CHAPTER

7 Cognition and Mental Abilities

OVERVIEW

ISBN 1-256-37427-X

"At the Braefield School for the Deaf, I met Joseph, a boy of 11 who had just entered school for the first time—an 11-year-old with no language whatever. He had been born deaf, but this had not been realized until he was in his fourth year. His failure to talk, or understand speech, at the normal age was put down to 'retardation,' then to 'autism,' and these diagnoses had clung to him. When his deafness finally became apparent he was seen as 'deaf and dumb,' dumb not only literally, but metaphorically, and there was never any attempt to teach him language.

Joseph longed to communicate, but could not. Neither speaking nor writing nor signing was available to him, only gestures and pantomimes, and a marked ability to draw. What has happened to him? I kept asking myself. What is going on inside, how has he come to such a pass? He looked alive and animated, but profoundly baffled: His eyes were attracted to speaking mouths and signing hands—they darted to our mouths and hands, inquisitively, uncomprehendingly, and, it seemed to me, yearningly. He perceived that something was 'going on' between us, but he could not comprehend what it was—he had, as yet, almost no idea of symbolic communication, of what it was to have a symbolic currency, to exchange meaning....

Joseph was unable, for example, to communicate how he had spent the weekend.... It was not only language that was missing: there was not, it was evident, a clear sense of the past, of 'a day ago' as distinct from 'a year ago.' There was a strange lack of historical sense, the feeling of a life that lacked autobiographical and historical dimension...a life that only existed in the moment, in the present....

Joseph saw, distinguished, categorized, used; he had no problems with perceptual categorization or generalization, but he could not, it seemed, go much beyond this, hold abstract ideas in mind, reflect, play, plan. He seemed completely literal—unable to juggle images or hypotheses or possibilities, unable to enter an imaginative or figurative realm. And yet, one still felt, he was of normal intelligence, despite the manifest limitations of intellectual functioning. It was not that he lacked a mind, but that he was not using his mind fully...." (Sacks, 2000, pp. 32–34)

As Sacks suggests, language and thought are intertwined. We find it difficult to imagine one without the other, and we consider both part of what it means to be human. Psychologists use the term **cognition** to refer to all the processes that we use to acquire and apply information. We have already considered the cognitive processes of perception, learning, and memory. In this chapter, we focus on three cognitive processes that we think of as characteristically human: thinking, problem solving, and decision making. We also discuss two mental abilities that psychologists have tried to measure: intelligence and creativity.

Enduring Issues in Cognition and Mental Abilities

The "Enduring Issues" in this chapter are highlighted in four prominent places. We will encounter the diversity–universality theme when we explore the differences and similarities in the way people process information and again when we discuss exceptional abilities. We make two additional references to the enduring issues as we discuss the stability–change of intelligence test scores over time and again when we explore how measures of intelligence and performance sometimes vary as a function of expectations and situations (person–situation).

BUILDING BLOCKS OF THOUGHT

What are the three most important building blocks of thought?

When you think about a close friend, you may have in mind complex statements about her, such as "I'd like to talk to her soon" or "I wish I could be more like her." You may also have an image of her—probably her face, but perhaps the sound of her voice as well. Or you may think of your friend by using various concepts or categories such as *woman*, *kind*, *strong*, *dynamic*, and *gentle*. When we think, we make use of all these things—language, images, and concepts—often simultaneously. These are the three most important building blocks of thought.

LEARNING OBJECTIVE

- **Describe the three basic building blocks of thought and give an example of each. Explain how phonemes, morphemes, and grammar (syntax and semantics) work together to form a language.**

cognition The processes whereby we acquire and use knowledge.

ISBN 1-256-37427-X

Language

What steps do we go through to turn a thought into a statement?

Human **language** is a flexible system of symbols that enables us to communicate our ideas, thoughts, and feelings. Joseph, the deaf boy described at the beginning of this chapter, had great difficulty communicating because he knew no languages. Although all animals communicate with each other, language is unique to humans (MacWhinney, 2005).

One way to understand language is to consider its basic structure. Spoken language is based on units of sound called **phonemes**. The sounds of *t*, *th*, and *k*, for instance, are all phonemes in English. By themselves, phonemes are meaningless and seldom play an important role in helping us to think. But phonemes can be grouped together to form words, prefixes (such as *un-* and *pre-*), and suffixes (such as *-ed* and *-ing*). These meaningful combinations of phonemes are known as **morphemes**—the smallest meaningful units in a language. Unlike phonemes, morphemes play a key role in human thought. They can represent important ideas such as "red" or "calm" or "hot." The suffix *-ed* captures the idea of "in the past" (as in *visited* or *liked*). The prefix *pre-* conveys the idea of "before" or "prior to" (as in *preview* or *predetermined*).

We can combine morphemes to create words that represent quite complex ideas, such as *pre-exist-ing, un-excell-ed, psycho-logy*. In turn, words can be arranged to form sentences according to the rules of **grammar**. The two major components of grammar are *syntax* and *semantics*. *Syntax* is the system of rules that governs how we combine words to form meaningful phrases and sentences. For example, in English and many other languages, the meaning of a sentence is often determined by word order. "Sally hit the car" means one thing; "The car hit Sally" means something quite different; and "Hit Sally car the" is meaningless.

Semantics describes how we assign meaning to morphemes, words, phrases, and sentences—in other words, the content of language. When we are thinking about something—say, the ocean—our ideas often consist of phrases and sentences, such as "The ocean is unusually calm tonight." Sentences have both a *surface structure*—the particular words and phrases—and a *deep structure*—the underlying meaning. The same deep structure can be conveyed by different surface structures:

The ocean is unusually calm tonight.
Tonight the ocean is particularly calm.
Compared with most other nights, tonight the ocean is calm.

Alternatively, the same surface structure can convey different meanings or deep structures, but a knowledge of language permits one to know what is meant within a given context:

Surface Structure	Might mean… Or…
Flying planes can be dangerous.	An airborne plane…
	The profession of pilot…
Visiting relatives can be a nuisance.	Relatives who are visiting…
	The obligation to visit relatives…
The chicken is ready to eat.	Food has been cooked sufficiently…
	The bird is hungry…

language A flexible system of communication that uses sounds, rules, gestures, or symbols to convey information.

phonemes The basic sounds that make up any language.

morphemes The smallest meaningful units of speech, such as simple words, prefixes, and suffixes.

grammar The language rules that determine how sounds and words can be combined and used to communicate meaning within a language.

Syntax and semantics enable speakers and listeners to perform what linguist Noam Chomsky calls *transformations* between surface structure and deep structure. According to Chomsky (1957; Chomsky, Place, & Schoneberger, 2000), when you want to communicate an idea, you start with a thought, then choose words and phrases that will express the idea, and finally, produce the speech sounds that make up those words and phrases, as shown by the left arrow in **Figure 7–1**. When you want to understand a sentence, your task is reversed. You must start with speech sounds and work your way up to the meaning of those sounds, as represented by the right arrow in **Figure 7–1**.

Our remarkable ability to perform these transformations becomes clear when you attempt to comprehend the following sentence: when lettres wihtin wrods are jubmled or trnasposed (as

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they are in this sentence), raeding speed is redcued, though not as much as you might expect (approximately 11%–26%). However, it is much more difficult to extract the meaning of a sentence when letter substitutions are made (such as "qroblem" or "problnc" for "problem") (Rayner, White, Johnson, & Liversedge, 2006).

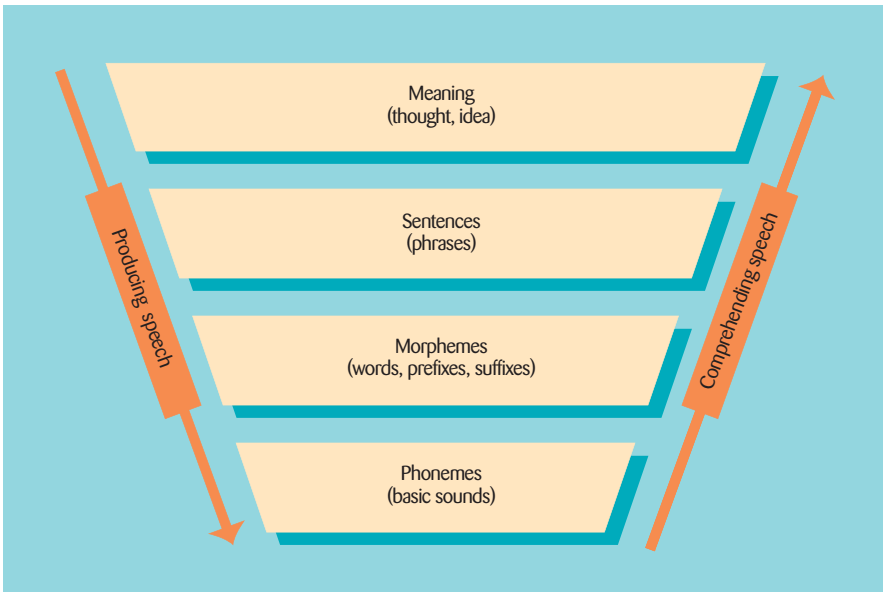


Figure 7–1
The direction of movement in speech production and comprehension.
Producing a sentence involves movement from thoughts and ideas to basic sounds; comprehending a sentence requires movement from basic sounds back to the underlying thoughts and ideas.

Images

What role do images play in thinking?

Using language is not the only way to think about things. Think for a moment about Abraham Lincoln. Your thoughts of Lincoln may have included such phrases as "wrote the Gettysburg Address" and "president during the Civil War." But you probably also had some mental images about him: bearded face, lanky body, or log cabin. An **image** is a mental representation of some sensory experience, and it can be used to think about things. We can visualize the Statue of Liberty; we can smell Thanksgiving dinner; we can hear Martin Luther King, Jr., saying, "I have a dream!" Images also allow us to use concrete forms to represent complex and abstract ideas, as when newspapers use pie charts and graphs to illustrate how people voted in an election (Stylianou, 2002; C. C. Yang, Chen, & Hong, 2003).

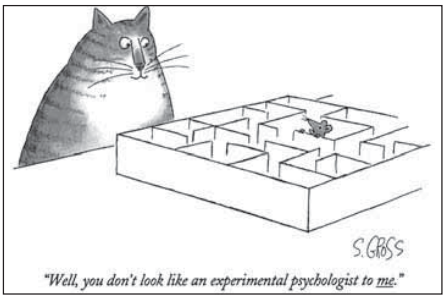
Concepts

How do concepts help us to think more efficiently?

Concepts are mental categories for classifying specific people, things, or events. *Dogs*, *books*, *fast*, *beautiful*, and *interesting* are all concepts. When you think about a specific thing—say, Mt. Everest—you may think of facts, such as that it is 29,029 feet high or that it is on the border between Nepal, Tibet, and China. You may also have an image of it. But you are also likely to think of the concepts that apply to it, such as *mountain*, *highest, dangerous,* and *snow-covered*. Concepts help us to think efficiently about things and how they relate to one another. They also give meaning to new experiences and allow us to organize our experiences. For example, most children soon develop a concept of *fish* that allows them to recognize, think about and understand new kinds of fish when they see them for the first time. And over time, we often find it necessary to modify some of our concepts to better match our experiences. Thus, as they grow older, children come to understand that whales and dolphins are not fish (though, like fish, they swim in water) and they modify their concepts of *fish* and *mammals* accordingly. Conversely, for most of us there is no need to understand that killer whales and pilot whales are actually dolphins and thus no need to modify our concepts of *dolphins* and *whales* accordingly.

Although it is tempting to think of concepts as simple and clear-cut, most of the concepts that we use are rather "fuzzy": They overlap one another and are often poorly defined. For example, most people can tell a mouse from a rat, but listing the critical differences between the two would be difficult (Rosch, 1973, 2002). If we cannot explain the difference between mouse and rat, how can we use these *fuzzy concepts* in our thinking? It turns out that we often construct a **prototype** (or **model**) of a representative mouse and one of a representative rat, and then use those prototypes in our thinking (Rosch, 1978, 2002; Voorspoels, Vanpaemel, & Storms, 2008). For example, when thinking about birds, most of us have a prototype, in mind—such as a robin or a sparrow—that captures for us the essence of *bird*. When we encounter new objects, we compare them with this prototype to determine whether they are, in fact, birds. And when we think about birds, we usually think about our prototypical bird.

Concepts, then, like words and images, help us to formulate thoughts. But human cognition involves more than just passively thinking about things. It also involves actively



"Well, you don't look like an experimental psychologist to *me*."

Source: © *The New Yorker Collection*, 1994, Sam Gross from *cartoonbank.com*. All Rights Reserved.

image A mental representation of a sensory experience.

concepts Mental categories for classifying objects, people, or experiences.

prototype (or model) According to Rosch, a mental model containing the most typical features of a concept.

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Pablo Picasso, the great 20th-century artist, developed a style of painting known as Cubism. In paintings such as *Nude with Bunch of Irises and Mirror*, 1934, shown here, he re-formed objects into basic geometric shapes. We recognize the figure in this painting as a woman because its shapes represent the "concept" of a female.

CHECK YOUR UNDERSTANDING

1. _____, _____, and _____ are the three most important building blocks of thought.
2. In language, units of sound, called _____, are combined to form the smallest units of meaning, called _____. These smallest meaningful units can then be combined to create words, which in turn can be used to build phrases and whole _____.
3. Language rules that specify how sounds and words can be combined into meaningful sentences are called rules of _____.
4. Indicate whether the following statements are true (T) or false (F).
   a. _____ Images help us to think about things because images use concrete forms to represent complex ideas.
   b. _____ People decide which objects belong to a concept by comparing the object's features to a model or prototype of the concept.
   c. _____ Concepts help us give meaning to new experiences.

