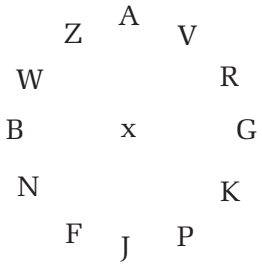
MODULE 14.3

# Consciousness and Attention

In Chapter 1, we considered the mind–body problem: In a universe composed of matter and energy, why is there such a thing as consciousness? And how does it relate to the brain? These questions may or may not be answerable, and consciousness may or may not turn out to be a scientifically useful concept. However, at this point, let's consider some attempts to study consciousness scientifically. Even if we can't answer the deepest questions, we can at least deal with a few of the subordinate issues.

Consciousness is difficult to define, but for practical purposes, researchers use this operational definition: If a cooperative person reports the presence of one stimulus and cannot report the presence of a second stimulus, then he or she was **conscious** of the first and not of the second. This definition does not apply (one way or the other) to individuals who cannot speak—such as infants, people with Broca's aphasia, or nonhuman animals. We might draw inferences about their consciousness based on other criteria, but we won't use them for research on consciousness.

By this definition, consciousness is almost synonymous with attention. At any moment, a huge number of stimuli reach your brain, but you are conscious of (i.e., able to report) only those to which you direct your attention. Various stimuli compete for your conscious attention (Dehaene & Changeux, 2004). A stimulus can grab your attention by its size, brightness, or movement, but you can also voluntarily direct your attention to one stimulus or another in what is called a "top-down" process—that is, one governed by other cortical areas, principally the prefrontal and parietal cortex (Buschman & Miller, 2007; Rossi, Bichot, Desimone, & Ungerleider, 2007). To illustrate, keep your eyes fixated on the central *x* in the following display. Then attend to the G at the right and step by step shift your attention clockwise around the circle. Notice how you can indeed see different parts of the circle without moving your eyes.




Psychologists have noted the phenomenon of **inattentional blindness** or *change blindness*: Of all that your eyes see at any instant, you are conscious of only those few to which you direct your attention (Huang, Treisman, & Pashler, 2007). If you observe a complex scene, and something in it changes slowly, or changes while you blink your eyes, there is a fairly high chance that you will not notice it (Henderson & Hollingworth, 2003; Rensink, O'Regan, & Clark, 1997). You would notice it, however, if you were paying attention to the particular item that was changing. You can experience this phenomenon with the Online Try It Yourself exercise "Change Blindness."

TRY IT YOURSELF ONLINE

## Brain Activity Associated With Consciousness

Although we don't have even a good hypothesis about *why* brain activity is (sometimes) conscious, we might be able to discover which types of brain activity are conscious (Crick & Koch, 2004). The ideal design is to present a single stimulus, such as a light or sound, that becomes conscious on some occasions but not others. Then determine in what way the brain activity differed between the occasions with and without consciousness.

One clever study used this approach: Researchers flashed a word on a screen for 29 milliseconds (ms). In some cases, it was preceded and followed by a blank screen:


In these cases, people identified the word almost 90% of the time. In other cases, however, the researchers flashed a word for the same 29 ms but preceded and followed it with a masking pattern:

Under these conditions, people almost never identify the word and usually say they didn't see any word at all. Although the physical stimulus was the same in both cases—a word flashed for 29 ms—people were conscious of it in the first case but not the second. Using fMRI and evoked potentials, the researchers found that the stimulus initially activated the primary visual cortex for both the conscious and unconscious conditions but activated it more strongly in the conscious condition (because of less interference). Also, in the conscious condition, the activity spread to several additional areas (Dehaene et al., 2001).

These data imply that consciousness of a stimulus depends on the amount of brain activity. Becoming conscious of something means that its information has taken over more of your brain's activity. What is the current sensation in your left foot? Chances are, before you read this question, you were not conscious of *any* sensation in your left foot. When you directed your attention to your foot, activity increased in the corresponding part of the somatosensory cortex (Lambie & Marcel, 2002). Similarly, when you direct your attention to some visual stimulus, your brain's response to that stimulus increases, while responses to other stimuli decrease (Kamitani & Tong, 2005; Wegener, Freiwald, & Kreiter, 2004). If you are told to pay attention to color or motion, activity increases in the areas of your visual cortex responsible for color or motion perception (Chawla, Rees, & Friston, 1999); in fact, they increase even before the stimulus (Driver & Frith, 2000). Somehow, the instructions prime those areas to magnify their responses.

