CNAC/MNAM/Dist. Réunion des Musées Nationaux/ Art Resource, NY

Gateway **THEME**

The origins of intelligent behavior lie in thinking, language, problem solving, and creativity.

8

Cognition, Language, and Creativity

Color Is the Keyboard

Russian painter Wassily Kandinsky once commented, "Color is the keyboard, the eyes are the harmonies, the soul is the piano with many strings. The artist is the hand that plays, touching one key or another, to cause vibrations in the soul." A look at one of his paintings, such as "Contrasting Sounds," shown here, suggests that he painted just like he spoke.

The creativity of individuals like Kandinsky raises many questions. Do creative people have special talents? Kandinsky himself may have had *synesthesia*—his brain allowed him to experience sounds as colors and shapes so that he was literally painting what he "saw." Or can anyone learn to be creative? Many of the painters of Kandinsky's day shared the goal of recording their subjective impressions rather than eternal objects. Surely, all of the artists who together invented *Impressionism* did not have synesthesia.

Do all people think in images, even if they are not as vivid as Kandinsky's? Is it possible to describe in language what we experience, to the point of using *metaphors*, just as Kandinsky described painting? How do we form concepts, like the concept "impressionism"?

At higher levels, these are the same abilities that define many of history's geniuses, such as Einstein, Darwin, Mozart, Newton, Michelangelo, Galileo, Madame Curie, Edison, Martha Graham, and others (Michalko, 2001; Robinson, 2010). Like all creative activities, Kandinsky's art raises questions about human cognition. How do we think? How are we able to solve problems? How do people create works of art, science, and literature? For some preliminary answers, we will investigate thinking, problem solving, and creativity in the pages that follow.

Gateway QUESTIONS

- *8.1 What is the nature of thought?*
- *8.2 In what ways are images related to thinking?*
- *8.3 What are concepts and how are they learned?*
- *8.4 What is language and what role does it play in thinking?*
- *8.5 What do we know about problem solving?*
- *8.6 What is the nature of creative thinking?*
- *8.7 How accurate is intuition?*
- *8.8 What can be done to promote creativity?*

What Is Thinking?—Brains over Brawn

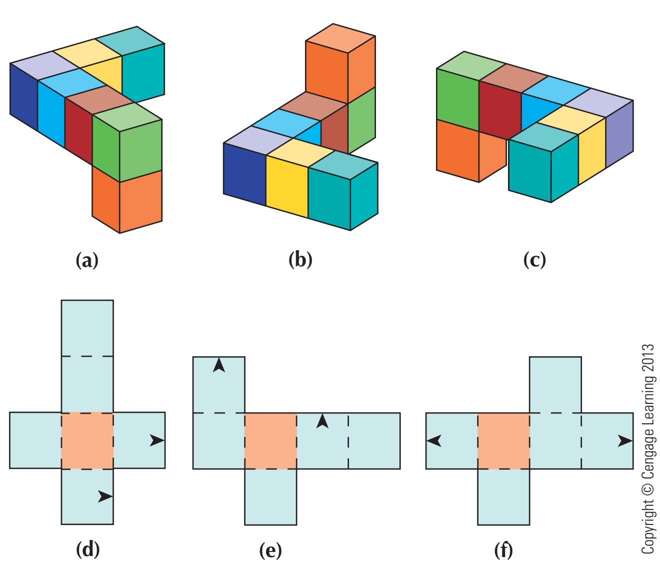
Gateway Question 8.1: *What is the nature of thought?*

Humans are highly adaptable creatures. We live in deserts, jungles, mountains, frenzied cities, placid retreats, and recently, in space stations. Unlike other species, our success owes more to intelligence and thinking abilities than it does to physical strength or speed (Reed, 2010). Let's see how concepts, language, and mental images make thinking possible.

Cognition refers to mentally processing information (Sternberg, 2011). Our thoughts take many forms, including problem solving, reasoning, and even daydreaming (to name but a few). Although thinking is not limited to humans, imagine trying to teach an animal to match the feats of Shakuntala Devi, who once set a "world record" for mental calculation by multiplying two randomly chosen 13-digit numbers (7,686,369,774,870 times 2,465,099,745,779) in her head, giving the answer in 28 seconds. (That's 18,947,668,104,042,434,089,403,730 if you haven't already figured it out.)

Some Basic Units of Thought

At its most basic, thinking is an *internal representation* (mental expression) of a problem or situation. Picture a television interviewer who mentally tries out several lines of questioning before actually beginning a live interview. By *planning* her moves, she can avoid many mistakes. Imagine planning what to study for an exam, what to say at a job interview, or how to get to your spring break hotel. Better yet, in each of these cases imagine what might happen if you didn't, or couldn't, plan at all.



● **Figure 8.1** Imagery in thinking. *(Top)* Subjects were shown a drawing similar to *(a)* and drawings of how *(a)* would look in other positions, such as *(b)* and *(c)*. Subjects could recognize *(a)* after it had been "rotated" from its original position. However, the more *(a)* was rotated in space, the longer it took to recognize it. This result suggests that people actually formed a three-dimensional image of *(a)* and rotated the image to see if it matched (Shepard, 1975). *(Bottom)* Try your ability to manipulate mental images: Picture each of these shapes as a piece of paper that can be folded to make a cube. After they have been folded, on which cubes do the arrow tips meet (Kosslyn, 1985)?

The power of being able to mentally represent problems is dramatically illustrated by chess grand master Miguel Najdorf, who once simultaneously played 45 chess games while blindfolded. How did Najdorf do it? Like most people, he used the basic units of thought: images, concepts, and language (or symbols). **Images** are picture-like mental representations. **Concepts** are ideas that represent categories of objects or events. **Language** consists of words or symbols, and rules for combining them. Thinking often involves all three units. For example, blindfolded chess players rely on visual images, concepts ("Game 2 begins with a strategy called an English opening"), and the notational system, or "language," of chess.

In a moment we will delve further into imagery, concepts, and language. Be aware, however, that thinking involves attention, pattern recognition, memory, decision making, intuition, knowledge, and more. This chapter is only a sample of what cognitive psychology is about.

Mental Imagery—Does a Frog Have Lips?

Gateway Question 8.2: *In what ways are images related to thinking?*

Almost everyone has visual and auditory images. More than half of us have imagery for movement, touch, taste, smell, and pain. Thus, mental images are sometimes more than just "pictures." For example, your image of a bakery may also include its delicious odor. As mentioned earlier, some people, like Kandinsky, even have a rare form of imagery called **synesthesia** (sin-es-THEE-zyah). For these individuals, images cross normal sensory barriers (Cytowic & Eagleman, 2009; Kadosh & Henik, 2007). For one such person, spiced chicken tastes "pointy"; for another, pain is the color orange; and for a third, human voices unleash a flood of colors and tastes (Dixon, Smilek, & Merikle, 2004; Robertson & Sagiv, 2005). Despite such variations, most of us use images to think, remember, and solve problems. For instance, we may use mental images to:

- Make a decision or solve a problem (choosing what clothes to wear; figuring out how to arrange furniture in a room).
- Change feelings (thinking of pleasant images to get out of a bad mood; imagining yourself as thin to stay on a diet).
- Improve a skill or prepare for some action (using images to improve a tennis stroke; mentally rehearsing how you will ask for a raise).
- Aid memory (picturing Mr. Cook wearing a chef's hat so you can remember his name).

The Nature of Mental Images

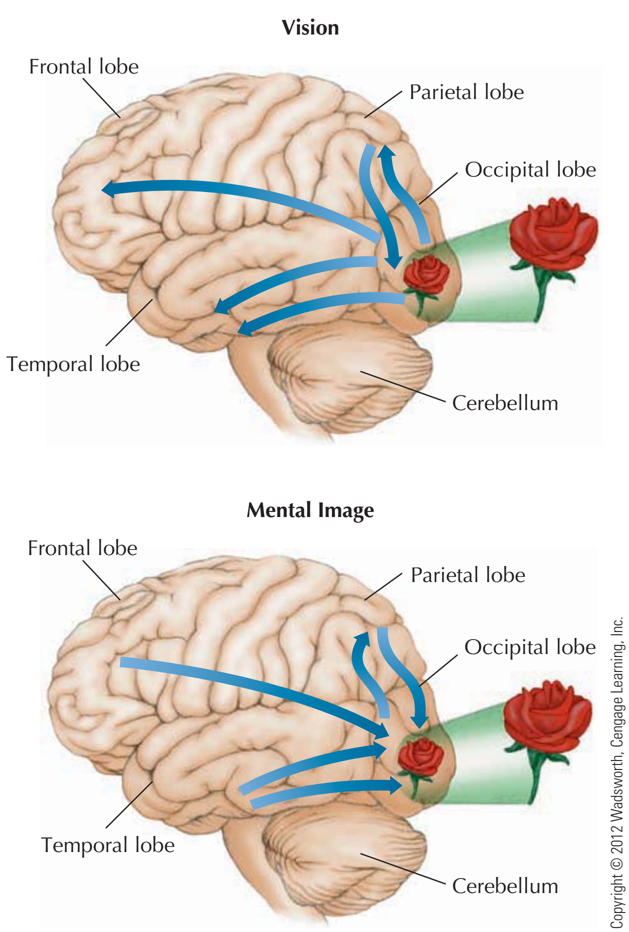
Mental images are not flat, like photographs. Researcher Stephen Kosslyn showed this by asking people, "Does a frog have lips and a stubby tail?" Unless you often kiss frogs, you will probably tackle this question by using mental images. Most people picture a frog, "look" at its mouth, and then mentally "rotate" the frog in mental space to check its tail (Kosslyn, 1983). Mental rotation is partly based on imagined movements (● Figure 8.1). That is, we mentally "pick up" an object and turn it around (Wraga et al., 2005, 2010).

"Reverse Vision"

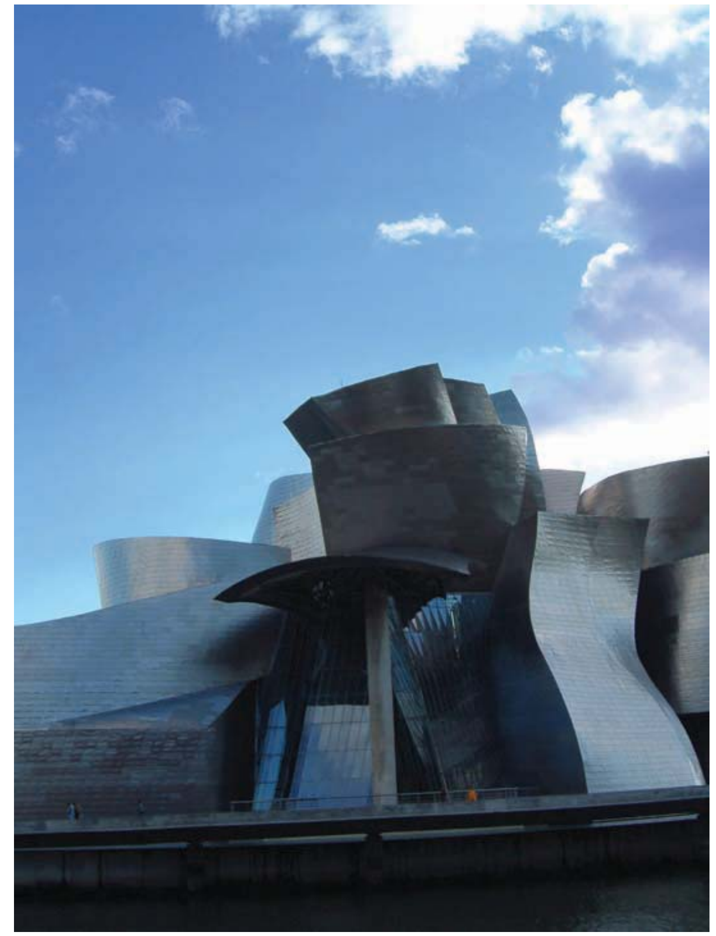
What happens in the brain when a person has visual images? Seeing something in your "mind's eye" is similar to seeing real objects. Information from the eyes normally activates the brain's primary visual area, creating an image (● Figure 8.2). Other brain areas then help us recognize the image by relating it to stored knowledge. When you form a mental image, the system works in reverse. Brain areas in which memories are stored send signals back to the visual cortex, where once again, an image is created (Ganis, Thompson, & Kosslyn, 2004; Kosslyn, 2005). For example, if you visualize a friend's face right now, the area of your brain that specializes in perceiving faces will become more active (O'Craven & Kanwisher, 2000).

Using Mental Images

How are images used to solve problems? We use *stored images* (information from memory) to apply past experiences to problem solving. Let's say you are asked, "How many ways can you use an empty egg carton?" You might begin by picturing uses you have already seen, such as sorting buttons into a carton. To give more original answers, you will probably need to use *created images*, which are assembled or invented, rather than simply remembered. Thus, an



● **Figure 8.2** When you see a flower, its image is represented by activity in the primary visual area of the cortex, at the back of the brain. Information about the flower is also relayed to other brain areas. If you form a mental image of a flower, information follows a reverse path. The result, once again, is activation of the primary visual area.



The Guggenheim Museum in Bilbao, Spain, was designed by architect Frank Gehry. Could a person lacking mental imagery design such a masterpiece? Three people out of 100 find it impossible to produce mental images, and 3 out of 100 have very strong imagery. Most artists, architects, designers, sculptors, and filmmakers have excellent visual imagery.

artist may completely picture a proposed sculpture before beginning work. People with good imaging abilities tend to score higher on tests of creativity (Morrison & Wallace, 2001), even if they are blind (Eardley & Pring, 2007). In fact, Albert Einstein, Thomas Edison, Lewis Carroll, and many other of history's most original intellects relied heavily on imagery (West, 1991).

Does the "size" of a mental image affect thinking? To find out, first picture a cat sitting beside a housefly. Now try to "zoom in" on the cat's ears so you see them clearly. Next, picture a rabbit sitting beside an elephant. How quickly can you "see" the rabbit's front feet? Did it take longer than picturing the cat's ears?

Cognition The process of thinking or mentally processing information (images, concepts, words, rules, and symbols).
Image Most often, a mental representation that has picture-like qualities; an icon.
Concept A generalized idea representing a category of related objects or events.
Language Words or symbols, and rules for combining them, that are used for thinking and communication.
Synesthesia Experiencing one sense in terms normally associated with another sense; for example, "seeing" colors when a sound is heard.

