Module 13

Brain Hemisphere Organization and the Biology of Consciousness

Monica Murphy/Getty Images

Module Learning Objectives

13-1 Explain how split-brain research helps us understand the functions of our two brain hemispheres.

13-2 Explain what is meant by "dual processing," as revealed by today's cognitive neuroscience.

Our Divided Brain

13-1 **What do split brains reveal about the functions of our two brain hemispheres?**

Our brain's look-alike left and right hemispheres serve differing functions. This *lateralization* is apparent after brain damage. Research collected over more than a century has shown that accidents, strokes, and tumors in the left hemisphere can impair reading, writing, speaking, arithmetic reasoning, and understanding. Similar lesions in the right hemisphere have effects that are less visibly dramatic.

Does this mean that the right hemisphere is just along for the ride—a silent, "subordinate" or "minor" hemisphere? Many believed this was the case until 1960, when researchers found that the "minor" right hemisphere was not so limited after all. The story of this discovery is a fascinating episode in psychology's history.

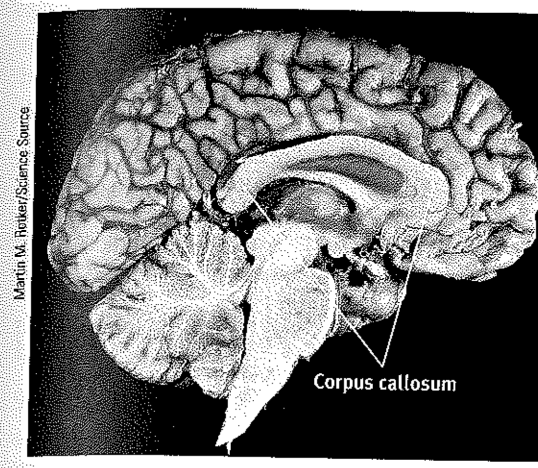
Splitting the Brain

In 1961, two Los Angeles neurosurgeons, Philip Vogel and Joseph Bogen, speculated that major epileptic seizures were caused by an amplification of abnormal brain activity bouncing back and forth between the two cerebral hemispheres. If so, they wondered, could they put an end to this biological tennis game by severing the **corpus callosum** (see **FIGURE 13.1**)? This wide band of axon fibers connects the two hemispheres and carries messages between them. Vogel and Bogen knew that psychologists Roger Sperry, Ronald Myers, and Michael Gazzaniga had divided the brains of cats and monkeys in this manner, with no serious ill effects.

So the surgeons operated. The result? The seizures all but disappeared. The patients with these **split brains** were surprisingly normal, their personality and intellect hardly affected. Waking from surgery, one even joked that he had a "splitting headache" (Gazzaniga, 1967). By sharing their experiences, these patients have greatly expanded our understanding of interactions between the intact brain's two hemispheres.

corpus callosum [KOR-pus kah-LOW-sum] the large band of neural fibers connecting the two brain hemispheres and carrying messages between them.

split brain a condition resulting from surgery that isolates the brain's two hemispheres by cutting the fibers (mainly those of the corpus callosum) connecting them.



Martin M. Rotker/Science Source

Figure 13.1
The corpus callosum This large band of neural fibers connects the two brain hemispheres. To photograph this half brain, a surgeon separated the hemispheres by cutting through the corpus callosum and lower brain regions.

AP® Exam Tip
The classic split-brain studies are famous in psychology, which means they are likely to show up on the AP® exam.

To appreciate these findings, we need to focus for a minute on the peculiar nature of our visual wiring. As **FIGURE 13.2** illustrates, information from the left half of your field of vision goes to your right hemisphere, and information from the right half of your visual field goes to your left hemisphere, which usually controls speech. (Note, however, that each eye receives sensory information from both the right and left visual fields.) Data received by either hemisphere are quickly transmitted to the other across the corpus callosum. In a person with a severed corpus callosum, this information-sharing does not take place.

Knowing these facts, Sperry and Gazzaniga could send information to a patient's left or right hemisphere. As the person stared at a spot, they flashed a stimulus to its right or left. They could do this with you, too, but in your intact brain, the hemisphere receiving the information would instantly pass the news to the other side. Because the split-brain surgery had cut the communication lines between the hemispheres, the researchers could, with these patients, quiz each hemisphere separately.

In an early experiment, Gazzaniga (1967) asked these people to stare at a dot as he flashed HE·ART on a screen (**FIGURE 13.3** on the next page). Thus, HE appeared in their left visual field (which transmits to the right hemisphere) and ART in the right field (which transmits to the left hemisphere). When he then asked them to *say* what they had seen, the patients reported that they had seen ART. But when asked to *point* to the word they had seen, they were startled when their left hand (controlled by the right hemisphere) pointed to HE. Given an opportunity to express itself, each hemisphere reported what it had seen. The right hemisphere (controlling the left hand) intuitively knew what it could not verbally report.

