had troublesome seizures. Most notably, 80 percent of the patients no longer use drugs or are taking only one anticonvulsant medication. The researchers concluded that those with Rasmussen’s syndrome, a nervous system disorder characterized by chronic inflammation of the brain, and those with congenital vascular injuries benefit most from the surgery.

Surely some drawbacks will always remain. For example, some neurological functions do not transfer from one hemisphere to the other. All the “hemis” remain blind in one-half of each eye. They also continue to have some degree of paralysis on one side of their bodies. Fine motor movement is lost in one hand. In general, the effect of removing one hemisphere is related to the age of the child at the time of surgery. If performed early enough, the surgery does not seem to cause deficits in higher mental functions in adulthood. Two different theoretical conclusions have been drawn from this finding. One is that no shift from one hemisphere to the other has occurred because lateralization of function is not present in early infancy. The other is that hemispheric differences are present very early in life, but the young brain has the ability to reorganize itself in the face of damage to specific areas. Studies comparing the abilities of persons with left and right hemispherectomies suggest that the latter plasticity explanation is more likely to be correct.

For example, research on those who had hemispherectomies (some in the first few months of life) indicate that those who have had the left hemisphere removed have some continuing difficulty with both syntax and the processing of speech sounds. When asked to judge the acceptability of the three sentences “I paid the money by the man,” “I was paid the money to the lady,” and “I was paid the money by the boy,” those who had had the left hemisphere removed failed...
to recognize the first two as grammatically incorrect. The researchers concluded that the right hemisphere does not accurately comprehend the meaning of passive sentences. There are limits to the plasticity of the infant brain, and some hemispheric differences seem to be present very early in life.


### Hemispheres and Lateralization

**PsychSim 5: Hemispheric Specialization**

Hemispheric Specialization is a graphic demonstration of how messages reach the two sides of the brain and of the special functions of each side—for example, speech is controlled in the left hemisphere. The processing of a visual stimulus through the brain is the example used. Roger Sperry’s work with split-brain patients is also illustrated, and the responses of normal people are compared with those of split-brain patients.

**Classroom Exercise: Behavioral Effects of the Split-Brain Operation**

Edward Morris suggests a classroom exercise that is most useful in providing a dynamic visual image of the consequences of the split-brain procedure. Choose two volunteers, both of whom are right-handed, and sit them next to each other at the same desk (if possible, have them sit in the same chair). The one on the left represents the brain’s left hemisphere, the one on the right represents the brain’s right hemisphere. Instruct the volunteers to place their outer hands behind their back, their inner hands on the desk, one crossing over the other. The two hands represent the split-brain patient’s left and right hands. The student sitting on the right (representing the patient’s left hand) should be instructed not to speak.

Begin by simulating apparent visual deficits. Tell the volunteer on the right to look only to the left, and the volunteer on the left to look only to the right. Use a piece of poster board to separate the students and their lines of sight. Introduce a flashcard or actual object to the right visual field and ask the volunteer representing the right hand to name it or choose the correct object from a selection of objects. He or she should have no difficulty, demonstrating the link between the right visual field and the left hemisphere. Repeat this with another object in the right visual field, this time asking the volunteer representing the left hand to choose. Choosing incorrectly (or not at all) will demonstrate the right hemisphere’s lack of awareness of the right visual field. Follow the same procedure for the left visual field. Although mute, this time the right hemisphere will pick the correct object. When asked, the left hemisphere will most likely guess and pick incorrectly. You might conclude that in more normal settings the split-brain patient will be able to scan both visual fields, allowing both hemispheres to receive the information presented to only one hemisphere in the laboratory.

Blindfold the students and place a familiar object, such as a quarter, in the left hand. Ask the volunteer representing the left hand to indicate only in a nonverbal manner whether he or she recognizes the object. Ask the speaker (the volunteer representing the right hand) to name the object. Often, the students representing the left hand will guess but be incorrect. Elicit audience reaction to the possible relationship between hemispheric language dominance and the experience of the split-brain patient. Encourage students to generate ideas concerning how the left hand may communicate knowledge in other ways. For example, the volunteer representing the left hand might select the object from an array of objects placed in front of the pair upon removal of the blindfolds.

Morris describes additional activities in the article cited here.