Answers: 1. language, images, concepts. 2. phonemes, morphemes, sentences. 3. grammar. 4. a. (T); b. (T); c. (T).

APPLY YOUR UNDERSTANDING

1. "I will spend tonight studying." "Tonight I will be studying." These two sentences exhibit the same
   a. surface structure.
   b. syntax.
   c. phonology.
   d. deep structure.
2. Harry cannot list the essential differences between dogs and cats, but he has no trouble thinking about dogs and cats. This is most likely due to the fact that he
   a. has a prototype of a representative dog and another of a representative cat.
   b. has developed a morpheme for a dog and another morpheme for a cat.
   c. is exhibiting functional fixedness.
   d. is using heuristics.

Answers: 1. d. 2. a.

using words, images, and concepts to fashion an understanding of the world, to solve problems, and to make decisions. In the next three sections, we see how this is done.

LEARNING OBJECTIVE

- **Summarize the evidence for the idea that people in different cultures perceive and think about the world in different ways. Explain what is meant by "linguistic determinism" and summarize the evidence for and against it.**

LANGUAGE, THOUGHT, AND CULTURE

How do language, thought, and culture influence each other?

ENDURING ISSUES

Diversity–Universality Do We All Think Alike?

For at least 100 years, psychologists and philosophers assumed the basic processes of human cognition are universal. They accepted that cultural differences affect thought—thus, Masai elders in the Serengeti count their wealth in heads of cattle, whereas Wall Street bankers measure theirs in stocks and bonds. But habits of thought—the ways people process information—were assumed to be the same everywhere. The tendency to categorize objects and experiences, the ability to reason logically, and the desire to understand situations in terms of cause and effect were thought to be part of human nature, regardless of cultural setting (Goode, 2000a). In this section, we will examine the validity of these viewpoints. ■

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Do people from different cultures perceive and think about the world in different ways? A series of controlled experiments suggests they do. In one experiment (Nisbett, Peng, Choi, & Norenzayan, 2001), American and Japanese students were shown an underwater scene and asked to describe what they saw. Most Japanese participants described the scene as a whole, beginning with the background; by contrast, most American participants described the biggest, brightest, fastest fish. Nisbett and his colleagues concluded these studies reflect fundamental, qualitative differences in how Easterners and Westerners perceive and think about the world. They also emphasized that the origin of these differences is cultural rather than genetic, because the cognitive approach of U.S.-born Asian Americans is indistinguishable from that of European Americans (Peng & Nisbett, 1999; Nisbett et al., 2001; Nisbett & Norenzayan, 2002).

The Dani of New Guinea can perceive and remember the many colors of their world just as readily as you can, even though their language has only two color terms—*light* and *dark*. Human thought is not limited to the words in a person's language. Language may indeed influence thought, but it doesn't seem to restrict thought to the extent that Whorf believed.

As we have seen, language is one of the building blocks of thought. Can language influence how we think and what we can think about? Benjamin Whorf (1956) strongly believed that it does. According to Whorf's **linguistic relativity hypothesis**, the language we speak determines the pattern of our thinking and our view of the world—a position known more generally as **linguistic determinism**. For Whorf, if a language lacks a particular expression, the corresponding thought will probably not occur to speakers of that language. For example, the Hopi of the southwestern United States have only two nouns for things that fly. One noun refers to birds; the other is used for everything else. A plane and a dragonfly, for instance, are both referred to with the same noun. According to Whorf, Hopi speakers would not see as great a difference between planes and dragonflies as we do, because their language labels the two similarly.

The linguistic relativity hypothesis has intuitive appeal—it makes sense to think that limits of language will produce limits in thinking. However, research indicates that language doesn't seem to restrict thinking to the extent that some linguistic determinists believed. For example, the Dani of New Guinea have only two words for colors—dark and light—yet they see and can easily learn to label other basic colors like red, yellow, and green. They also judge the similarity of colors much as English-speaking people do (E. R. Heider & Oliver, 1972). Thus, the ability to think about colors is quite similar across cultures, even when these cultures have quite different color terms in their languages (Roberson, Davies, & Davidoff, 2000; P. E. Ross, 2004). Moreover, experience and thought actually influence language. For example, the growth of personal computers and the Internet has inspired a vocabulary of its own, such as *RAM*, *gigabyte*, *online*, *CPU*, and *blogs*. In short, people create new words when they need them.

Psychologists have not dismissed the Whorf hypothesis altogether, but rather have softened it, recognizing that language, thought, and culture are intertwined (Chiu, Leung, & Kwan, 2007; Bennardo, 2003). Experience shapes language; and language, in turn, affects subsequent experience (K. Fiedler, 2008). This realization has caused us to examine our use of language more carefully, as we will see in the next section. **Explore** on **MyPsychLab**

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Is Language Male Dominated?

Does language contribute to gender stereotyping?

The English language has traditionally used masculine terms such as *man* and *he* to refer to all people—female as well as male. Several studies suggest that this affects the way English speakers think. Hyde (1984) discovered that the use of "he" or "she" to describe a factory worker affected how children assessed the performance of male and female workers. Children who heard workers described by the masculine pronoun "he" rated female workers poorly; those who heard workers identified by the pronoun "she" judged female workers

linguistic relativity hypothesis Whorf's idea that patterns of thinking are determined by the specific language one speaks.

linguistic determinism The belief that thought and experience are determined by language.

ISBN 1-256-37427-X

most positively; and the ratings of children who heard gender-neutral descriptions of workers fell in between those of the two other groups.

More recent research has focused on the unconscious, automatic nature of gender stereotyping and language (Palomares, 2004; Parks & Roberton, 2004). In an experiment requiring men and women to respond rapidly to gender-neutral and gender-specific pronouns, both sexes responded more quickly to stimuli containing traditional gender stereotypes (e.g., nurse/she) than to stimuli containing nontraditional ones (e.g., nurse/he). This occurred even among participants who were explicitly opposed to gender stereotyping (Banaji & Hardin, 1996).

As we have seen, language, cognition, and culture are interrelated in a complex fashion, each contributing to how people communicate, think, and behave. However, as we noted at the beginning of this chapter, nonhumans do communicate with one another. The nature of communication and cognition in nonhuman animals is a topic to which we will now turn.

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CHECK YOUR UNDERSTANDING

1. According to Whorf's _____ _____ hypothesis, the language we speak shapes our thinking.
2. Indicate whether the following statements are true (T) or false (F).
   a. _____ Many words in our language correspond to concepts.
   b. _____ Experience shapes language.
   c. _____ Thoughts are limited to the words in the language that a person speaks.

Answers: 1. linguistic relativity. 2. a. (T); b. (T); c. (F).

APPLY YOUR UNDERSTANDING

1. Cross-cultural studies indicate that people from different cultures with very different languages nonetheless perceive and are able to think about such things as colors in very similar ways even if their language contains no words for these things. These data _____ Whorf's theory.
   a. support
   b. contradict
   c. neither support nor contradict

Answer: 1. b.

LEARNING OBJECTIVE

- **Summarize research evidence that supports the statement that "nonhuman animals have some humanlike cognitive capacities." Explain the following statement: "All animals communicate, but only humans use language to communicate."**

NONHUMAN LANGUAGE AND THOUGHT

Can scientists learn what is on an animal's mind?

The Question of Language

What kind of communication and language do other animals use?

The forms of animal communication vary widely. Honeybees enact an intricate waggle dance that tells their hive mates not only exactly where to find pollen, but also the quality of that pollen (Biesmeijer & Seeley, 2005). Humpback whales perform long, haunting solos ranging from deep bass rumblings to high soprano squeaks. The technical term for such messages is **signs**, general or global statements about the animal's *current* state. But fixed, stereotyped signs don't constitute a language. The distinguishing features of language are *meaningfulness* (or semantics), *displacement* (talking or thinking about the past or the future), and *productivity* (the ability to produce and understand new and unique words and expressions such as slang terms). Using these criteria, as far as we know, no other species has its own language.

signs Stereotyped communications about an animal's current state.

For more than two decades, however, Francine Patterson (Bonvillian & Patterson, 1997; F. G. Patterson, 1981) used American Sign Language with a lowland gorilla named Koko. By age 5, Koko had a working vocabulary of 500 signs—similar to a 5-year-old deaf

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child using sign language, though far lower than a hearing, speaking child's vocabulary of 1,000–5,000 words (F. G. Patterson & Cohn, 1990). In her mid-20s, Koko signed about her own and her companions' happy, sad, or angry emotions. Most interesting, Koko referred to the past and the future (displacement). Using signs *before* and *later, yesterday* and *tomorrow* appropriately, she mourned the death of her pet kitten and expressed a desire to become a mother.

Critics suggest that researchers such as Patterson may be reading meaning and intentions into simple gestures. To reduce the ambiguity of hand signs, other researchers have used computer keyboards to teach and record communications with apes (Rumbaugh, 1977; Rumbaugh & Savage-Rumbaugh, 1978); to document behavior with and without humans on camera; to use double-blind procedures; and also to study another ape species, bonobos. Most impressive—and surprising—was a bonobo named Kanzi (Savage-Rumbaugh & Lewin, 1994). Initially in the lab, Kanzi was adopted by an older female who lacked keyboard skills. Some months later, Kanzi, who had been accompanying his "mother" to lessons but who was not receiving formal training, was learning keyboard symbols and spoken English on his own—much as children do.

Professor Sue Savage-Rumbaugh and Kanzi. Savage-Rumbaugh continued Kanzi's naturalistic education through social interaction during walks outside. Kanzi now understands spoken English and more than 200 keyboard symbols. He responds to completely new vocal and keyboard requests and uses the keyboard to make requests, comment on his surroundings, state his intentions, and—sometimes—indicate what he is thinking about.

That apes can learn signs without intensive training or rewards from human trainers is clear. Whether they can grasp the deep structure of language is less clear (Blumberg & Wasserman, 1995). Moreover, at best, apes have reached the linguistic level of a 2- to 2-1/2-year-old child. Critics see this as evidence of severe limitations, whereas others view it as an extraordinary accomplishment.

Animal Cognition

Do some animals think like humans?

As we have seen, language is only one of the building blocks of thought. Without language, can nonhumans nonetheless think? The question is particularly difficult to answer because psychologists have only recently developed techniques for learning how other animals use their brains and for identifying the similarities and differences between human and nonhuman thought (Bolhuis & Giraldeau, 2005). **Watch** on **MyPsychLab**

Watch Birds and Language at www.mypsychlab.com

Numerous studies indicate that other animals have some humanlike cognitive capacities. Parrots, for example, are exceptionally good vocal mimics. But do parrots know what they are saying? According to Irene Pepperberg (2000, 2006, 2007), Alex, an African gray parrot, did. Alex could count to 6; identify more than 50 different objects; and classify objects according to color, shape, material, and relative size. Pepperberg contends that rather than demonstrating simple mimicry, the parrot's actions reflected reasoning, choice, and, to some extent, thinking.

Other researchers have taught dolphins to select which of two objects is identical to a sample object—the basis of the concepts *same* and *different* (Harley, Roitblat, & Nachtigall, 1996; Herman, Uyeyama, & Pack, 2008)—and to respond accurately to numerical concepts such as *more* and *less* (Jaakkola, Fellner, Erb, Rodriguez, & Guarino, 2005). What's more, rhesus and capuchin monkeys can learn the concept of *numeration*, or the capacity to use numbers, and *serialization*, or the ability to place objects in a specific order based on a concept (Terrace, Son, & Brannon, 2003; A. A. Wright & Katz, 2007). In short, humans are not unique in their ability to form concepts.

But do chimps, dolphins, and parrots know what they know? Do nonhuman animals have a *sense of self* (Bard, Todd, Bernier, Love, & Leavens, 2006; Herman, 2002)? George Gallup (1985, 1998) noticed that after a few days' exposure, captive chimpanzees began making faces in front of a mirror and used it to examine and groom parts of their bodies they had never seen before. To test whether the animals understood that they were seeing

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themselves, Gallup anesthetized them and painted a bright red mark above the eyebrow ridge and on the top of one ear. The first time the chimps looked at the mirror after awakening, they reached up and touched the red marks, presumably recognizing themselves.

Since Gallup's initial study, hundreds of researchers have used the mirror test and more recently live video displays with many other animals (Hirata, 2007). Only four nonhuman species—chimpanzees, bonobos (formerly called "pygmy chimpanzees"), orangutans, and less frequently gorillas—show signs of self-awareness (Bard et. al., 2006; Boysen & Himes, 1999; Gallup, 1985; Heschl & Burkart, 2006; Vauclair, 1996). For that matter, even human infants do not demonstrate mirror-recognition until 18 to 24 months of age.

If chimpanzees possess self-awareness, do they understand that others have information, thoughts, and emotions that may differ from their own? Observational studies suggest they do have at least a limited sense of other-awareness (Goodall, 1971; Parr, 2003; Savage-Rumbaugh & Fields, 2000). One measure of other-awareness is *deception*. For example, if a chimpanzee discovers a hidden store of food and another chimpanzee happens along, the first may begin idly grooming himself. Presumably, the first chimpanzee recognizes that the second (a) is equally interested in food, and (b) will interpret the grooming behavior as meaning there is nothing interesting nearby. Both in the wild and in captive colonies, chimpanzees frequently practice deception in matters of food, receptive females, and power or dominance.

So far, we have been talking about *what* humans and nonhumans think about. As we will see in the next section, cognitive psychologists are equally interested in *how* people use thinking to solve problems and make decisions.

