The Biology of Mind

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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 inveterate 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 6: 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.
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.


Classroom Demonstration: The Action Potential

The Online Psychology Lab (OPL) has a wonderful animation of the action potential (opl.apa.org/contributions/ITL/ap.htm, donated to OPL by Ian Winship, University of Alberta). Watch sodium and potassium ions change spots in the axon. Pause the animation at any point.

Classroom Exercise: Neural Transmission

I (SF) use a brief classroom exercise to teach neural transmission. With a bag of Hershey’s chocolate Kisses, index cards with Na⁺ written on them, and some willing volunteers, you can provide a memorable demonstration of neural transmission. Have five volunteers who enjoy eating chocolate come to the front of the class. Four will serve as dendrites (D) and one as a cell body (CB). Recruit five more students to serve as the axon (A) and two or more to act as terminal branches (TB) (each branch should be given a few chocolate Kisses to hold onto).
Arrange your students like this.

D    D                                           TB
D    D                                           CB   A   A   A   A

Assuming that you have enough students, create a second neuron of students who will receive the signal from this neuron.

Explain that sodium ions are floating throughout the body (toss the sodium ion cards around your volunteers) and that the Hershey’s Kisses are neurotransmitters (perhaps acetylcholine, responsible for muscle movement).

Begin by suggesting that you are the terminal branch of a nearby neuron and toss Hershey’s 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 pop them into their mouth (receptor sites) and immediately pick up one of several cards (sodium ions). 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. (At this point, they should also spit out the neurotransmitter, but it’s probably best if they just eat the chocolate.)

The next person in the axon then picks up a card while the previous person drops theirs, and so on down the line. When the end of the axon has been reached, the terminal fibers toss their Hershey’s Kisses in the direction of the dendrites and cell body of the nearby neuron, repeating the process. If you didn’t create a second neuron, just have the terminal branches toss the chocolate to the rest of the class.

You can extend the demonstration by using Hershey’s Kisses with differently colored wrappers to illustrate the effects of agonistic and antagonistic drugs. I use Hershey’s Hugs—silver wrapper, brown stripes—for an agonist and Hershey’s Special Dark Kisses—purple wrapper—for an antagonist. If you use acetylcholine for your example, then discuss nicotine as an agonist (one symptom of nicotine poisoning is twitching of the muscles) and curare as an antagonist (one symptom of curare poisoning is paralysis).

The demo takes about 20 minutes, and one bag of Hershey’s 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 behind the membrane.
4. Receptor: one person who stands between the dendrite membranes with outstretched arms.
5. Dendrite: two people, each with one hand on the shoulder of the “receptor.”
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 the 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 and Neurostimulation

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 labora-
tory 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. In one study, naloxone, an endorphin antagonist reduced the feelings of joy and euphoria after a long run, as compared with those who received a saline placebo (Janal, Colt, Clark, & Glusman, 1984).

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.

Intracranial neurostimulation, in which electrodes are placed on the brain, is being used for some people for whom traditional pain therapies do not help. Pain following a stroke has been helped by neurostimulation of the motor cortex, for example. Interestingly, stimulating the sensory cortex caused the pain to worsen in some people. In looking at the way the body is mapped on the motor cortex, you will see that electrode placement for arm and face pain is easy. Leg pain is trickier because the electrodes need to be placed between the hemispheres or on the top of the brain near the center and then higher intensities need to be used to reach deeper to the neurons responsible for the legs. Physicians will use an external device to stimulate the electrodes for a week or so, as they find the optimal level of stimulation for the patient. Once that level has been found, they’ll implant an automatic pulse generator, usually over a chest muscle. For neuropathic pain, deep brain stimulation—implanting electrodes in the sensory part of the thalamus—seems to be more effective (Levy, Deer, & Henderson, 2010).


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 5 in every 100,000 people worldwide, usually between the ages of 40 and 60. 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 those with ALS 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. Currently, there is no cure for ALS, although the drug riluzole slows its progression.