Further studies found that a conscious stimulus also induces precise synchrony of responses in neurons over various areas of the brain (Eckhorn et al., 1988; Gray, König, Engel, & Singer, 1989; Melloni et al., 2006; Womelsdorf et al., 2007). Synchrony also emerges when people recognize a pattern. When people look at an ambiguous pattern and see a face in it, synchronized patterns occur in widespread areas of the brain. When people look at the same pattern but fail to see the face, that synchrony does not occur (Roelfsema, Engel, König, & Singer, 1997; Roelfsema, Lamme, & Spekreijse, 2004).

**STOP & CHECK**

**17.** In the experiment by Dehaene et al., how were the conscious and unconscious stimuli similar? How were they different?

**18.** In this experiment, how did the brain's responses differ to the conscious and unconscious stimuli?

**ANSWERS**

**17.** The conscious and unconscious stimuli were physically the same (a word flashed on the screen for 29 ms). The difference was that a stimulus did not become conscious if it was preceded and followed by an interfering pattern. **18.** If a stimulus became conscious, it activated the same brain areas as an unconscious stimulus but more strongly, and then the activity spread to additional areas. Also, brain responses become synchronized when a pattern is conscious.

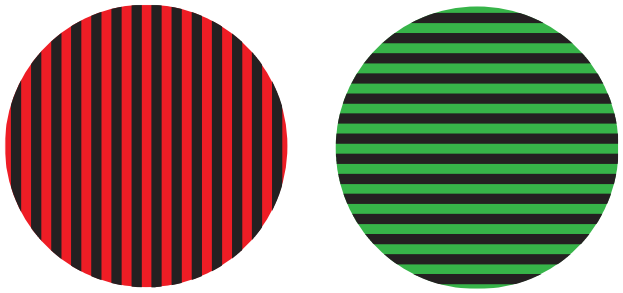


**Figure 14.17 Binocular rivalry**
If possible, look at the two parts through tubes, such as those from the inside of rolls of toilet paper or paper towels. Otherwise, touch your nose to the paper between the two parts so that your left eye sees one pattern while your right eye sees the other. The two views will compete for your consciousness, and your perception will alternate between them.

**TRY IT YOURSELF**

Here is a second kind of research. Look at Figure 14.17, but hold it so close to your eyes that your nose touches the page, right between the two circles. Better yet, look at the two parts through a pair of tubes, such as the tubes inside rolls of paper towels or toilet paper. You will see red and black vertical lines with your left eye and green and black horizontal lines with your right eye. (Close one eye and then the other to make sure you see completely different patterns with the two eyes.) Seeing something is closely related to seeing *where* it is, and the red vertical lines cannot be in the same place as the green horizontal lines. Because your brain cannot perceive both patterns in the same location, your perception alternates. For a while, you see the red and black lines, and then gradually, the green and black invade your consciousness. Then your perception shifts back to the red and black. For the average person, each perception lasts about 2 seconds before switching to the other, but some people switch faster or slower. Sometimes, you will see red lines in part of the visual field and green lines in the other. These shifts, known as **binocular rivalry,** are slow and gradual, sweeping from one side to another. The stimulus seen by each eye evokes a particular pattern of brain response, which researchers can measure with fMRI or similar methods. As that first perception fades and the stimulus seen by the other eye replaces it, the first pattern of brain activity fades also, and a different pattern of activity replaces it. Each shift in perception is accompanied by a shift in the pattern of activity over a large portion of the brain (Lee, Blake, & Heeger, 2005).

Both the red–black and green–black patterns you just experienced were stationary. To make the brain responses easier to monitor, researchers presented to one eye a stationary stimulus and to the other eye a pattern that pulsated in size and brightness, as shown in Figure 14.18. Then they recorded brain activity in several areas. At times when people reported consciousness of the pulsating stimulus, pulsating activity at the same rhythm was prominent in much of the brain, as