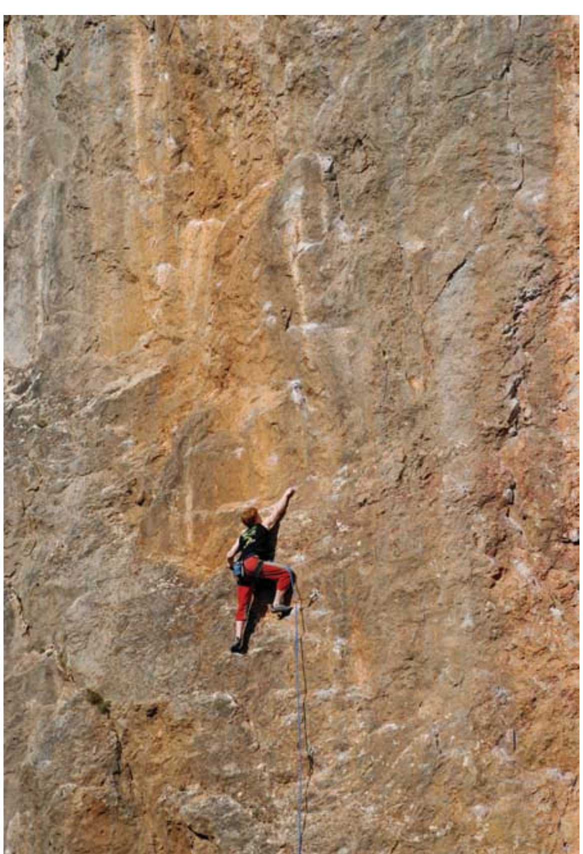
When a rabbit is pictured with an elephant, the rabbit's image must be small because the elephant is large. Using such tasks, Stephen Kosslyn (1985) found that the smaller an image is, the harder it is to "see" its details. To put this finding to use, try forming oversize images of things you want to think about. For example, to understand electricity, picture the wires as large pipes with electrons the size of golf balls moving through them; to understand the human ear, explore it (in your mind's eye) like a large cave; and so forth.

Kinesthetic Imagery

Do muscular responses relate to thinking? In a sense, we think with our bodies as well as our heads. *Kinesthetic (motor) images* are created from muscular sensations (Guillot et al., 2009). Such images help us think about movements and actions.

As you think and talk, kinesthetic sensations can guide the flow of ideas. For example, if a friend calls and asks you the combination of a lock you loaned her, you may move your hands as if twirling the dial on the lock. Or, try answering this question: Which direction do you turn the hot-water handle in your kitchen to shut off the water? Most people haven't simply memorized the words "Turn it clockwise" or "Turn it counterclockwise." Instead you will probably "turn" the faucet in your imagination before answering. You may even make a turning motion with your hand before answering.

Kinesthetic images are especially important in music, sports, dance, skateboarding, martial arts, and other movement-oriented skills. An effective way to improve such skills is to practice by rehearsing kinesthetic images of yourself performing flawlessly (Guillot & Collet, 2008).



Vixit/Shutterstock

Rock climbers use kinesthetic imagery to learn climbing routes and to plan their next few moves (Smyth & Waller, 1998).

Concepts—I'm Positive, It's a Whatchamacallit

Gateway Question 8.3: *What are concepts and how are they learned?*

As noted earlier, a **concept** is an idea that represents a category of objects or events. Concepts help us identify important features of the world. That's why experts in various areas of knowledge are good at classifying objects. Bird watchers, tropical fish fanciers, 5-year-old dinosaur enthusiasts, and other experts all learn to look for identifying details that beginners tend to miss. If you are knowledgeable about a topic, such as horses, flowers, or football, you literally see things differently than less well-informed people do (Harel et al., 2010; Ross, 2006).

Forming Concepts

How are concepts learned? **Concept formation** is the process of classifying information into meaningful categories (Ashby & Maddox, 2005). At its most basic, concept formation is based on experience with **positive** and **negative instances** (examples that belong, or do not belong, to the concept class). Concept formation is not as simple as it might seem. Imagine a child learning the concept of *dog*.

Dog Daze

A child and her father go for a walk. At a neighbor's house, they see a medium-sized dog. The father says, "See the dog." As they pass the next yard, the child sees a cat and says, "Dog!" Her father corrects her, "No, that's a *cat*." The child now thinks, "Aha, dogs are large and cats are small." In the next yard, she sees a Komondor and says, "Cat!" "No, that's a dog," replies her father.

The child's confusion is understandable. At first, she might even mistake a sleeping Komondor for a mop. However, with more positive and negative instances, the child will eventually recognize everything from Great Danes to Chihuahuas as members of the same category—dogs.

As adults, we often acquire concepts by learning or forming *rules*. A **conceptual rule** is a guideline for deciding whether objects or events belong to a concept class. For example, a triangle must be a closed shape with three sides made of straight lines. Rules are an efficient way to learn concepts, but examples remain important. It's unlikely that memorizing rules would allow a new listener to accurately categorize *rhythm and blues*, *hip-hop*, *fusion*, *salsa*, *metal*, *country*, and *rap* music.

The Komondor is the hairiest dog breed.

Types of Concepts

Are there different kinds of concepts? Yes, **conjunctive concepts**, or "and concepts," are defined by the presence of two or more features (Reed, 2010). In other words, an item must have "this feature *and* this feature *and* this feature." For example, a *motorcycle* must have two wheels *and* an engine *and* handlebars.

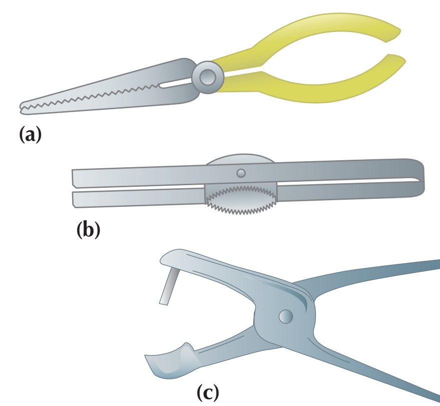
Relational concepts are based on how an object relates to something else, or how its features relate to one another. All of the following are relational concepts: *larger*, *above*, *left*, *north*, and *upside down*. Another example is *brother*, which is defined as "a male considered in his relation to another person having the same parents."

Disjunctive concepts have at *least one* of several possible features. These are "either/or" concepts. To belong to the category, an item must have "this feature *or* that feature *or* another feature." For example, in baseball, a *strike* is *either* a swing and a miss *or* a pitch over the plate *or* a foul ball. The either/or quality of disjunctive concepts makes them harder to learn.

● **Figure 8.3** When does a cup become a bowl or a vase? Deciding whether an object belongs to a conceptual class is aided by relating it to a prototype, or ideal example. Subjects in one experiment chose number 5 as the "best" cup. (After Labov, 1973.)

Prototypes

When you think of the concept *bird*, do you mentally list the features that birds have? Probably not. In addition to rules and features, we use **prototypes**, or ideal models, to identify concepts (Burnett et al., 2005; Rosch, 1977). A robin, for example, is a prototypical bird; an ostrich is not. In other words, some items are better examples of a concept than others are (Smith, Redford, & Haas, 2008). Which of the drawings in ● Figure 8.3 best represents a cup? At some point, as a cup grows taller or wider, it becomes a vase or a bowl. How do we know when the line is crossed? Probably, we mentally compare objects to an "ideal" cup, like number 5. That's why it's hard to identify concepts when we can't come up with relevant prototypes. What, for example, are the objects shown in ● Figure 8.4? As you can see, prototypes are especially helpful when we try to categorize complex stimuli (Minda & Smith, 2001).



● **Figure 8.4** Use of prototypes in concept identification. Even though its shape is unusual, item *(a)* can be related to a model (an ordinary set of pliers) and thus recognized. But what are items *(b)* and *(c)*? If you don't recognize them, look ahead to ● Figure 8.6. (Adapted from Bransford & McCarrell, 1977.)

Concept A generalized idea representing a class of related objects or events.

Concept formation The process of classifying information into meaningful categories.

Positive instance In concept learning, an object or event that belongs to the concept class.

Negative instance In concept learning, an object or event that does not belong to the concept class.

Conceptual rule A formal rule for deciding if an object or event is an example of a particular concept.

Conjunctive concept A class of objects that have two or more features in common. (For example, to qualify as an example of the concept an object must be both red *and* triangular.)

Relational concept A concept defined by the relationship between features of an object or between an object and its surroundings (for example, "greater than," "lopsided").

Disjunctive concept A concept defined by the presence of at least one of several possible features. (For example, to qualify an object must be either blue *or* circular.)

Prototype An ideal model used as a prime example of a particular concept.

Faulty Concepts

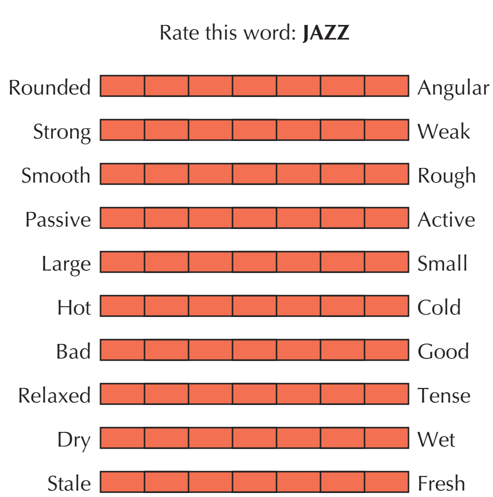
Using inaccurate concepts often leads to thinking errors. For example, *social stereotypes* are oversimplified concepts of groups of people (Le Pelley, et al., 2010). Stereotypes about men, African Americans, women, conservatives, liberals, police officers, or other groups often muddle thinking about members of the group. A related problem is *all-or-nothing thinking* (one-dimensional thought). In this case, we classify things as absolutely right or wrong, good or bad, fair or unfair, black or white, honest or dishonest. Thinking this way prevents us from appreciating the subtleties of most life problems (Bastian & Haslam, 2006).

BRIDGES

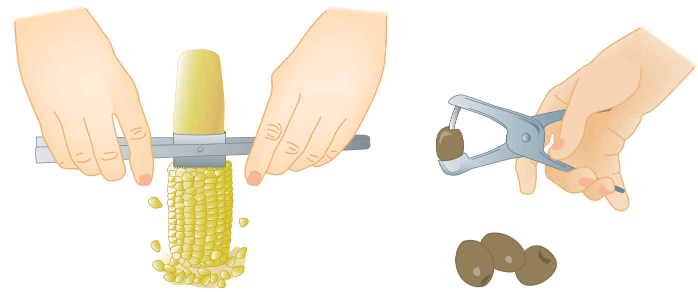
Stereotypes have a major impact on social behavior and frequently contribute to prejudice and discrimination. **See Chapter 17, pages 591–593, for more information.**

Connotative Meaning

Generally speaking, concepts have two types of meaning. The **denotative meaning** of a word or concept is its exact definition. The **connotative meaning** is its emotional or personal meaning. The denotative meaning of the word *naked* (having no clothes) is the same for a nudist as it is for a movie censor, but we could expect their connotations to differ. Connotative differences can influence how we think about important issues. The arts of *political spin* and *propaganda* often amount to manipulating connotations. For example, facing a terminal illness, would you rather engage in *end-of-life counseling* or attend a *death panel*? Similarly, if you are resisting an invasion of your territory, the term *defender of culture* has a more positive connotation than does *terrorist* (Payne, 2009).



● **Figure 8.5** This is an example of Osgood's semantic differential. The connotative meaning of the word *jazz* can be established by rating it on the scales. Mark your own rating by placing dots or X's in the spaces. Connect the marks with a line; then have a friend rate the word and compare your responses. It might be interesting to do the same for *rock and roll*, *classical*, and *rap*. You also might want to try the word *psychology*. (From C. E. Osgood. Copyright © 1952 American Psychological Association. Reprinted by permission.)



● **Figure 8.6** Context can substitute for a lack of appropriate prototypes in concept identification.

Can you clarify what a connotative meaning is? Yes, connotative meaning can be measured with a technique called the *semantic differential*, as shown in ● Figure 8.5. When we rate words or concepts, most of their connotative meaning boils down to the dimensions *good/bad*, *strong/weak*, and *active/passive*. These dimensions give words very different connotations, even when their denotative meanings are similar. For example, I am *conscientious*; you are *careful*; he is *nitpicky*! Because we are conscientious (not nitpicky, right?), let's further explore language.

Knowledge Builder: Images and Concepts

RECITE

1. List three basic units of thought: ________________________, ________________________, ________________________
2. Synesthesia is the use of kinesthetic sensations as a vehicle for thought. T or F?
3. Humans appear capable of forming three-dimensional images that can be moved or rotated in mental space. T or F?
4. A *mup* is defined as anything that is small, blue, and hairy. *Mup* is a ____________________________ concept.
5. The connotative meaning of the word *naked* is "having no clothes." T or F?
6. Stereotyping is an example of oversimplification in thinking. T or F?

REFLECT

Think Critically

7. It takes longer to answer the question, "Does a frog have lips and a stubby tail?" than the question, "Does a frog have lips?" Can you think of an explanation other than mental rotation to explain this difference?
8. A Democrat and a Republican are asked to rate the word *democratic* on the semantic differential. Under what conditions would their ratings be most alike?

Self-Reflect

Name some ways in which you have used imagery in the thinking you have done today. Were the images you used created or stored? Were any synesthetic or kinesthetic?

Write a conceptual rule for the following idea: *unicycle*. Were you able to define the concept with a rule? Would positive and negative instances help make the concept clearer for others?

A true sports car has two seats, a powerful engine, good brakes, and excellent handling. What kind of a concept is the term *sports car*? What do you think of as a prototypical sports car?

Critical Thinking: What's North of My Fork?

It is clear that our thoughts influence the words we use. But might the reverse be true? Do the words we use affect our thoughts and actions? The answer may lie in a remote part of northeastern Australia. Cognitive psychologist Lera Boroditsky has reported that aboriginal children from Cape York can accurately point to any compass direction as early as age 5. In contrast, most Americans cannot do this even as adults (Boroditsky, 2011).

But why? According to Boroditsky, Kuuk Thaayorre, the language of the Cape York Australian aboriginals, relies exclusively on *absolute* directional references, unlike English. Like English, Kuuk Thaayorre has words for "north," "south," and so on. Unlike English, Kuuk Thaayorre lacks words for *relative* directional references, such as "left" and "right."

For long distances, an English speaker might say, "Chicago is north of here." But for short distances, the same speaker will shift to a relative reference and might say, "My brother is sitting to my right." In contrast, a speaker of Kuuk Thaayorre always uses absolute directional references, saying things like "My friend is sitting southeast of me" and "The dessert spoon is west of the coffee cup." If you are a young aboriginal child, you had best master your absolute directions or most conversations will be impossible to follow.

Another interesting consequence for speakers of Kuuk Thaayorre is how they arrange time. In one study, English speakers given a set of cards depicting a series of events (for example, a person getting older or a meal being cooked and eaten) and asked to put them in order usually arranged them from left to right. Hebrew speakers usually arranged the cards from right to left, presumably because this is the direction in which Hebrew is written. In contrast, speakers of Kuuk Thaayorre arrange temporal sequences from east to west. If the sorter is facing north, the cards would be arranged from right to left but if the sorter is facing south, the cards would be arranged from left to right, and so on (Boroditsky & Gaby, 2010).