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CHECK YOUR UNDERSTANDING

1. Chimpanzees, orangutans, and bonobos are the only two nonhuman species to consistently show
   a. self-awareness.
   b. problem-solving ability.
   c. numeration comprehension.
2. Humans use language to communicate. What is the nonhuman animal equivalent of language?
   a. grunts
   b. squeaks
   c. signs

Answers: 1. a. 2. c.

APPLY YOUR UNDERSTANDING

1. When you visit the zoo, you notice a chimpanzee using a mirror to groom itself. This is a sign of:
   a. self-awareness
   b. numeration
   c. displacement

Answer: 1. a.

LEARNING OBJECTIVES

- **Explain why problem representation is an important first step in solving problems. In your explanation include divergent and convergent thinking, verbal, mathematical and visual representation, and problem categorization.**
- **Distinguish between trial and error, information retrieval, algorithms, and heuristics as ways of solving problems. Give an example of hill-climbing, subgoals, means-end analysis, and working backward. Explain how "mental sets" can help or hinder problem solving.**

PROBLEM SOLVING

What are three general aspects of the problem-solving process?

Solve the following problems:

PROBLEM 1 You have three measuring spoons. (See **Figure 7–2.**) One is filled with 8 teaspoons of salt; the other two are empty, but have a capacity of 2 teaspoons each. Divide the salt among the spoons so that only 4 teaspoons of salt remain in the largest spoon.

Most people find this problem easy. Now try solving a more complex problem (the answers to all of the problems are at the end of this chapter).

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PROBLEM 2 You have three measuring spoons. (See **Figure 7–3**.) One (spoon A) is filled with 8 teaspoons of salt. The second and third spoons are both empty. The second spoon (spoon B) can hold 5 teaspoons, and the third (spoon C) can hold 3 teaspoons. Divide the salt among the spoons so that spoon A and spoon B each have exactly 4 teaspoons of salt and spoon C is empty.

Most people find this problem much more difficult than the first one. Why? The answer lies in interpretation, strategy, and evaluation. Problem 1 is considered trivial because interpreting what is needed is easy, the strategies for solving it are simple, and the steps required to move closer to a solution can be verified effortlessly. Problem 2, by contrast, requires some thought to interpret what is needed; the strategies for solving it are not immediately apparent; and the steps required to see actual progress toward the goal are harder to evaluate. These three aspects of problem solving—interpretation, strategy, and evaluation—provide a useful framework for investigating this topic.

Figure 7–2
Figure for Problem 1

Interpreting Problems

Why is representing the problem so important to finding an effective solution?

The first step in solving a problem is called **problem representation**, which means interpreting or defining the problem. It is tempting to leap ahead and try to solve a problem just as it is presented, but this impulse often leads to poor solutions. For example, if your business is losing money, you might define the problem as deciphering how to cut costs. But by defining the problem so narrowly, you have ruled out other options. A better representation of this problem would be to figure out ways to boost profits—by cutting costs, by increasing income, or both. Problems that have no single correct solution and that require a flexible, inventive approach call for **divergent thinking**—or thinking that involves generating many different possible answers. In contrast, **convergent thinking** is thinking that narrows its focus in a particular direction, assuming that there is only one solution (or at most a limited number of right solutions).

To see the importance of problem representation, consider the next two problems.

Figure 7–3
Figure for Problem 2

PROBLEM 3 You have four pieces of chain, each of which is made up of three links. (See **Figure 7–4**.) All links are closed at the beginning of the problem. It costs 2 cents to open a link and 3 cents to close a link. How can you join all 12 links together into a single, continuous circle without paying more than 15 cents?

Problem 3 is difficult because people assume that the best way to proceed is to open and close the end links on the pieces of chain. As long as they persist with this "conceptual block," they will be unable to solve the problem. If the problem is represented differently, the solution is obvious almost immediately (see Answer Key at the end of this chapter for solutions).

If you have successfully interpreted Problem 3, give Problem 4 a try.

PROBLEM 4 A monk wishes to get to a retreat at the top of a mountain. He starts climbing the mountain at sunrise and arrives at the top at sunset of the same day. During the course of his ascent, he travels at various speeds and stops often to rest. He spends the night engaged in meditation. The next day, he starts his descent at sunrise, following the same narrow path that he used to climb the mountain. As before, he travels at various speeds and stops often to rest. Because he takes great care not to trip and fall on the way down, the descent takes as long as the ascent, and he does not arrive at the bottom until sunset. Prove that there is one place on the path that the monk passes at exactly the same time of day on the ascent and on the descent.

This problem is extremely difficult to solve if it is represented verbally or mathematically. It is considerably easier to solve if it is represented visually, as you can see from the explanation that appears at the end of this chapter. Interestingly, Albert Einstein relied heavily on his powers of visualization to understand phenomena that he would later describe by using complex mathematical formulas. This great thinker believed his extraordinary genius resulted in part from his skill in representing problems visually (Kosslyn, 2002).

problem representation The first step in solving a problem; it involves interpreting or defining the problem.

divergent thinking Thinking that meets the criteria of originality, inventiveness, and flexibility.

convergent thinking Thinking that is directed toward one correct solution to a problem.

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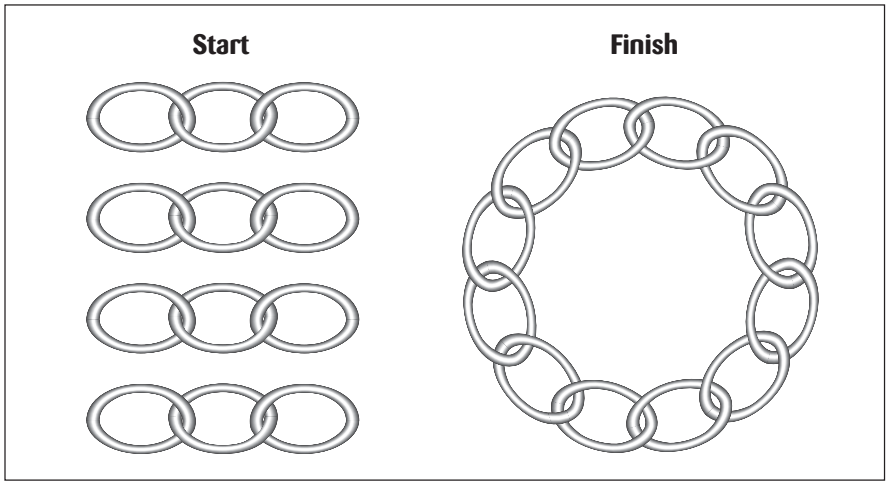

Figure 7–4
Figure for Problem 3

Another aspect of successfully representing a problem is deciding to which category the problem belongs. In fact, gaining expertise in any field consists primarily of increasing your ability to represent and categorize problems so that they can be solved quickly and effectively (Tanaka, Curran, & Sheinberg, 2005). Star chess players, for example, can readily categorize a game situation by comparing it with various standard situations stored in their long-term memories (Huffman, Matthews, & Gagne, 2001; A. J. Waters, Gobet, & Leyden, 2002). This strategy helps them interpret the current pattern of chess pieces with greater speed and precision than a novice chess player can. **Simulate** on **MyPsychLab**

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Implementing Strategies and Evaluating Progress

Why are heuristics usually better for solving problems than is trial and error?

Once you have properly interpreted a problem, the next steps are to select a solution strategy and evaluate progress toward your goal. A solution strategy can be anything from simple trial and error, to information retrieval based on similar problems, to a set of step-by-step procedures guaranteed to work (called an algorithm), to rule-of-thumb approaches known as heuristics.

Trial and Error Trial and error is a strategy that works best when choices are limited. For example, if you have only three or four keys to choose from, trial and error is the best way to find out which one unlocks your friend's front door. In most cases, however, trial and error wastes time because there are many different options to test.

Information Retrieval One approach is to retrieve information from long-term memory about how such a problem was solved in the past. Information retrieval is an especially important option when a solution is needed quickly. For example, pilots simply memorize the slowest speed at which a particular airplane can fly before it stalls.

Algorithms Complex problems require complex strategies. An **algorithm** is a problem-solving method that guarantees a solution if it is appropriate for the problem and is properly carried out. For example, to calculate the product of 323 and 546, we multiply the

algorithm A step-by-step method of problem solving that guarantees a correct solution.

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numbers according to the rules of multiplication (the algorithm). If we do it accurately, we are guaranteed to get the right answer.

Heuristics Because we don't have algorithms for every kind of problem, we often turn to **heuristics**, or rules of thumb. Heuristics do not guarantee a solution, but they may bring it within reach.

A very simple heuristic is **hill climbing**: We try to move continually closer to our goal without going backward. At each step, we evaluate how far "up the hill" we have come, how far we still have to go, and precisely what the next step should be. On a multiple-choice test, for example, one useful hill-climbing strategy is first to eliminate the alternatives that are obviously incorrect.

Another problem-solving heuristic is to create **subgoals**, which involves breaking a problem into smaller, more manageable pieces that are easier to solve individually than the problem as a whole (Nunokawa, 2001; S. K. Reed, 2003). Consider the problem of the Hobbits and the Orcs.

PROBLEM 5 Three Hobbits and three Orcs are on the bank of a river. They all want to get to the other side, but their boat will carry only two creatures at a time. Moreover, if at any time the Orcs outnumber the Hobbits, the Orcs will attack the Hobbits. How can all the creatures get across the river without danger to the Hobbits?

You can find the solution to this problem by thinking of it in terms of a series of subgoals. What has to be done to get just one or two creatures across the river safely, temporarily leaving aside the main goal of getting everyone across? We could first send two of the Orcs across and have one of them return. That gets one Orc across the river. Now we can think about the next trip. It's clear that we can't then send a single Hobbit across with an Orc, because the Hobbit would be outnumbered as soon as the boat landed. Therefore, we have to send either two Hobbits or two Orcs. By working on the problem in this fashion—concentrating on subgoals—we can eventually get everyone across.

Once you have solved Problem 5, try Problem 6, which is considerably more difficult (the answers to both problems are at the end of the chapter).

PROBLEM 6 This problem is identical to Problem 5, except that there are five Hobbits and five Orcs, and the boat can carry only three creatures at a time.

Subgoals are often helpful in solving a variety of everyday problems. For example, a student whose goal is to write a term paper might set subgoals by breaking the project into a series of separate tasks: choosing a topic, doing research, writing the first draft, editing, and so on. Even the subgoals can sometimes be broken down into separate tasks: Writing the first draft might break down into the subgoals of writing the introduction, describing the position to be taken, supporting the position with evidence, drawing conclusions, writing a summary, and writing a bibliography. Subgoals make problem solving more manageable because they free us from the burden of having to "get to the other side of the river" all at once.

One of the most frequently used heuristics, called **means-end analysis**, combines hill climbing and subgoals. Like hill climbing, means-end analysis involves analyzing the difference between the current situation and the desired end, and then doing something to reduce that difference. But in contrast to hill climbing—which does not permit detours away from the final goal in order to solve the problem—means-end analysis takes into account the entire problem situation. It formulates subgoals in such a way as to allow us temporarily to take a step that appears to be backward in order to reach our goal in the end. One example is the pitcher's strategy in a baseball game when confronted with the best batter in the league. The pitcher might opt to walk this batter intentionally even though doing so moves away from the major subgoal of keeping runners off base. Intentional walking might enable the pitcher to keep a run from scoring and so contribute to the ultimate goal of winning the game. This flexibility in thinking is a major benefit of means-end analysis.

heuristics Rules of thumb that help in simplifying and solving problems, although they do not guarantee a correct solution.

hill climbing A heuristic, problem-solving strategy in which each step moves you progressively closer to the final goal.

subgoals Intermediate, more manageable goals used in one heuristic strategy to make it easier to reach the final goal.

means-end analysis A heuristic strategy that aims to reduce the discrepancy between the current situation and the desired goal at a number of intermediate points.

ISBN 1-256-37427-X

But means-end analysis also poses the danger of straying so far from the end goal that the goal disappears altogether. One way of avoiding this situation is to use the heuristic of **working backward**. With this strategy, the search for a solution begins at the goal and works backward toward the "givens." Working backward is often used when the goal has more information than the givens and when the operations involved can work in two directions. For example, if you wanted to spend exactly $100 on clothing, it would be difficult to reach that goal simply by buying some items and hoping that they totaled exactly $100. A better strategy would be to buy one item, subtract its cost from $100 to determine how much money you have left, then purchase another item, subtract its cost, and so on, until you have spent $100.

Obstacles to Solving Problems

How can a "mental set" both help and hinder problem solving?

Many factors can either help or hinder problem solving. One factor is a person's level of motivation, or emotional arousal. Generally, we must generate a certain surge of excitement to motivate ourselves to solve a problem, yet too much arousal can hamper our ability to find a solution. (See Chapter 8, "Motivation and Emotion.")

Another factor that can either help or hinder problem solving is **mental set**—our tendency to perceive and to approach problems in certain ways. A mental set can be helpful if we have learned operations that can legitimately be applied to the present situation. In fact, much of our formal education involves learning useful mental sets. But sets can also create obstacles, especially when a novel approach is needed. The most successful problem solvers can choose from many different mental sets and can also judge when to change sets or when to abandon them entirely.

One type of mental set that can seriously hinder problem solving is called **functional fixedness**. Consider **Figure 7–5**. Do you see a way to mount the candle on the

working backward A heuristic strategy in which one works backward from the desired goal to the given conditions.

mental set The tendency to perceive and to approach problems in certain ways.

functional fixedness The tendency to perceive only a limited number of uses for an object, thus interfering with the process of problem solving.