An 8-minute YouTube video (www.youtube.com/watch?v=aArmlrF18s) puts a face to ALS. Through his own words, Marc West and his family talk about what it is like to live with ALS. Another inspiring story about a person stricken with ALS is Until I Say Good-Bye by Susan Spencer-Wendel, a former Palm Beach Post reporter. Diagnosed in 2011, Spencer-Wendel wanted to get the most out of every moment she had left, traveling around the world with her family and documenting everything by typing with her right thumb on her iPhone.


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 (for example, 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)!

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 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.
sexual functioning or with achieving satisfactory sexual intimacy with their partners.


**Lecture/Discussion Topic: The Sympathetic Nervous System and the Polygraph**

Humans have been trying for centuries to determine who is lying and who is telling the truth. We still can’t determine this with any comfortable degree of accuracy. The polygraph doesn’t measure lying; it measures sympathetic nervous system arousal. The following brief history of the polygraph can be used here or when you discuss emotions. If you do not use this information here, you may want to use it in relation to the Emotion unit.

During World War I, psychologist William Marston developed a test for use with accused spies (Bunn, 1997). (Marston was an undergraduate in the lab of Hugo Münsterberg, the German sociologist considered the father of industrial psychology; Münsterberg was invited to create the lab by none other than William James himself). Marston used blood pressure as his measure. If a person were lying—more important, nervous while lying—then their blood pressure would go up (Polygraph history, 2011). The ability to detect lies evidently weighed on Marston’s mind. At the dawn of World War II, he created a comic book character: Wonder Woman, with her lasso that compelled people to tell the truth.

In the modern era, polygraphs measure heart rate, breathing, and galvanic skin response (how well skin conducts electricity; sweaty skin conducts electricity better). Polygraph administrators ask baseline questions, the answers to which they know to be true, and then target questions. If there is more sympathetic nervous system arousal to the target questions, then the person is assumed to be lying. Research shows that the polygraph is pretty good at identifying who is lying. Unfortunately it is also pretty good at generating false positives—identifying people as lying when in fact they are telling the truth (Bunn, 1997). Some people are generally nervous taking the test, so they will perspire even when telling the truth.

The polygraph is also pretty easy to fool. You can raise your sympathetic nervous system arousal when answering baseline questions. There are a number of ways you can do this: For example, put a sharp tack in your shoe (Wolchover, 2011), then on the baseline questions, push your foot against the tack. Pain reliably causes sympathetic nervous system arousal. On the target questions, do not push your foot against the tack.

Are polygraph test results admissible in court? It depends on the state, but the answer is either no or only if both the defense and prosecution allow it (LaMance, 2013).


**Lecture/Discussion Topic: The Sympathetic Nervous System and Performance**

Students may think that they are the only ones who get nervous before a performance. Ask students what symptoms of sympathetic nervous system arousal they experience before giving a speech. You will hear things such as dry mouth, need to urinate, butterflies (all signs of the digestive system going offline), and shaking (muscles are tense, poised to fight or run). This is also a nice time to note that our bodies have one response to stress: sympathetic nervous system arousal. When our primary stressor was the presence of predators, this served us pretty well. While the sympathetic nervous system response still works well if we are being physically attacked, it generally doesn’t work well in helping us cope with today’s stressors, such as giving a speech.

Players in the National Football League (NFL) have shared some of their sympathetic nervous system arousal experiences. For example, some players vomit before games. During pregame, other players are running back and forth to the locker room to urinate or defecate (Gargano, 2010).

Musicians are not immune to performance-related sympathetic nervous system arousal. Before a performance, some musicians experience the tell-tale signs of nervousness: a pounding heart, sweaty hands, and shaking. Ruth Ann McClain, a flutist from Memphis, often suffered from debilitating performance anxiety. “‘My hands were so cold and wet, I thought I’d drop my flute,’ Ms. McClain said recently, remembering a performance at the National Flute Convention in the...
late 1980s. Her heart thumped loudly in her chest, she added; her mind would not focus, and her head felt as if it were on fire. She tried to hide her nervousness, but her quivering lips kept her from performing with sensitivity and nuance.” A 1997 survey of orchestral musicians found that 27 percent of them had used a beta-blocker, a drug developed as a heart medication that keeps the sympathetic nervous system from getting too aroused (Tindall, 2004). The author of an article of a classical music news site asks, “If you have to take drugs in order to do something, should you really be doing it?” (Burton, 2013). Note that there are some good psychotherapies for treating this type of anxiety, and that students will hear more about them when you get to that section of the course.