Findings like these lend support to the **linguistic relativity hypothesis**, the idea that the words we use not only reflect our thoughts but can shape them as well. So the next time you think your future is "ahead" of you and your past is "behind," think again. For speakers of Aymara, a South American language, it is the past that is "ahead" (Miles et al., 2010). So watch your back.

Answers: 1. images, concepts, and language or symbols (others could be listed) **2.** F **3.** T **4.** conjunctive **5.** F **6.** T **7.** The first question could simply be more difficult. The difficulty of questions must be carefully matched in studies of mental imagery. **8.** If they both assume the word refers to a form of government, not a political party or a candidate.

Language—Say What?

Gateway Question 8.4: *What is language and what role does it play in thinking?*

As we have seen, thinking may occur without language. Everyone has searched for a word to express an idea that exists as a vague image or feeling. Nevertheless, most thinking relies heavily on language, because words *encode* (translate) the world into symbols that are easy to manipulate (● Figure 8.7). Likewise, the words we use can greatly affect our thinking (see "What's North of My Fork?").

The study of meaning in words and language is known as **semantics**. It is here that the link between language and thought becomes most evident. Has one country's army "invaded" another country or "liberated" it? Is the martini glass "half full" or "half empty"? Would you rather eat "rare prime beef" or "bloody slab of dead cow"? Suppose, on an intelligence test, you were asked to circle the word that does not belong in this series:

SKYSCRAPER CATHEDRAL TEMPLE PRAYER

Ebby May/Getty Images

● **Figure 8.7** Wine tasting illustrates the encoding function of language. To communicate their experiences to others, wine connoisseurs must put taste sensations into words. The wine you see here is "marked by deeply concentrated nuances of plum, blackberry, and currant, with a nice balance of tannins and acid, building to a spicy oak finish." (Don't try this with a Pop-tart®!)

Denotative meaning The exact, dictionary definition of a word or concept; its objective meaning.

Connotative meaning The subjective, personal, or emotional meaning of a word or concept.

Linguistic relativity hypothesis The idea that the words we use not only reflect our thoughts but can shape them as well.

Semantics The study of meanings in language.

Human Diversity — Bilingualism—*Si o No, Oui ou Non,* Yes or No?

***Are there advantages** to being able to speak more than one language?* Definitely. **Bilingualism** is the ability to speak two languages. Studies have found that students who learn to speak two languages well have better mental flexibility, general language skills, control of attention, and problem-solving abilities (Bialystok & DePape, 2009; Craik & Bialystok, 2005).

Unfortunately, millions of minority American children who do not speak English at home experience *subtractive bilingualism*. Immersed in English-only classrooms, in which they are expected to "sink or swim," they usually end up losing some of their native language skills. Such children risk becoming less than fully competent in *both* their first and second languages. In addition, they tend to fall behind educationally. As they struggle with English, their grasp of arithmetic, social studies, science, and other subjects may also suffer. In short, English-only instruction can leave them poorly prepared to succeed in the majority culture (Durán, Roseth, Hoffman, 2010; Matthews & Matthews, 2004).

For the majority of children who speak English at home, the picture can be quite different, because learning a second language is almost always beneficial. It poses no threat to the child's home language and improves a variety of cognitive skills. This has been called *additive bilingualism* because learning a second language adds to a child's overall competence (Hinkel, 2005).

An approach called **two-way bilingual education** can help children benefit from bilingualism and avoid its drawbacks (Lessow-Hurley, 2005). In such programs, majority group children and children with limited English skills are taught part of the day in English and part in a second language. Both majority and minority language speakers become fluent in two languages, and they perform as well or better than single-language students in English and general academic abilities.

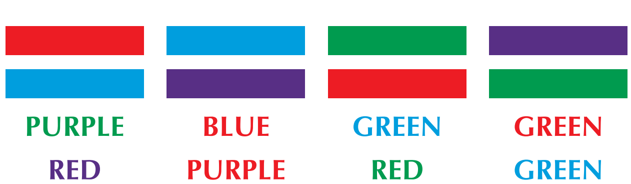
Then why isn't two-way bilingual education more widely used? Bilingual education tends to be politically unpopular among majority language speakers (Garcia, 2008). Language is an important sign of group membership. Even where the majority culture is highly dominant, some of its members may feel that recent immigrants and "foreign languages" are eroding their culture. Regardless, an ability to think and communicate in a second language is a wonderful gift. Given the cognitive benefits, fostering bilingualism may also turn out to be one of the best ways to improve competitiveness in our rapidly globalizing information economy.

If you circled *prayer*, you answered as most people do. Now try another problem, again circling the odd item:

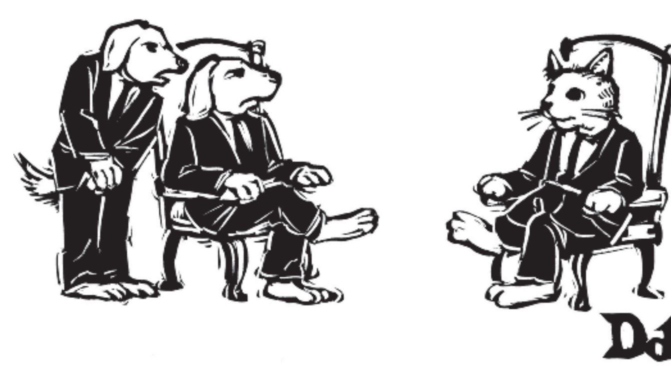
CATHEDRAL	PRAYER	TEMPLE	SKYSCRAPER

Did you circle *skyscraper* this time? The new order subtly alters the meaning of the last word (Mayer, 1995). This occurs because words get much of their meaning from *context*. For example, the word *shot* means different things when we are thinking of marksmanship, bartending, medicine, photography, or golf (Carroll, 2008; Miller, 1999).

More subtle effects also occur. For example, most people have difficulty quickly naming the color of the ink used to print the words in the bottom two rows of ● Figure 8.8. The word meanings are just too strong to ignore.



● **Figure 8.8** The Stroop interference task. Test yourself by naming the colors in the top two rows as quickly as you can. Then name the colors of the *ink* used to print the words in the bottom two rows (do not read the words themselves). Was it harder to name the ink colors in the bottom rows? (Adapted from MacLeod, 2005.)



"You'll have to phrase it another way. They have no word for 'fetch.'"

Drew Dernavich/Cartoonbank

Language also plays a major role in defining ethnic communities and other social groups. Thus, language can be a bridge or a barrier between cultures. Translating languages can cause a rash of semantic problems. Perhaps the San Jose, California, public library can be excused for once displaying a large banner that was supposed to say "You are welcome" in a native Philippine language. The banner actually said "You are circumcised." Likewise, we may forgive Pepsi for translating "Come alive, you Pepsi generation," into Thai as "Pepsi brings your ancestors back from the dead." However, in more important situations, such as in international business and diplomacy, avoiding semantic confusion may be vital (see "Bilingualism—*Si o No, Oui ou Non*, Yes or No?").

The Structure of Language

What does it take to make a language? First, a language must provide symbols that can stand for objects and ideas (Jay, 2003). The symbols we call words are built out of **phonemes** (FOE-neems: basic speech sounds) and **morphemes** (MOR-feems: speech sounds collected into meaningful units, such as syllables or words). For instance, in English the sounds *m*, *b*, *w*, and *a* cannot form a syllable *mbwa*. In Swahili, they can (also, see ● Figure 8.9).

Next, a language must have a **grammar**, or set of rules for making sounds into words and words into sentences (Reed, 2010). One part of grammar, known as **syntax**, concerns rules for word order. Syntax is important because rearranging words almost always changes the meaning of a sentence: "Dog bites man" versus "Man bites dog."

Traditional grammar is concerned with "surface" language—the sentences we actually speak. Linguist Noam Chomsky has focused instead on the unspoken rules we use to change core ideas into various sentences. Chomsky (1986) believes that we do not learn all the sentences we might ever say. Rather, we actively *create* them by applying **transformation rules** to universal, core patterns. We use these rules to change a simple declarative sentence to other voices or forms (past tense, passive voice, and so forth). For example, the core sentence "Dog bites man" can be transformed to these patterns (and others as well):

Past: The dog bit the man.
Passive: The man was bitten by the dog.
Negative: The dog did not bite the man.
Question: Did the dog bite the man?

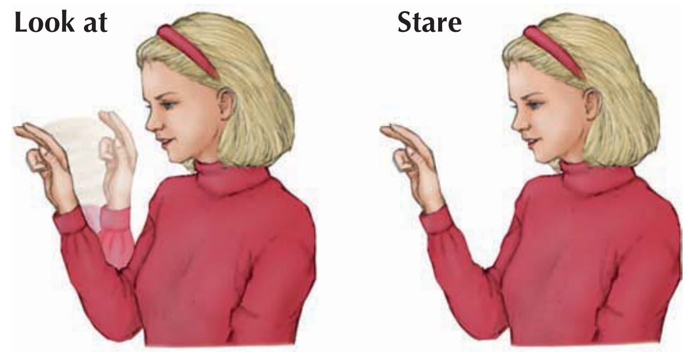
Children seem to be using transformation rules when they say things such as "I runned home." That is, the child applied the normal past tense rule to the irregular verb *to run*.

A true language is also *productive*—it can generate new thoughts or ideas. In fact, words can be rearranged to produce a nearly infinite number of sentences. Some are silly: "Please don't feed me to the goldfish." Some are profound: "We hold these truths to be self-evident, that all men are created equal." In either case, the productive quality of language makes it a powerful tool for thinking.

Derek Croucher/Getty Images

Albanian	mak, mak
Chinese	gua, gua
Dutch	rap, rap
English	quack, quack
French	coin, coin
Italian	qua, qua
Spanish	cuá, cuá
Swedish	kvack, kvack
Turkish	vak, vak

● **Figure 8.9** Animals around the world make pretty much the same sounds. Notice, however, how various languages use slightly different phonemes to express the sound a duck makes.



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● **Figure 8.10** ASL has only 3,000 root signs, compared with roughly 600,000 words in English. However, variations in signs make ASL a highly expressive language. For example, the sign LOOK-AT can be varied in ways to make it mean look at me, look at her, look at each, stare at, gaze, watch, look for a long time, look at again and again, reminisce, sightsee, look forward to, predict, anticipate, browse, and many more variations.

Gestural Languages

Contrary to common belief, language is not limited to speech. Consider the case of Ildefonso, a young man who was born deaf. At age 24, Ildefonso had never communicated with another human, except by mime. Then at last, Ildefonso had a breakthrough: After much hard work with a sign language teacher, he understood the link between a cat and the gesture for it. At that magic moment, he grasped the idea that "cat" could be communicated to another person, just by signing the word.

American Sign Language (ASL), a gestural language, made Ildefonso's long-awaited breakthrough possible. ASL is not pantomime or a code. It is a true language, like German, Spanish, or Japanese (Liddell, 2003). In fact, those who use other gestural languages, such as French Sign, Mexican Sign, or Old Kentish Sign, may not easily understand ASL (Quinto-Pozos, 2008).

Although ASL has a *spatial* grammar, syntax, and semantics all its own (● Figure 8.10), both speech and signing follow similar universal language patterns. Signing children pass through the stages of language development at about the same age as speaking children do. Some psychologists now believe that speech evolved from gestures, far back in human history (Corballis, 2002). Gestures help us string words together as we speak (Morsella & Krauss, 2004). Some people would have difficulty speaking with their hands tied to their sides. Do you ever make hand gestures when you are speaking on the phone? If so, you may be displaying a rem-

Bilingualism An ability to speak two languages.
Two-way bilingual education A program in which English-speaking children and children with limited English proficiency are taught half the day in English and half in a second language.
Phonemes The basic speech sounds of a language.
Morphemes The smallest meaningful units in a language, such as syllables or words.
Grammar A set of rules for combining language units into meaningful speech or writing.
Syntax Rules for ordering words when forming sentences.
Transformation rules Rules by which a simple declarative sentence may be changed to other voices or forms (past tense, passive voice, and so forth).

© Myrleen Ferguson Cate/PhotoEdit

Infants can express the idea "pick me up" in gestures before they can make the same request in words. Their progression from gestures to speech may mirror the evolution of human language abilities (Genty et al., 2009).

nant of the gestural origins of language. Perhaps that's also why the same brain areas become more active when a person speaks or signs (Emmorey et al., 2003).

Sign languages naturally arise out of a need to communicate visually. But they also embody a personal identity and define a distinct community. Those who "speak" sign share not just a language, but a rich culture as well (Singleton & Newport, 2004).

Animal Language

Do animals use language? Animals do communicate. The cries, gestures, and mating calls of animals have broad meanings immediately understood by other animals of the same species (Searcy & Nowicki, 2005). For the most part, however, natural animal communication is quite limited. Even apes and monkeys make only a few dozen distinct cries, which carry messages such as "attack," "flee," or "food here." More important, animal communication lacks the productive quality of human language. For example, when a monkey gives an "eagle distress call," it means something like, "I see an eagle." The monkey has no way of saying, "I don't see an eagle," or "Thank heavens that wasn't an eagle," or "That sucker I saw yesterday was some huge eagle" (Pinker & Jackendoff, 2005). Let's consider some of psychology's experiences in trying to teach chimpanzees to use language.

Chimp Language

Early attempts to teach chimps to talk were a dismal failure. The world record was held by Viki, a chimp who could say only four words (*mama*, *papa*, *cup*, and *up*) after 6 years of intensive training (Fleming, 1974; Hayes, 1951). (Actually, all four words sounded something like a belch.) Then there was a breakthrough. In the late 1960s, Beatrix and Allen Gardner used operant conditioning and imitation to teach a female chimp named Washoe to use ASL. Washoe learned to put together primitive sentence strings like "Come-gimme sweet," "Gimme tickle," and "Open food drink." At her peak, Washoe could construct six-word sentences and use about 240 signs (Gardner & Gardner, 1989).

At around the same time, David Premack taught Sarah the chimpanzee to use 130 "words" consisting of plastic chips arranged on a magnetized board (● Figure 8.11). From the beginning of her training, Sarah was required to use proper word order. She learned to answer questions; to label things "same" or "different"; to classify objects by color, shape, and size; and to form compound sentences (Premack & Premack, 1983). Sarah even learned to use conditional sentences. A *conditional statement* contains a qualification, often in the if/then form: "If Sarah take apple, then Mary give Sarah chocolate." or "If Sarah take banana, then Mary no give Sarah chocolate."