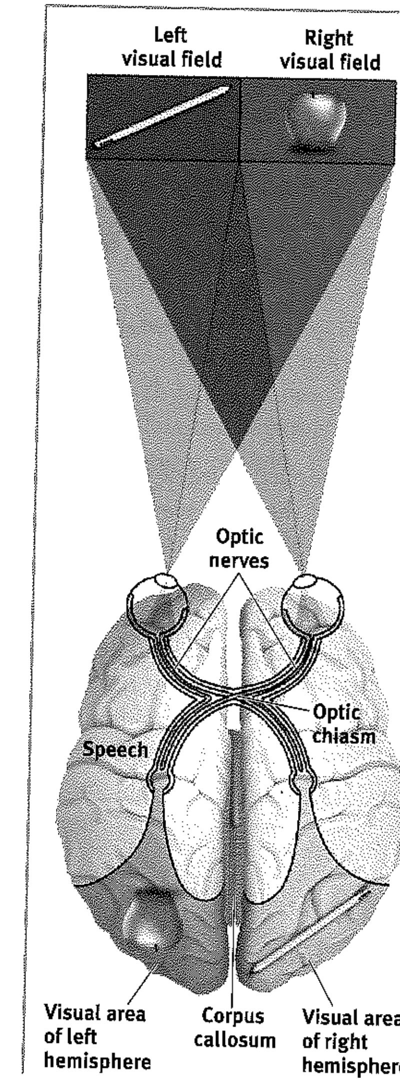


Figure 13.2
The information highway from eye to brain

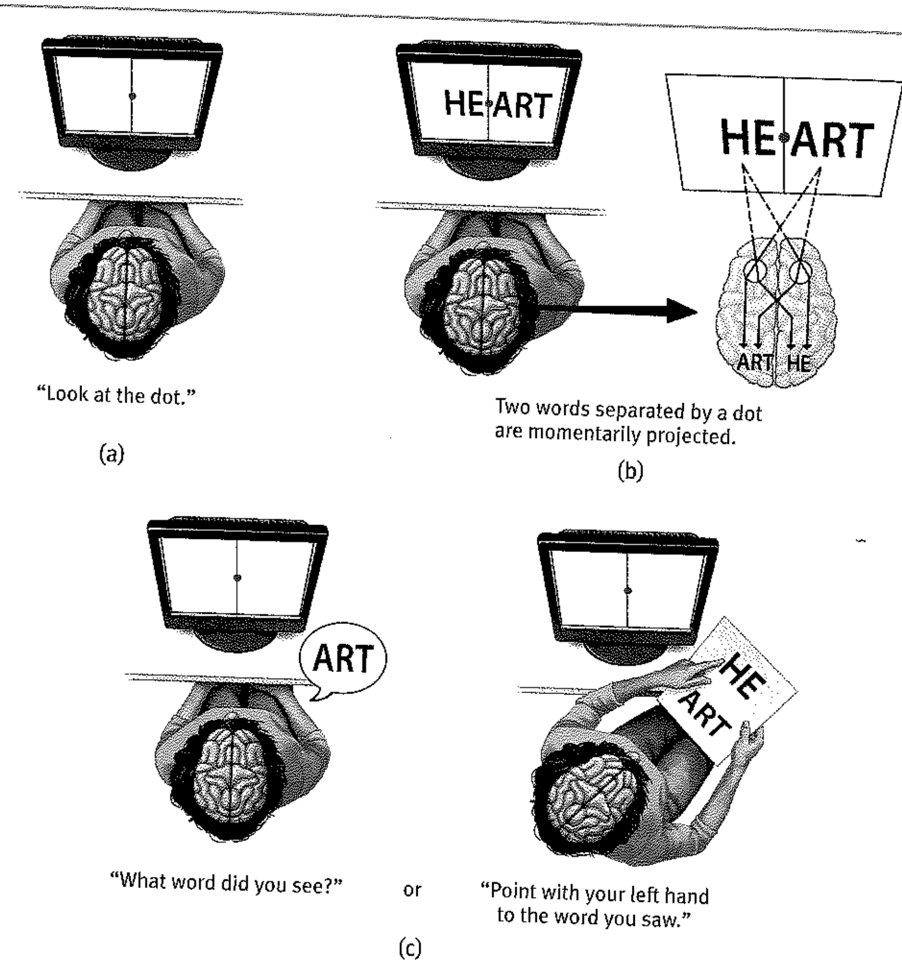


Figure 13.3
Testing the divided brain When an experimenter flashes the word HEART across the visual field, a woman with a split brain reports seeing the portion of the word transmitted to her left hemisphere. However, if asked to indicate with her left hand what she saw, she points to the portion of the word transmitted to her right hemisphere. (From Gazzaniga, 1983.)

When a picture of a spoon was flashed to their right hemisphere, the patients could not *say* what they had viewed. But when asked to *identify* what they had viewed by feeling an assortment of hidden objects with their left hand, they readily selected the spoon. If the experimenter said, "Correct!" the patient might reply, "What? Correct? How could I possibly pick out the correct object when I don't know what I saw?" It is, of course, the left hemisphere doing the talking here, bewildered by what the nonverbal right hemisphere knows.