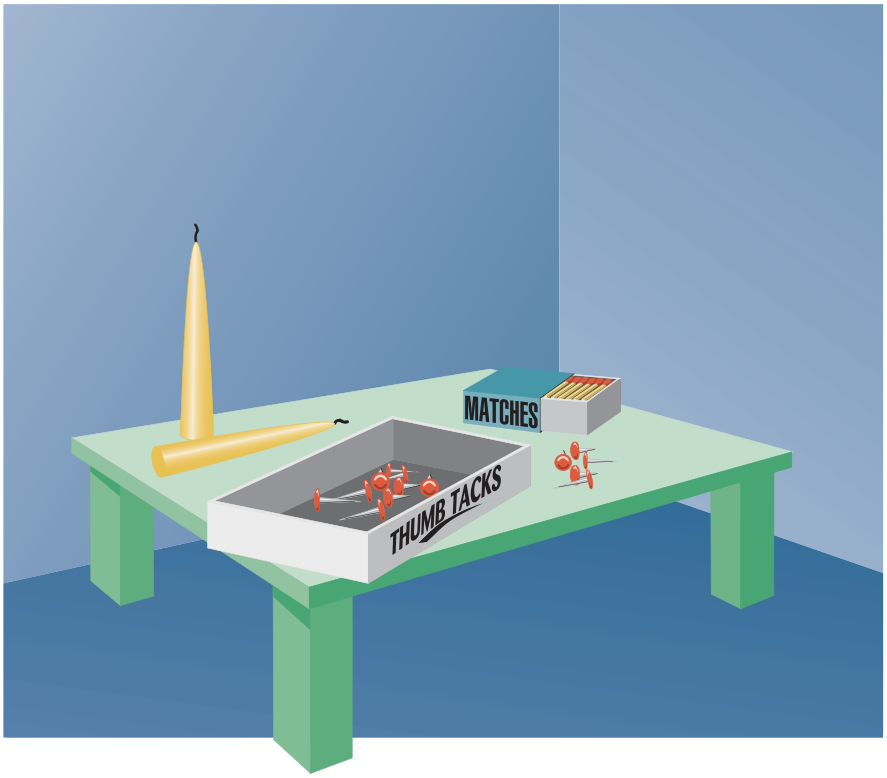

Figure 7–5
To test the effects of functional fixedness, participants might be given the items shown on the table and asked to mount a candle on the wall. See **Figure 7–12** for a solution.

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APPLYING PSYCHOLOGY

Becoming a More Skillful Problem Solver

Even the best problem solvers occasionally get stumped, but you can do some things that will help you find a solution. These tactics encourage you to discard unproductive approaches and find strategies that are more effective.

1. **Eliminate poor choices.** When we are surer of what won't work than what will, the *tactic of elimination* can be very helpful. After listing all the possible solutions you can think of, discard all the solutions that seem to lead in the wrong direction. Now, examine the list more closely. Some solutions that seem to be ineffective may turn out to be good on closer examination.
2. **Visualize a solution.** If you are stumped by a problem, try using visual images. For example, in the Hobbit and Orc problems draw a picture of the river, and show the Hobbits and Orcs at each stage of the solution as they are ferried across. Drawing a diagram might help you grasp what a problem calls for, but you also can visualize mentally.
3. **Develop expertise.** We get stumped on problems because we lack the knowledge to find a quick solution. Experts not only know more about a particular subject but also organize their information in larger "chunks" that are extensively interconnected, much like a cross-referencing system in a library.
4. **Think flexibly.** Striving to be more flexible and creative is an excellent tactic for becoming a better problem solver. This will help you avoid *functional fixedness* or prevent a *mental set* from standing in the way of solving a problem.

wall? If not, you are probably stymied by functional fixedness. (The solution to this problem appears at the end of the chapter.) The more you use an object in only one way, the harder it is to see new uses for it and to realize that an object can be used for an entirely different purpose. See "Applying Psychology: Becoming a More Skillful Problem Solver" for techniques that will improve your problem-solving skills.

Because creative problem solving requires generating original ideas, deliberate strategies don't always help. Solutions to many problems rely on insight, often a seemingly arbitrary flash "out of the blue." (See Chapter 5, "Learning.") Psychologists have only recently begun to investigate such spontaneous problem-solving processes as insight and intuition (Gilhooly & Murphy, 2005; Sinclair & Ashkanasy, 2005), but research indicates that such "mental breakthroughs" are likely to occur only when we widen our scope of attention from a few obvious but incorrect alternatives to more diverse possible solutions (B. Bower, 2008). This conclusion is supported by neuroimaging, which reveals that insight is generally preceded by periods of increased electrical activity in the frontal regions of the brain involved in *suppressing* unwanted thoughts (Kounios et al., 2008; Qiu, Li, Jou, Wu, & Zhang, 2008).

The value of looking for new ways to represent a difficult problem cannot be overstressed. Be open to potential solutions that at first seem unproductive. The solution may turn out to be more effective, or it may suggest related solutions that will work. This is the rationale behind the technique called **brainstorming**: When solving a problem, generate a lot of ideas before you review and evaluate them (Baruah & Paulus, 2008; McGlynn, McGurk, Effland, Johll, & Harding, 2004; Paulus & Brown, 2007).

brainstorming A problem-solving strategy in which an individual or a group produces numerous ideas and evaluates them only after all ideas have been collected.

THINKING CRITICALLY ABOUT . . .

Solving Problems

Think for a moment of the last time you were confronted with a difficult problem.

1. What types of thinking or reasoning did you use to deal with that problem?
2. Having read this portion of the chapter, would you respond differently if you were faced with a similar problem? If so, what would you do differently?
3. You are headed for Mount Rushmore, and you can see it from a distance. You have no map. What is the best problem-solving strategy you can use to get there, and why?

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CHECK YOUR UNDERSTANDING

1. Match each problem-solving strategy with the appropriate definition.

___ algorithm	a. rule-of-thumb approach that helps in simplifying and solving problems, although it doesn't guarantee a correct solution
___ heuristic	b. strategy in which each step moves you closer to a solution
___ hill climbing	c. step-by-step method that guarantees a solution
___ means-end analysis	d. strategy in which one moves from the goal to the starting point
___ working backward	e. strategy that aims to reduce the discrepancy between the current situation and the desired goal at a number of intermediate points
___ subgoal creation	f. breaking down the solution to a larger problem into a set of smaller, more manageable steps

2. Match each form of thinking with its definition and the kind of problems to which it is suited.

___ divergent thinking
___ convergent thinking

a. suited to problems for which there is one correct solution or a limited number of solutions
b. thinking that involves generating many different ideas
c. suited to problems that have no one right solution and require an inventive approach
d. thinking that limits its focus to a particular direction

Answers: 1. Algorithm—c. heuristic—a. hill climbing—b. means-end analysis—e. working backward—d. subgoal creation—f. 2. divergent thinking—b. and c. convergent thinking—a. and d.

APPLY YOUR UNDERSTANDING

1. Your car is not operating correctly. The mechanic opens the hood and says, "We've been seeing lots of cars recently with fouled plugs or dirty fuel filters. Let's start there and see if that's your problem, too." The mechanic is using a(n)
   a. heuristic.
   b. algorithm.
   c. compensatory decision model.
   d. noncompensatory decision model.
2. You are at a football game when it begins to rain heavily. As you get soaked, you see the people next to you pull folded plastic garbage bags out of their pockets to use as a temporary "raincoat." Your failure to realize that the garbage bag might also be used as rain protection is an example of
   a. an algorithm.
   b. a heuristic.
   c. means-end analysis.
   d. functional fixedness.

Answers: 1. a. 2. d.

LEARNING OBJECTIVE

- **Explain how decision making differs from problem solving. Describe the process of compensatory decision making and the use of decision-making heuristics. Explain how framing can affect decisions, and how hindsight bias and counterfactual thinking affect the way we view our decisions after the fact.**

DECISION MAKING

How does decision making differ from problem solving?

Decision making is a special kind of problem solving in which we already know all the possible solutions or choices. The task is not to come up with new solutions, but rather to identify the best available one. This process might sound fairly simple, but sometimes we have to juggle a large and complex set of criteria as well as many possible options. For example,

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Table 7–1 COMPENSATORY DECISION TABLE FOR PURCHASE OF A NEW CAR

	Price (weight = 4)	Gas mileage (weight = 8)	Service record (weight = 10)	Weighted Total
Car 1	5 (20)	2 (16)	1 (10)	(46)
Car 2	1 (4)	4 (32)	4 (40)	(76)

Ratings: 5 = excellent; 1 = poor

suppose that you are looking for an apartment among hundreds available. A reasonable rent is important to you, but so are good neighbors, a good location, a low noise level, and cleanliness. If you find an inexpensive, noisy apartment with undesirable neighbors, should you take it? Is it a better choice than a more expensive, less noisy apartment in a better location? How can you make the best choice?

Compensatory Decision Making

How would you go about making a truly logical decision?

The logical way to make a decision is to rate each of the available choices on all the criteria you are using, arriving at some overall measure of the extent to which each choice matches your criteria. For each choice, the attractive features can offset or compensate for the unattractive features. This approach to decision making is therefore called a **compensatory model**.

Table 7–1 illustrates one of the most useful compensatory models applied to a car-buying decision. The buyer's three criteria are weighted in terms of importance: price (not weighted heavily), gas mileage, and service record (both weighted more heavily). Next, each car is rated from 1 (poor) to 5 (excellent) on each of the criteria. Car 1 has an excellent price (5) but relatively poor gas mileage (2) and service record (1); and Car 2 has a less desirable price but fairly good mileage and service record. Each rating is then multiplied by the weight for that criterion (e.g., for Car 1, the price rating of 5 is multiplied by the weight of 4, and the result is put in parentheses next to the rating). Finally, ratings are totaled for each car. Clearly, Car 2 is the better choice: It is more expensive, but that disadvantage is offset by its better mileage and service record and these two criteria are more important than price to this particular buyer.

Although most people would agree that using such a table is a good way to decide which car to buy, at times people will abandon the compensatory decision-making process in the face of more vivid anecdotal information. For example, if a friend had previously bought Car 2 and found it to be a lemon, many people will choose Car 1 despite Car 2's well-thought out advantages. Moreover, as we will see in the next section, it is often not possible or desirable to rate every choice on all criteria. In such situations people typically use heuristics that have worked well in the past to simplify decision making, even though they may lead to less-than-optimal decision making (Dhami, 2003).

Decision-Making Heuristics

How can heuristic approaches lead us to make bad decisions?

Research has identified a number of common heuristics that people use to make decisions. We use the **representativeness** heuristic whenever we make a decision on the basis of certain information that matches our model of the typical member of a category. For example, if every time you went shopping you bought the least expensive items and if all of these items turned out to be poorly made, you might eventually decide not to buy anything that seems typical of the category "very cheap."

Another common heuristic is **availability** (E. Greene & Ellis, 2008; Schwarz & Vaughn, 2002). In the absence of full and accurate information, we often base decisions on

compensatory model A rational decision-making model in which choices are systematically evaluated on various criteria.

representativeness A heuristic by which a new situation is judged on the basis of its resemblance to a stereotypical model.

availability A heuristic by which a judgment or decision is based on information that is most easily retrieved from memory.

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whatever information is most readily available, even though this information may not be accurate or complete. A familiar example of the availability heuristic is the so-called *subway effect* (Gilovich, 1991; Gilovich, Griffin, & Kahneman, 2002). It seems to be a law of nature that if you are waiting at a subway station, one train after another will come along headed in the opposite direction from the direction that you want to go. The problem here is that by the time a subway train does come along, we have already left the scene, so we never get to see the opposite situation: several subway trains going in our direction before one comes the other way. As a result, we tend to assume that those situations seldom or never occur, and so we make our decisions accordingly.

Yet another heuristic, closely related to availability, is **confirmation bias**—the tendency to notice and remember evidence that supports our beliefs and to ignore evidence that contradicts them (Nickerson, 1998; Van Swol, 2007). For example, individuals who believe that AIDS is something that happens to "other people" (homosexual men and intravenous drug users, not middle-class heterosexuals) are more likely to remember articles about rates of HIV infection in these groups or in third-world countries than articles about AIDS cases among people like themselves (Fischhoff & Downs, 1997). Convinced that HIV is not something that they personally need to worry about, they ignore evidence to the contrary.

A related phenomenon is our tendency to see *connections* or *patterns of cause and effect* where none exist (Kahneman & Tversky, 1996; Rottenstreich & Tversky, 1997). For example, many parents strongly believe that sugar may cause hyperactivity in children and that arthritis pain is related to weather—despite research evidence to the contrary. The list of commonsense beliefs that persist in the face of contrary evidence is long (Redelmeier & Tversky, 2004).

Framing

Does the way information is presented affect decisions?

Numerous studies have shown that subtle changes in the way information is presented can dramatically affect the final decision (Hadfield, 2008; L. W. Jones, Sinclair, & Courneya, 2003; LeBoeuf & Shafir, 2003; T. Mann, Sherman, & Updegraff, 2004). A classic study (McNeil, Pauker, Sox, & Tversky, 1982) illustrates how **framing** can influence a medical decision. In this study, experimental participants were asked to choose between surgery and radiation therapy to treat lung cancer. However, the framing of the information they were provided was manipulated. In the *survival frame*, participants were given the statistical outcomes of both procedures in the form of survival statistics, thus emphasizing the 1- and 5-year *survival* rates after treatment. In the *mortality frame*, the participants were given the same information, presented (or framed) according to *death* rates after 1 year and after 5 years. Although the actual number of deaths and survivors associated with each procedure was identical in both the survival and mortality frames, the percentage of participants who chose one procedure over another varied dramatically *depending on how the information was framed.* Probably most surprising was that this framing effect was found even when 424 experienced radiologists served as the research participants!