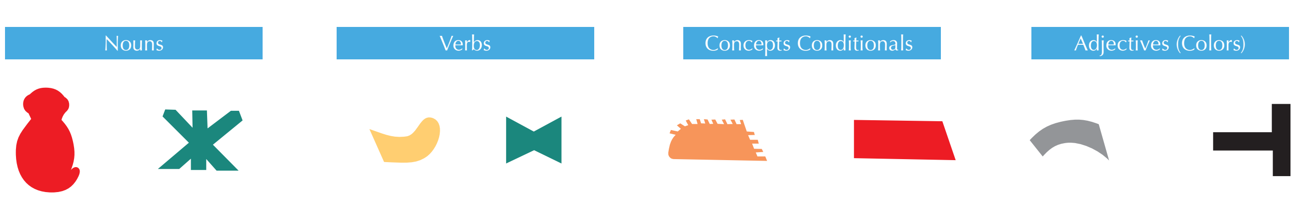
Can it be said with certainty that the chimps understand such interchanges? Most researchers working with chimps believe that they have indeed communicated with them. Especially striking are the chimps' spontaneous responses. Washoe once "wet" on psychologist Roger Fouts' back while riding on his shoulders. When Fouts asked, with some annoyance, why she had done it, Washoe signed, "It's funny!"

Criticisms

Although such interchanges are impressive, communication and real language usage are different things. Even untrained chimps use simple gestures to communicate with humans. For example, a chimp will point at a banana that is out of reach, while glancing back and forth between the banana and a person standing nearby (Leavens & Hopkins, 1998). (The meaning of the gesture is clear. The meaning of the exasperated look on the chimp's face is less certain, but it probably means, "Give me the banana, you idiot.")

Some psychologists doubt that apes can really use language. For one thing, chimps rarely "speak" without prompting from humans. Also, the apes may be simply performing operant responses to get food or other "goodies" (Hixon, 1998). By making certain signs, the apes then manipulate their trainers to get what they want. You might say the critics believe the apes have made monkeys out of their trainers.

At this point, numerous chimps, a gorilla named Koko, and an assortment of dolphins, sea lions, and parrots have learned to communicate with word symbols of various kinds. Yet, even if some



● **Figure 8.11** Here is a sample of some of the word-symbols that Sarah the chimpanzee used to communicate with humans. (After Premack & Premack, 1972).

criticisms can be answered, linguists remain unconvinced that animals can truly use language. The core issue is that problems with syntax (word order) have plagued almost all animal language studies. For example, when a chimp named Nim Chimpsky (no relation to Noam Chomsky) wanted an orange, he would typically signal a grammarless string of words: "Give orange me give eat orange me eat orange give me eat orange give me you." This might be *communication*, but it is not *language*.

Kanzi's Lexigrams

In the 1980s, Duane Rumbaugh and Sue Savage-Rumbaugh taught Kanzi, a pygmy chimpanzee, to communicate by pushing buttons on a computer keyboard. Each of the 250 buttons is marked with a **lexigram**, or geometric word-symbol (● Figure 8.12). Some of the lexigrams Kanzi knows are quite abstract, like symbols for "bad" and "good" (Lyn, Franks, & Savage-Rumbaugh, 2008). Using the lexigrams, Kanzi can create primitive sentences several words long. He can also understand about 650 spoken sentences. During testing, Kanzi hears spoken words over headphones, so his caretakers cannot visually prompt him (Savage-Rumbaugh, Shanker, & Taylor, 1998).

Kanzi's sentences consistently follow correct word order. Like a child learning language, Kanzi picked up some rules from his caregivers (Segerdahl, Fields, & Savage-Rumbaugh, 2005). However, he has developed other patterns on his own. For example, Kanzi usually places action symbols in the order he wants to carry them out, such as "chase tickle" or "chase hide." In this respect, Kanzi's grammar is on a par with that of a 2-year-old child.

Kanzi's ability to invent a simple grammar may help us better understand the roots of human language. It is certainly the strongest answer yet to critics (Benson et al., 2002). On the other hand, Chomsky insists that if chimps were biologically capable of language, they would use it on their own. Although the issue is far from resolved, such research may unravel the mysteries of language learning.

The Great Ape Trust of Iowa

● **Figure 8.12** Kanzi's language learning has been impressive. He can comprehend spoken English words. He can identify lexigram symbols when he hears corresponding words. He can use lexigrams when the objects they refer to are absent and he can, if asked, lead someone to the object. All these skills were acquired through observation, not conditioning (Segerdahl, Fields, & Savage-Rumbaugh, 2005).

Knowledge Builder — Language

RECITE

1. True languages are ____________________ because they can be used to generate new possibilities.
2. The basic speech sounds are called ______________; the smallest meaningful units of speech are called ____________________.
3. Two-way bilingual education almost always has a subtractive effect on general academic abilities. T or F?
4. Noam Chomsky believes that we create an infinite variety of sentences by applying ____________ ____________ to universal language patterns.
5. ASL can be used to communicate, but it is not a true language. T or F?
6. One of the chimpanzee Sarah's most outstanding achievements was the construction of sentences involving
   a. negation *b.* conditional relationships *c.* adult grammar *d.* unprompted questions
7. Critics consider "sentences" constructed by apes to be simple ____________________ responses having little meaning to the animal.
8. Kanzi's use of lexigrams has suffered from the same problems with syntax as other animal-language studies. T or F?

REFLECT

Think Critically

9. Chimpanzees and other apes are intelligent and entertaining animals. If you were doing language research with a chimp, what major problem would you have to guard against?

Self-Reflect

Here's some mnemonic help: You use a *phone* to send *phonemes*. To *morph* them into words, you have to hit them with a *grammar*. What wrong is with sentence this? (The answer is not a *sin tax*, but it still may tax you.)

Just for fun, see if you can illustrate the productive quality of language by creating a sentence that no one has ever before spoken.

You must learn to communicate with an alien life-form whose language cannot be reproduced by the human voice. Do you think it would it be better to use a gestural language or lexigrams? Why?

Answers: 1. productive **2.** phonemes, morphemes **3.** F **4.** transformation rules **5.** F **6.** *b* **7.** operant **8.** F **9.** The problem of anthropomorphizing (ascribing human characteristics to animals) is especially difficult to avoid when researchers spend many hours "conversing" with and even living with chimps.

Problem Solving—Getting an Answer in Sight

Gateway Question 8.5: *What do we know about problem solving?*

We all solve many problems every day. Problem solving can be as commonplace as figuring out how to make a nonpoisonous meal out of leftovers or as significant as developing a cure for cancer. How do we solve such problems?

Lexigram A geometric shape used as a symbol for a word.

A good way to start a discussion of problem solving is to solve a problem. Give this one a try:

> A famous ocean liner (the *Queen Latifah*, of course) is steaming toward port at 20 miles per hour. The ocean liner is 50 miles from shore when a seagull takes off from its deck and flies toward port. At the same instant, a speedboat leaves port at 30 miles per hour. The bird flies back and forth between the speedboat and the *Queen Latifah* at a speed of 40 miles per hour. How far will the bird have flown when the two boats pass?

If you don't immediately see the answer to this problem, read it again. (The answer is revealed in the "Insightful Solutions" section.)

Mechanical Solutions

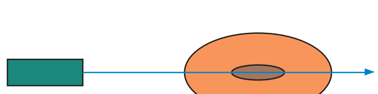
For routine problems, a **mechanical solution** may be adequate. Mechanical solutions are achieved by trial and error or by rote (Goldstein, 2011). If you forget the combination to your bike lock, you may be able to discover it by trial and error. In an era of high-speed computers, many trial-and-error solutions are best left to machines. A computer could generate all possible combinations of the five numbers on the lock in a split second. (Of course, it would take a long time to try them all.) When a problem is solved by *rote*, thinking is guided by an **algorithm**, or learned set of rules that always leads to an answer. A simple example of an algorithm is the steps needed to divide one number into another (by doing arithmetic, not by using a calculator). Becoming a problem-solving expert in any particular field involves, at a minimum, becoming familiar with the algorithms available in that field. Imagine wanting to be a mathematician and yet being unwilling to learn any algorithms. If you have a good background in math, you may have solved the problem of the bird and the boats by rote. (Your authors hope you didn't. There is an easier solution.)

Solutions by Understanding

Many problems cannot be solved mechanically. In that case, **understanding** (deeper comprehension of a problem) is necessary. Try this problem:

A person has an inoperable stomach tumor. A device is available that produces rays that at high intensity will destroy tissue (both healthy and diseased). How can the tumor be destroyed without damaging surrounding tissue? (Also see the sketch in ● Figure 8.13.)

What does this problem show about problem solving? German psychologist Karl Duncker gave college students this problem in a classic series of studies. Duncker asked them to think aloud as they worked. He found that successful students first had to discover the *general properties* of a correct solution. A **general solution** defines the requirements for success, but not in enough detail to guide further action. This phase was complete when students realized that the intensity of the rays had to be lowered on their way to the tumor. Then, in the second phase, they proposed a number of **functional** (workable) **solutions** and selected the best one (Duncker, 1945). (One solution is to focus weak rays on the tumor from several angles. Another is to rotate the person's body to minimize exposure of healthy tissue.)



● **Figure 8.13** A schematic representation of Duncker's tumor problem. The dark spot represents a tumor surrounded by healthy tissue. How can the tumor be destroyed without injuring surrounding tissue? (After Duncker, 1945.)

It might help to summarize with a more familiar example. Almost everyone who has tried to play a poker game like Texas Hold'em begins at the mechanical, trial-and-error level. If you want to take the easy (i.e., rote) route, printed odds tables are available for every stage of play. In time, those who persist begin to understand the general properties of the game. After that, they can play fast enough to keep up with other players. With enough practice, this is exactly how novices become experts in a wide variety of fields.

Heuristics

"You can't get there from here," or so it often seems when facing a problem. Solving problems often requires a strategy. If the number of alternatives is small, a **random search strategy** may work. This is another example of trial-and-error thinking in which all possibilities are tried, more or less randomly. Imagine that you are traveling and you decide to look up an old friend, Charlie Harper, in a city you are visiting. You open the phone book and find 47 listings for C. Harper. Of course, you could dial each number until you find the right one. "Forget it," you say to yourself. "Is there any way I can narrow the search?" "Oh, yeah! I remember hearing that Charlie lives by the beach." Then you take out a map and call only the numbers with addresses near the waterfront.

The approach used in this example is a **heuristic** (hew-RIS-tik: a strategy for identifying and evaluating problem solutions). Typically, a heuristic is a "rule of thumb" that *reduces the number of alternatives* thinkers must consider (Benjafield, Smilek, & Kingstone, 2010). Although this raises the odds of success, it does not guarantee a solution. Rest assured that expert problems solvers are good at using heuristic strategies like these:

- Try to identify how the current state of affairs differs from the desired goal. Then find steps that will reduce the difference.
- Try working backward from the desired goal to the starting point or current state.
- If you can't reach the goal directly, try to identify an intermediate goal or subproblem that at least gets you closer.
- Represent the problem in other ways, with graphs, diagrams, or analogies, for instance.
- Generate a possible solution and test it. Doing so may eliminate many alternatives, or it may clarify what is needed for a solution.

Insightful Solutions

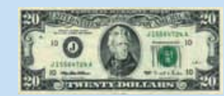
A thinker who suddenly solves a problem has experienced **insight**. Insight is so rapid and clear that we may wonder why we didn't see the solution sooner (Schilling, 2005). Insights are usually based on reorganizing a problem (Hélie & Sun, 2010). This allows us to see

Water lilies

Problem: Water lilies growing in a pond double in area every 24 hours. On the first day of spring, only one lily pad is on the surface of the pond. Sixty days later, the pond is entirely covered. On what day is the pond half-covered?

Twenty dollars

Problem: Jessica and Blair both have the same amount of money. How much must Jessica give Blair so that Blair has $20 more than Jessica?



How many pets?

Problem: How many pets do you have if all of them are birds except two, all of them are cats except two, and all of them are dogs except two?

Between 2 and 3

Problem: What one mathematical symbol can you place between 2 and 3 that results in a number greater than 2 and less than 3?

One word

Problem: Rearrange the letters NEWDOOR to make one word.

● **Figure 8.14**

problems in new ways and makes their solutions seem obvious (DeYoung, Flanders, & Peterson, 2008).

Let's return now to the problem of the boats and the bird. The best way to solve it is by insight. Because the boats will cover the 50-mile distance in exactly 1 hour, and the bird flies 40 miles per hour, the bird will have flown 40 miles when the boats meet. Very little math is necessary if you have insight into this problem. ● Figure 8.14 lists some additional insight problems you may want to try (the answers can be found in ■ Table 8.1).

The Nature of Insight

Psychologist Janet Davidson (2003) believes that insight involves three abilities. The first is *selective encoding*, which refers to selecting information that is relevant to a problem, while ignoring distractions. For example, consider the following problem:

> If you have white socks and black socks in your drawer, mixed in the ratio of 4 to 5, how many socks will you have to take out to ensure you have a pair of the same color?

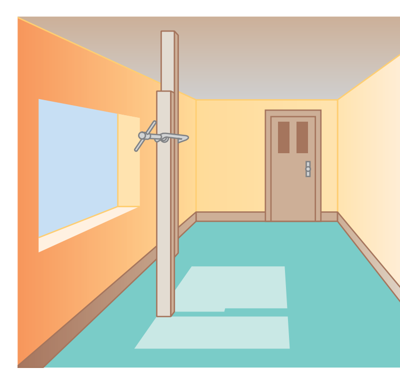
A person who recognizes that "mixed in a ratio of 4 to 5" is irrelevant will be more likely to come up with the correct answer of 3 socks.

Insight also relies on *selective combination*, or bringing together seemingly unrelated bits of useful information. Try this sample problem:

> With a 7-minute hourglass and an 11-minute hourglass, what is the simplest way to time the boiling of an egg for 15 minutes?

The answer requires using both hourglasses in combination. First, the 7-minute and the 11-minute hourglasses are started. When the 7-minute hourglass runs out, it's time to begin boiling the egg. At this point, 4 minutes remain on the 11-minute hourglass. Thus, when it runs out it is simply turned over. When it runs out again, 15 minutes will have passed.

A third source of insights is *selective comparison*. This is the ability to compare new problems with old information or with problems already solved. A good example is the hat rack problem, in which subjects must build a structure that can support an overcoat in the middle of a room. Each person is given only two long sticks and a C-clamp to work with. The solution, shown in ● Figure 8.15, is to clamp



● **Figure 8.15** A solution to the hat rack problem.

Mechanical solution A problem solution achieved by trial and error or by a fixed procedure based on learned rules.

Algorithm A learned set of rules that always leads to the correct solution of a problem.

Understanding In problem solving, a deeper comprehension of the nature of the problem.

General solution A solution that correctly states the requirements for success but not in enough detail for further action.

Functional solution A detailed, practical, and workable solution.

Random search strategy Trying possible solutions to a problem in a more or less random order.

Heuristic Any strategy or technique that aids problem solving, especially by limiting the number of possible solutions to be tried.

Insight A sudden mental reorganization of a problem that makes the solution obvious.