**Classroom Exercise/Student Project: The Wagner Preference Inventory**

Handout 4, the Wagner Preference Inventory, provides an opportunity to stimulate critical thinking about some of the controversial applications of research on the divided brain. The inventory is designed to indicate which, if any, hemisphere is dominant. It consists of 12 sets of four statements each. Each statement in a group presumably corresponds to a different function of the two hemispheres, namely: (a) left, logical; (b) left, verbal; (c) right, manipulative/spatial; and (d) right, creative. Scoring is accomplished by adding the number of times each letter is selected. Students should enter the totals in the large cells in the quadrant at the bottom of the handout. Below the quadrant are two rectangles which, if any, hemisphere is dominant. It consists of 12 sets of four statements each. Each statement in a group presumably corresponds to a different function of the two hemispheres, namely: (a) left, logical; (b) left, verbal; (c) right, manipulative/spatial; and (d) right, creative. Scoring is accomplished by adding the number of times each letter is selected. Students should enter the totals in the large cells in the quadrant at the bottom of the handout. Below the quadrant are two rectangles for total left and right scores obtained by adding (a) and (b) for the left score and (c) and (d) for the right score. According to the authors, Rudolph Wagner and Kelly Wells, a difference of at least three points (expressed as a ratio) between L and R is needed to show a sig-
significant difference between the functioning of the two hemispheres. Otherwise, the functioning of the hemispheres is thought to be balanced. An example of a ratio for a dominant left hemisphere would be 11/1, a dominant right would be 4/8, and a balanced situation would be 5/7, or 7/5.

In validating their inventory, Wagner and Wells administered it to six criterion groups: students in a logic class, creative writers, vocational/technical high school teachers, nurses, painters (artists), and musicians. Predictions regarding the preferences of the six groups were: logic students—left, logic (a); creative writers—left, verbal (b) and right, creative (d); vocational/technical high school teachers—right, manipulative (c); nurses—right, manipulative (c); painters—right, creative (d); musicians—right, creative (d). Results generally supported these predictions. The authors concluded that these findings suggest that a behavioral inventory can assess cerebral preference or dominance and may be useful not only in research but also in clinical work—for example, in providing career guidance.

In discussing the exercise, you can review the text treatment of the divided brain. Students should be alerted to the potential danger in locating complex human capacities such as scientific or artistic abilities in either hemisphere. Descriptions of the left-right dichotomy run ahead of the scientific findings. The practice of science and creation of art emerge from the integrated activity of both hemispheres. In contrast, this inventory assumes that logical-verbal skills are located in the left hemisphere, while spatial-creative abilities reside in the right. While people may differ in their preferred modes of cognitive processing, the attempt to link these complex activities to hemispheric preference goes beyond the data.


*Lecture/Discussion Topic: The Wada Sodium Amobarbital Test*

Hemispheric specialization has been studied by briefly sedating a person’s entire hemisphere. In class, you may want to expand on the important clinical use, as well as research use, of the Wada or “intracarotid” sodium amobarbital test to study hemispheric function.

In 1960, John Wada and Ted Rasmussen pioneered the technique of injecting the barbiturate sodium amobarbital into the carotid artery to briefly anesthetize the hemisphere affecting one side of the body. As Bryan Kolb and Ian Whishaw explain, injections are now typically made through a catheter inserted into the femoral artery. The procedure enables researchers to study the functions of speech, memory, and movement that may be localized in either hemisphere. Typically, the cerebral hemisphere controlling the other side of the body is injected several days after the other hemisphere to be certain there is no residual drug effect.

Kolb and Whishaw describe how the procedure was used to localize speech in Guy, a 32-year-old lawyer who had a vascular malformation over the region corresponding to the posterior speech zone. The malformation was beginning to produce epilepsy; thus, the ideal surgical treatment was the removal of the abnormal vessels. However, removing vessels over the posterior speech zone posed a serious risk of permanent aphasia. Since Guy was left-handed, it was conceivable that his speech was located in his right hemisphere. In that case, surgery would have been less dangerous.

During the Wada test, patients complete a series of simple tasks involving language, memory, and object recognition. Asking them to name some common objects, to spell some simple words, and to recite the days of the week backward may be used to test speech. If the injected hemisphere is nondominant for speech, patients continue to perform the verbal tasks, although there may be an initial 30-second interval during which they are likely to appear confused. With urging, they resume speaking. If, on the other hand, the injected hemisphere is dominant for speech, patients stop talking until they recover from the anesthetic.