Explaining Our Decisions

How do we explain to ourselves the decisions we make?

Hindsight Whether a choice is exceptionally good, extraordinarily foolish, or somewhere in between, most people think about their decisions after the fact. The term **hindsight bias** refers to the tendency to view outcomes as inevitable and predictable after we know the outcome, and to believe that we could have predicted what happened, or perhaps that we did (Hoffrage & Pohl, 2003; Nestler, Blank, & von Collani, 2008). For example, physicians remember being more confident about their diagnoses when they learn that they were correct than they were at the time of the actual diagnoses.

confirmation bias The tendency to look for evidence in support of a belief and to ignore evidence that would disprove a belief.

framing The perspective from which we interpret information before making a decision.

hindsight bias The tendency to see outcomes as inevitable and predictable after we know the outcome.

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Psychologists have long viewed the hindsight bias as a cognitive flaw—a way of explaining away bad decisions and maintaining our confidence (Louie, Curren, & Harich, 2000). A team of researchers in Berlin, however, argues that the hindsight bias serves a useful function (Hoffrage, Hertwig, & Gigerenzer, 2000). "Correcting" memory is a quick and efficient way to replace misinformation or faulty assumptions, so that our future decisions and judgments will be closer to the mark.

"If Only" At times, everyone imagines alternatives to reality and mentally plays out the consequences. Psychologists refer to such thoughts about things that never happened as **counterfactual thinking**—in which thoughts are counter to the facts (Roese, 1997; Segura & McCloy, 2003; Walchle & Landman, 2003). Counterfactual thinking often takes the form of "If only" constructions, in which we mentally revise the events or actions that led to a particular outcome: "If only I had studied harder"; "If only I had said no"; "If only I had driven straight home." It is tempting to think that such imaginary, after-the-fact thinking, is of no value. However, research shows that under some circumstances counterfactual thinking can play a constructive role helping one to regulate behavior, learn from mistakes, and improve future performance (Epstude & Roese, 2008).

MULTITASKING

With the advent of the digital age, multitasking has become a way of life. We listen to iPods while jogging, program our TiVo while watching a movie, e-mail and surf the Web simultaneously, and follow the directions of a GPS while driving and talking to a passenger in a car. Fortunately, our brains appear reasonably well equipped for at least some multitasking. The prefrontal cortex (Figure 2–8), which as we saw in Chapter 2 ("The Biological Basis of Behavior") governs goal-directed behavior and suppresses impulses, also enables us to mentally toggle between separate tasks with relative ease (Jäncke, Brunner, & Esslen, 2008; Modirrousta & Fellows, 2008).

Is multitasking really efficient? Research indicates that if the tasks are dissimilar and the person is an experienced multitasker and is intelligent, multitasking can be effective up to a point. But in general, research has shown that multitasking often slows down thinking, decreases accuracy, and in some cases increases stress (Bühner, König, Pick, & Krumm, 2006; Kinney, 2008; Mark, Gudith & Klocke, 2008; J. S. Rubinstein, Meyer, & Evans, 2001). Moreover, despite a commonly held belief that young people are more adept at multitasking than older adults, research that compared 18- to 21-year-olds to 35- to 39-year-olds found the negative effects of multitasking were generally more pronounced in the younger group (Westwell, 2007).

Perhaps nowhere is the impact of multitasking more important than when driving a car. It is estimated that about 8% of drivers at any given moment are using their cell phones while driving (Glassbrenner, Carra, & Nichols, 2004). Numerous studies have shown that driving performance is adversely affected by multitasking (Strayer & Drews, 2007). Braking time is slowed and attention to events in the peripheral visual field is reduced. Even when the participants in one study were specifically instructed to give more attention to driving than the extraneous task, or were well practiced at multitasking, driving performance was adversely affected by multitasking (J. Levy & Pashler, 2008; J. Levy, Pashler, & Boer, 2006).

Texting while driving is even worse. One British study using 17- to 24-year-old participants found that texting while driving reduced braking time by 35%, which was much worse than the effect of alcohol or marijuana. Steering control while texting was reduced 91%, compared to a 35% reduction under the influence of marijuana (RAC Foundation, 2008). Research such as this has prompted Professor David Meyer, a noted researcher in the area of multitasking, to conclude that "If you're driving while cellphoning, then your performance is going to be as poor as if you were legally drunk" (NPR, 2008).

counterfactual thinking Thinking about alternative realities and things that never happened.

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CHECK YOUR UNDERSTANDING

1. Match each decision-making heuristic with the appropriate definition.
   ___ representativeness heuristic
   ___ availability heuristic
   ___ confirmation bias
   a. making judgments on the basis of whatever information can be most readily retrieved from memory
   b. attending to evidence that supports your existing beliefs and ignoring other evidence
   c. making decisions on the basis of information that matches your model of what is "typical" of a certain category
2. The way a question is framed usually will not affect its answer. Is this statement true (T) or false (F)?
3. Julio's girlfriend gets a speeding ticket, and he blames himself, saying, "If only I hadn't let her borrow my car." His thinking is an example of _____.
4. "Young people are better than older people at multitasking." Is this statement true (T) or false (F)?

Answers: 1. representativeness heuristic—c. availability heuristic—a. confirmation bias—b. 2. (F) 3. hindsight bias. 4. (F)

APPLY YOUR UNDERSTANDING

1. In deciding where to go on vacation, you decide you want a place where you can relax, a place that is warm, and a place that you can reach inexpensively. But you will not consider any place that is more than 1,000 miles away. What kind of decision-making model are you using?
   a. visualization
   b. brainstorming
   c. noncompensatory
   d. compensatory
2. You are driving down the highway at the posted speed limit. After a while you mention to your passenger, "It sure looks like everyone is either going slower or faster than the speed limit. Hardly anyone seems to be going the same speed as I am." In fact, most of the cars on the highway are also traveling at the speed limit. Your erroneous conclusion is most likely due to
   a. framing.
   b. hindsight bias.
   c. mental set.
   d. the availability heuristic.

Answers: 1. c. 2. d.

LEARNING OBJECTIVES

- **Compare and contrast the theories of intelligence put forth by Spearman, Thurstone, Sternberg, Gardner, and Goleman.**
- **Describe the similarities and differences between the Stanford-Binet Intelligence Scale and the Wechsler Intelligence Scales, and explain how they differ from group tests, performance tests, and culture-fair tests of intelligence. Explain what is meant by test "reliability" and "validity" and how psychologists determine whether an intelligence test is reliable or valid.**
- **Summarize the criticisms of intelligence tests and the relationship between IQ test scores and job success.**

INTELLIGENCE AND MENTAL ABILITIES

What types of questions are used to measure intelligence?

In many societies, one of the nicest things you can say is "You're smart"; and one of the most insulting is "You're stupid." Intelligence is so basic to our view of human nature that any characterization of a person that neglects to mention that person's intelligence is likely to be considered incomplete. Although psychologists have studied intelligence almost since psychology emerged as a science, they still struggle to understand this complex and elusive concept. In the next few sections, you may come to appreciate the difficulty of their task. Toward that end, we begin by asking you some questions intended to measure intelligence:

1. Describe the difference between *laziness* and *idleness*.
2. Which direction would you have to face so that your right ear would be facing north?
3. What does *obliterate* mean?
4. In what way are an hour and a week alike?

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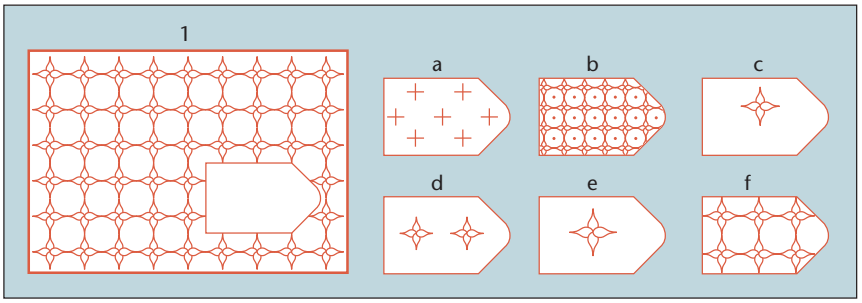
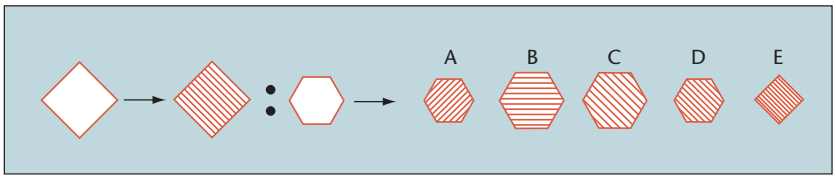
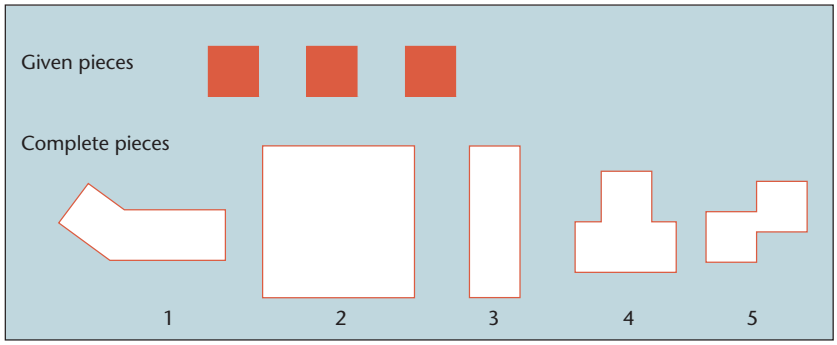
5. Choose the lettered block that best completes the pattern in the following figure.



6. If three pencils cost 25 cents, how many pencils can you buy for 75 cents?
7. Select the lettered pair that best expresses a relationship similar to that expressed in the original pair:
   Crutch: Locomotion::
   a. paddle: canoe
   b. hero: worship
   c. horse: carriage
   d. spectacles: vision
   e. statement: contention
8. Decide how the first two items in the following figure are related to each other. Then find the one item at the right that goes with the third item in the same way that the second item goes with the first.



9. For each item in the following figure, decide whether it can be completely covered by using some or all of the given pieces without overlapping any.



These questions were taken from various tests of **intelligence**, or general mental ability. (The answers appear at the end of the chapter.) We will discuss intelligence tests later in this chapter. But first, let's consider some historical and contemporary theories of intelligence.

Theories of Intelligence

What are some of the major theories of intelligence?

For more than a century, one of the most basic questions addressed by psychologists is whether intelligence is a single, general mental ability or whether it is composed of many separate abilities (Lubinski, 2000).

intelligence A general term referring to the ability or abilities involved in learning and adaptive behavior.

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These dancers possess an abundance of what Howard Gardner calls bodily-kinesthetic intelligence.

triarchic theory of intelligence Sternberg's theory that intelligence involves mental skills (analytical intelligence), insight and creative adaptability (creative intelligence), and environmental responsiveness (practical intelligence).

theory of multiple intelligences Howard Gardner's theory that there is not one intelligence, but rather many intelligences, each of which is relatively independent of the others.

emotional intelligence According to Goleman, a form of intelligence that refers to how effectively people perceive and understand their own emotions and the emotions of others, and can regulate and manage their emotional behavior.

Early Theorists Charles Spearman, an early 20th-century British psychologist, maintained that intelligence is quite general—that people who are bright in one area are usually bright in other areas as well. The American psychologist L. L. Thurstone disagreed with Spearman. Thurstone argued that intelligence is composed of seven distinct kinds of mental abilities (Thurstone, 1938): *spatial ability*, *memory*, *perceptual speed*, *word fluency*, *numerical ability*, *reasoning*, and *verbal meaning*. Unlike Spearman, Thurstone believed that these abilities are relatively independent of one another. Thus, a person with exceptional spatial ability (the ability to perceive distance, recognize shapes, and so on) might lack word fluency.

Contemporary Theorists Contemporary psychologists have considerably broadened the concept of intelligence and how it can best be measured (E. Benson, 2003). For example, Robert Sternberg (1986, 2003) has proposed a **triarchic theory of intelligence**. Sternberg argues that human intelligence encompasses a much broader array of abilities than the limited skills assessed by traditional intelligence tests. *Analytical intelligence* refers to the mental processes emphasized by most theories of intelligence, such as the ability to learn how to do things, acquire new knowledge, solve problems, and carry out tasks effectively. According to Sternberg, this is the aspect of intelligence assessed by most intelligence tests. *Creative intelligence* is the ability to adjust to new tasks, use new concepts, respond effectively in new situations, gain insight, and adapt creatively. *Practical intelligence* is the ability to find solutions to practical and personal problems.

Another contemporary theory of intelligence is the **theory of multiple intelligences** advanced by Howard Gardner and his associates at Harvard (J.-Q. Chen & Gardner, 2005; Gardner, 1983, 2004). Gardner, like Thurstone, believes that intelligence is made up of several distinct abilities, each of which is relatively independent of the others. Precisely how many separate abilities might exist is difficult to determine, but Gardner lists eight: *logical–mathematical*, *linguistic*, *spatial*, *musical*, *bodily-kinesthetic*, *interpersonal*, *intrapersonal*, and *naturalistic*. The first four are self-explanatory. Bodily-kinesthetic intelligence is the ability to manipulate one's body in space; a skilled athlete shows high levels of this kind of intelligence. People who are extraordinarily talented at understanding and communicating with others, such as exceptional teachers and parents, have strong interpersonal intelligence. People who understand themselves and who use this knowledge effectively to attain their goals rank high in intrapersonal intelligence. Finally, naturalistic intelligence reflects an individual's ability to understand, relate to, and interact with the world of nature.