"Do not let your left hand know what your right hand is doing."
-Matthew 6:3

A few people who have had split-brain surgery have been for a time bothered by the unruly independence of their left hand, which might unbutton a shirt while the right hand buttoned it, or put grocery store items back on the shelf after the right hand put them in the cart. It was as if each hemisphere was thinking "I've half a mind to wear my green (blue) shirt today." Indeed, said Sperry (1964), split-brain surgery leaves people "with two separate minds." With a split brain, both hemispheres can comprehend and follow an instruction to copy—*simultaneously*—different figures with the left and right hands (Franz et al., 2000; see also **FIGURE 13.4**). (Reading these reports, I fantasize a patient enjoying a solitary game of "rock, paper, scissors"—left versus right hand.)

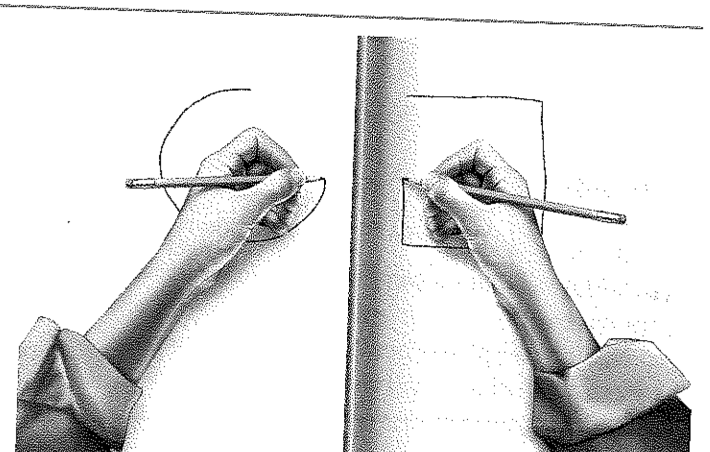


Figure 13.4
Try this! A person who has undergone split-brain surgery can simultaneously draw two different shapes.

When the "two minds" are at odds, the left hemisphere does mental gymnastics to rationalize reactions it does not understand. If a patient follows an order sent to the right hemisphere ("Walk"), a strange thing happens. Unaware of the order, the left hemisphere doesn't know why the patient begins walking. Yet, when asked why, the patient doesn't say "I don't know." Instead, the interpretive left hemisphere improvises—"I'm going into the house to get a Coke." Gazzaniga (1988), who considers these patients "the most fascinating people on earth," concluded that the conscious left hemisphere is an "interpreter" or press agent that instantly constructs theories to explain our behavior.

Right-Left Differences in the Intact Brain

So, what about the 99.99+ percent of us with undivided brains? Does each of *our* hemispheres also perform distinct functions? Several different types of studies indicate they do. When a person performs a *perceptual* task, for example, brain waves, bloodflow, and glucose consumption reveal increased activity in the *right* hemisphere. When the person speaks or calculates, activity increases in the *left* hemisphere.

AP® Exam Tip

Notice that David Myers never refers to your left brain or your right brain. You have two brain hemispheres, each with its own responsibilities, *but you only have one brain.* It's very misleading when the media refers to the left brain and the right brain, and this happens frequently.

A dramatic demonstration of hemispheric specialization happens before some types of brain surgery. To locate the patient's language centers, the surgeon injects a sedative into the neck artery feeding blood to the left hemisphere, which usually controls speech. Before the injection, the patient is lying down, arms in the air, chatting with the doctor. Can you predict what probably happens when the drug puts the left hemisphere to sleep? Within seconds, the person's right arm falls limp. If the left hemisphere is controlling language, the patient will be speechless until the drug wears off. If the drug is injected into the artery to the right hemisphere, the *left* arm will fall limp, but the person will still be able to speak.

To the brain, language is language, whether spoken or signed. Just as hearing people usually use the left hemisphere to process speech, deaf people use the left hemisphere to process sign language (Corina et al., 1992; Hickok et al., 2001). Thus, a left-hemisphere stroke disrupts a deaf person's signing, much as it would disrupt a hearing person's speaking. The same brain area is involved in both (Corina, 1998). (For more on how the brain enables language, see Module 36.)

Although the left hemisphere is adept at making quick, literal interpretations of language, the right hemisphere

- *excels in making inferences* (Beeman & Chiarello, 1998; Bowden & Beeman, 1998; Mason & Just, 2004). Primed with the flashed word *foot,* the left hemisphere will be especially quick to recognize the closely associated word *heel.* But if primed with *foot, cry,* and *glass,* the right hemisphere will more quickly recognize another word distantly related to all three *(cut).* And if given an insight-like problem—"What word goes with *boot, summer,* and *ground?"*—the right hemisphere more quickly than the left recognizes the solution: *camp.* As one patient explained after a right-hemisphere stroke, "I understand words, but I'm missing the subtleties."
- *helps us modulate our speech* to make meaning clear—as when we ask "What's that in the road ahead?" instead of "What's that in the road, a head?" (Heller, 1990).
- *helps orchestrate our sense of self.* People who suffer partial paralysis will sometimes obstinately deny their impairment—strangely claiming they can move a paralyzed limb—if the damage is to the right hemisphere (Berti et al., 2005).