In Guy’s case, speech was localized in the left hemisphere. During the test of that hemisphere, he could not speak; he later reported that when asked about the presence of a particular object, he wondered what the question meant. When he finally realized what was being asked, he had no idea how to answer. Like people who have had split-brain surgery, Guy was able to identify one object among many by pointing with his left hand. His nonspeaking right hemisphere controlled that hand. His sleeping left hemisphere had no memory of the objects.


*Student Project/Classroom Exercise: Hemispheric Specialization*

Ernest Kemble and his colleagues suggest an easy student project for demonstrating hemispheric specialization. It is based on an earlier experimental approach that requires research participants to balance a wooden dowel on the forefinger of the right hand, and then of the left, while engaging in a verbal task or while remaining silent. Investigators have found that balancing duration was disrupted by a verbal task only when the right hand was used. Presumably, the verbal activity required of the left hemisphere makes balancing with the right hand more difficult. Since the right
hemisphere is less involved in language, balancing with the left hand is not disrupted.

Having already been introduced to methodology, students might apply it in designing their own experiment. Using this basic background, they should be able to state the hypothesis and identify independent and dependent variables as well as important controls. As designed by Kemble and his colleagues, the experiment requires only wooden dowels, a timer (preferably a stopwatch), and a list of verbal problems, such as spelling problems (for example, repeat the alphabet backward, recite the alphabet forward giving every third letter, spell “Afghanistan” backward, etc.). In Kemble’s experiment, participants were allowed to practice balancing the dowel for 5 minutes, alternating the right and left hands, and then received eight test trials (four with each hand). Each time, the participant placed the dowel on the right or left forefinger with the other hand. On the experimenter’s command the supporting hand was removed, and the experimenter started a stopwatch that was stopped when the dowel dropped or touched any part of the person’s body. Four trials on each hand were conducted in silence, four while performing a verbal task. The order of conditions was systematically varied across participants. Finally, mean balancing times for each hand under both silent and verbal conditions were calculated.

Results? First, the dominant hand showed a marginally significant superiority in balancing time during silence. Durations were significantly longer for males than for females regardless of hand. Verbal performance impaired performance in both hands, although the decline was greater for the right hand. No sex difference was observed in this effect. Conclusion? Whereas the left hemisphere seems to be more importantly involved in verbal tasks, both hemispheres participate. Referring to the left hemisphere as the “language” hemisphere is an oversimplification.

Two additional examples will reinforce and extend your discussion of hemispheric differences in the intact brain.

Either reproduce the figure at the top of the next column or draw it on the chalkboard. Researchers have found that if people are asked to name the large component letter, that is, the H, they have more activity in the right hemisphere (holistic perception). On the other hand, if they are asked to name the small component letters, they have more activity in the left hemisphere.

As another example, copy or create a transparency of the two faces below the “Ds” and conduct an experiment with students in class. Ask your students to indicate whether the left or right face looks happier. Most people choose the face on the left. Information from the left side of the picture goes to the right hemisphere, which is dominant for interpreting emotional expressions.


Lecture/Discussion Topic: Left-Handedness

It may come as a surprise to your students that handedness is a matter of degree, and only dextrals (right-handers) are clearly handed. Some sinistrals (left-handers) may cut paper, catch balls, and hold forks with their left hands but write with the right. No single activity reliably identifies handedness. Classifying a person requires answers to a series of questions about which hand is used in particular activities; people may be defined as sinistral only if they receive a left-hand score over a certain arbitrary number. Loren and Jean Chapman designed Handout 5, the Hand Usage Questionnaire, from a larger survey created by D. Raczkowski and colleagues. For each item, score a 1 for right, 2 for either, and 3 for left. The Chapmans designated those respondents with scores of 13 to 17 as right-handed, those scoring between 33 and 39 as left-handed, and those scoring between 18 and 32 as ambilateral.

In The Thorn Birds, author Colleen McCullough provides a vivid illustration of the cultural bias against left-handedness. The confrontation occurs in a rural New Zealand school in the early twentieth century.
Meggie’s worst sin was being left-handed. When she gingerly picked up her slate pencil to embark on her first writing lesson, Sister Agatha descended on her like Caesar on the Gauls. . . .