Finally, Daniel Goleman (1997) has proposed a theory of **emotional intelligence**, which refers to how effectively people perceive and understand their own emotions and the emotions of others and can manage their emotional behavior. Five traits are generally recognized as contributing to emotional intelligence (Goleman, 1997; Goleman, Boyatzis, & McKee, 2002).

- ***Knowing one's own emotions.*** The ability to monitor and recognize our own feelings. This is of central importance to self-awareness and all other dimensions of emotional intelligence.
- ***Managing one's emotions.*** The ability to control impulses, to cope effectively with sadness, depression, and minor setbacks, as well as to control how long emotions last.
- ***Using emotions to motivate oneself.*** The capacity to marshal emotions toward achieving personal goals.

THINKING CRITICALLY ABOUT . . .

Multiple Intelligences

Gardner's theory clearly includes abilities not normally included under the heading of intelligence.

1. We earlier defined intelligence as general intellectual or mental ability. Do you agree that all of Gardner's facets of intelligence fit that definition? Should some be excluded? Or should the definition of intelligence perhaps be modified to include them? What might such a modified definition look like?
2. Some people have excellent "color sense"—they seem to know which colors go well together. Should this ability be included as one aspect of intelligence? What about rhyming ability?
3. In answering the first two questions, what criteria did you use for deciding which abilities to include as aspects of intelligence and which to exclude? Do other people share your viewpoint, or do their criteria differ? How might you go about deciding which viewpoints have most merit?

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SUMMARY TABLE

COMPARING GARDNER'S, STERNBERG'S, AND GOLEMAN'S THEORIES OF INTELLIGENCE

Gardner's multiple intelligences	Sternberg's triarchic intelligence	Goleman's emotional intelligence
Logical-mathematical Linguistic	Analytical	
Spatial Musical Bodily-kinesthetic	Creative	
Interpersonal	Practical	Recognizing emotions in others and managing relationships
Intrapersonal		Knowing yourself and motivating yourself with emotions
Naturalistic		

- *Recognizing the emotions of other people.* The ability to read subtle, nonverbal cues that reveal what other people really want and need.
- *Managing relationships.* The ability to accurately acknowledge and display one's own emotions, as well as being sensitive to the emotions of others.

The **"Summary Table"** reviews the contemporary theories described here. These theories shape the content of intelligence tests and other measures that evaluate the abilities of millions of people. We consider these next.

Intelligence Tests

What kinds of intelligence tests are in use today?

The Stanford–Binet Intelligence Scale The first test developed to measure intelligence was designed by two Frenchmen, Alfred Binet and Théodore Simon. The test, first used in Paris in 1905, was designed to identify children who might have difficulty in school. **Watch** on **MyPsychLab**

Watch Are Intelligence Tests Valid? Robert Guthrie at www.mypsychlab.com

The first *Binet–Simon Scale* consisted of 30 tests arranged in order of increasing difficulty. With each child, the examiner started with the easiest tests and worked down the list until the child could no longer answer questions. A well-known adaptation of the *Binet–Simon Scale*, the *Stanford–Binet Intelligence Scale*, was prepared at Stanford University by L. M. Terman, first published in 1916 and updated repeatedly since then. The current Stanford–Binet Intelligence Scale is designed to measure four virtually universal abilities related to traditional views of intelligence: *verbal reasoning*, *abstract/visual reasoning*, *quantitative reasoning*, and *short-term memory*. The Stanford–Binet is best suited for children, adolescents, and very young adults. Questions 1 and 2 on page 234 were drawn from an early version of the Stanford-Binet.

Terman also introduced the now famous term **intelligence quotient (IQ)** to establish a numerical value of intelligence, setting the score of 100 for a person of average intelligence. **Figure 7–6** shows an approximate distribution of IQ scores in the population.

intelligence quotient (IQ) A numerical value given to intelligence that is determined from the scores on an intelligence test on the basis of a score of 100 for average intelligence.

The Wechsler Intelligence Scales The most commonly used individual test of intelligence for adults is the **Wechsler Adult Intelligence Scale—Third Edition (WAIS-III)**, originally developed in the late 1930s by psychologist David Wechsler. The Stanford–Binet emphasizes

Wechsler Adult Intelligence Scale—Third Edition (WAIS-III) An individual intelligence test developed especially for adults; measures both verbal and performance abilities.

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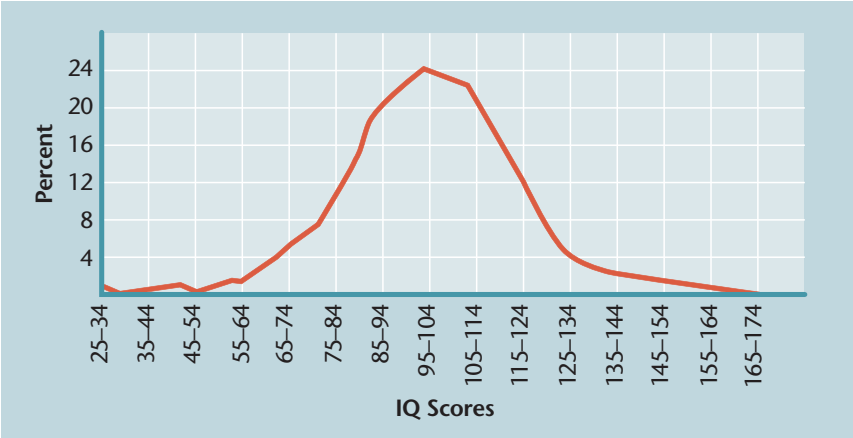

Figure 7–6
The approximate distribution of IQ scores in the population.
Note that the greatest percentage of scores fall around 100. Very low percentages of people score at the two extremes of the curve.

The Wechsler Intelligence Scales, developed by David Wechsler, are individual intelligence tests administered to one person at a time. There are versions of the Wechsler Scales for both adults and children. Here, a child is being asked to copy a pattern using blocks.

Wechsler Intelligence Scale for Children—Third Edition (WISC-III) An individual intelligence test developed especially for school-aged children; measures verbal and performance abilities and also yields an overall IQ score.

verbal skills, but Wechsler believed adult intelligence consists more of the ability to handle life situations than to solve verbal and abstract problems.

The WAIS-III is divided into two parts, one stressing verbal skills, the other performance skills. The verbal scale includes tests of information, simple arithmetic, and comprehension. The performance scale measures routine tasks such as asking people to "find the missing part" (buttonholes in a coat, for example), to copy patterns, and to arrange three to five pictures so that they tell a story.

Although the content of the WAIS-III is somewhat more sophisticated than that of the Stanford–Binet, Wechsler's chief innovation was in scoring. His test gives separate verbal and performance scores as well as an overall IQ score. Moreover, on some items one or two extra points can be earned, depending on the complexity of the answer given. This unique scoring system gives credit for the reflective qualities that we expect to find in intelligent adults. Finally, on some questions both speed and accuracy affect the score. Questions 3 and 4 on page 234 resemble questions on the WAIS III.

Wechsler also developed a similar intelligence test for use with school-age children. Like the WAIS-III, the **Wechsler Intelligence Scale for Children–Third Edition (WISC-III)** yields separate verbal and performance scores as well as an overall IQ score.

Group Tests With the Stanford–Binet, the WAIS-III, and the WISC-III, an examiner takes a single person to an isolated room, spreads the materials on a table, and spends from 30 to 90 minutes administering the test. The examiner may then take another hour or so to score the test according to detailed instructions in a manual. This is a time-consuming, costly operation. Moreover, under some circumstances the examiner's behavior can influence the score. For these reasons, test makers have devised **group tests**, which a single examiner can administer to many people at once. Instead of sitting across the table from a person who asks you questions, you receive a test booklet that contains questions for you to answer in writing within a certain amount of time.

Group tests have some distinct advantages over individualized tests. They eliminate bias on the part of the examiner, answer sheets can be scored quickly and objectively, and it is possible to collect data from large numbers of test takers. But group tests also have some distinct disadvantages. The examiner is less likely to notice whether a person is tired, ill, or confused by the directions. People who are not used to being tested tend to do less well on group tests than on individual tests. Questions 5 through 9 on page 235 are drawn from group tests.

Performance and Culture-Fair Tests To perform well on the intelligence tests that we have discussed, people must be proficient in the language in which the test is given. How, then, can we test non-native English speakers in English-speaking countries? Psychologists have designed two general forms of tests for such situations: performance tests and culture-fair tests.

Performance tests consist of problems that minimize or eliminate the use of words. One of the earliest performance tests, the *Seguin Form Board*, is essentially a puzzle. The examiner removes specifically designed cutouts, stacks them in a predetermined order, and asks the person to replace them as quickly as possible. A more recent performance test, the *Porteus Maze*, consists of a series of increasingly difficult printed mazes. People trace their

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way through the maze without lifting the pencil from the paper. Such tests require the test taker to pay close attention to a task for an extended period and continuously to plan ahead in order to make the correct choices.

Culture-fair tests, like performance tests, minimize or eliminate the use of language (Ortiz & Dynda, 2005). But they also try to downplay skills and values—such as the need for speed—that vary from culture to culture. In the *Goodenough–Harris Drawing Test*, for example, people are asked to draw the best picture of a person that they can. Drawings are scored for proportions, correct and complete representation of the parts of the body, detail in clothing, and so on. An example of a culture-fair item from the *Progressive Matrices* is Question 5 on page 235. This test consists of 60 designs, each with a missing part. The person is given six to eight possible choices to replace the part.

Biological Measures of Intelligence Thus far we have considered psychological measures of intelligence. However, numerous efforts have been made to assess intelligence using biological measures (Haier, 2003; W. Johnson, Jung, Colom, & Haier, 2008). Beginning early in the 20th century, psychologists attempted to correlate brain size with intelligence. The correlations were very weak but always positive, suggesting a slight relation between the two. More recently, investigators have compared the sizes and metabolic functioning of such brain structures as the cerebellum and hippocampus, revealing small but significant differences among the brains of people with different forms of mental retardation (Lawrence, Lott, & Haier, 2005). Other researchers have found modest relationships between intelligence and the electrical response of brain cells to stimulation (Stelmack, Knott, & Beauchamp, 2003).

To date, no known biological measure of intelligence approaches the accuracy of psychological tests, but findings such as these suggest that measures of intelligence may someday involve a biological component.

What Makes a Good Test?

What are some important characteristics of a good test?

How can we tell whether intelligence tests will produce consistent results no matter when they are given? And how can we tell whether they really measure what they claim to measure? Psychologists address these questions by referring to a test's reliability and validity. Issues of reliability and validity apply equally to all psychological tests, not just to tests of mental abilities. In Chapter 10, for example, we reexamine these issues as they apply to personality assessment.

Reliability By **reliability**, psychologists mean the dependability and consistency of the scores that a test yields. How do we know whether a test is reliable? The simplest way to find out is to give the test to a group and then, after a short time, to give the same people the same test again. If they obtain similar scores each time, the test is said to have high *test-retest reliability*. For example, **Table 7–2** shows the IQ scores of eight people tested 1 year apart using the same test. Although the scores did change slightly, none changed by more than six points.

How do we know that people have not simply remembered the answers from the first testing and repeated them the second time around? To avoid this possibility, psychologists prefer to give two equivalent tests, both designed to measure the same thing. If people score the same on both forms, the tests are considered reliable. One way to create alternate forms is to split a single test into two parts—for example, to assign odd-numbered items to one part and even-numbered items to the other. If scores on the two halves agree, the test has **split-half reliability**.

group tests Written intelligence tests administered by one examiner to many people at one time.

performance tests Intelligence tests that minimize the use of language.

culture-fair tests Intelligence tests designed to eliminate cultural bias by minimizing skills and values that vary from one culture to another.

reliability Ability of a test to produce consistent and stable scores.

split-half reliability A method of determining test reliability by dividing the test into two parts and checking the agreement of scores on both parts.

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Table 7–2 IQ SCORES ON THE SAME TEST GIVEN 1 YEAR APART

Person	First Testing	Second Testing
A	130	127
B	123	127
C	121	119
D	116	122
E	109	108
F	107	112
G	95	93
H	89	94

ENDURING ISSUES

Stability–Change Test Reliability and Changes in Intelligence

If a person takes an intelligence test on Monday and obtains an IQ score of 90, and then retakes the test on Tuesday and scores 130, clearly something is amiss. But what? People vary from moment to moment and day to day. Changes in health and motivation can affect test results even with the most reliable tests. And although IQ scores tend to be remarkably stable after the age of 5 or 6, intellectual ability does sometimes change dramatically—for better or worse. One person's mental ability may decline substantially after a mild head injury; another person's scores on intelligence tests may rise after years of diligent intellectual study.

Since scores on even the best tests vary somewhat from one day to the next, many testing services now report a person's score along with a range of scores that allows for variations. For example, a score of 110 might be reported with a range of 104–116. This implies that the true score is most likely within a few points of 110, but almost certainly does not fall lower than 104 or higher than 116. ■

These methods of testing reliability can be very effective. But psychological science demands more precise descriptions than "very reliable" or "fairly reliable." Psychologists express reliability in terms of **correlation coefficients**, which measure the relation between two sets of scores (see Appendix A for a discussion of correlation coefficients). If test scores on one occasion are absolutely consistent with those on another occasion, the correlation coefficient is 1.0. If there is no relationship between the scores, the correlation coefficient is zero. In **Table 7–2**, where there is a very close, but not perfect, relationship between the two sets of scores, the correlation coefficient is .96.