Simply looking at the two hemispheres, so alike to the naked eye, who would suppose they contribute uniquely to the harmony of the whole? Yet a variety of observations—of people with split brains, of people with normal brains, and even of other species' brains—converge beautifully, leaving little doubt that we have unified brains with specialized parts (Hopkins & Cantalupo, 2008; MacNeilage et al., 2009; and see Close-up: Handedness on the next page).

Close-up

Handedness

Nearly 90 percent of us are primarily right-handed (Leask & Beaton, 2007; Medland et al., 2004; Peters et al., 2006). Some 10 percent of us (somewhat more among males, somewhat less among females) are left-handed. (A few people write with their right hand and throw a ball with their left, or vice versa.) Almost all right-handers (96 percent) process speech primarily in the left hemisphere, which tends to be the slightly larger hemisphere (Hopkins, 2006). Left-handers are more diverse. Seven in ten process speech in the left hemisphere, as right-handers do. The rest either process language in the right hemisphere or use both hemispheres.

IS HANDEDNESS INHERITED?

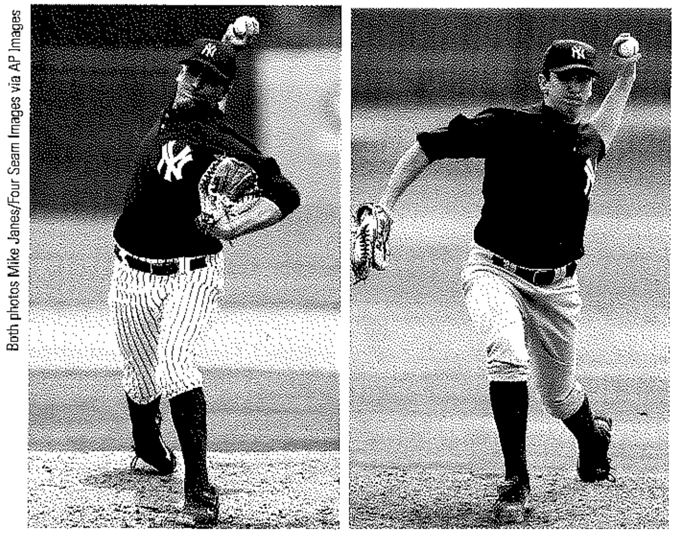
Judging from prehistoric human cave drawings, tools, and hand and arm bones, this veer to the right occurred long ago (Corballis, 1989; MacNeilage et al., 2009). Right-handedness prevails in all human cultures, and even in monkeys and apes. Moreover, it appears prior to culture's impact: More than 9 in 10 fetuses suck the right hand's thumb (Hepper et al., 1990, 2004). Twin studies indicate only a small genetic influence on individual handedness (Vuoksimaa et al., 2009). But the universal prevalence of right-handers in humans and other primates suggests that either genes or some prenatal factors influence handedness.

Most people also kick with their right foot, look through a microscope with their right eye, and (had you noticed?) kiss the right way—with their head tilted right (Güntürkün, 2003).

SO, IS IT ALL RIGHT TO BE LEFT-HANDED?

Judging by our everyday conversation, left-handedness is not all right. To be "coming out of left field" is hardly better than to be "gauche" (derived from the French word for "left"). On the other hand, right-handedness is "right on," which any "righteous," "right-hand man" "in his right mind" usually is.

Left-handers are more numerous than usual among those with reading disabilities, allergies, and migraine headaches (Geschwind & Behan, 1984). But in Iran, where students report which hand they write with when taking the university entrance exam, lefties have outperformed righties in all subjects (Noroozian et al., 2003). Left-handedness is also more common among musicians, mathematicians, professional baseball and cricket players, architects, and artists, including such luminaries as Michelangelo, Leonardo da Vinci, and Picasso.[1] Although left-handers must tolerate elbow jostling at the dinner table, right-handed desks, and awkward scissors, the pros and cons of being a lefty seem roughly equal.



Both photos Mike Janes/Four Seam Images via AP Images

The rarest of baseball players: an ambidextrous pitcher Using a glove with two thumbs, Minor League New York Yankees pitcher Pat Venditte, shown here in 2012, pitches to right-handed batters with his right hand, then switches to face left-handed batters with his left hand. During his college career at Creighton University, after one switch-hitter switched sides of the plate, Venditte switched pitching arms, which triggered the batter to switch again, and so on. The umpires ultimately ended the comedy routine by applying a little-known rule: A pitcher must declare which arm he will use before throwing his first pitch to a batter (Schwarz, 2007).