Thus began a battle royal. Meggie was incurably and hopelessly left-handed. When Sister Agatha forcibly bent the fingers of Meggie’s right hand correctly around the pencil and poised it above the slate, Meggie sat there with her head reeling and no idea in the world how to make the afflicted limb do what Sister Agatha insisted it could. She became mentally deaf, dumb and blind; that useless appendage her right hand was no more linked to her thought processes than her toes. She dribbled a line clear off the edge of the slate because she could not make it bend. . . . nothing Sister Agatha could do would make Meggie’s right hand form an A. Then surreptitiously Meggie would transfer her pencil to her left hand, and with her arm curled awkwardly around three sides of the slate she would make a row of beautiful copperplate A’s.

Sister Agatha won the battle. On morning line-up she tied Meggie’s left arm against her body with rope, and would not undo it until the dismissal bell rang at three in the afternoon. Even at lunchtime she had to eat, walk around and play games with her left side firmly immobilized. It took three months, but eventually she learned to write correctly according to the tenets of Sister Agatha, although the formation of her letters was never good. To make sure she would never revert back to using it, her left arm was kept tied to her body for a further two months: then Sister Agatha made the whole school assemble to say a rosary of thanks to Almighty God for His wisdom in making Meggie see the error of her ways. God’s children were all right-handed; left-handed children were the spawn of the Devil. (p. 37)

Carl Sagan, in The Dragons of Eden, suggested one possible origin for this bias. In some preindustrial societies, hands were used for personal hygiene after defecation. The unaesthetic and potentially disease-spreading consequences were reduced by right-handed people consistently using the right hand for eating and greeting while leaving toilet hygiene to the left. Sagan suggests that today’s bias results from the left hand becoming associated with excretory activities.

In contrast to earlier times, today teachers tend to leave left-handers alone. This may help explain an interesting shift in the frequency of left-handed writing in the United States, from 2.1 percent in 1932 to more than 11 percent in 1972. Six of forty-four U.S. presidents have been left-handed—Garfield, Truman, Ford, George H. W. Bush, Clinton, and Obama—a number that is close to the accepted approximation of 10 percent left-handers in the population.

The probability of two right-handed people having a left-handed child is 0.09. This figure rises to 0.19 if one parent is left-handed and to 0.26 if both are left-handed. Although these data are consistent with there being a genetic influence on handedness, environmental factors could account for the differences as well.

Left-handers tend to perform somewhat better than right-handers in mathematics, music, and chess. Although left-handers may suffer aphasia from damage to either brain hemisphere, they recover from strokes more quickly and more completely than right-handers in whom the language function is completely dependent upon the left hemisphere. Some experts have suggested that having language represented in both hemispheres creates the potential for interference effects and explains why left-handers seem more prone to stuttering. Others have suggested that the bilateral distribution of language may actually produce superior abilities, such as those evidenced by Leonardo da Vinci, Benjamin Franklin, and Michelangelo. In addition to suffering reading disabilities, allergies, and migraine headaches, left-handers are more likely to suffer disorders of the immune system, ulcerative colitis, hyperactivity, and alcohol dependence.

Your left-handed students may be interested in knowing that Topeka-based Lefthanders International is there to help them (785-234-2177). The organization can tell them where to find left-handed spiral notebooks, knives, soup ladles, and even clocks that run counterclockwise.

Several theories of handedness might be discussed in class. One is that left-handedness results from brain damage. If the left hemisphere is damaged early in life, functions shift to the right. The more extensive the damage, the greater the shift. Varying degrees of damage would produce varying degrees of handedness and lateralization. Although some left-handers seem to have pathological sinistrality (left-handedness based on brain damage), they account for only a small percentage. At the same time, it appears clear that prenatal and perinatal (about the time of birth) influences play a role in determining hand preference. For example, some research suggests that high levels of sex hormones—specifically, testosterone—during the prenatal period are associated with the greater likelihood of left-handedness. In addition, stresses involving reduced oxygen at birth (for example, prolonged labor, being a twin, Rh incompatibilities) are quite clearly related to left-handedness.

The right-shift theory, on the other hand, postulates a genetic explanation. Although there is no gene for handedness itself, there is a dominant gene that creates a left-hemisphere advantage for language and, in the process, a bias toward left-hemisphere hand control. With the recessive gene, the brain’s “natural” condition is equivalent hemispheres. The degree of left-handedness exhibited is then largely a matter of specific learning experiences. Assuming that both alleles occur equally often, those with two recessive genes would compose 25 percent of the population. Without a strong environmental bias, we would expect half to be right-handed and half to be left-handed. Thus, about 12.5
percent of the population would be left-handed, which is approximately what actually occurs.