It’s common for students to experience sympathetic nervous system arousal before an exam. Students can either let this arousal get in the way of their performance, or they can reframe it so that they perceive the arousal as an asset. Researchers invited students into the lab for a practice GRE test. Half the students, the reappraisal group, were told, in part, that sympathetic nervous system arousal during a test can help students. The other half were not given any such information. Those in the reappraisal group showed higher sympathetic nervous system arousal, and they outperformed the controls on the math portion of the GRE practice test; there were no differences on the verbal part of the test. After the students had taken the actual GRE, they reported their results to the lab. The results were very similar to the practice GRE results: The reappraisal group outperformed the control group, again just on the GRE math, not the verbal section (Jamieson, Mendes, Blackstock, & Schmader, 2010). Researchers at Stanford University delivered a similar message to half the students taking Introductory Psychology the day before the first exam. Freshmen who received the reappraisal message outperformed those who did not receive the message by a statistically significant margin. The message had no impact on upperclassmen, perhaps because of their greater experience with college-level exams (Martin Hard, Brady, S.T., & Gross, J. J. (2014, January). Your anxiety can help you: Reappraising arousal before an exam enhances performance. Poster presented at the National Institute on the Teaching of Psychology, St. Petersburg Beach, FL.


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 corticotropin-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.

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 the unit on 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 (2007) 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 (2007) of Claremont 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.

Adam Guastella and colleagues (2010) delivered oxytocin or a placebo intranasally to people diagnosed with an autism spectrum disorder and to a control group. They found that for those with an autism spectrum disorder oxytocin increased performance on an emotion-recognition test.

Shelley Taylor (2006), 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.)

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 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: 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 audio-tape 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.

New research by Andrea Soddu (Mayne, 2014) reveals that the PET scan is a much more effective neuroimaging technique for detecting whether a person is in a minimally conscious state. If there is metabolic activity in only the cerebellum and brainstem, then the person is in a vegetative state. If there is some metabolic activity in at least one hemisphere, the person is minimally conscious.

Fans of Formula 1 racing are aware of the December 2013 skiing accident that left driver Michael Schumacher in a coma. In April 2014, he came out of his coma, but as of this writing (July 2014) appears to be in a minimally conscious state.

Mental states change over time. Some patients have recovered function almost completely after being thought to be in a vegetative state. 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.


Lecture/Discussion Topic: Concussions in Sports

Ask your students to watch the 113-minute Frontline episode “League of Denial: The NFL’s Concussion Crisis” (www.pbs.org/wgbh/pages/frontline/league-of-denial). In small groups, as a class, or in an online discussion forum, give students these questions to prompt discussion.

1. What did you learn about concussions from this program?
2. What was the most surprising thing that you learned from the program?
3. What should be done for former NFL players who have suffered numerous concussions?
4. What should be done to prevent concussions in football?
5. What would you guess are the top 10 sports/recreational activities that produce concussions in U.S. youth (19 years and younger)?

The top 10 sports/recreational activities that produce concussions or traumatic brain injury in U.S. youth are

1. Bicycling
2. Football
3. Playground
4. Basketball
5. Soccer
6. Baseball
7. All-terrain vehicle riding
8. Skateboarding
9. Swimming
10. Hockey

much of our behavior and thought. Muscles in the
represents the cortex, or “gray matter,” which controls
of them with palms outward. The skin on the hands
exercise) for a more detailed model.

See the original description (reference at the end of the
model in class. What follows are a few highlights.