[1] Strategic factors explain the higher-than-normal percentage of lefties in sports. For example, it helps a soccer team to have left-footed players on the left side of the field (Wood & Aggleton, 1989). In golf, however, no left-hander won the Masters tournament until Canadian Mike Weir did so in 2003.

The Biology of Consciousness

13-2 What is the "dual processing" being revealed by today's cognitive neuroscience?

consciousness our awareness of ourselves and our environment.

Today's science explores the biology of **consciousness.** Evolutionary psychologists speculate that consciousness must offer a reproductive advantage (Barash, 2006). Consciousness helps us act in our long-term interests (by considering consequences) rather than merely seeking short-term pleasure and avoiding pain. Consciousness also promotes our survival by anticipating how we seem to others and helping us read their minds: "He looks really angry! I'd better run!"

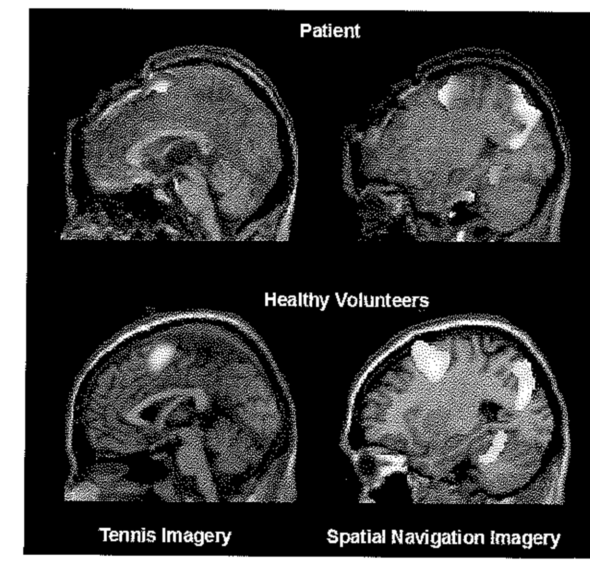
Such explanations still leave us with the "hard problem": How do brain cells jabbering to one another create our awareness of the taste of a taco, the idea of infinity, the feeling of fright? Today's scientists are pursuing answers.

Cognitive Neuroscience

cognitive neuroscience the interdisciplinary study of the brain activity linked with cognition (including perception, thinking, memory, and language).

Scientists assume, in the words of neuroscientist Marvin Minsky (1986, p. 287), that "the mind is what the brain does." We just don't know *how* it does it. Even with all the world's chemicals, computer chips, and energy, we still don't have a clue *how* to make a conscious robot. Yet today's **cognitive neuroscience**—the interdisciplinary study of the brain activity linked with our mental processes—is taking the first small step by relating specific brain states to conscious experiences.

A stunning demonstration of consciousness appeared in brain scans of a noncommunicative patient—a 23-year-old woman who had been in a car accident and showed no outward signs of conscious awareness (Owen et al., 2006). When researchers asked her to *imagine* playing tennis, fMRI scans revealed brain activity in a brain area that normally controls arm and leg movements (**FIGURE 13.5**). Even in a motionless body, the researchers concluded, the brain—and the mind—may still be active. A follow-up study of 22 other "vegetative" patients revealed 3 more who also showed meaningful brain responses to questions (Monti et al., 2010).



Courtesy of Adrian M. Owen, The Brain and Mind Institute, Western University

Figure 13.5
Evidence of awareness? When asked to imagine playing tennis or navigating through her home, a vegetative patient's brain (top) exhibited activity similar to a healthy person's brain (bottom). Researchers wonder if such fMRI scans might enable a "conversation" with some unresponsive patients, by instructing them, for example, to answer *yes* to a question by imagining playing tennis and *no* by imagining walking around their home.

Many cognitive neuroscientists are exploring and mapping the conscious functions of the cortex. Based on your cortical activation patterns, they can now, in limited ways, read your mind (Bor, 2010). They can, for example, tell which of 10 similar objects (hammer, drill, and so forth) you are viewing (Shinkareva et al., 2008).

Despite such advances, much disagreement remains. One view sees conscious experiences as produced by the synchronized activity across the brain (Gaillard et al., 2009; Koch & Greenfield, 2007; Schurger et al., 2010). If a stimulus activates enough brainwide coordinated neural activity—with strong signals in one brain area triggering activity elsewhere—it crosses a threshold for consciousness. A weaker stimulus—perhaps a word flashed too briefly to consciously perceive—may trigger localized visual cortex activity that quickly dies out. A stronger stimulus will engage other brain areas, such as those involved with language, attention, and memory. Such reverberating activity (detected by brain scans) is a telltale sign of conscious awareness. How the synchronized activity produces awareness—how matter makes mind—remains a mystery.