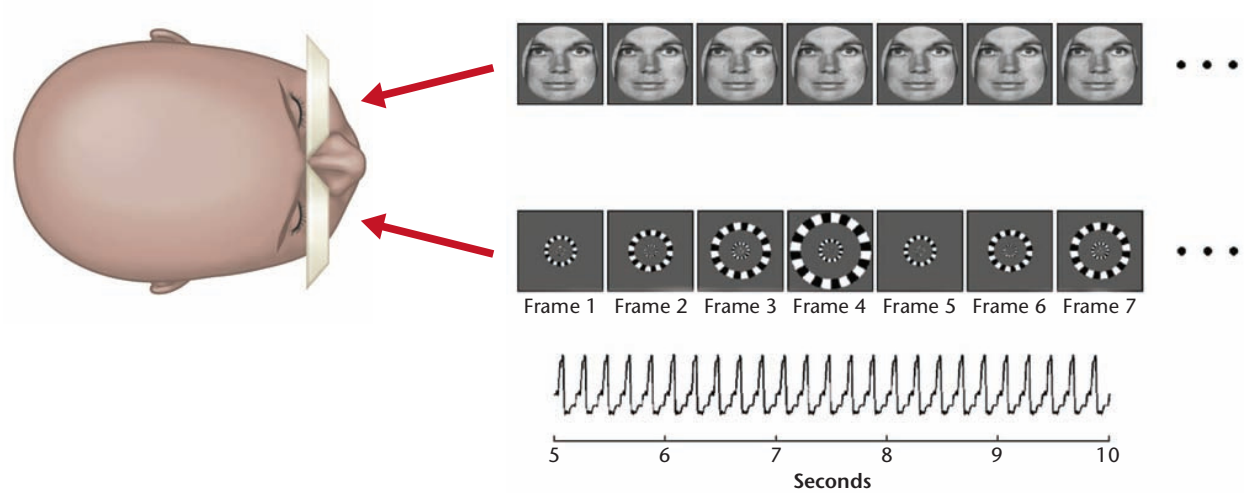



**Figure 14.18 Stimuli for a study of binocular rivalry**
The pattern in one eye was stationary. The one in the other eye pulsated a few times per second. Researchers could then examine brain activity to find cells that followed the rhythm of the stimulus. *(Reprinted from* NeuroImage, 23/1, *Cosmelli et al. "Waves of consciousness: Ongoing cortical patterns during binocular rivalry," 128–140, 2004, with permission from Elsevier.)*

shown in Figure 14.19. When people reported consciousness of the stationary stimulus, the pulsating activity was weak (Cosmelli et al., 2004). Again, the conclusion is that a conscious stimulus strongly activates much of the brain, virtually taking over brain activity. When the same stimulus is unconscious, it produces weaker and less widespread activity.

**STOP & CHECK**

**19.** How could someone use fMRI to determine which of two patterns in binocular rivalry is conscious at a given moment?

**ANSWER** **19.** Make one stimulus pulsate at a given rhythm and look for brain areas showing that rhythm of activity. The rhythm takes over widespread areas of the brain when that pattern is conscious.

## Consciousness as a Threshold Phenomenon

In binocular rivalry, you might be aware of one pattern in one part of the visual field and another pattern in another part, but each point in the visual field sees just one or the other. Is that a general principle, or do occasions arise when you are "partly" conscious of one stimulus and partly conscious of another? Does consciousness come in degrees?

This is not an easy question to answer, but one study suggests that consciousness is a yes–no phenomenon. Researchers flashed blurry words on a screen for brief fractions of a second and asked people to identify each word, if possible, and rate *how* conscious they were of the word on a scale from 0 to 100. People almost always rated a word either 0 or 100. They almost never said they were partly conscious of something (Sergent & Dehaene, 2004). These results suggest that consciousness is a threshold phenomenon. When a stimulus