Lecture/Discussion Topic: The Right Brain Movement

One result of the recognition that the cerebral hemispheres have special functions is what might be called the “right brain movement.” Pioneer Roger Sperry reported that, as his own experiments progressed, he found himself gaining a new appreciation for the talents of the nonverbal hemisphere, gradually becoming convinced that its abilities are undervalued by societies that emphasize verbal, logical, and quantitative achievement. “The main theme to emerge,” wrote Sperry in 1973, “is that . . . our educational system as well as science in general tends to neglect nonverbal forms of intellect.”

In 1991, one author writing in a respected education journal suggested the following:

The different functions of the right and left hemispheres of the brain require different approaches to education. Due to their emphasis on language and verbal processing, schools have failed to give adequate stimulation to the right side of the brain, and thus tend to discriminate against right brain dominant students. Many students show a preferred right brain (intuitive) thinking style and consequently have struggled in school because their thinking style did not conform to typical left-brain or logic-based thinking.

The notion that we may have undervalued the right hemisphere has spurred a number of educators and management consultants to attempt to redress the imbalance. For example, in her 1979 bestseller, Drawing on the Right Side of the Brain, Betty Edwards instructs students to suppress the verbal left hemisphere and turn on the artistic right as a means of learning to draw. In one exercise, students copy a drawing after turning the original upside down, making it more difficult for the left hemisphere to recognize the subject matter.

Similarly, the heads of some of the nation’s largest corporations are being advised to rely more on the “creative right brain processes.” Weston Agor, author of Intuitive Management: Integrating Left and Right Brain Management Skills, believes that companies should assess brain dominance (whether a person tends to think more with his or her right or left hemisphere) before hiring, firing, promoting, forming committees, or assigning work. More and more companies seem to be heeding his advice. The Whole Brain Corporation, headed by Ned Herrmann, analyzes people to determine their “brain dominance profile.” Herrmann maintains that different patterns of brain dominance lead to distinctly different skills, and thus to different careers. Presumably, people in jobs that don’t match their profile will perform poorly. Herrmann believes that the best executives are those who use both sides of their brains equally. Whole Brain instructs its corporate clients to conduct seminars that not only assess brain dominance but also provide training in creative problem solving. Some people can be taught to use their right brain, and a corporation must decide whether they are worth the effort.

What do researchers investigating split-brain patients think of the right brain movement? Many are highly critical. For example, Jerre Levy, one of Roger Sperry’s collaborators, states: “They’re taking findings with split-brain patients who don’t have a corpus callosum and generalizing to normal people.” Researchers are also critical of some of the movement’s methods for increasing creativity. For example, one management training magazine advocated playing loud music to drown out parts of a verbal presentation to activate right hemisphere processing. It also suggested lighting incense before a brainstorming session “so you can read an idea in the smoke.” Perhaps most important, researchers are critical of the movement’s claims that its methods are based on hard fact. Roger Sperry notes that while the normal differences between left and right hemispheres “may be exaggerated in some individuals, many of the practical implications of this cannot as yet be proved or disproved.” Investigators also emphasize that the latest research shows that both hemispheres are involved in virtually everything we do. The two cooperate with one another. The simple left-right dichotomy is misleading and oversimplified. Michael Gazzaniga, who assisted Sperry in much of the original split-brain research, recommends, “The left hemisphere—don’t leave home without it.”

Levy emphasizes the following points in challenging what she calls the “two-brain” myth. First, there is no activity to which only one hemisphere makes a contribution. For example, when a person reads a story, the right hemisphere may play a special role in decoding
the visual information, while the left hemisphere plays a special role in understanding syntax. Second, logic is not confined to the left hemisphere. In fact, patients with right-hemisphere damage show more major problems in this area than do patients with left-hemisphere damage. For example, patients paralyzed on the left side of their body will often make grandiose plans that are impossible to execute and never see the illogic of those plans. Third, there is no evidence that either creativity or intuition is an exclusive property of the right hemisphere. For example, researchers have found that both hemispheres are equally skilled in discriminating musical chords. Painter Lovis Corinth, after suffering right-hemisphere damage, continued to paint, his style more expressive and bolder than before. Fourth, since the hemispheres do not function independently in a normal brain, it is impossible to educate one hemisphere at a time. The right hemisphere is educated as fully as the left in a literature class; the left hemisphere is educated as much as the right in an art class. Finally, although there is evidence of a significant correlation between the amount of hemispheric activity and the relative strength of verbal or spatial skills, there is no evidence that people are purely “left-brained” or “right-brained.”