Dual Processing: The Two-Track Mind

Many cognitive neuroscience discoveries tell us of a particular brain region (such as the visual cortex mentioned above) that becomes active with a particular conscious experience. Such findings strike many people as interesting but not mind-blowing. (If everything psychological is simultaneously biological, then our ideas, emotions, and spirituality must all, somehow, be embodied.) What *is* mind-blowing to many of us is the growing evidence that we have, so to speak, two minds, each supported by its own neural equipment.

AP® Exam Tip
Dual processing is another one of those big ideas that shows up in several units. Pay attention!

At any moment, you and I are aware of little more than what's on the screen of our consciousness. But beneath the surface, unconscious information processing occurs simultaneously on many parallel tracks. When we look at a bird flying, we are consciously aware of the result of our cognitive processing ("It's a hummingbird!") but not of our subprocessing of the bird's color, form, movement, and distance. One of the grand ideas of recent cognitive neuroscience is that much of our brain work occurs off stage, out of sight. Perception, memory, thinking, language, and attitudes all operate on two levels—a conscious, deliberate

dual processing the principle that information is often simultaneously processed on separate conscious and unconscious tracks.

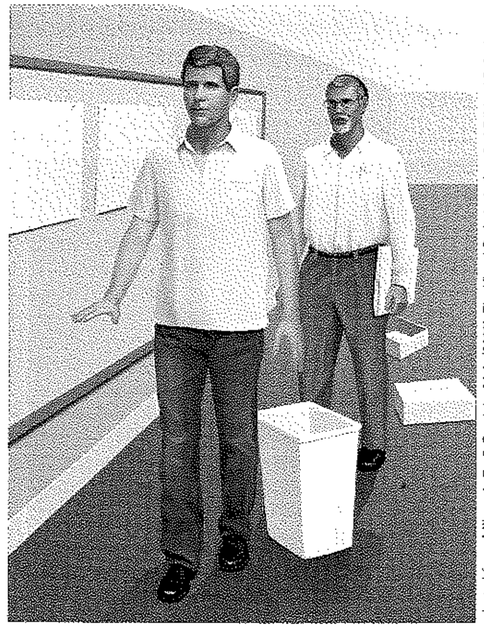
"high road" and an unconscious, automatic "low road." Today's researchers call this **dual processing.** We know more than we know we know.

Sometimes science confirms widely held beliefs. Other times, as this next story illustrates, science is stranger than science fiction.

During my sojourns at Scotland's University of St. Andrews, I came to know cognitive neuroscientists David Milner and Melvyn Goodale (2008). When overcome by carbon monoxide, a local woman, whom they call D. F., suffered brain damage that left her unable to recognize and discriminate objects visually. Consciously she could see nothing. Yet she exhibited *blindsight*—she would act as if she could see. Asked to slip a postcard into a vertical or horizontal mail slot, she could do so without error. Although unable to report the width of a block in front of her, she could grasp it with just the right finger-thumb distance. If you were to experience temporary blindness (with magnetic pulses to your brain's primary visual cortex area) this, too, would create blindsight—as you correctly guess the color or orientation of an object that you cannot consciously see (Boyer et al., 2005).

How could this be? Don't we have one visual system? Goodale and Milner knew from animal research that the eye sends information simultaneously to different brain areas, which support different tasks (Weiskrantz, 2009, 2010). Sure enough, a scan of D. F.'s brain activity revealed normal activity in the area concerned with reaching for, grasping, and navigating objects, but damage in the area concerned with consciously recognizing objects. (See another example in **FIGURE 13.6.**)

So, would the reverse damage lead to the opposite symptoms? Indeed, there are a few such patients—who can see and recognize objects but have difficulty pointing toward or grasping them.



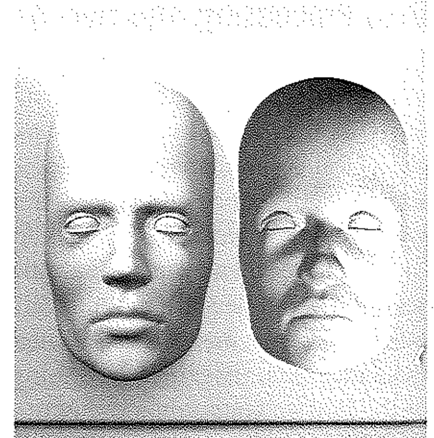
adapted from: Milner, A. D., & Goodale, M.A. (2006). The Visual Brain in Action. 2nd Edition/ Oxford: Oxford University Press, 297 pp. (paperback 2006)

Figure 13.6
When the blind can "see" In a compelling demonstration of blindsight and the two-track mind, a researcher trails a blindsight patient down a cluttered hallway. Although told the hallway was empty, the patient meandered around all the obstacles without any awareness of them.

How strangely intricate is this thing we call vision, conclude Goodale and Milner in their aptly titled book, *Sight Unseen.* We may think of our vision as one system controlling our visually guided actions, but it is actually a dual-processing system. A *visual perception track* enables us "to think about the world"—to recognize things and to plan future actions. A *visual action track* guides our moment-to-moment movements.