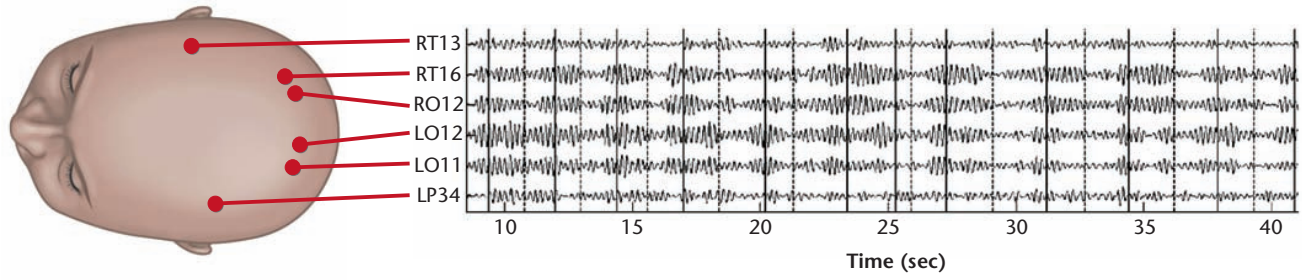



**Figure 14.19 Brain activity during binocular rivalry**
When the person reported seeing the pulsating stimulus, neurons throughout much of the brain responded vigorously at the same rhythm as the stimulus. When the person reported the stationary stimulus, the rhythmic activity was subdued. *(Reprinted from* NeuroImage, 23/1, *Cosmelli et al., "Waves of consciousness: Ongoing cortical patterns during binocular rivalry," 128–140, 2004, with permission from Elsevier.)*

activates enough neurons to a sufficient extent, the activity reverberates, magnifies, and extends over much of the brain. If a stimulus fails to reach that level, the pattern fades away.

## The Fate of an Unattended Stimulus

Consider again the phenomenon of binocular rivalry. While you are attending to, say, the green and black stimulus, your brain does not completely discard information from the red and black stimulus in your other eye. Certainly, if a bright stimulus suddenly flashed in that eye, it would capture your attention. More interestingly, suppose a word fades onto the screen slowly, and you are to report the time at which your attention shifts to the previously unattended eye. The newly appearing word will capture your attention, causing you to shift your attention faster than you would have otherwise. Moreover, if it is a word from your own language, or better yet your own name, it captures your attention faster than if it were a word from some language you do not understand, using some other alphabet (Jiang, Costello, & He, 2007). If a meaningful stimulus captures your attention faster than a meaningless stimulus, somehow your brain had to know it was meaningful *before* it became conscious!

Numerous other studies also show subtle effects on behavior by unconscious stimuli. In one study, a signal flashed on a screen for 50 ms or less, surrounded by interfering stimuli, indicating how much money a person could win by a handgrip response after a second, easily perceived stimulus. Under these conditions, people showed no conscious perception of the stimulus. However, on the average, they made a more vigorous handgrip response after a signal indicating a larger possible payoff (Pessiglione et al., 2007). In another study, people saw one stimulus in one eye and an incompatible stimulus in the other eye (binocular rivalry) for just half a second. With such a brief presentation, people almost always reported conscious perception of just one stimulus or the other. However, if one of the stimuli was a face with an emotional expression, people responded emotionally even on trials when they were not conscious of seeing the face (M. A. Williams, Morris, McGlone, Abbott, & Mattingley, 2004). Figure 14.20 shows the stimuli. The conclusion is that much of brain activity is unconscious, and even unconscious activity can influence behavior in at least subtle ways.

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**Figure 14.20 Stimuli to test unconscious arousal of the amygdala**
People wore filters so that one eye saw the green picture and the other eye saw the red picture. Here the green pictures are houses and the red ones are faces with emotional expressions; in other cases, green and red were reversed. *(Reprinted with permission from "Amygdala responses to fearful and happy facial expressions under conditions of binocular suppression," by M. A. Williams et al., Journal of Neuroscience, 24, 2898–2904. Copyright 2004 by the Society for Neuroscience.)*

**STOP & CHECK**

**20.** If someone is aware of the stimulus on the right in a case of binocular rivalry, what evidence indicates that the brain is also processing the stimulus on the left?

**ANSWER**

**20.** If a stimulus gradually appears on the left side, attention shifts to the left faster if that stimulus is a meaningful word than if it is a word from an unfamiliar language.

# The Timing of Consciousness

Are you conscious of events instant by instant as they happen? It certainly seems that way, but if there were a delay between an event and your consciousness of it, how would you know?

Consider the **phi phenomenon**, which perceptual researchers noted long ago: If you see a dot in one position, alternating with a similar dot nearby, it will seem to you that the dot is moving back and forth. Considering just the simplest case, imagine what happens if you see a dot moving from one position to another: • → •. You see a dot in one position, you see it move, and you see it in the second position. Okay, but *when* did you see it move? When you saw it in the first position, you didn't know it was going to appear in the second position. You could not perceive it as moving until *after* it appeared in the second position. Evidently, you perceived it as moving from one position to the second after it appeared in the second position! In other words, the second position caused a change in your perception of what occurred before it.