Human Diversity — How to Weigh an Elephant

Does the culture we grow up in affect our ability to use selective comparison to solve problems? See if you can will solve this problem:

> A treasure hunter wanted to explore a cave, but he was afraid that he might get lost. Obviously, he did not have a map of the cave; all that he had with him were some common items such as a flashlight and a bag. What could he do to make sure he did not get lost trying to get back out of the cave later? (Adapted from Chen, Mo, & Honomichl, 2004.)

To solve his problem, the man could leave a trail of small objects, such as pebbles or sand, while traveling through the cave, and then follow this trail out to exit.

Seventy-five percent of American college students, but only 25 percent of Chinese students, were able to solve the cave problem. Why was there such a difference in the two groups? It seems that American students benefited from having heard the story of Hansel and Gretel when they were growing up. As you may recall, Hansel and Gretel were able to find their way out of the woods because Hansel made a trail of breadcrumbs that led back home (Chen, Mo, & Honomichl, 2004).

Now try this problem:

> In a village by a river, the chief of a tribe guards a sacred stone statue. Every year, the chief goes downriver to the next village to collect taxes. There, he places the statue in a tub at one end of a hanging balance. To pay their taxes, the villagers have to fill a tub at the other end of the scale with gold coins until the scale balances. This year, the chief forgot to bring his balance scale. How can he figure out how much gold to collect to match the statue's weight? (Adapted from Chen, Mo, & Honomichl, 2004.)

To solve this problem, the chief could put a tub in the river, and place the statue in the tub. Then he could mark the water level on the outside of the tub. To pay their taxes, the villagers would have to put gold coins in the tub until it sank to the same level as it did when the statue was in it.

Sixty-nine percent of Chinese students, but only 8 percent of American students, were able to solve this problem. Again, it seems that being exposed to a similar problem in the past was helpful. Most Chinese are familiar with a traditional tale about weighing an elephant that is too big to put on a scale. In the story, the elephant is placed in a boat and the water level is marked. After the elephant is removed, the boat is filled with small stones until the water again reaches the mark. Then, each of the stones is weighed on a small scale and the total weight of the elephant is calculated (Chen, Mo, & Honomichl, 2004).

Every culture prepares its members to solve some types of problems more easily than others (Boroditsky, 2011). As a result, learning about other cultures can make us more flexible and resourceful thinkers—and that's no fairy tale.

the two sticks together so that they are wedged between the floor and ceiling. If you were given this problem, you would be more likely to solve it if you first thought of how pole lamps are wedged between floor and ceiling (see "How to Weigh an Elephant").

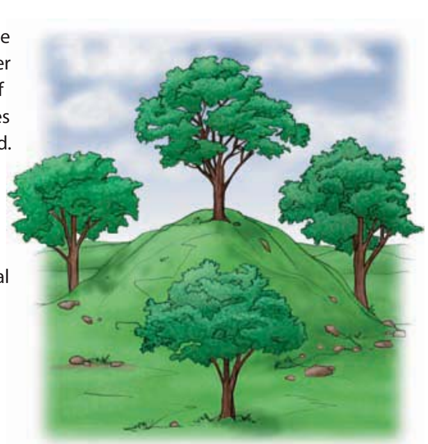
Fixations

One of the most important barriers to problem solving is **fixation**, the tendency to get "hung up" on wrong solutions or to become blind to alternatives (Sternberg, 2011). Usually this occurs when we place unnecessary restrictions on our thinking (German & Barrett, 2005). How, for example, could you plant four small trees so that each is an equal distance from all the others? (The answer is shown in ● Figure 8.16.)

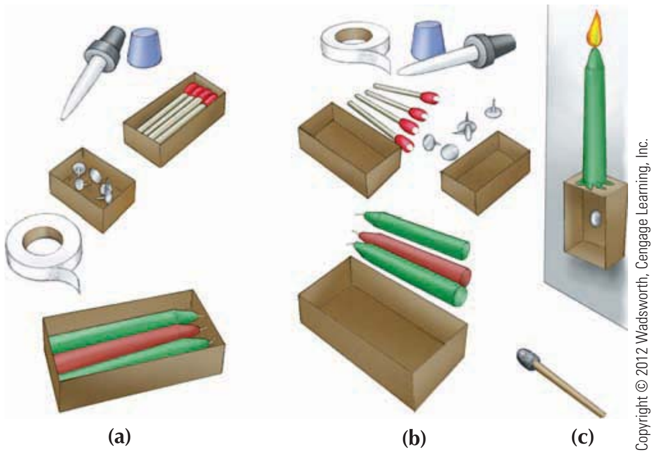
A prime example of restricted thinking is **functional fixedness**. This is an inability to see new uses (functions) for familiar objects or for things that were used in a particular way (German & Barrett, 2005). If you have ever used a dime as a screwdriver, you've overcome functional fixedness.

How does functional fixedness affect problem solving? Karl Duncker illustrated the effects of functional fixedness by asking students to mount a candle on a vertical board so the candle could burn normally. Duncker gave each student three candles, some matches, some cardboard boxes, some thumbtacks, and other items. Half of Duncker's subjects received these items *inside* the cardboard boxes. The others were given all the items, including the boxes, spread out on a tabletop.

Duncker found that when the items were in the boxes, solving the problem was very difficult. Why? If students saw the boxes as *containers*, they didn't realize the boxes might be part of the solution (if you haven't guessed the solution, check ● Figure 8.17). Undoubtedly, we could avoid many fixations by being more flexible in categorizing the world (Kalyuga & Hanham, 2011; Langer, 2000). For instance, creative thinking could be facilitated in the container prob-



● **Figure 8.16** Four trees can be placed equidistant from one another by piling dirt into a mound. Three of the trees are planted equal distances apart around the base of the mound. The fourth tree is planted on the top of the mound. If you were fixated on arrangements that involve level ground, you may have been blind to this three-dimensional solution.



● **Figure 8.17** Materials for solving the candle problem were given to subjects in boxes *(a)* or separately *(b)*. Functional fixedness caused by condition *(a)* interfered with solving the problem. The solution to the problem is shown in *(c)*.

lem by saying "This *could be* a box," instead of "This *is* a box." When tested with the candle problem, 5-year-old children show no signs of functional fixedness. Apparently, this is because they have had less experience with the use of various objects. It is sometimes said that to be more creative, you should try to see the world without preconceptions, as if through the eyes of a child. In the case of functional fixedness that may actually be true (German & Defeyter, 2000).

Common Barriers to Problem Solving

Functional fixedness is just one of the mental blocks that prevent insight (Reed, 2010). Here's an example of another: A $5 bill is placed on a table, and a stack of objects is balanced precariously on top of the bill. How can the bill be removed without touching or moving the objects? A good answer is to split the bill on one of its edges. Gently pulling from opposite ends will tear the bill in half and remove it without toppling the objects. Many people fail to see this solution because they have learned not to destroy money (Adams, 2001). Notice again the impact of placing something in a category, in this case, "things of value" (which should not be destroyed). Other common mental blocks can hinder problem solving, too, as listed here:

1. **Emotional barriers:** inhibition and fear of making a fool of oneself, fear of making a mistake, inability to tolerate ambiguity, excessive self-criticism

   Example: An architect is afraid to try an unconventional design because she fears that other architects will think it is frivolous.

2. **Cultural barriers:** values that hold that fantasy is a waste of time; that playfulness is for children only; that reason, logic, and numbers are good; that feelings, intuitions, pleasure, and humor are bad or have no value in the serious business of problem solving

   Example: A corporate manager wants to solve a business problem but becomes stern and angry when members of his marketing team joke playfully about possible solutions.

TABLE 8.1 Solutions to Insight Problems

Water lilies: Day 59
Twenty dollars: $10
How many pets?: Three (one bird, one cat, and one dog)
Between 2 and 3: A decimal point
One word: ONE WORD (You may object that the answer is two words, but the problem called for the answer to be "one word," and it is.)

3. **Learned barriers:** conventions about uses (functional fixedness), meanings, possibilities, taboos

   Example: A cook doesn't have any clean mixing bowls and fails to see that he could use a frying pan as a bowl.

4. **Perceptual barriers:** habits leading to a failure to identify important elements of a problem

   Example: A beginning artist concentrates on drawing a vase of flowers without seeing that the "empty" spaces around the vase are part of the composition, too.

Experts and Novices

So far, we have seen that problem-solving expertise is based on *acquired strategies* (learned heuristics) and specific *organized knowledge* (systematic information). Experts are better able to see the true nature of problems and to define them more flexibly in terms of general principles (Anderson, 2010; Kalyuga, & Hanham, 2011). For example, chess experts are much more likely than novices to have heuristics available for solving problems. However, what really sets master players apart is their ability to intuitively recognize *patterns* that suggest what lines of play should be explored next. This helps eliminate a large number of possible moves. The chess master, therefore, does not waste time exploring unproductive pathways (Ross, 2006).

In other words, becoming a star performer does not come from some general strengthening of the mind. Master chess players don't necessarily have better memories than beginners (except for realistic chess positions) (Gobet & Simon, 1996; Goldstein, 2011; see ● Figure 8.18). And, typically, they don't explore more moves ahead than lesser players.

Expertise also allows more *automatic processing*, or fast, fairly effortless thinking based on experience with similar problems. Automatic processing frees "space" in short-term memory, making it easier to work on the problem (Kalyuga, Renkl, & Paas, 2010). At the highest skill levels, expert performers tend to rise above rules and plans. Their decisions, thinking, and actions become rapid, fluid, and insightful (Hélie & Sun, 2010). Thus, when a

Fixation The tendency to repeat wrong solutions or faulty responses, especially as a result of becoming blind to alternatives.

Functional fixedness A rigidity in problem solving caused by an inability to see new uses for familiar objects.

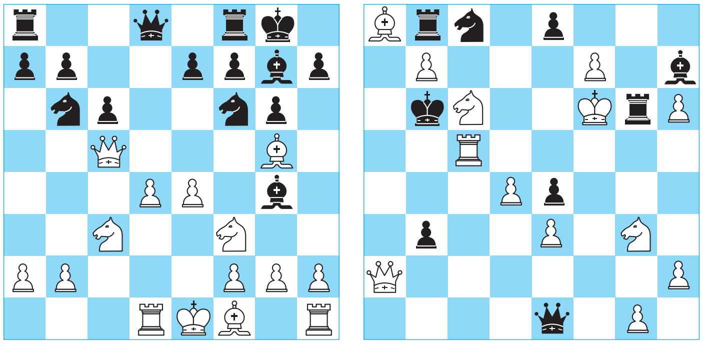


Figure 8.18 The left chessboard shows a realistic game. The right chessboard is a random arrangement of pieces. Expert chess players can memorize the left board at a glance, yet they are no better than beginners at memorizing the random board (Ross, 2006). Expert performance at most thinking tasks is based on acquired strategies and knowledge. If you would like to excel at a profession or a mental skill, plan on adding to your knowledge every day (Reed, 2010).

chess master recognizes a pattern on the chessboard, the most desirable tactic comes to mind almost immediately. Mind you, this capacity comes at a price. Expert chess players can automatically recognize 50,000 to 100,000 patterns, a level of skill that takes about 10 years to build up (Ross, 2006).

To develop expertise in a field, then, requires us to learn available heuristic solution strategies as well as to develop a deeper general understanding of the field. Throw into the mix that expertise also involves learning thousands of patterns and practicing solving many problems and you can see that developing expertise involves years of hard work. Think about that the next time someone says of an expert, "She makes it look easy."

Knowledge Builder: Problem Solving

RECITE

1. Insight refers to rote, or trial-and-error, problem solving. T or F?
2. The first phase in problem solving by understanding is to discover the general properties of a correct solution. T or F?
3. Problem-solving strategies that guide the search for solutions are called ________________________.
4. A common element underlying insight is that information is encoded, combined, and compared
   a. mechanically *b.* by rote *c.* functionally *d.* selectively
5. Functional fixedness is a major barrier to
   a. insightful problem solving *b.* using random search strategies *c.* mechanical problem solving *d.* achieving fixations through problem solving
6. Organized knowledge, acquired heuristics, and the ability to recognize patterns are all characteristics of human expertise. T or F?

REFLECT

Think Critically

7. Do you think that it is true that "a problem clearly defined is a problem half solved"?
8. Sea otters select suitably sized rocks and use them to hammer shellfish loose for eating. They then use the rock to open the shell. Does this qualify as thinking?

Relate

Identify at least one problem you have solved mechanically. Now identify a problem you solved by understanding. Did the second problem involve finding a general solution or a functional solution? Or both? What heuristics did you use to solve the problem?

What is the most insightful solution you've ever come up with? Did it involve selective encoding, combination, or comparison?

Can you think of a time when you overcame functional fixedness to solve a problem?

Answers: 1. F **2.** T **3.** heuristics **4.** *d* **5.** *a* **6.** T **7.** Although this might be an overstatement, it is true that clearly defining a starting point and the desired goal can serve as a heuristic in problem solving. **8.** Psychologist Donald Griffin (1992) believes it does because thinking is implied by actions that appear to be planned with an awareness of likely results.

Creative Thinking—Down Roads Less Traveled

Gateway Question 8.6: *What is the nature of creative thinking?*

Original ideas have changed the course of human history. Much of what we now take for granted in art, medicine, music, technology, and science was once regarded as radical or impossible. How do creative people like Thomas Edison or Wassily Kandinsky achieve the breakthroughs that advance us into new realms? Psychologists have learned a great deal about how creativity occurs and how to promote it, as you will soon learn (Hennessey & Amabile, 2010).

We have seen that problem solving may be mechanical, insightful, or based on understanding. To this we can add that thinking may be **inductive** (going from specific facts or observations to general principles) or **deductive** (going from general principles to specific situations). Thinking may also be **logical** (proceeding from given information to new conclusions on the basis of explicit rules) or **illogical** (intuitive, associative, or personal).

What distinguishes creative thinking from more routine problem solving? Creative thinking involves all these thinking styles, plus *fluency*, *flexibility*, and *originality*. Let's say that you would like to find creative uses for the billions of plastic containers discarded each year. The creativity of your suggestions could be rated in this way: **Fluency** is defined as the total number of suggestions you are able to make. **Flexibility** is the number of times you shift from one class of possible uses to another. **Originality** refers to how novel or unusual your ideas are. By counting the number of times you showed fluency, flexibility, and originality, we could rate your creativity, or capacity for *divergent thinking* (Baer, 1993; Runco, 2004).