On rare occasions, the two conflict. Shown the *hollow face illusion,* people will mistakenly perceive the inside of a mask as a protruding face (**FIGURE 13.7**). Yet they will unhesitatingly and accurately reach into the inverted mask to flick off a buglike target stuck on the face (Króliczak et al., 2006). What their conscious mind doesn't know, their hand does.

Figure 13.7
The hollow face illusion We tend to see an illusory protruding face even on an inverted mask (right). Yet research participants will accurately reach for a speck on the face inside the inverted mask, suggesting that our unconscious mind seems to know the truth of the illusion.



David Mack/Science Source

Another patient, who lost all his left visual cortex—leaving him blind to objects presented on the right side of his field of vision—can nevertheless sense the emotion expressed in faces he does not consciously perceive (De Gelder, 2010). The same is true of normally sighted people whose visual cortex has been disabled with magnetic stimulation. This suggests that brain areas below the cortex are processing emotion-related information.

People often have trouble accepting that much of our everyday thinking, feeling, and acting operates outside our conscious awareness (Bargh & Chartrand, 1999). We are understandably biased to believe that our intentions and deliberate choices rule our lives. But consciousness, though enabling us to exert voluntary control and to communicate our mental states to others, is but the tip of the information-processing iceberg. Being intensely focused on an activity (such as reading this module, I'd love to think) increases your total brain activity no more than 5 percent above its baseline rate. And even when you rest, "hubs of dark energy" are whirling inside your head (Raichle, 2010).

Experiments show that when you move your wrist at will, you consciously experience the decision to move it about 0.2 seconds before the actual movement (Libet, 1985, 2004). No surprise there. But your brain waves jump about 0.35 seconds before you consciously perceive your decision to move (**FIGURE 13.8**)! This readiness potential has enabled researchers (using fMRI brain scans) to predict—with 60 percent accuracy and up to 7 seconds ahead—participants' decisions to press a button with their left or right finger (Soon et al., 2008). The startling conclusion: Consciousness sometimes arrives late to the decision-making party.

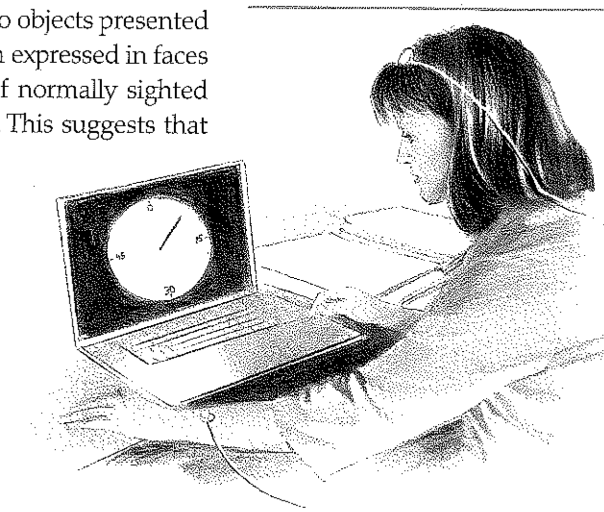


Figure 13.8
Is the brain ahead of the mind? In this study, volunteers watched a computer clock sweep through a full revolution every 2.56 seconds. They noted the time at which they decided to move their wrist. About one-third of a second before that decision, their brain-wave activity jumped, indicating a *readiness potential* to move. Watching a slow-motion replay, the researchers were able to predict when a person was about to decide to move (following which, the wrist did move) (Libet, 1985, 2004). Other researchers, however, question the clock measurement procedure (Miller et al., 2011).

Running on automatic pilot allows our consciousness—our mind's CEO—to monitor the whole system and deal with new challenges, while neural assistants automatically take care of routine business. Walking the familiar path to your next class, your feet do the work while your mind rehearses the presentation you're about to give. A skilled tennis player's brain and body respond automatically to an oncoming serve before becoming consciously aware of the ball's trajectory (which takes about three-tenths of a second). Ditto for other skilled athletes, for whom action precedes awareness. *The bottom line:* In everyday life, we mostly function like an automatic point-and-shoot camera, but with a manual (conscious) override.

Our unconscious parallel processing is faster than sequential conscious processing, but both are essential. Sequential processing is skilled at solving new problems, which require our focused attention. Try this: If you are right-handed, you can move your right foot in a smooth counterclockwise circle, and you can write the number 3 repeatedly with your right hand—but probably not at the same time. (Try something equally difficult: Tap a steady beat three times with your left hand while tapping four times with your right hand.) Both tasks require conscious attention, which can be in only one place at a time. If time is nature's way of keeping everything from happening at once, then consciousness is nature's way of keeping us from thinking and doing everything at once.

Before You Move On

▶ **ASK YOURSELF**

What are some examples of things you do on "automatic pilot"? What behaviors require your conscious attention?