Susan J. Shapiro of Indiana University East suggests
ful starting point for students who are still attempting to
human brain. The strategy can provide a very help
using students’ hands as a three-dimensional model of
brain, with at least one brain structure contributed by
each student. In putting the brain together (they can
c Decide whether it should be 3-D or a cross section),
y should write the name of each structure on a sticky
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

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 activ-
ity, tell students to read carefully the text section on the
human brain, paying special attention to the illustra-
tions. Ask each student to choose the five most impor-
ant structures and to explain 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 mini-
um of five structures to build into their Play-Doh
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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 help-
ful 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 informa-
tion 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 sensa-
tion on the opposite sides of the body). The wrists rep-
resent 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 judg-
ments. To move a finger, the student needs to move
muscles at the base of the fingers. At about this loca-
tion, 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 knuck-
les, 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 consti-
tutes 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 respon-
sible 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 (candywarehouse.com). Order online or call 310-343-4099. A bag of 12 pops is $29.40. Or you could choose 10 pounds of sour gummy brains ($79.50) or 1 kilogram of jelly-filled gummy brains ($7.50) instead.

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 Basic Half Brain Model ($74.40). 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 more expensive. 3B Scientific’s (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 Gelatin Brain 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.

Several life-size molds are available online, such as one for $9.99 from spirithalloween.com. For the most lifelike of gelatin brains, use peach or watermelon gelatin mix, fat-free evaporated milk, and red, green, and blue food coloring (full recipe: www.food.com/recipe/brain-gelatin-74582). If you really want to get your students’ attention, you can do what this professor reportedly did: notalwayslearning.com/giving-the-class-a-piece-of-his-mind.

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 tapping together two 11.5” × 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 Kennesaw State 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. (The case studies in this handout are different from the ones Sheldon uses. Please see her article for the originals.)

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 Robinia’s motor cortex is operating as she walks. You might ask the class whether the left or right motor cortex is operating when Robinia moves her left hand. 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 below and on the next page.

<table>
<thead>
<tr>
<th>Neuroanatomy structure</th>
<th>Related function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robinia</td>
<td></td>
</tr>
<tr>
<td>Right motor cortex (frontal lobe)</td>
<td>Controls left hand</td>
</tr>
<tr>
<td>Visual cortex (occipital lobe)</td>
<td>Seeing her boyfriend</td>
</tr>
<tr>
<td>Auditory cortexes (temporal lobe)</td>
<td>Hearing her boyfriend</td>
</tr>
<tr>
<td>Right hemisphere</td>
<td>Recognizing her boyfriend’s face</td>
</tr>
<tr>
<td>Thalamus</td>
<td>Relays the sound of her boyfriend’s voice to temporal lobe</td>
</tr>
<tr>
<td>Left sensory cortex (parietal lobe)</td>
<td>Feeling her boyfriend’s hand in her right hand</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>Coordinates walking</td>
</tr>
<tr>
<td>Amygdala</td>
<td>Important in strong emotions, like being upset</td>
</tr>
</tbody>
</table>

| Julieta               |                 |
| Both motor cortexes (frontal lobe) | Move arm and hand muscles to play |
| Right sensory cortex (parietal lobe) | Feeling the strings with her left hand |
| Left sensory cortex (parietal lobe) | Feeling the bow in her right hand |
| Visual cortexes (occipital lobe) | Seeing the audience |
| Thalamus | Sensory relay—e.g., sending the sound of the music to temporal lobes |
| Frontal lobes | Deciding what music to play |
| Medulla | Increases her heart rate |
### Neuroanatomy structure

<table>
<thead>
<tr>
<th>Structure</th>
<th>Related function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amygdala</td>
<td>Important in strong emotions, such as fear when in front of an audience</td>
</tr>
<tr>
<td>Reticular formation</td>
<td>keeps her alert during playing</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>Coordinating left and right hands to play; motor memory for songs</td>
</tr>
<tr>
<td>Hippocampus</td>
<td>Processing her experience for long-term memory storage</td>
</tr>
<tr>
<td>Arnaud</td>
<td></td>
</tr>
<tr>
<td>Auditory cortex (temporal lobe)</td>
<td></td>
</tr>
<tr>
<td>Frontal lobe</td>
<td>Listening to others in his group</td>
</tr>
<tr>
<td>Left hemisphere</td>
<td>Deciding what to write down; attention</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Processing and producing language</td>
</tr>
<tr>
<td></td>
<td>Feelings of hunger since he missed lunch</td>
</tr>
</tbody>
</table>