In routine problem solving or thinking, there is one correct answer, and the problem is to find it. This leads to **convergent thinking** (lines of thought converge on the answer). **Divergent thinking** is the reverse, in which many possibilities are developed from one starting point (Cropley, 2006; see ■ Table 8.2 for some examples). It is worth noting that divergent thinking is also a characteristic of **daydreams** (vivid waking fantasies). For most people,

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Fluency is an important part of creative thinking. Mozart produced more than 600 pieces of music. Shakespeare wrote 154 sonnets. Salvador Dali (shown here) created more than 1500 paintings as well as sculptures, drawings, illustrations, books, and even an animated cartoon. Not all of these works were masterpieces. However, a fluent outpouring of ideas fed the creative efforts of each of these geniuses.

fantasy and daydreaming are associated with greater mental flexibility or creativity (Langens & Schmalt, 2002). Regardless, no matter when or how it occurs, creative thinking produces new answers, ideas, or patterns rather than repeating learned solutions (Davidovitch & Milgram, 2006).

Problem finding is another characteristic of creative thinking. Many of the problems we solve are "presented" to us—by employers, teachers, circumstances, or life in general. **Problem finding** involves actively seeking problems to solve. When you are thinking creatively, a spirit of discovery prevails: You are more likely to find unsolved problems and *choose* to tackle them. Thus, problem finding may be a more creative act than the convergent problem solving that typically follows it (Runco, 2004).

TABLE 8.2 Convergent and Divergent Problems

Convergent Problems
What is the area of a triangle that is 3 feet wide at the base and 2 feet tall?
Erica is shorter than Zoey but taller than Carlo, and Carlo is taller than Jared. Who is the second tallest?
If you simultaneously drop a baseball and a bowling ball from a tall building, which will hit the ground first?
Divergent Problems
What objects can you think of that begin with the letters BR?
How could discarded aluminum cans be put to use?
Write a poem about fire and ice.

Tests of Creativity

Divergent thinking can be measured in several ways (Kaufman, 2009). In the *Unusual Uses Test*, you would be asked to think of as many uses as possible for some object, such as the plastic containers

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Unorthodox Japanese inventor Kenji Kawakami created the "hay fever hat" so no one with allergies would ever have to go without tissue paper. In addition to being original or novel, a creative solution must be high quality and relevant of the problem. Is this a creative solution to the "problem" of access to tissues?

Inductive thought Thinking in which a general rule or principle is gathered from a series of specific examples; for instance, inferring the laws of gravity by observing many falling objects.

Deductive thought Thought that applies a general set of rules to specific situations; for example, using the laws of gravity to predict the behavior of a single falling object.

Logical thought Drawing conclusions on the basis of formal principles of reasoning.

Illogical thought Thought that is intuitive, haphazard, or irrational.

Fluency In tests of creativity, fluency refers to the total number of solutions produced.

Flexibility In tests of creativity, flexibility is indicated by the number of different types of solutions produced.

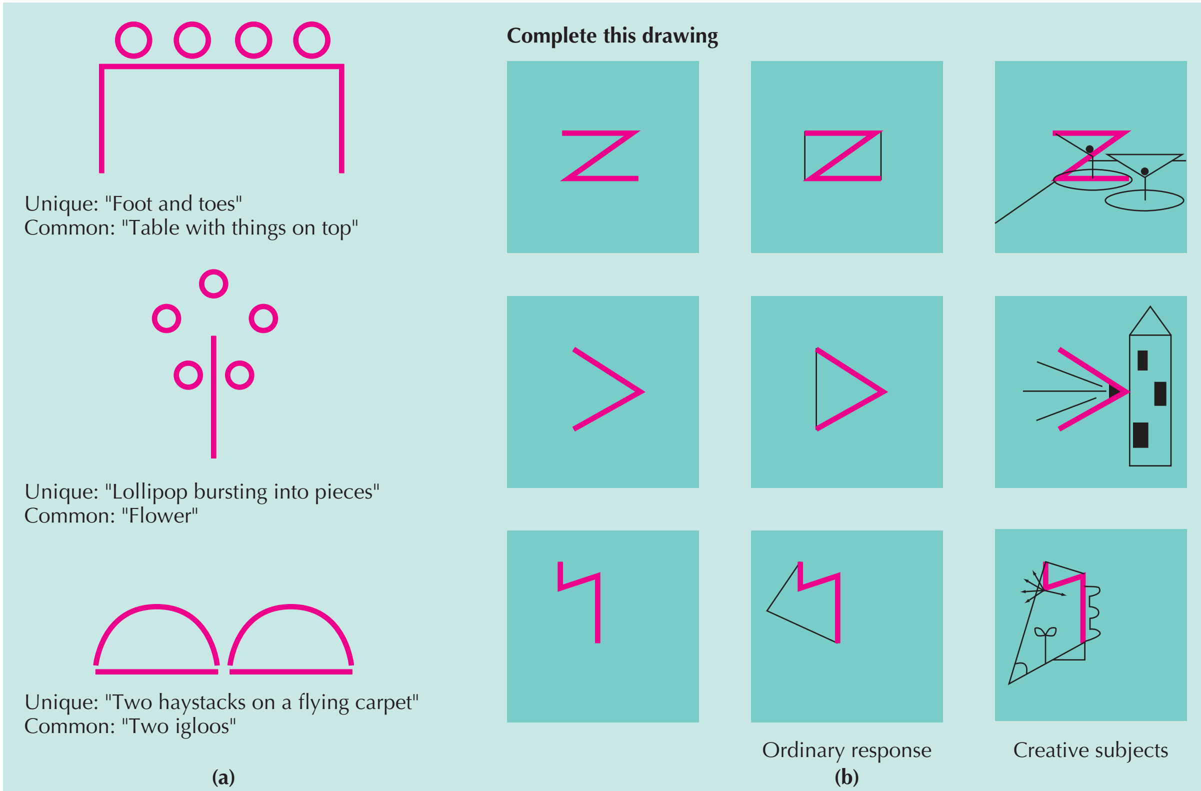
Originality In tests of creativity, originality refers to how novel or unusual solutions are.

Convergent thinking Thinking directed toward discovery of a single established correct answer; conventional thinking.

Divergent thinking Thinking that produces many ideas or alternatives; a major element in original or creative thought.

Daydream A vivid waking fantasy.

Problem finding The active discovery of problems to be solved.



● **Figure 8.19** Some tests of divergent thinking. Creative responses are more original and more complex. (*(a)* Adapted from Wallach & Kogan, 1965; *(b)* adapted from Barron, 1958.)

mentioned earlier. In the *Consequences Test*, you would list the consequences that would follow a basic change in the world. For example, you might be asked, "What would happen if everyone suddenly lost their sense of balance and could no longer stay upright?" People try to list as many reactions as possible. If you were to take the *Anagrams Test*, you would be given a word such as *creativity* and asked to make as many new words as possible by rearranging the letters. Each of these tests can be scored for fluency, flexibility, and originality. (For an example of other tests of divergent thinking, see ● Figure 8.19).

Isn't creativity more than divergent thought? What if a person comes up with a large number of useless answers to a problem? A good question. Divergent thinking is an important part of creativity, but there is more to it. To be creative, the solution to a problem must be more than novel, unusual, or original. It must also be *high quality* and *relevant* to solving the original problem (Kaufman & Sternberg, 2010). This is the dividing line between a "harebrained scheme" and a "stroke of genius." In other words, the creative person brings reasoning and critical thinking to bear on new ideas once they are produced (Runco, 2003).

Stages of Creative Thought

Is there any pattern to creative thinking? Typically, five stages occur during creative problem solving:

1. **Orientation.** As a first step, the person defines the problem and identifies its most important dimensions.
2. **Preparation.** In the second stage, creative thinkers saturate themselves with as much information about the problem as possible.
3. **Incubation.** Most major problems produce a period during which all attempted solutions will be futile. At this point, problem solving may proceed on a subconscious level: Although the problem seems to have been set aside, it is still "cooking" in the background.
4. **Illumination.** The stage of incubation is often ended by a rapid insight or series of insights. These produce the "Aha!" experience, often depicted in cartoons as a lightbulb appearing over the thinker's head.
5. **Verification.** The final step is to test and critically evaluate the solution obtained during the stage of illumination. If the solution proves faulty, the thinker reverts to the stage of incubation.

Of course, creative thought is not always so neat. Nevertheless, the stages listed are a good summary of the most typical sequence of events.

You may find it helpful to relate the stages to the following true (more or less) story. Legend has it that the king of Syracuse (a city in ancient Greece) once suspected that his goldsmith had substituted cheaper metals for some of the gold in a crown and kept the extra gold. Archimedes, a famous mathematician and thinker, was given the problem of discovering whether the king had been cheated.

Archimedes began by defining the problem (*orientation*): "How can I tell what metals have been used in the crown without damaging it?" He then checked all known methods of analyzing metals *(preparation)*. All involved cutting or melting the crown, so he was forced to temporarily set the problem aside *(incubation)*. Then one day as he stepped into his bath, Archimedes suddenly knew he had the solution *(illumination)*. He was so excited that he is said to have run naked through the streets shouting, "Eureka, eureka!" (I have found it, I have found it!).

On observing his own body floating in the bath, Archimedes realized that different metals of equal weight would displace different amounts of water. A pound of brass, for example, occupies more space than a pound of gold, which is denser. All that remained was to test the solution (*verification*). Archimedes placed an amount of gold (equal in weight to that given the goldsmith) in a tub of water. He marked the water level and removed the gold. He then placed the crown in the water. Was the crown pure gold? If it was, it would raise the water to exactly the same level. Unfortunately, the purity of the crown and the fate of the goldsmith are to this day unknown! (Too bad Archimedes didn't grow up in China. If he had heard the "weighing-the-elephant" tale, he might have quickly solved the crown problem.)

The preceding account is a good general description of creative thinking. However, rather than springing from sudden insights, much creative problem solving is **incremental**. That is, it is the end result of many small steps. This is certainly true of many inventions, which build on earlier ideas. Some authors believe that truly exceptional creativity requires a rare combination of thinking skills, personality, and a supportive social environment. This mix, they believe, accounts for creative giants such as Edison, Freud, Mozart, Picasso, and others (Robinson, 2010; Simonton, 2009).

Positive Psychology: The Creative Personality

What makes a person creative? According to the popular stereotype, highly creative people are eccentric, introverted, neurotic, socially inept, unbalanced in their interests, and on the edge of madness. After all, isn't there a "fine line between genius and insanity"? Although there is some evidence that the brain chemistry of creative people and mentally ill people is similar (de Manzano, 2010), mentally ill people are generally not creative and vice versa (Robinson, 2010).

A notable exception to the preceding conclusion concerns mood disorders. A person with a mood disorder may be manic (agitated, elated, and hyperactive), depressed, or both. One study found that parents with a history of mood swings, as well as their children, scored higher in creativity than did normal parents and their children (Simeonova et al., 2005). Further, many of history's renowned artists, writers, poets, and composers, including Vincent Van Gogh, Edgar Allan Poe, Emily Dickinson, Ernest Hemmingway, and many others, also experienced pronounced mood swings (Jamison, 1999; McDermott, 2001).

In general, however, direct studies of creative individuals paint a very different picture (Hennessey & Amabile, 2010; Robinson, 2010; Winner, 2003):

1. Although people with high IQs can be quite creative (Park, Lubinski, Benbow, 2008), there is generally little correlation between creativity tests and IQ test scores (Preckel, Holling, & Wiese, 2006).
2. Creative people usually have a greater-than-average range of knowledge and interests, and they are more fluent in combining ideas from various sources. They are also good at using mental images and metaphors in thinking (Riquelme, 2002).
3. Creative people are open to a wide variety of experiences. They accept irrational thoughts and are uninhibited about their feelings and fantasies. They tend to use broad categories, to question assumptions, to break mental sets, and they find order in chaos. They also experience more unusual states of consciousness, such as vivid dreams and mystical experiences (Ayers, Beaton, & Hunt, 1999).
4. Creative people enjoy symbolic thought, ideas, concepts, and possibilities. They tend to be interested in truth, form, and beauty, rather than in fame or success. Their creative work is an end in itself (Robinson, 2010; Sternberg & Lubart, 1995).
5. Creative people value their independence and prefer complexity. However, they are unconventional and nonconforming primarily in their work; otherwise they do not have unusual, outlandish, or bizarre personalities.

Living More Creatively

Can creativity be learned? It is beginning to look as if some creative thinking skills can be learned. In particular, you can become more creative by practicing divergent thinking and by taking risks, analyzing ideas, and seeking unusual connections between ideas (Baer, 1993; Sternberg, 2001). Don't forget to read this chapter's *Psychology in Action* module for more on creativity.

BRIDGES

Humanistic psychologist Abraham Maslow believed that we must live honestly and creatively to make full use our potentials. **See Chapter 10, pages 348–349, for a discussion of self-actualization.**

Intuition—Mental Shortcut? Or Dangerous Detour?

Gateway Question 8.7: *How accurate is intuition?*

At the same time that intuitive thought may contribute to creative problem solving, it can also lead to thinking errors. To see how this can happen, try the following problems:

Problem 1 An epidemic breaks out, and 600 people are about to die. Doctors have two choices. If they give drug A, 200 lives will be saved. If they give drug B, there is a one-third chance that 600 people will be saved, and a two-thirds chance that none will be saved. Which drug should they choose?

Problem 2 Again, 600 people are about to die, and doctors must make a choice. If they give drug A, 400 people will die. If they give drug B, there is a

Incremental problem solving Thinking marked by a series of small steps that lead to an original solution.

Critical Thinking: Have You Ever Thin Sliced Your Teacher?

Think back to your least favorite teacher (not your current one, of course!). How long did it take you to figure out that he or she wasn't going to make your list of star teachers?

In an intriguing study, psychologist Nalini Ambady asked people to watch video clips of teachers they did not know. After watching three 10-second segments, participants were asked to rate the teachers. Amazingly, their ratings correlated highly with year-end course evaluations made by actual students (Ambady & Rosenthal, 1993). Ambady obtained the same result when she presented an even thinner "slice" of teaching behavior, just three 2-second clips. A mere 6 seconds is all that participants needed to form intuitive judgments of the instructors' teaching!

In his book *Blink*, Malcolm Gladwell (2005) argues that this was not a case of hurried irrationality. Instead, it was "thin-slicing," or quickly making sense of thin slivers of experience. According to Gladwell, these immediate, intuitive reactions can sometimes form the basis of more carefully reasoned judgments. They are a testament to the power of the *cognitive unconscious*, which is a part of the brain that does automatic, unconscious processing (Wilson, 2002). Far from being irrational, intuition may be an important part of how we think.

The trick, of course, is figuring out when thin-slicing can be trusted and when it can't. After all, first impressions aren't always right. For example, have you ever had a teacher you came to appreciate only after classes were well under way or only after the course was over? In many circumstances, quick impressions are most valuable when you take the time to verify them through further observation.

---

one-third chance that no one will die, and a two-thirds chance that 600 will die. Which drug should they choose?

Most people choose drug A for the first problem and drug B for the second. This is fascinating because the two problems are identical. The only difference is that the first is stated in terms of lives saved, the second in terms of lives lost. Yet, even people who realize that their answers are contradictory find it difficult to change them (Kahneman & Tversky, 1972, 1973).