Another example: Suppose you hear a recorded word that is carefully engineered to sound halfway between *dent* and *tent*. We'll call it **ent*. If you hear it in the phrase "*ent in the fender," it sounds like *dent*. If you hear it in the phrase "*ent in the forest," it sounds like *tent*. That is, later words changed what you heard before them (Connine, Blasko, & Hall, 1991).

**STOP & CHECK**

**21.** In what way does the phi phenomenon imply that a new stimulus sometimes changes consciousness of what went before it?

**ANSWER**

**21.** Someone who sees a dot on the left and then a dot on the right perceives the dot as moving from left to right. The perceived movement would have occurred before the dot on the right, but the person had no reason to infer that movement until after the dot appeared on the right.

# Neglect

People sometimes perceive their body or surroundings inaccurately. These phenomena are interesting in their own right, as well as for their potential relevance to issues of consciousness and attention.

Many people with damage to parts of the right hemisphere show a widespread **spatial neglect**—a tendency to ignore the left side of the body or the left side of objects. (Damage in the left hemisphere seldom produces significant neglect of the right side.) They also generally ignore much of what they hear in the left ear and feel in the left hand, especially if they simultaneously feel something in the right hand. They may put clothes on only the right side of the body. However, all these results vary. Someone might show neglect in one situation and not another or at one time and not another (Buxbaum, 2006). The type of neglect depends on the location of damage. People with damage to the inferior part of the right parietal cortex tend to neglect everything to the left of their own body. People with damage to the superior temporal cortex neglect the left side of objects, regardless of their location (Hillis et al., 2005).

If asked to point "straight ahead," most patients with neglect point to the right of center. If a patient with neglect is shown a long horizontal line and asked to divide it in half, generally the person picks a spot well to the right of center, as if part of the left side wasn't there (Richard, Honoré, Bernati, & Rousseaux, 2004).

People with intact brains generally do not hit the center of the line but veer 2% to 3% to the left of center. Also, if they are asked to indicate a rating of something along a scale from left to right, they show a slight tendency to prefer the left side (Nicholls, Orr, Okubo, & Loftus, 2006). For example, on the questions that follow, most people would rate their political views slightly more conservative on the first question than on the second:

1. Rate your political views on the following scale:

|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|

most conservative moderate most liberal

2. Rate your political views on the following scale:

|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|—|

most liberal moderate most conservative

TRY IT YOURSELF

You might try the following demonstration. Try marking the center of the line below. Then measure it to see how close you came. Most people miss slightly to the left. Curiously, people with extensive musical training usually get within 1% of the exact center (Patston, Corballis, Hogg, & Tippet, 2006).

Some patients with neglect also show deviations in their estimates of the midpoint of a numerical range. For example, what is halfway between 11 and 19? The correct answer is, of course, 15, but some people with neglect say "17." Evidently, they discount the lower numbers as if they were on the left side (Doricchi, Guariglia, Gasparini, & Tomaiuolo, 2005; Zorzi, Priftis, & Umiltà, 2002). At least in Western society, many people visualize the numbers like a line stretching to the right, as in the *x* axis of a graph.

Neglect results from many deficits that vary from one person to another, but in many cases, the main problem is attention rather than impaired sensation. One patient was shown a letter E, composed of small Hs, as in Figure 14.21(c). She identified it as a big E composed of small Hs, indicating that she saw the whole figure. However, when she was then asked to cross off all the Hs, she crossed off only the ones on the right. When she was shown the figures in Figure 14.21(e), she identified them as an O composed of little Os and an X composed of little Xs. Again, she could see both halves of both figures, but when she was asked to cross off all the elements, she crossed off only the ones on the right. The researchers summarized by saying she saw the forest but only half the trees (Marshall & Halligan, 1995).

Several procedures can increase attention to the neglected side. First, simply telling the person to pay attention to the left side helps temporarily. So does having the person look left while at the same time feeling an object with the left hand (Vaishnavi, Calhoun, & Chatterjee, 2001) or hearing a sound from the left side of the world (Frassinetti, Pavani, & Làdavas,

**Figure 14.22 A simple way to reduce sensory neglect**
Ordinarily, someone with right parietal lobe damage neglects the left arm. However, if the left arm crosses over or under the right, attention to the left arm increases.