Sally Springer and Greg Deutsch conclude that, as a general rule, there is no evidence that just one hemisphere is involved in a given cognitive task. This includes language. During language tasks, blood flow is greater to the left hemisphere in most right-handed persons, but it also increases to a lesser extent in the right hemisphere. Both hemispheres also contribute to drawing. The left hemisphere seems more involved in the identification of details and internal elements, while the right hemisphere is more involved in orientation, location, and dimensionality. In an issue of *Current Directions of Psychological Science* devoted to lateralization of function in the human brain, editors Marie Barich and Wendy Heller conclude, “If there is one unifying theme for the articles in the Special Issue, it is that the direction of future research in lateralization of function lies in exploring how the hemispheres act as complementary processing systems and integrate their activities.”

Drawing from the research literature, James Kalat provides a vivid example of how all but the simplest tasks involve the cooperation of both hemispheres. Assume that you are asked to tap one finger as soon as you see a flash of light. You can tap your right finger a few milliseconds faster than the left if you see the light in the right visual field. Similarly, you can tap your left finger a few milliseconds faster if you see a flash in the left visual field. The explanation is that the information does not have to cross the corpus callosum. Now assume that the task becomes a tad more complicated. Instead of tapping for any light you see, you tap only for certain kinds of stimuli, so you have to process the information before tapping your finger. The result is that you will tap a bit more slowly, and reaction times do not depend on which finger is tapping or which visual field sees the stimulus. The slightly more difficult task requires you to use both hemispheres, and so it does not matter where the light appears.

In his review of hemispheric asymmetry, Joseph Hellige seems to present an even stronger case against the right brain movement or attempts to train “whole-brain thinking.” He concludes, “Several neuroscientists have suggested that the concept of hemisphericity be viewed with skepticism or abandoned altogether. This is not to deny that individuals differ in their preferred modes of cognitive processing. They clearly do. Some of the training programs may even do a reasonable job of encouraging a worthwhile diversity of thought. However, there is no evidence that this is accomplished by expanding the neural space used for thinking.”


HANDOUT 1a

Drug Effects

1. List as many of the different types of recreational drugs and/or pharmacological medications available today that you know about.

2. Select one of the drugs listed above and describe some of the effects it is known to have or thought to cause in humans. These can be intended effects, side effects, etc. Limit yourself to direct effects (specific changes in the body, neural actions, mood, etc.); do not include indirect effects (for example, criminal acts committed to support an addiction).

3. Given what you have listed above as known direct effects, hypothesize about three other effects the drug may have. List three parts of the central nervous system or peripheral nervous system that you believe may be affected. For each, briefly describe what you believe happens to them or in them when the drug is taken into the human body. Be as explicit as possible.
   
a. What is affected, and what happens?
   
b. What is affected, and what happens?
   
c. What is affected, and what happens?
Drug Effects

1. List as many of the different types of recreational drugs and/or pharmacological medications available today that you know about.

2. Select one of the drugs listed above and describe some of the effects it is known to have or thought to cause in humans. These can be intended effects, side effects, etc. Limit yourself to direct effects (specific changes in the body, neural actions, mood, etc.); do not include indirect effects (for example, criminal acts committed to support an addiction).

3. Given what you have listed above as known direct effects, hypothesize about three other effects the drug may have. List three parts of the central nervous system or peripheral nervous system that you believe may be affected. For each, briefly describe what you believe happens to them or in them when the drug is taken into the human body. Be as explicit as possible.
   a. What is affected, and what happens?

   b. What is affected, and what happens?

   c. What is affected, and what happens?
HANDOUT 1b (continued)

4. Research in the scientific literature one of the drug effects you listed in 3 to verify whether it occurs, and whether your hypotheses about where and how it occurs were correct. Describe the information you uncover in your research and provide a citation of the sources you used.