#### Function and Behavior

**Classroom Exercise: Neuropsychology of Zombies**

Harvard child psychiatrist Dr. Steven Schlozman garnered a lot of media attention a few years ago, but not for his work with clients or for his scholarly research in professional journals. Instead, he’s earned the interest and adoration of sci-fi fans worldwide with his novel *Zombie Autopsies*. You can easily find interviews with Dr. Schlozman, twitter chats, and reviews of his novel on the Internet. However, if you plan it right, you can use the topic of zombies to pique the interest of your students and develop a memorable learning activity about the brain. Like a good zombie virus, you can catch your students off guard and engage them with the topic before they even realize what’s happened.

For the uninitiated, the stereotypical zombie story centers around the idea that a virus or other pathogen infects people like a contagion, leading to mindless wandering, uninhibited eating of human flesh, and decay in the human hosts. Zombie fiction has a devoted fan base. Most aficionados enjoy the characters, plot devices, and “zombie culture” for the pure fantasy of it. However, others regard the zombie genre as a rich source of fodder for discussions about medical ethics, tactics to control human pandemics, and even consciousness.

You can use the topic of zombies as a lecture launcher or as a closing activity, depending on how and when you want to frame your discussion. Either way, you may want to begin by dividing your class into small groups. Then show a brief video clip from a zombie movie or perhaps from the AMC TV series *The Walking Dead*. Do not tell them why you are showing the video clip; simply say something ambiguous like, “Here is a video that captures some of the issues we’ll be talking about today.” After showing the video, ask your students to indicate how many of them have ever watched a zombie movie or a show about zombies, and then ask for a volunteer to explain what zombie movies are typically all about. Have your students generate a list of typical zombie traits (they can focus on behavior, emo-

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*PsychSim 6: 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.

*PsychSim 6: Brain Treasure Hunt*

In a game-like context, students explore the major brain regions and identify and label each region or area.

*Student Project: Color the Brain*

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.

If you would like your students to do just one coloring sheet, distribute Handout 4 to your students. Ask students to color and label the 10 brain areas listed. Encourage students to choose colors based on brain function. Red, for example, may be a good choice for the strong emotions associated with the amygdala. Choosing a color with a rationale tied to the brain area’s role provides the deep processing in this assignment.

On the back of the sheet, students can write a bit about what each brain area does and why they chose that particular color.

tion, or any other psychological dimensions you feel are relevant.

When your students have generated their list of zombie traits, have the small groups discuss what brain regions would have to be affected in a zombie-infected person in order to produce the zombie behaviors and activities on their list. After about 15 minutes, show your video clip again (or a different one), and then review the groups’ conclusions. Some regions you might choose to discuss are

• frontal lobes (lack of inhibition)
• limbic areas (the amygdala) and cingulate cortex (lack of emotion, rage/aggression)
• hypothalamus (insatiable hunger for human flesh, biting)
• motor cortex and cerebellum (changes in balance, motor control)
• mirror neurons (lack of empathy for victims) (See the unit on Learning.)
• language areas (why do zombies always moan?)


Older Brain Structures

**Lecture/Discussion Topic: Conjoined Twins and a Shared Thalamus**

Tatiana and Krista Hogan are craniopagus (joined at the head) conjoined twins. What makes them especially unusual is that they share a number of brain structures, most notably the thalamus. Ask students what that means for Tatiana and Krista. What would you experience if you shared a thalamus with another person?

What is physically felt by one, such as pain or touch, is immediately felt by the other. What one sees, the other sees. What one tastes, the other tastes.

Krista and Tatiana have distinct personalities with distinct likes and dislikes. Krista, for example, really likes ketchup, but Tatiana doesn’t. For siblings who do not share a thalamus, this is not a problem. But when Tatiana tastes everything that Krista puts in her own mouth, it is more problematic.

The girls also appear to share thoughts. Their father reports that the girls may be sitting quietly, and then, without saying a word, get up and pull a prank they had evidently been “discussing.”