2002). Something similar is true for unimpaired people also. Suppose you are staring straight ahead and an experimenter is flashing stimuli on the left and right sides. Your task is to identify something about each stimulus, such as whether it was on the top or bottom half of the screen. If someone touches you just before a visual stimulus, you will respond slightly faster if the touch was on the same side of the body as the visual stimulus (Kennett, Eimer, Spence, & Driver, 2001). That is, a touch stimulus briefly increases attention to one side of the body or the other.

Other manipulations also shift the attention of patients with neglect to their left side. For example, some patients with neglect report feeling nothing with the left hand, especially if the right hand feels something else at the time. However, if you cross one hand over the other as shown in Figure 14.22, the person is more likely to report feeling the left hand, which is now on the right side of the body (Aglioti, Smania, & Peru, 1999). Also, the person ordinarily has trouble pointing to anything in the left visual field but has somewhat better success if the hand was so far to the left that he or she would have to move it to the right to point to the object (Mattingley, Husain, Rorden, Kennard, & Driver, 1998). Again, the conclusion is that neglect is not due to a loss of sensation but a difficulty in directing attention to the left side.

Many patients with neglect also have deficits with spatial working memory (Malhotra et al., 2005) and with shifting attention, even when location is irrelevant. For example, one patient could not listen to two sounds and say which one came first, unless the sounds were very prolonged (Cusack, Carlyon, & Robertson, 2000). In short, the problems associated with neglect extend to many kinds of attention, not just the left–right dimension.

**STOP & CHECK**

**22.** What is the evidence that spatial neglect is a problem in attention, not just sensation?

**23.** What are several procedures that increase attention to the left side in a person with spatial neglect?

**ANSWERS**

**22.** When a patient with neglect sees a large letter composed of small letters, he or she can identify the large letter but then neglects part of it when asked to cross off all the small letters. Also, someone who neglects the left hand pays attention to it when it is crossed over the right hand. **23.** Simply telling the person to attend to something on the left sometimes helps temporarily. Having the person look to the left while feeling something on the left side increases attention to the felt object. Crossing the left hand over the right increases attention to the left hand. Moving a hand far to the left makes it easier for the person to point to something in the left visual field because the hand will move toward the right to point at the object.

MODULE 14.3 IN CLOSING

## Attending to Attention and Being Conscious of Consciousness

Before the 1970s, many psychological researchers, especially those studying learning in rats, were not convinced that the concept of attention was useful at all. Today, the concept of attention is well established in cognitive psychology, although the concept of consciousness still has a tentative status. Research in this area is difficult because we cannot observe consciousness itself, and we have no access to it beyond what people report. Scientists are justifiably nervous about self-reports. Still, I hope this module convinced you that research on consciousness is neither impossible nor pointless. Technological advances enable us to do research that would have been impossible in the past. Future methods may facilitate still more possibilities.

*Continued*

## SUMMARY

1. Attention to a stimulus is almost synonymous with being conscious of it. Various stimuli compete for attention or consciousness. **428**
2. It is possible to direct attention toward a stimulus deliberately. **428**
3. When someone is conscious of a stimulus, the representation of that stimulus spreads over a large portion of the brain. **428**
4. People almost never say they were partly conscious of something. It may be that consciousness is a threshold phenomenon: We become conscious of anything that exceeds a certain level of brain activity, and we are not conscious of other events. **430**
5. Many stimuli influence our behavior without being conscious. Even before a stimulus becomes conscious, the brain processes the information enough to identify something as meaningful or meaningless. **431**
6. We are not always conscious of events instantaneously as they occur. Sometimes, a later event modifies our conscious perception of a stimulus that went before it. **431**
7. Damage to parts of the right hemisphere produce spatial neglect for the left side of the body or the left side of objects. **431**
8. Neglect results from a deficit in attention, not sensation. For example, someone with neglect can see an entire letter enough to say what it is, even though that same person ignores the left half when asked to cross out all the elements that compose it. **432**
9. People with sensory neglect also have difficulties with working memory and with shifting attention from one stimulus to another, even when the stimuli do not vary from left to right. **433**

## KEY TERMS

Terms are defined in the module on the page number indicated. They're also presented in alphabetical order with definitions in the book's Subject Index/Glossary. Interactive flashcards, audio reviews, and crossword puzzles are among the online resources available to help you learn these terms and the concepts they represent.

binocular rivalry **429**
conscious **428**
inattentional blindness **428**
phi phenomenon **431**
spatial neglect **432**

### THOUGHT QUESTION

The operational definition of consciousness applies only to people willing and able to report that they are conscious of some events and not others. Research using this definition has determined certain brain correlates of consciousness. Could we now use those brain correlates to infer consciousness or its absence in newborn infants, brain-damaged people, or nonhuman animals?