How reliable are intelligence tests? In general, people's IQ scores on most intelligence tests are quite stable (Meyer et al., 2001). Performance and culture-fair tests are somewhat less reliable. However, as we've discussed, scores on even the best tests vary somewhat from one day to another.

correlation coefficients Statistical measures of the degree of association between two variables.

validity Ability of a test to measure what it has been designed to measure.

content validity Refers to a test's having an adequate sample of questions measuring the skills or knowledge it is supposed to measure.

Validity Do intelligence tests really measure "intelligence"? When psychologists ask this question, they are concerned with test validity. **Validity** refers to a test's ability to measure what it has been designed to measure. How do we know whether a given test actually measures what it claims to measure?

One measure of validity is known as **content validity**—whether the test contains an adequate sample of the skills or knowledge that it is supposed to measure. Most widely used intelligence tests seem to measure at least some of the mental abilities

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that we think of as part of intelligence. These include planning, memory, understanding, reasoning, concentration, and the use of language. Although they may not adequately sample all aspects of intelligence equally well, they at least seem to have some content validity.

Another way to measure a test's validity is to see whether a person's score on that test closely matches his or her score on another test designed to measure the same thing. The two different scores should be very similar if they are both measures of the same ability. Most intelligence tests do this well: Despite differences in test content, people who score high on one test tend to score high on others. However, this outcome doesn't necessarily mean that the two tests actually measure intelligence. Conceivably, they could both be measuring the same thing, but that thing might not be intelligence. To demonstrate that the tests are valid measures of intelligence, we need an independent measure of intelligence against which to compare test scores. Determining test validity in this way is called **criterion-related validity**. Ever since Binet invented the intelligence test, the main criterion against which intelligence test scores have been compared has been school achievement. Even the strongest critics agree that IQ tests predict school achievement very well (Aiken & Groth-Marnat, 2005; Anastasi & Urbina, 1997).

Criticisms of IQ Tests What is it about IQ tests, then, that makes them controversial? As you might guess from our earlier discussion of theories of intelligence, one source of disagreement and criticism concerns their content. Since psychologists disagree on the very nature of intelligence, it follows that they will disagree on the merits of particular tests of intelligence.

That said, there is general agreement among psychologists that at the least, intelligence tests measure the ability to take tests. This fact could explain why people who do well on one IQ test also tend to do well on other tests. And it could also explain why intelligence test scores correlate so closely with school performance: Academic grades also depend heavily on test-taking ability.

Apart from predicting academic grades, how useful are intelligence tests? IQ tests also tend to predict success after people finish their schooling. People with high IQ scores tend to enter high-status occupations: Physicians and lawyers tend to have higher IQs than truck drivers and janitors. Critics point out, however, that this pattern can be explained in various ways. For one thing, because people with higher IQs tend to do better in school, they stay in school longer and earn advanced degrees, thereby opening the door to high-status jobs. Moreover, children from wealthy families generally grow up in environments that encourage academic success and reward good performance on tests (Blum, 1979; Ceci & Williams, 1997). In addition, they are more likely to have financial resources for postgraduate education or advanced occupational training, as well as family connections that pave the way to occupational success. Still, higher grades and intelligence test scores do predict occupational success and performance on the job (Kuncel, Hezlett, & Ones, 2004; Mcquillan, 2007; Ree & Earles, 1992).

Goleman's concept of emotional intelligence is specifically intended to predict success in the real world. Since this is a relatively new concept, researchers have only begun to evaluate it (Austin, Saklofske, Huang, & McKenney, 2004; Matthews, Zeidner, & Roberts, 2002; Mayer, Salovey, & Caruso, 2008). However, some studies have shown promising results (Bar-On, Handley, & Fund, 2006). For example, one study found that students with higher emotional intelligence scores adapted better socially and academically at school (Mestre, Guil, Lopes, Salovey, & Gil-Olarte, 2006). As you might expect, the ability to manage and regulate one's emotions is also important to success in the workplace (Cherniss & Goleman, 2001; Druskat, Sala, & Mount, 2006).

Though some investigators argue that emotional intelligence is no different from traits that are already assessed by more traditional measures of intelligence and personality (M. Davies, Stankov, & Roberts, 1998; Waterhouse, 2006), the theory of emotional intelligence continues to gain support from psychological research (Mayer, Salovey, & Caruso, 2008). It has captured the attention of managers and others responsible for

criterion-related validity Validity of a test as measured by a comparison of the test score and independent measures of what the test is designed to measure.

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hiring, promoting, and predicting the performance of people in the workplace (Salovey, 2006; Yu & Yuan, 2008). In addition, recent research on emotional intelligence is advancing our understanding of the factors that contribute to the development of some forms of mental illness (Malterer, Glass, & Newman, 2008). (See Chapter 12, "Psychological Disorders.")

Another major criticism of intelligence tests is that their content and administration do not take into account cultural variations and, in fact, discriminate against minorities. High scores on most IQ tests require considerable mastery of standard English, thus biasing the tests in favor of middle- and upper-class White people (Ortiz & Dynda, 2005). Moreover, White middle-class examiners may not be familiar with the speech patterns of lower income African American children or children from homes in which English is not the primary language, a complication that may hamper good test performance (Sattler, 2005). In addition, certain questions may have very different meanings for children of different social classes. The WISC-III, for instance, asks, "What are you supposed to do if a child younger than you hits you?" The "correct" answer is "Walk away." But for a child who lives in an environment where survival depends on being tough, the "correct" answer might be "Hit him back." This answer, however, receives zero credit. **Explore** on **MyPsychLab**

Explore Think: Intelligence and IQ Testing: Controversy and Consensus at www.mypsychlab.com

ENDURING ISSUES

Person–Situation Tracking the Future

Tracking, the practice of assigning students who "test low" to special classes for slow learners, can work to the student's disadvantage if the test results do not reflect the student's true abilities. However, the opposite mistake may sometimes work to the student's advantage: A student of mediocre ability who is identified early on as above average may receive special attention, encouragement, and tutoring that would otherwise have been considered "wasted effort" on the part of teachers. Thus, intelligence test scores can set up a self-fulfilling prophecy, so that students defined as slow become slow, and those defined as quick become quick. In this way, intelligence tests may not only predict achievement but also help determine it (R. Rosenthal, 2002). ■

Although some investigators argue that the most widely used and thoroughly studied intelligence tests are not unfairly biased against minorities (Damas, 2002; Gottfredson, 2009; Herrnstein & Murray, 1994), others contend that a proper study of cultural bias has yet to be made (E. Hunt & Carlson, 2007). The issue of whether tests are unfair to minorities will be with us for some time (N. Brody, 2007).

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CHECK YOUR UNDERSTANDING

1. Indicate whether the following statements are true (T) or false (F).
   a. ___ Intelligence is synonymous with problem-solving ability.
   b. ___ The early American psychologist L. L. Thurstone maintained that intelligence was quite general and should not be thought of as several distinct abilities.
   c. ___ Intrapersonal intelligence reflects the adage, "Know thyself."
   d. ___ Sternberg's and Gardner's theories of intelligence both emphasize practical abilities.
2. In 1916, the Stanford psychologist L. M. Terman introduced the term _____ _____, or _____, and set the score of _____ for a person of average intelligence.
3. _____ tests eliminate or minimize the use of words in assessing mental abilities. Like these tests, _____-_____ tests minimize the use of language, but they also include questions that minimize skills and values that vary across cultures.

Answers: a. (F). b. (F). c. (T). d. (T). 2. intelligence quotient, I.Q., 100. 3. Performance, culture-fair.

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APPLY YOUR UNDERSTANDING

1. Margaret is trying to create a 10-item intelligence test. She compares scores from her test to scores on the Stanford–Binet test in an attempt to determine her test's
   a. reliability.
   b. validity.
   c. standard scores.
   d. standard deviation.
2. A friend of yours says, "Everyone has different talents and abilities. Some people are really good at math but just kind of average at everything else. Other people are really good at music or athletics or dancing but can't add two numbers to save their lives. Because you have an ability in one area doesn't mean you're talented at other things." Your friend's view of abilities most closely matches which of the following theorists discussed in this section of the chapter?
   a. Spearman
   b. Gardner
   c. Thurstone
   d. Binet

Answers: 1. b. 2. b.

HEREDITY, ENVIRONMENT, AND INTELLIGENCE

What determines individual differences in intelligence?

Is intelligence inherited, or is it the product of the environment? Sorting out the importance of each factor as it contributes to intelligence is a complex task.

LEARNING OBJECTIVES

- **Summarize the evidence that both heredity and environment (including intervention programs) affect intelligence.**
- **What is the "Flynn Effect"? What are some of the explanations that have been offered for it?**
- **Summarize the evidence regarding gender differences and cultural differences in mental abilities.**
- **Explain what is required for a diagnosis of mental retardation and summarize what is known about its causes. Describe what is meant by "inclusion" and whether it has been shown to be beneficial.**
- **Explain what is meant by saying a person is "gifted." Explain the pros and cons of special programs for gifted children.**

Heredity

Why are twin studies useful in studying intelligence?

As we saw in Chapter 2, "The Biological Basis of Behavior," scientists can use studies of identical twins to measure the effects of heredity in humans. Twin studies of intelligence begin by comparing the IQ scores of identical twins who have been raised together. As **Figure 7–7** shows, the correlation between their IQ scores is very high. In addition to identical genes, however, these twins grew up in very similar environments: They shared parents, home, teachers, vacations, and probably friends, too. These common experiences could explain their similar IQ scores. To check this possibility, researchers have tested identical twins who were separated early in life—generally before they were 6 months old—and raised in different families. As **Figure 7–7** shows, even when identical twins are raised in different families, they tend to have very similar test scores; in fact, the similarity is much greater than that between non-twin siblings who grow up in the *same* environment.

These findings make a strong case for the heritability of intelligence, though as we pointed out in Chapter 2 twin studies do not constitute "final proof." However, other evidence also demonstrates the role of heredity. For example, adopted children have been found to have IQ scores that are more similar to those of their *biological* mothers than to those of the mothers who are raising them. Do psychologists, then, conclude that intelligence is an inherited trait and that environment plays little, if any, role?

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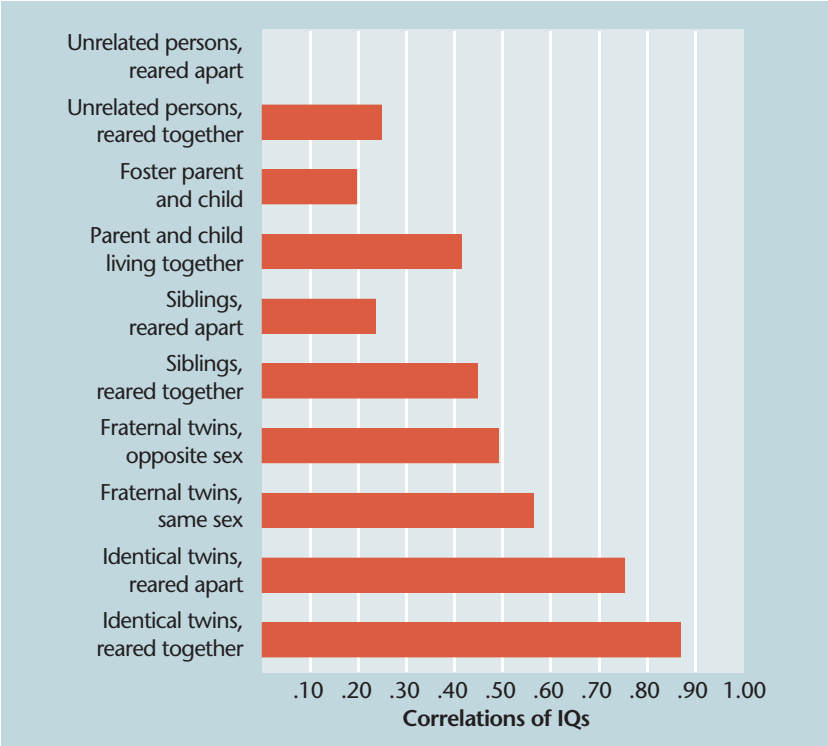

Figure 7–7
Correlations of IQ scores and family relationships.

Identical twins who grow up in the same household have IQ scores that are almost identical to each other. Even when they are reared apart, their scores are highly correlated.

Source: Reprinted from "Genetics and intelligence: A review," by L. Erienmeyer-Kimling and L. F. Jarvik, *Science, 142* (1963), pp. 1477–79. Copyright © 1963 by the American Association for the Advancement of Science. Reprinted by permission of Copyright Clearance Center on behalf of AAAS.

Environment

What have we learned from early intervention programs about the influence of the environment on intellectual development?

Probably no psychologist denies that genes play a role in determining intelligence, but most believe that genes provide only a base or starting point (Garlick, 2003). Each of us inherits a certain body build from our parents, but our actual weight is greatly determined by what we eat and how much we exercise. Similarly, although we inherit certain mental capacities, their development depends on what we see around us as infants, how our parents respond to our first attempts to talk, what schools we attend, which books we read, which television programs we watch—even what we eat (Sternberg & Grigorenko, 2001). Moreover, recent evidence indicates that the role of heredity varies with social economic status: In impoverished families, it appears to have little or no bearing on intelligence; in affluent families, its influence appears to be stronger (Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003).

Environment affects children even before birth, such as through prenatal nutrition (M. D. Sigman, 2000). During infancy, malnutrition can lower IQ scores by an average of 20 points (Stock & Smythe, 1963). Conversely, vitamin supplements can increase young children's IQ scores, possibly even among well-nourished children (D. Benton & Roberts, 1988; Schoenthaler, Amos, Eysenck, Peritz, & Yudkin, 1991).