5. Identify three different things about this drug you do not know but you would need to know to understand how and why it produces the effects on the human body you described. Then, for each fact, indicate some specific resources you could use to find the information you would need.
Instructions: How might each of the following parts of the brain be active while we drive a car?

Cerebellum

Medulla

Pons

Reticular formation

Thalamus

Hypothalamus

Amygdala

Hippocampus

Corpus callosum

Frontal lobe:
  Motor cortex

  Frontal cortex

Parietal lobe:
  Sensory cortex

Occipital lobe:
  Visual cortex

Temporal lobe:
  Auditory cortex

**Case Studies**

*Instructions:* Three situations are described below. In each case, describe the parts of the brain activated in that situation.

Anne, the landscape artist, is standing at her easel, painting with her right hand as she looks out the window at her garden. She’s listening to classical music as she paints.

Crazy Eddie, the professional wrestler, is in the ring wrestling. The crowd is yelling and his opponent is taunting him. Eddie yells back at his opponent. The two of them are out of breath and sweating profusely. They continue their well-orchestrated series of wrestling moves.

Jill is a law student studying for her exam. She is reading about violent rape and murder cases. She is snacking on popcorn and drinking coffee.

The Wagner Preference Inventory

Instructions: Read the statements carefully. There are 12 groups of 4 statements each. Place an “X” in the bracket in front of each item you select. Mark one item only under each of the 12 numbered items. Choose the activity you prefer even though it does not necessarily mean that you have the ability to do it. If you are undecided, make a decision anyway by guessing.

1. ( ) a. Major in logic  ( ) a. Be in charge of computer programming
   ( ) b. Write a letter  ( ) b. Study word origins and meaning
   ( ) c. Fix things at home  ( ) c. Putter in the yard
   ( ) d. Major in art  ( ) d. Invent a new gadget
2. ( ) a. Be a movie critic  ( ) a. Analyze production costs
   ( ) b. Learn new words  ( ) b. Describe a new product in words
   ( ) c. Improve your skills in a game  ( ) c. Sell a new product on the market
   ( ) d. Create a new toy  ( ) d. Draw a picture of a new product
3. ( ) a. Improve your strategy in a game  ( ) a. Explain the logic of a theory
   ( ) b. Remember people’s names  ( ) b. Be a copy writer for ads
   ( ) c. Engage in sports  ( ) c. Work with wood and clay
   ( ) d. Play an instrument by ear  ( ) d. Invent a story
   ( ) b. Write for a magazine  ( ) b. Read about famous men and women
   ( ) c. Build new shelves at home  ( ) c. Run a traffic control tower
   ( ) d. Draw a landscape or seascape  ( ) d. Mold with clay and putty
5. ( ) a. Analyze market trends  ( ) a. Analyze your budget
   ( ) b. Write a movie script  ( ) b. Study literature
   ( ) c. Do carpentry work  ( ) c. Visualize and re-arrange furniture
   ( ) d. Imagine a new play  ( ) d. Be an artist
6. ( ) a. Analyze management practices  ( ) a. Plan a trip and make a budget
   ( ) b. Locate words in a dictionary  ( ) b. Write a novel
   ( ) c. Put jigsaw puzzles together  ( ) c. Build a house or shack
   ( ) d. Paint in oil  ( ) d. Make crafts your hobby

Quadrant analysis

To ascertain your score: Write down the number of times you chose “a” in the box labeled “a”; do the same for “b,” “c,” and “d.” Add the total number of times you chose “a” or “b,” and write the number in the box marked L. Add your “c” and “d” answers and write that total in the box labeled R. A difference between the two boxes of at least 3 points indicates that the higher-scoring hemisphere is dominant. Thus, for example, 8/4 is left-dominant, 3/9 is right-dominant, and 6/6, 5/7, and 7/5 indicate hemispheric balance.

**Hand Usage Questionnaire**

Please indicate below which hand you ordinarily use for each activity.

With which hand do you:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. draw?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>2. write?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>3. use a bottle opener?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>4. throw a snowball to hit a tree?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>5. use a hammer?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>6. use a toothbrush?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>7. use a screwdriver?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>8. use an eraser on paper?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>9. use a tennis racket?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>10. use a scissors?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>11. hold a match when striking it?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>12. stir a can of paint?</td>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>13. On which shoulder do you rest a bat before swinging?</td>
<td>Left</td>
<td>Right</td>
</tr>
</tbody>
</table>