A 7-minute ABC News video that tells a bit about the girls’ story is available on YouTube (www.youtube.com/watch?v=2MKNsI5CWoU). If you would like to show only the segment that covers what it means to share a thalamus, start the video at the 4:48 mark (www.youtube.com/watch?v=YWDsxA5nNblt#t=288). That story ran when the girls were three years old.


**Lecture/Discussion Topic: Why Can’t We Tickle 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 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-ticking, 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.

In 2011, BBC News Magazine printed an article that gives a solid summary of Clive Wearing’s condition (www.bbc.co.uk/news/magazine-15791973). For more information, read Forever Today, the book written by his wife, Deborah Wearing. Short clips from the documentary Life Without Memory: The Case of Clive Wearing can be found on YouTube. For the full documentary, contact your librarian on how best to access it. Worth’s LaunchPad also includes a video, titled Clive Wearing: Living Without Memory.


Lecture/Discussion Topic: H.M.’s Brain
Henry Molaison, known in psychology for decades as H. M., is covered in the Memory unit. To address his frequent epileptic seizures, a surgeon removed his hippocampi. This left him unable to form any new memories. You may choose to introduce his case here because of its relevance to brain function. Following his death in 2008, Molaison’s brain was cut into 2401 very thin slices. Visit thebrainobservatory.org/hm to learn much more about Molaison and the project, including news articles, videos, and, after signing up for a free account, access to his brain atlas. The 2-minute video showing researchers taking a few slices is alone worth the visit. For a broader view, watch the 10-minute NOVA Science Now episode, which includes interviews with researchers who spent their careers learning from Henry Molaison.


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 2, in the unit on Motivation, the last six items of which assess extraversion) and Zuckerman’s research on sensation-seeking (see 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. As research findings confirm, 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 mouth; if you do, the baby will smother. What should you do?

Participants are about equally divided on the right course of action. Greene suggests that the dilemma is challenging because it creates a conflict between a strong emotional response (don’t ever kill a baby) and a strong cognitive response (if you don’t kill the baby, everyone dies). Two findings from neuroimaging studies support this interpretation. First, the anterior cingulate cortex, a brain region associated with response conflict, exhibits increased activity. This indicates that the moral dilemma is not difficult merely because it requires more time to process. Second, the dorsolateral prefrontal cortex and inferior parietal cortex, regions associated with cognitive control, show greater activity when people favor the promotion of the best overall consequences. That is, when people say it is okay to smother the baby, they exhibit increased activity in the brain area associated with high-level cognitive function.

The Princeton team concludes that when a tough moral dilemma is posed, the reasoning processes of the brain conflict with the more automatic emotional response, and the decision takes longer. Our gut moral instinct, suggests Greene—that is, “what people know deep down is right”—was not designed for the modern world. Abstract reasoning goes on in the more recently evolved parts of the brain. “My hope,” writes Greene, “is that by understanding how we think, we can teach ourselves to think better, that is, in ways that better serve the needs of humanity as a whole.”

Continuing research on how the brain tackles difficult moral dilemmas highlights the potential tension between the cool cognition associated with the dorsolateral prefrontal cortex and the moral emotions such as compassion, empathy, and guilt that are associated with the ventromedial prefrontal cortex (VMPFC). For example, Michael Koenigs (then a postdoctoral fellow at the National Institute of Neurological Disorders, now at the University of Wisconsin, Madison) and his colleagues compared moral judgments made by neurologically normal people with those who had damage to the VMPFC. They used variations on the trolley dilemma (which you might also present to your class):

A runaway trolley is hurtling down the tracks toward five people who will be killed if it proceeds on its present course. You can save these five people by diverting the trolley onto a different set of tracks, one that has only one person on it, but if you do this that person will be killed. Is it morally permissible to turn the trolley and thus prevent five deaths at the cost of one?

Most respondents say Yes. They make a utilitarian judgment (associated with the dorsolateral prefrontal cortex) that will lead to the greater aggregate welfare.