Intuition

As the example shows, we often make decisions intuitively, rather than logically or rationally. **Intuition** is quick, impulsive thought. It may provide fast answers, but it can also be misleading and sometimes disastrous (see "Have You Ever Thin Sliced Your Teacher?")

Two noted psychologists, Daniel Kahneman (KON-eh-man) and Amos Tversky (tuh-VER-ski) (1937–1996), studied how we make decisions in the face of uncertainty. They found that human judgment is often seriously flawed (Kahneman, 2003; Kahneman, Slovic, & Tversky, 1982). Let's explore some common intuitive thinking errors, so you will be better prepared to avoid them.

Representativeness

One very common pitfall in judgment is illustrated by the question: Which is more probable?

A. Snowboarder Shaun White will not be in the lead after the first run of a halfpipe competition but will win the competition.

B. Snowboarder Shaun White will not be in the lead after the first run of a halfpipe competition.

Tversky and Kahneman (1982) found that most people regard statements like A as more probable than B. However, this intuitive answer overlooks an important fact: The likelihood of two events occurring together is lower than the probability of either one alone. (For example, the probability of getting one head when flipping a coin is one-half, or .5. The probability of getting two heads when flipping two coins is one-fourth, or .25.) Therefore, A is less likely to be true than B.

According to Tversky and Kahneman, such faulty conclusions are based on the **representativeness heuristic**. That is, we tend to give a choice greater weight if it seems to be representative of what we already know. Thus, you probably compared the information about Shaun White with your mental model of what a snowboarding professional's behavior should be like. Answer A seems to better represent the model. Therefore, it seems more likely than answer B, even though it isn't. In courtrooms, jurors are more likely to think a defendant is guilty if the person appears to fit the profile of a person likely to commit a crime (Davis & Follette, 2002). For example, a young single male from a poor neighborhood would be more likely to be judged guilty of theft than a middle-aged married father from an affluent suburb.

Underlying Odds

Another common error in judgment involves ignoring the **base rate**, or underlying probability of an event. People in one experiment were told that they would be given descriptions of 100 people—70 lawyers and 30 engineers. Subjects were then asked to guess, without knowing anything about a person, whether she or he was an engineer or a lawyer. All correctly stated the probabilities as 70 percent for lawyer and 30 percent for engineer. Participants were then given this description:

Eric is a 30-year-old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. He is well liked by his colleagues.

Notice that the description gives no new information about Eric's occupation. He could still be either an engineer or a lawyer. Therefore, the odds should again be estimated as 70-30. However, most people changed the odds to 50-50. Intuitively, it seems that Eric has an equal chance of being either an engineer or a lawyer. But this guess completely ignores the underlying odds.

Perhaps it is fortunate that we do at times ignore underlying odds. Were this not the case, how many people would get married in the face of a 50 percent divorce rate? Or how many would start high-risk businesses? On the other hand, people who smoke, drink and then drive, or skip wearing auto seat belts ignore rather high odds of injury or illness. In many high-risk situations, ignoring base rates is the same as thinking you are an exception to the rule.

Framing

The most general conclusion about intuition is that the way a problem is stated, or **framed**, affects decisions (Tversky & Kahneman, 1981). As the first example in this discussion revealed, people often give different answers to the same problem if it is stated in slightly different ways. To gain some added insight into framing, try another thinking problem:

> A couple is divorcing. Both parents seek custody of their only child, but custody can be granted to just one parent. If you had to make a decision based on the following information, to which parent would you award custody of the child?
>
> **Parent A:** average income, average health, average working hours, reasonable rapport with the child, relatively stable social life.
>
> **Parent B:** above-average income, minor health problems, lots of work-related travel, very close relationship with the child, extremely active social life.

Most people choose to award custody to Parent B, the parent who has some drawbacks but also several advantages (such as above-average income). That's because people tend to look for *positive qualities* that can be *awarded* to the child. However, how would you choose if you were asked this question: Which parent should be denied custody? In this case, most people choose to deny custody to Parent B. Why is Parent B a good choice one moment and a poor choice the next? It's because the second question asked who should be *denied* custody. To answer this question, people tend to look for *negative qualities* that would *disqualify* a parent. As you can see, the way a question is framed can channel us down a narrow path so we attend to only part of the information provided, rather than weighing all the pros and cons (Shafir, 1993).

Usually, the *broadest* way of framing or stating a problem produces the best decisions. However, people often state problems in increasingly narrow terms until a single, seemingly "obvious" answer emerges. For example, to select a career, it would be wise to consider pay, working conditions, job satisfaction, needed skills, future employment outlook, and many other factors. Instead, such decisions are often narrowed to thoughts such as, "I like to write, so I'll be a journalist," "I want to make good money and law pays well," or "I can be creative in photography." Framing decisions so narrowly greatly increases the risk of making a poor choice. If you would like to think more critically and analytically, it is important to pay attention to how you are defining problems before you try to solve them. Remember, shortcuts to answers often short-circuit clear thinking.

"Hot" Cognition

One final factor bears mentioning: Emotions also tend to affect good judgment. When we must make a choice, our emotional reactions to various alternatives can determine what intuitively seems to be the right answer. Of course, taking action in the heat of anger, passion, or stress may not be the wisest move. It may be better to "cool down" a bit before picking that bar fight, running off and eloping, or immediately declining that daunting job offer (Johnson, Batey, & Holdsworth, 2009). Personal rituals, such as counting to ten, meditating for a moment, and even engaging in superstitious behaviors like crossing your fingers before moving ahead, can be calming (Damisch, Stoberock, & Mussweiler, 2010).

Even mild emotions, such as low-level stress, can subtly influence how we think and act (for an example, see "Extra Hot, Decaf, Double-Shot..."). Emotions such as fear, hope, anxiety, liking, or disgust can eliminate possibilities from consideration or promote them to the top of the list (Kahneman, 2003). For many people, choosing which political candidate to vote for is a good example of how emotions can cloud clear thinking. Rather than comparing candidates' records and policies, it is tempting to vote for the person we like rather than the person who is most qualified for the job.

A Look Ahead

We have discussed only some of the intuitive errors made in the face of uncertainty. In the upcoming *Psychology in Action* section, we will return to the topic of creative thinking for a look at ways to promote creativity.

Knowledge Builder — Creativity and Intuition

RECITE

1. Fluency, flexibility, and originality are characteristics of
   a. convergent thought *b.* deductive thinking *c.* creative thought *d.* trial-and-error solutions
2. List the typical stages of creative thinking in the correct order.
   ____________ ____________ ____________ ____________ ____________
3. Reasoning and critical thinking tend to block creativity; these are noncreative qualities. T or F?
4. To be creative, an original idea must also be high quality and relevant. T or F?

Continued

Intuition Quick, impulsive thought that does not make use of formal logic or clear reasoning.
Representativeness heuristic A tendency to select wrong answers because they seem to match preexisting mental categories.
Base rate The basic rate at which an event occurs over time; the basic probability of an event.
Framing In thought, the terms in which a problem is stated or the way that it is structured.

Critical Thinking

Extra Hot, Decaf, Double-Shot. . .

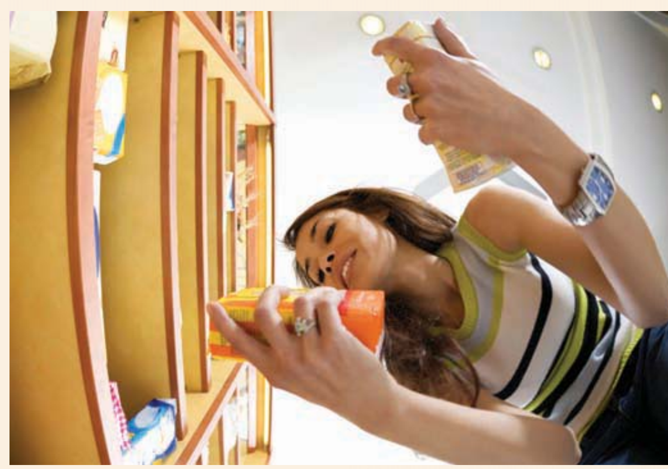
. . . sugar-free, venti with vanilla soy, light whip, peppermint white chocolate mocha, nonfat, no foam with extra syrup, double-cupped, please. Overhearing the order while standing in line at their favorite coffee shop, the older woman remarked to her husband, "Don't you miss the days when all you could order was a coffee with cream and sugar?" Behind them, a young man whispered in his friend's ear, "Poor old people!" One stereotype of elderly people is that they have trouble coping with modern life.

But are the elderly the only ones sometimes left bewildered by tasks as simple as ordering a cup of coffee? Isn't the freedom of having a wide variety of choices a good thing (Leotti, Iyengar, & Ochsner, 2010)? Maybe not. According to behavioral economist Dilip Soman (2010), we are all struggling to make choices in an ever more complex world.

In one study, consumers were given an option to purchase jam. Half of them could choose from 6 different flavors, the other half had 24 flavors to choose from. Although consumers with more choice expressed more interest, they were actually 10 times *less* likely to purchase any jam (Iyengar & Lepper, 2000). Similarly, restaurants whose menus feature a broader variety of choices often find that patrons are more likely to order from a smaller number of familiar choices (Soman, 2010). Apparently, businesses that increase the variety of their product offerings are not guaranteed increased sales (Gourville & Soman, 2005).

It may be faintly amusing that people have trouble exercising choice in a coffee shop, grocery store, or restaurant. It's not that funny when more important issues are involved, such as choosing the best medicine or medical procedure. Imagine, for example, facing too many options when deciding whether to remove a seriously ill infant from life support (Botti, Orfali, & Iyengar, 2009).

Why are more complex choices so tough to make? Researchers like Soman have identified a number of factors, such as increased stress, cognitive overload, difficulty remembering all of the choices, and confusion about the possibilities (Soman, 2010). Although the growing complexity of modern life may increase our freedom, our choices may be expanding beyond our capacity to cope. So try ordering a coffee with cream and sugar sometime.



Diego Cervo/Shutterstock

5. Intelligence and creativity are highly correlated; the higher a person's IQ is, the more likely he or she is to be creative. T or F?
6. Kate is single, outspoken, and very bright. As a college student, she was deeply concerned with discrimination and other social issues and participated in several protests. Which statement is more likely to be true?
   a. Kate is a bank teller. *b.* Kate is a bank teller and a feminist.

REFLECT

Think Critically

7. A coin is flipped four times with one of the following results: *(a)* H T T H, *(b)* T T T T, *(c)* H H H H, *(d)* H H T H. Which sequence would most likely precede getting a head on the fifth coin flip?

Relate

Make up a question that would require convergent thinking to answer. Now do the same for divergent thinking.

Which of the tests of creativity described in the text do you think you would do best on? (Look back if you can't remember them all.)

To better remember the stages of creative thinking, make up a short story that includes these words: *orient*, *prepare*, *in Cuba*, *illuminate*, *verify*.

Explain in your own words how representativeness and base rates contribute to thinking errors.

Answers: 1. c **2.** orientation, preparation, incubation, illumination, verification **3.** F **4.** T **5.** F **6.** *a* **7.** The chance of getting heads on the fifth flip is the same in each case. Each time you flip a coin, the chance of getting a head is 50 percent, no matter what happened before. However, many people intuitively think that *b* is the answer because a head is "overdue," or that *c* is correct because the coin is "on a roll" for heads.

Psychology in Action

Enhancing Creativity—Brainstorms

Gateway Question 8.8: *What can be done to promote creativity?*

Thomas Edison explained his creativity by saying, "Genius is 1 percent inspiration and 99 percent perspiration." Many studies of creativity show that "genius" and "eminence" owe as much to persistence and dedication as they do to inspiration (Robinson, 2010; Winner, 2003). Once it is recognized that creativity can be hard work, then something can be done to enhance it. Here are some suggestions:

1. Break Mental Sets and Challenge Assumptions

A **mental set** is the tendency to perceive a problem in a way that blinds us to possible solutions. Mental sets are a major barrier to creative thinking. They usually will lead us to see a problem in preconceived terms that impede our problem solving attempts. (Fixations and functional fixedness, which were described earlier, are specific types of mental sets.)

Try the problems pictured in ● Figure 8.20. If you have difficulty, try asking yourself what assumptions you are making. The problems are designed to demonstrate the limiting effects of a mental set. (The answers to these problems, along with an explanation of the sets that prevent their solution, are found in ● Figure 8.21.)

Now that you have been forewarned about the danger of faulty assumptions, see if you can correctly answer the following questions. If you get caught on any of them, consider it an additional reminder of the value of actively challenging the assumptions you are making in any instance of problem solving.

1. A farmer had 19 sheep. All but 9 died. How many sheep did the farmer have left?
2. It is not unlawful for a man living in Winston-Salem, North Carolina, to be buried west of the Mississippi River. T or F?
3. Some months have 30 days, some have 31. How many months have 28 days?
4. I have two coins that together total 30 cents. One of the coins is not a nickel. What are the two coins?
5. If there are 12 one-cent candies in a dozen, how many two-cent candies are there in a dozen?

These questions are designed to cause thinking errors. Here are the answers:

1. Nineteen—9 alive and 10 dead. **2.** F. It is against the law to bury a living person anywhere. **3.** All of them. **4.** A quarter and a nickel. One of the coins is not a nickel, but the other one is! **5.** 12.

2. Define Problems Broadly

An effective way to break mental sets is to enlarge the definition of a problem. For instance, assume that your problem is to design a better doorway. This is likely to lead to ordinary solutions. Why not change the problem to design a better way to get through a wall? Now your solutions will be more original. Best of all might be to state the problem as follows: Find a better way to define separate areas for living and working. This could lead to truly creative solutions (Adams, 2001).

Let's say you are leading a group that's designing a new can opener. Wisely, you ask the group to think about *opening* in general, rather than about can openers. This was just the approach that led to the pop-top can. As the design group discussed the concept of opening, one member suggested that nature has its own openers, like the soft seam on a pea pod. Instead of a new can-opening tool, the group invented the self-opening can (Stein, 1974).

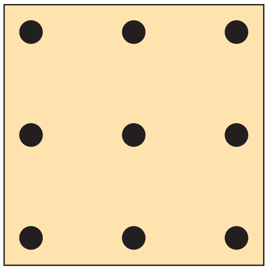
3. Restate the Problem in Different Ways

Stating problems in novel ways also tends to produce more creative solutions. See if you can cross out six letters to make a single word out of the following:

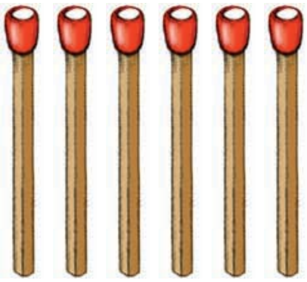
CSRIEXLEATTTERES

If you're having difficulty, it may be that you need to restate the problem. Were you trying to cross out 6 letters? The real solution is to cross out the letters in the words "six letters," which yields the word CREATE.