# CHAPTER 14 Exploration and Study

In addition to the study materials provided at the end of each module, you may supplement your review of this chapter by using one or more of the book's electronic resources, which include its companion Website, interactive Cengage Learning eBook, Exploring Biological Psychology CD-ROM, and CengageNOW. Brief descriptions of these resources follow. For more information, visit **www.cengage.com/psychology/kalat**.

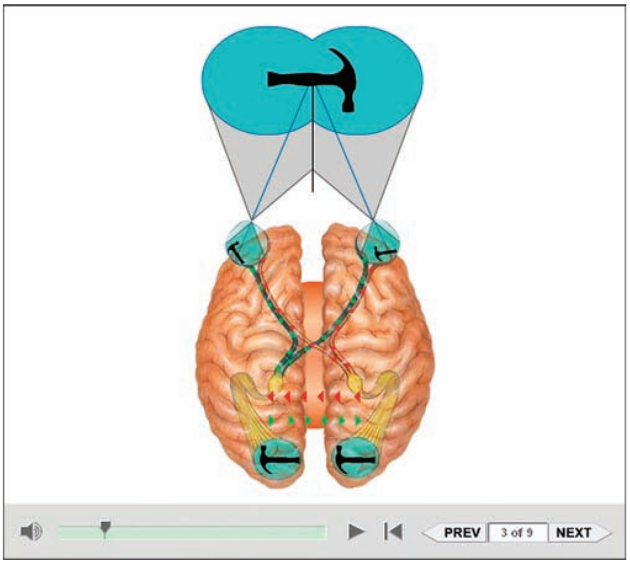
The book's companion Website, accessible through the author Web page indicated above, provides a wide range of study resources such as an interactive glossary, flashcards, tutorial quizzes, updated Web links, and Try It Yourself activities, as well as a limited selection of the short videos and animated explanations of concepts available for this chapter.

## Exploring Biological Psychology

The Exploring Biological Psychology CD-ROM contains videos, animations, and Try It Yourself activities. These activities—as well as many that are new to this edition—are also available in the text's fully interactive, media-rich

Cengage Learning eBook,* which gives you the opportunity to experience biological psychology in an even greater interactive and multimedia environment. The Cengage Learning eBook also includes highlighting and note-taking features and an audio glossary. For this chapter, the Cengage Learning eBook includes the following interactive explorations:

Lateralization and Language
Split Brain
Hemisphere Control
Visual-Spatial Processing
Wernicke-Geschwind Model
Situated Cognition
McGurk Effect
Change Blindness
Binocular Rivalry
Capture of Attention by a Meaningful Stimulus
Phi Phenomenon




The video *Visual Spatial Processing* illustrates how functional magnetic resonance imaging technology (fMRI) is being used to track visual-spatial processing skills.

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- provide interactive exercises and study tools to help you fully understand chapter concepts; and
- include a posttest for you to take to confirm that you are ready to move on to the next chapter.

* Requires a Cengage Learning eResources account. Visit **www.cengage.com/login** to register or login.

## Suggestions for Further Exploration

The book's companion Website includes a list of suggested articles available through InfoTrac College Edition for this chapter. You may also want to explore some of the following books and Websites. The text's companion Website provides live, updated links to the sites listed below.

### *Books*

**Baars, B. J., & Gage, N. M. (Eds.).** (2007). *Cognition, brain, and consciousness*. San Diego, CA: Elsevier. Review of research on brain mechanisms of attention and consciousness.

**Deacon, T.** (1997). *The symbolic species*. New York: Norton. Deep analysis of the evolution of language and intelligence.

**Ornstein, R.** (1997). *The right mind*. New York: Harcourt Brace. Very readable description of split-brain research and the differences between the left and right hemispheres.

### *Websites*

The National Aphasia Association
**http://www.aphasia.org/**

The Bonobo Foundation
**http://www.blockbonobofoundation.org/**

The British Dyslexia Association
**http://www.bdadyslexia.org.uk**