Now consider a slightly different dilemma. Once again, the trolley is headed for five people. You are on a footbridge over the tracks next to a large man. The only 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. Other critics, such as Terence Hines, argue that some differences found by researchers are the result of confirmation bias and statistical issues. Because of what Einstein accomplished in his lifetime, researchers may be expecting to see structural differences and so go looking for them. In one study, researchers compared Einstein’s brain with 28 other brains, and found only one difference that reached statistical significance. The more statistical comparisons you make, the more likely you are to find a difference just by chance. If there are legitimate structural differences between Einstein’s brain and the brain of the average person, we don’t know if those differences are meaningful or if they might be in the range of normal variation.

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 Raymond Babbitt (the Rain Man in the film). 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 could 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 dis-
abled. 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 differ-
ent: “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 piec-
es, 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.”

The original Rain Man. (2005, March 4). The Week,
pp. 40–41.

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 “sen-
sory 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 por-
tions are devoted to areas having the greatest sensitiv-
ity, 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 touch-
ing 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 sty-
lus. 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 feed-
back 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 ner-
vous system does not come with sensory relationships
prewired but that these relationships can be learned and
forgotten.”

Chute, D., & Schatz, P. (1999) Observing neural net-
working in vivo. In L. T. Benjamin, B. F. Nodine, R. M.
Ernst, & C. B. Broeker (Eds.), Handbook for the teach-
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Psychological Association.

Motiff, J. P. (1987). Physiological psychology: The sen-
sory homunculus. In V. P. Makosky, L. G. Whitemore,
& A. M. Rogers (Eds.), Activities handbook for the
teaching of psychology: Vol. 2 (pp. 51–52). Washington,

Brain Plasticity

Lecture/Discussion Topic: Hemispherectomy

The hemispherectomy provides a vivid example of
brain plasticity. Dating back to 1928, the hemispher-
ectomy 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.

A 6-minute Today Show segment, available on YouTube (www.youtube.com/watch?v=2MKNsI5CWoU), tells the story of one of the children with Rasmussen’s syndrome treated at Johns Hopkins.

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. 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 6: 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.


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, Juhn 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.

The Wada test does come with some risks, such as a 1 percent chance of stroke, so researchers have been looking at noninvasive techniques that are just as good at determining which hemisphere houses language. A 2011 meta-analysis found that functional magnetic resonance imaging (fMRI) appears to be a good alternative. Rather than anesthetize half the brain, let’s just look at which hemisphere shows greater activity during, say, reading. If fMRI cannot be used effectively because the bloodflow to that area of the brain has been disrupted, navigated transcranial magnetic stimulation (nTMS) is an alternative noninvasive option. With nTMS, the physician uses a large magnet to temporarily disrupt the
functioning of the brain in a specific area while being able to see on a computer screen a graphic representation of the patient’s brain.


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 pencil is a fine substitute), a timer (preferably a stopwatch or a smart phone stopwatch app), 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). 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 below or draw it on the board. Researchers have found that if people are asked to name the large compositive 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.

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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.


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?
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a. What is affected, and what happens?

b. What is affected, and what happens?

c. What is affected, and what happens?
4. Research in the scientific literature one of the drug effects you listed in question 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

Handout 3

Case Studies

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

Robinia is walking down the street with her right hand holding her boyfriend’s hand. Robinia is talking about an argument she had with her mother. Robinia, really upset and frustrated, throws her left hand up in the air.

Julieta is playing the violin in front of her first audience. She’s a little nervous and scared as revealed by her pounding heart, but all of the time she has spent practicing has paid off. Her performance is flawless.

Arnaud is participating in a small group discussion in his psychology class. As he listens to everyone’s ideas, he writes them down using his right hand. Unfortunately he missed lunch, and hunger is making it hard for him to pay attention.
Color the brain areas covered in the text, using a different color for each area. Label each area by drawing a line from the name of the brain area to its location on the diagram. On the back of this sheet briefly explain what each brain area does and why you chose that particular color for that brain area.
<table>
<thead>
<tr>
<th><strong>Brain area</strong></th>
<th><strong>Shade in box with color chosen</strong></th>
<th><strong>Briefly describe what this brain area does and provide rationale for the color you chose.</strong></th>
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<tbody>
<tr>
<td>Medulla</td>
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<td>Corpus callosum</td>
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