One way to restate a problem is to imagine how another person would view it. What would a child, engineer, professor, mechanic, artist, psychologist, judge, or minister ask about the



(a)



(b)

● **Figure 8.20** *(a)* Nine dots are arranged in a square. Can you connect them by drawing four continuous straight lines without lifting your pencil from the paper? *(b)* Six matches must be arranged to make four triangles. The triangles must be the same size, with each side equal to the length of one match. (The solutions to these problems appear in Fig. 8.21.)

Mental set A predisposition to perceive or respond in a particular way.

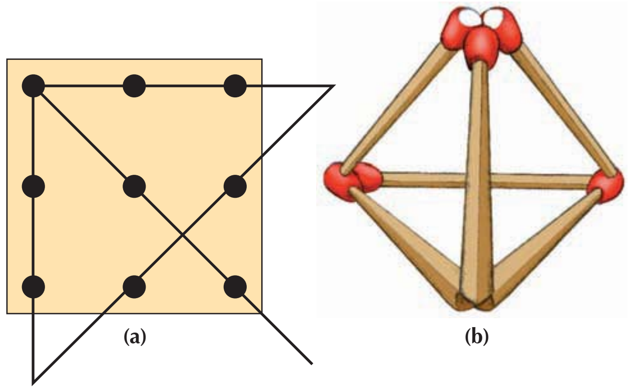


Figure 8.21 Problem solutions. *(a)* The dot problem can be solved by extending the lines beyond the square formed by the dots. Most people assume incorrectly that they may not do this. *(b)* The match problem can be solved by building a three-dimensional pyramid. Most people assume that the matches must be arranged on a flat surface. If you remembered the four-tree problem from earlier in the chapter, the match problem may have been easy to solve.

problem? Also, don't be afraid to ask "silly" or playful questions. Here are some examples:

If the problem were alive, what would it look like?
If the problem were edible, how would it taste?
How would the problem look from an airplane? How does it look from underneath?
Is any part of the problem pretty? Ugly? Stupid? Friendly?
If the problem could speak, what would it say?

At the very least, you should almost always ask the following questions:

What information do I have?
What don't I know?
What can I extract from the known information?
Have I used all of the information?
What additional information do I need?
What are the parts of the problem?
How are the parts related?
How could the parts be related?
Is this in any way like a problem I've solved before?

Remember, to think more creatively you must find ways to jog yourself out of mental sets and habitual modes of thought (Michalko, 2001; Simonton, 2009).

4. Seek Varied Input

Remember, creativity requires divergent thinking. Rather than digging deeper with logic, you are attempting to shift your mental "prospecting" to new areas. As an example of this strategy, Edward de Bono (1992) recommends that you randomly look up words in the dictionary and relate them to the problem. Often the words will trigger a fresh perspective or open a new avenue. For instance, let's say you are asked to come up with new ways to clean oil off a beach. Following de Bono's suggestion, you would read the following randomly selected words, relate each to the problem, and see what thoughts are triggered: *weed*, *rust*, *poor*, *magnify*, *foam*, *gold*, *frame*, *hole*, *diagonal*, *vacuum*, *tribe*, *puppet*, *nose*, *link*, *drift*, *portrait*, *cheese*, *coal*. You may get similar benefits from relating various objects to a problem. Or, take a walk, skim through a newspaper, or look through a stack of photographs to see what thoughts they trigger (Michalko, 2001). Exposing yourself to a wide variety of information is a good way to encourage divergent thinking (Clapham, 2001; Gilhooly et al., 2007).

5. Look for Analogies

Many "new" problems are really old problems in new clothing (Siegler, 1989). Representing a problem in a variety of ways is often the key to solution. Most problems become easier to solve when they are effectively represented. For example, consider this problem:

> Two backpackers start up a steep trail at 6 a.m. They hike all day, resting occasionally, and arrive at the top at 6 p.m. The next day they start back down the trail at 6 a.m. On the way down, they stop several times and vary their pace. They arrive back at 6 p.m. On the way down, one of the hikers, who is a mathematician, tells the other that she has realized that they will pass a point on the trail at exactly the same time as they did the day before. Her nonmathematical friend finds this hard to believe, since on both days they have stopped and started many times and changed their pace. The problem: Is the mathematician right?

Perhaps you will see the answer to this problem immediately. If not, think of it this way: What if there were two pairs of backpackers, one going up the trail, the second coming down, and both hiking *on the same day*? As one pair of hikers goes up the trail and the other goes down, they *must* pass one another at some point on the trail, right? Therefore, at that point they will be at the same place at the same time. Now, would your conclusion change if one of the pairs was going up the trail one day and the other was coming down the trail the next? If you mentally draw their path up the mountain and then visualize them coming back down it the next day, do you see that at some point the two paths will meet at the same point at the same time on both days? Well, what if the same pair of hikers were going up one day and coming back down the next? As you can now see, the mathematician was right.

6. Take Sensible Risks

A willingness to go against the crowd is a key element in doing creative work. Unusual and original ideas may be rejected at first by conventional thinkers. Often, creative individuals must persevere and take some risks before their ideas are widely accepted. For example, Post-It notes were invented by an engineer who accidentally created a weak adhesive. Rather than throw the mixture out, the engineer put it to a highly creative new use. However, it took him some time to convince others that a "bad" adhesive could be a useful product. Today, stick-on notepapers are one of the 3M Company's most successful products (Sternberg & Lubart, 1995).

7. Allow Time for Incubation

If you are feeling hurried by a sense of time pressure, you are almost always less likely to think creatively (Amabile, Hadley, & Kramer, 2002). You need to be able to revise or embellish initial solutions, even those based on rapid insight. Incubation is especially fruitful when you are exposed to external cues that relate to the problem (remember Archimedes' bath?). For example, Johannes Gutenberg, creator of the printing press, realized while at a wine harvest that the mechanical pressure used to crush grapes could also be used to imprint letters on paper (Dorfman, Shames, & Kihlstrom, 1996).

8. Delay Evaluation

Various studies suggest that people are most likely to be creative when they are given the freedom to play with ideas and solutions without having to worry about whether they will be evaluated. In the first stages of creative thinking, it is important to avoid criticizing your efforts. Worrying about the correctness of solutions tends to inhibit creativity (Basadur, Runco, & Vega, 2000).

Brainstorming

An alternative approach to enhancing creativity is called *brainstorming*. The essence of **brainstorming** is that producing and evaluating ideas are kept separate. This encourages divergent thinking. In group problem solving, each person is encouraged to produce as many ideas as possible without fear of criticism (Buyer, 1988). Only at the end of a brainstorming session are ideas reconsidered and evaluated. As ideas are freely generated, an interesting **cross-stimulation effect** takes place in which one participant's ideas trigger ideas from others (Brown et al., 1998).

How is brainstorming applied to individual problem solving? The essential point to remember is to *suspend judgment*. Ideas should first be produced without regard for logic, organization, accuracy, practicality, or any other evaluation. In writing an essay, for instance, you would begin by writing ideas in any order, the more the better, just as they occur to you. Later, you can go back and reorganize, rewrite, and criticize your efforts.

The basic rules for successful brainstorming are:

1. Absolutely do not criticize ideas until later in the session.
2. Modify or combine ideas freely. Don't worry about giving credit for ideas or keeping them neat. Mix them up!
3. Try to generate lots of ideas. In the early stages of brainstorming, quantity is more important than quality.
4. Let your imagination run amok! Seek unusual, remote, or wild ideas.
5. Record ideas as they occur.
6. Elaborate or improve on the most promising ideas. (Kaufman, 2009; Michalko, 2001)

Living More Creatively

Many people who think in conventional ways live intelligent, successful, and fulfilling lives. Just the same, creative thinking can add spice to life and lead to exciting personal insights (Kaufman, 2009). Psychologist Mihalyi Csikszentmihalyi (sik-sent-me-HALE-yee) (1997) makes these recommendations about how to become more creative:

- Find something that surprises you every day.
- Try to surprise at least one person every day.
- If something sparks your interest, follow it.
- Make a commitment to doing things well.
- Seek challenges.
- Take time for thinking and relaxing.
- Start doing more of what you really enjoy, less of what you dislike.
- Try to look at problems from as many viewpoints as you can.

Even if you don't become more creative by following these suggestions, they are still good advice. Life is not a standardized test with a single set of correct answers. It is much more like a blank canvas on which you can create designs that uniquely express your talents and interests. To live more creatively, you must be ready to seek new ways of doing things. Try to surprise at least one person today—yourself, if no one else.

Knowledge Builder: Enhancing Creativity

RECITE

1. Fixations and functional fixedness are specific types of mental sets. T or F?
2. The incubation period in creative problem solving usually lasts just a matter of minutes. T or F?
3. Exposure to creative models has been shown to enhance creativity. T or F?
4. In brainstorming, each idea is critically evaluated as it is generated. T or F?
5. Defining a problem broadly produces a cross-stimulation effect that can inhibit creative thinking. T or F?

REFLECT

Think Critically

6. Do you think there is any connection between your mood and your creativity?

Self-Reflect

Review the preceding pages and note which methods you could use more often to improve the quality of your thinking. Now mentally summarize the points you especially want to remember.

Answers: 1. T **2.** F **3.** T **4.** F **5.** F **6.** In general, more intense moods are associated with higher creativity (Davis, 2009).

Brainstorming Method of creative thinking that separates the production and evaluation of ideas.

Cross-stimulation effect In group problem solving, the tendency of one person's ideas to trigger ideas from others.

CENGAGE Learning

Chapter in Review Gateways to Cognition, Language, and Creativity

Gateway QUESTIONS REVISITED

8.1 What is the nature of thought?

8.1.1 Thinking is the manipulation of internal representations of external stimuli or situations.

8.1.2 Three basic units of thought are images, concepts, and language (or symbols).

8.2 In what ways are images related to thinking?

8.2.1 Most people have internal images of one kind or another. Sometimes they cross normal sense boundaries in a type of imagery called synesthesia.

8.2.2 Images may be three-dimensional, they may be rotated in space, and their size may change.

8.2.3 The same brain areas are involved in both vision and visual imagery.

8.2.4 Images may be stored or created.

8.2.5 Kinesthetic images are used to represent movements and actions. Kinesthetic sensations help structure the flow of thoughts for many people.

8.3 What are concepts and how are they learned?

8.3.1 A concept is a generalized idea of a class of objects or events.

8.3.2 Concept formation may be based on positive and negative instances or rule learning.

8.3.3 Concepts may be conjunctive ("and" concepts), disjunctive ("either/or" concepts), or relational.

8.3.4 In practice, concept identification frequently makes use of prototypes, or general models of the concept class.

8.3.5 Oversimplification and stereotyping contribute to thinking errors.

8.3.6 The denotative meaning of a word or concept is its dictionary definition. Connotative meaning is personal or emotional and can be measured with the semantic differential.

8.4 What is language and what role does it play in thinking?

8.4.1 Language encodes events into symbols, for easy mental manipulation. The study of meaning is called *semantics*.

8.4.2 Bilingualism is a valuable ability. Two-way bilingual education allows children to develop additive bilingualism while in school.

8.4.3 Language carries meaning by combining a set of symbols according to a set of rules (grammar), which includes rules about word order (syntax). A true language is productive and can be used to generate new ideas or possibilities.

8.4.4 Complex gestural systems, such as American Sign Language, are true languages.

8.4.5 Natural animal communication is relatively limited because it lacks symbols that can be rearranged easily.

8.4.6 Chimpanzees and other primates have been taught American Sign Language and similar systems. This suggests to some that primates are capable of very basic language use. Others question this conclusion.

8.5 What do we know about problem solving?

8.5.1 The solution to a problem may be arrived at mechanically (by trial and error or by rote application of algorithms), but mechanical solutions are often inefficient.

8.5.2 Solutions by understanding usually begin with discovery of the general properties of an answer, followed by a functional solution.

8.5.3 Problem solving is aided by heuristics, which narrow the search for solutions.

8.5.4 When understanding leads to a rapid solution, insight has occurred. Three elements of insight are selective encoding, selective combination, and selective comparison.

8.5.5 Insight and other problem solving can be blocked by fixation. Functional fixedness is a common fixation, but emotional blocks, cultural values, learned conventions, and perceptual habits are also problems.

8.5.6 Problem-solving experts also engage in automatic processing and pattern recognition.

8.6 What is the nature of creative thinking?

8.6.1 To be creative, a solution must be high quality and relevant as well as original. Creative thinking requires divergent thought, characterized by fluency, flexibility, and originality. Tests of creativity measure these qualities.

8.6.2 Five stages often seen in creative problem solving are orientation, preparation, incubation, illumination, and verification. Not all creative thinking fits this pattern.

8.6.3 Studies suggest that the creative personality has a number of characteristics, most of which contradict popular stereotypes. There is only a very small correlation between IQ and creativity.

8.6.4 Some creative thinking skills can be learned.

8.7 How accurate is intuition?

8.7.1 Intuitive thinking can be fast and accurate but also often leads to errors. Wrong conclusions may be drawn when an answer seems highly representative of what we already believe is true.

8.7.2 Another problem is ignoring the base rate (or underlying probability) of an event.

8.7.3 Clear thinking is usually aided by stating or framing a problem in broad terms.

8.7.4 Emotions also lead to intuitive thinking and poor choices.

8.8 *What can be done to promote creativity?*

8.8.1 Various strategies that promote divergent thinking tend to enhance creative problem solving.

8.8.2 In group situations, brainstorming may lead to creative solutions. The principles of brainstorming can also be applied to individual problem solving.

MEDIA RESOURCES

Web Resources

Internet addresses frequently change. To find an up-to-date list of URLs for the sites listed here, *visit your Psychology CourseMate.*

Amoeba Web Psychology Resources: Cognitive Psychology Go to the "Cognitive Psychology" link on this web page and you will find numerous other links to articles/information on many areas of cognitive psychology.

Synesthesia and the Synesthetic Experience Read first-hand accounts of the experiences of synesthetes.

Francis Galton on Mental Imagery Read a classic paper on mental imagery by one of the first psychologists.

Kinesthetic Images and the Piano Read this example of using kinesthetic imagery to improve performance.

How Does Our Language Shape the Way We Think? Read more about language and thinking.

Koko.org View the sign language (and art!) of Koko, the gorilla.

The Alex Foundation Explore the language abilities of African Gray parrots.

Classic Problems Try to solve some classic problems.

How Experts Differ from Novices Read more about the differences between experts and novices.

Functional Fixedness Read about tool use and functional fixedness.

Creativity Web Multiple links to resources on creativity.

Creative Thinking Techniques Try to apply a variety of creative thinking and lateral thinking techniques.

Thin Slicing Read what Malcolm Gladwell, the author of *Blink*, has to say about rapid cognition.

Interactive Learning

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