▶ **TEST YOURSELF**

What are the mind's two tracks, and what is "dual processing"?

Answers to the Test Yourself questions can be found in Appendix E at the end of the book.

Module 13 Review

13-1 What do split brains reveal about the functions of our two brain hemispheres?

- *Split-brain* research (experiments on people with a severed *corpus callosum*) has confirmed that in most people, the left hemisphere is the more verbal, and that the right hemisphere excels in visual perception and the recognition of emotion.
- Studies of healthy people with intact brains confirm that each hemisphere makes unique contributions to the integrated functioning of the brain.

13-2 What is the "dual processing" being revealed by today's cognitive neuroscience?

- *Cognitive neuroscientists* and others studying the brain mechanisms underlying consciousness and cognition have discovered that the mind processes information on two separate tracks, one operating at an explicit, conscious level and the other at an implicit, unconscious level. This *dual processing* affects our perception, memory, attitudes, and other cognitions.

Multiple-Choice Questions

1. A split-brain patient has a picture of a dog flashed to his right hemisphere and a cat to his left hemisphere. He will be able to identify the

a. cat using his right hand.
b. dog using his right hand.
c. dog using either hand.
d. cat using either hand.
e. cat using his left hand.

2. You are aware that a dog is viciously barking at you, but you are not aware of the type of dog. Later, you are able to describe the type and color of the dog. This ability to process information without conscious awareness best exemplifies which of the following?

a. Split brain
b. Blindsight
c. Consciousness
d. Cognitive neuroscience
e. Dual processing

3. Which of the following is most likely to be a function of the left hemisphere?

a. Speech
b. Evaluating perceptual tasks
c. Making inferences
d. Identifying emotion in other people's faces
e. Identifying one's sense of self

4. The dual-processing model refers to which of the following ideas?

a. The right and left hemispheres of the brain both process incoming messages.
b. Incoming information is processed by both conscious and unconscious tracks.
c. Each lobe of the brain processes incoming information.
d. The brain first processes emotional information and then processes analytical information.
e. The thalamus and hypothalamus work together to analyze incoming sensory information.

Practice FRQs

1. Brain lateralization means that each hemisphere has its own functions. Give an example of both a left hemisphere and a right hemisphere function. Then explain how the two hemispheres communicate with one another.

Answer

1 point: Left hemisphere functions include language, math, and logic.

1 point: Right hemisphere functions include spatial relationships, facial recognition, and patterns.

1 point: The corpus callosum carries information back and forth between the two hemispheres.

2. Because Jerry suffered severe seizures, his neurosurgeon decided to "split his brain." What does this mean? How might a psychologist use people who have had split-brain surgery to determine the location of speech control?

(3 points)

Module 14

Behavior Genetics: Predicting Individual Differences

Michael Tullberg/Getty Images

Module Learning Objectives

14-1 Define *genes*, and describe how behavior geneticists explain our individual differences.

14-2 Identify the potential uses of molecular genetics research.

14-3 Explain what is meant by heritability, and discuss how it relates to individuals and groups.

14-4 Discuss the interaction of heredity and environment.

Behind the story of our human brain—surely the most awesome thing on Earth—is the essence of our universal human attributes and our individual traits. What makes you *you?* In important ways, we are each unique. We look different. We sound different. We have varying personalities, interests, and cultural and family backgrounds.

We are also the leaves of one tree. Our human family shares not only a common biological heritage—cut us and we bleed—but also common behavioral tendencies. Our shared brain architecture predisposes us to sense the world, develop language, and feel hunger through identical mechanisms. Whether we live in the Arctic or the tropics, we prefer sweet tastes to sour. We divide the color spectrum into similar colors. And we feel drawn to behaviors that produce and protect offspring.

Our kinship appears in our social behaviors as well. Whether named Wong, Nkomo, Smith, or Gonzales, we start fearing strangers at about eight months, and as adults we prefer the company of those with attitudes and attributes similar to our own. Coming from different parts of the globe, we know how to read one another's smiles and frowns. As members of one species, we affiliate, conform, return favors, punish offenses, organize hierarchies of status, and grieve a child's death. A visitor from outer space could drop in anywhere and find humans dancing and feasting, singing and worshipping, playing sports and games, laughing and crying, living in families and forming groups. Taken together, such universal behaviors define our human nature.

What causes our striking diversity, and also our shared human nature? How much are human differences shaped by our differing genes? And how much by our *environment*—by every external influence, from maternal nutrition while in the womb to social support while nearing the tomb? To what extent are we formed by our upbringing? By our culture? By our current circumstances? By people's reactions to our genetic dispositions? This module and the next begin to tell the complex story of how our genes (nature) and environments (nurture) define us.

Courtesy of Kevin Feyen

The nurture of nature Parents everywhere wonder: Will my baby grow up to be peaceful or aggressive? Homely or attractive? Successful or struggling at every step? What comes built in, and what is nurtured—and how? Research reveals that nature and nurture together shape our development—every step of the way.