Quite by chance, psychologist H. M. Skeels found evidence in the 1930s that IQ scores among children also depend on environmental stimulation. While investigating orphanages for the state of Iowa, Skeels observed that the children lived in very overcrowded wards and that the few adults there had almost no time to play with the children, to talk to them, or to read them stories. Many of these children were classified as "subnormal" in intelligence. Skeels followed the cases of two girls who, after 18 months in an orphanage, were sent to a ward for women with severe retardation. Originally, the girls' IQs were in the range of retardation, but after a year on the adult ward, as if by magic, their IQs had risen to normal (Skeels, 1938). Skeels regarded this fact as quite remarkable—after all, the women with whom the girls had lived were themselves severely retarded. When he placed 13 other "slow" children as houseguests in such adult wards, within 18 months their mean IQ rose from 64 to 92 (within the normal range)—all apparently because they had had someone (even someone of below-normal intelligence) to play with them, to read to them, to cheer them on when they took their first steps, and to encourage them to talk (Skeels, 1942). During the same period, the mean IQ of a group of children who had been left in orphanages dropped from 86 to 61. Thirty years later, Skeels found that all 13 of the children raised on adult wards were self-supporting, their occupations ranging from waiting on tables to real-estate sales. Of the contrasting group, half were unemployed, four were still in institutions, and all of those who had jobs were dishwashers (Skeels, 1966). Later studies have reinforced Skeels's findings on the importance of intellectually stimulating surroundings as well as the importance of good nutrition (Capron & Duyme, 1989).

Intervention Programs: How Much Can We Boost IQ? In 1961, the Milwaukee Project set out to learn whether intervening in a child's family life could offset the negative effects of cultural and socioeconomic deprivation on IQ scores (Garber & Heber, 1982; Heber, Garber, Harrington, & Hoffman, 1972). The average score of the 40 pregnant

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women in the study was less than 75 on the Wechsler scale. Women in the control group received no special education or training; those in the experimental group were sent to school, given job training, and instructed in child care, household management, and personal relationships.

After the babies were born, the research team shifted their focus to them. For 6 years, the children whose mothers received special training spent most of each day in an infant-education center, where they were fed, taught, and cared for by paraprofessionals. The children whose mothers received no special training did not attend the center. Ultimately the children in the experimental group achieved an average IQ score of 126, 51 points higher than their mothers' average scores. In contrast, the average score of the children in the control group was 94. Thus, this landmark study supported the notion that intervention may indeed counter the negative effects of cultural and socioeconomic deprivation on IQ scores.

Individual differences in intelligence can be partly explained by differences in environmental stimulation and encouragement. The specific forms of stimulation given vary from culture to culture. Because our culture assigns importance to developing academic skills, the stimulation of reading and exploring information in books can give children an edge over those who are not so encouraged.

Head Start, the nation's largest intervention program, began in 1965. Since its inception, Head Start has provided comprehensive services to more than 25 million children and their families through child care, education, health, nutrition, and family support (National Head Start Association, 2008). Focusing on preschoolers between the ages of 3 and 5 from low-income families, the program has two key goals: to provide children with educational and social skills before they go to school, and to provide information about nutrition and health to both the children and their families. Head Start involves parents in all its aspects, from daily activities to administration of the program itself. This parental involvement has been crucial to Head Start's success (Cronan, Walen, & Cruz, 1994; Mendez-Baldwin, 2001).

Several studies evaluating the long-term effects of Head Start have found that it boosts cognitive and language abilities (W. S. Barnett, 1998; Wasik, Bond, & Hindman, 2006; Zhai, 2008; Zigler & Styfco, 2008). Studies following Head Start graduates until age 27 revealed higher academic achievement and lower delinquency level. Graduates also tended to stay in school longer and were more likely to graduate from college. Thus, Head Start seems to provide long-term, practical benefits (Zigler, 2003; Zigler & Styfco, 2008).

Overall, the effectiveness of early intervention appears to depend on the quality of the particular program (S. L. Ramey, 1999; C. T. Ramey & Ramey, 2007; Zigler & Styfco, 1993). Intervention programs that have clearly defined goals; that explicitly teach such basic skills as counting, naming colors, and writing the alphabet; and that take into account the broad context of human development, including health care and other social services, achieve the biggest and most durable gains.

The IQ Debate: A Useful Model

How can the study of plants help us to understand the relationship between heredity and environment?

Both heredity and environment have important effects on individual differences in intelligence, but is one of these factors more important than the other? A useful analogy comes from studies of plants (Turkheimer, 1991). Suppose that you grow one group of randomly assigned plants in enriched soil, and another group in poor soil. The enriched group will grow to be taller and stronger than the nonenriched group; the difference between the two groups in this case is due entirely to differences in their environment. *Within* each group of plants, however, differences among individual plants are likely to be primarily due to genetics, because all plants in the same group share essentially the same environment. Thus, the height and strength of any single plant reflects both heredity *and* environment.

Similarly, group differences in IQ scores might be due to environmental factors, but differences among people *within* groups could be due primarily to genetics. At the same time, the IQ scores of particular people would reflect the effects of both heredity *and* environment. Robert Plomin, an influential researcher in the field of human intelligence, concludes that "the world's literature suggests that about half of the total variance in IQ scores can be accounted for by genetic variance" (Plomin, 1997, p. 89). This finding means that environment accounts for the other half.

Head Start is a program designed to do just what its name implies: to give children from disadvantaged environments a head start in acquiring the skills and attitudes needed for success in school. Although researchers debate whether Head Start produces significant and lasting boosts in IQ, it does have many school-related benefits for those who participate in it.

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THINKING CRITICALLY ABOUT . . .

The Flynn Effect

Flynn and others have found that IQ scores are rising, but what does this really mean? As Flynn (1999) points out, it is hard to see how genes could account for so rapid an increase in IQ. Clearly, some aspect of the environment must account for most or all of the increase in IQ scores.

1. Of the possible explanations mentioned in the text, which seem to you to be most likely? Why? How might you go about determining whether one explanation is better than another?
2. Do you think IQ scores will continue to rise? Is your position on that question related to your answer to the first question?
3. Does a rise in IQ test scores necessarily mean that there has been a comparable increase in intelligence? Why or why not?

The Flynn Effect An interesting side note to this discussion is the fact that IQ scores have *gone up* in the population as a whole (Daley, Whaley, Sigman, Espinosa, & Neumann, 2003; Flynn, 2007). Because James Flynn (Flynn, 1984, 1987) of the University of Otago in New Zealand was the first to report this finding, it is often called the *Flynn Effect*. In his original research, Professor Flynn gathered evidence showing that, between 1932 and 1978, intelligence test scores rose about three points per decade. More recently, by pulling together data from five nations (Britain, Netherlands, Israel, Norway, and Belgium) Flynn (1999) has shown that the average increase in IQ may be as high as six points per decade. Consistent with this result is a finding by Flieller (1999) that children today between the ages of 10 and 15 years display significant cognitive advancement compared with children of the same age tested 20 and 30 years ago. And, as Neisser (1998) points out, accompanying this general increase in IQ scores is a decrease in the difference in intelligence scores between Blacks and Whites.

Although the Flynn Effect has many possible explanations, none of them seem to account entirely for the magnitude of the effect (Flynn, 1999; D. C. Rowe & Rodgers, 2002; Sundet, Borren, & Tambs, 2008). Rather than getting smarter, maybe people are simply getting better at taking tests. Environmental factors, such as improved nutrition and health care, may also contribute to this trend (Teasdale & Owen, 2005). Some psychologists have suggested that the sheer complexity of the modern world is responsible (Schooler, 1998). For example, the proliferation of televisions, computers, and video games could be contributing to the rise in IQ scores (Greenfield, 1998; Neisser, 1998).

Mental Abilities and Human Diversity: Gender and Culture

Do culture and gender influence mental abilities?

Research shows there are only negligible differences between men and women in mathematical ability.

Gender In 1974, psychologists Eleanor Maccoby and Carol Jacklin published a review of psychological research on gender differences. They found no differences at all between males and females in most of the studies they examined. However, a few differences did appear in cognitive abilities: Girls tended to display greater verbal ability, and boys tended to exhibit stronger spatial and mathematical abilities. Largely as a result of this research, gender differences in verbal, spatial, and mathematical abilities became so widely accepted that they were often cited as one of the established facts of psychological research (Hyde, Fennema, & Lamon, 1990; Hyde & Linn, 1988).

A closer examination of the research literature, including more recent work, indicates that while gender differences in some math and verbal skills exist, they are relatively small and often concentrated in very specific skills. For example, while girls do appear to display stronger verbal skills than boys, female superiority is generally only found when the assessment of verbal skill includes writing. Conversely, boys tend to outperform girls primarily on measures of visual-spatial skill, which appears to account for most of the gender-related differences revealed on standardized math tests (Halpern et al., 2007). Interestingly, the advantage

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males have over females in visual-spatial ability has been detected in infants as young as 3–5 months (J. Choi & Silverman, 2003; Halpern, 1997; D. S. Moore & Johnson, 2008; Quinn & Liben, 2008). Men also differ from women in another way: They are much more likely than women to fall at the extremes of the intelligence range (N. Brody, 2000; Halpern et al., 2007). In one review of several large studies, Hedges and Nowell (1995) found that males accounted for seven out of eight people with extremely high IQ scores. These authors also reported that males represented an almost equally large proportion of the IQ scores within the range of mental retardation.

What should we conclude from these findings? First, cognitive differences between males and females appear to be restricted to specific cognitive skills (Stumpf & Stanley, 1998). Scores on tests such as the Stanford–Binet or the WAIS reveal no gender differences in general intelligence (Halpern, 1992). Second, gender differences typically are small (Skaalvik & Rankin, 1994). Third, we do not know whether the differences that do exist are a result of biological or cultural factors (Hyde & Mezulis, 2002). Finally one extensive review of the literature concluded that "There is no single factor by itself that has been shown to determine sex differences in science and math. Early experience, biological constraints, educational policy, and cultural context each have effects, and these effects add and interact in complex and sometimes unpredictable ways" (Halpern et al., 2007, p. 41).

Culture For years, U.S. media have been reporting an achievement gap, especially in math, between American and Asian students. Recent media reports suggest even broader differences. **Watch** on **MyPsychLab**

Watch Cultural Influences: Robert Sternberg at www.mypsychlab.com

Psychological research tells us something about the causes of these achievement gaps. Two decades ago, a team of researchers led by the late Harold Stevenson (1924–2005) began to study the performance of first- and fifth-grade children in American, Chinese, and Japanese elementary schools (Stevenson, Lee, & Stigler, 1986). At that time, the American students at both grade levels lagged far behind the other two countries in math and came in second in reading. A decade later, when the study was repeated with a new group of fifth-graders, the researchers discovered that the American students performed even worse than they had earlier. In 1990, the research team also studied the original first-graders from all three cultures, now in the eleventh grade. The result? The American students retained their low standing in mathematics compared with the Asian students (Stevenson, 1992, 1993; Stevenson, Chen, & Lee, 1993).

The next question was, Why? Stevenson's team wondered whether cultural attitudes toward ability and effort might, in part, explain the differences. To test this hypothesis, the researchers asked students, their parents, and their teachers in all three countries whether they thought effort or ability had a greater impact on academic performance. From first through eleventh grade, American students on the whole disagreed with the statement that "everyone in my class has about the same natural ability in math." In other words, the Americans thought that "studying hard" has little to do with performance. Their responses appear to reflect a belief that mathematical skill is primarily a function of innate ability. American mothers expressed a similar view. Moreover, 41% of the American eleventh-grade teachers thought "innate intelligence" is the most important factor in mathematics performance. By contrast, Asian students, parents, and teachers believed that effort and "studying hard" determine success in math.

Such culturally influenced views of the relative importance of effort and innate ability may have profound consequences for the way that children, their parents, and their teachers approach the task of learning. Students who believe that learning is based on natural ability see little value in working hard to learn a difficult subject. By contrast, students who believe that academic success comes from studying are more likely to work hard. Indeed, even the brightest students will not get far without making an effort. Although many Americans no doubt believe in the value of effort and hard work, our widespread perception that innate ability is the key to academic success may be affecting the performance of U.S. students (Stevenson, Lee, & Mu, 2000).

In short, while Stevenson's research confirms the existence of significant differences in student performance across various cultures, the evidence suggests that these differences

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THINKING CRITICALLY ABOUT . . .

International Comparisons of School Achievement

1. Do you agree or disagree with the conclusions of Stevenson and his colleagues that cultural attitudes may account for some of the academic performance differences between American students and students from other countries? What additional evidence might provide support for your position?
2. If you were to research this topic today, would you do things differently than Stevenson's team did? Are there any other factors that might account for the differences in achievement that you would investigate? What specific questions would you ask of the parents, students, and teachers? What additional information about the school systems would you collect?
3. Given the results of this research, what specific steps would you take to improve the academic performance of American children?

reflect cultural attitudes toward the importance of ability and effort, rather than an underlying difference in intelligence across the cultures.

Extremes of Intelligence

What do psychologists know about the two extremes of human intelligence: very high and very low?

The average IQ score on intelligence tests is 100. Nearly 70% of all people have IQs between 85 and 115, and all but 5% of the population have IQs between 70 and 130. In this section, we focus on people who score at the two extremes of intelligence—those with mental retardation and those who are intellectually gifted.

Mental Retardation **Mental retardation** encompasses a vast array of mental deficits with a wide variety of causes, treatments, and outcomes. The American Psychiatric Association (1994) defines mental retardation as "significantly subaverage general intellectual functioning . . . that is accompanied by significant limitations in adaptive functioning" and that appears before the age of 21 (p. 39). There are also various degrees of mental retardation. Mild retardation corresponds to Stanford–Binet IQ scores ranging from a high of about 70 to a low near 50. Moderate retardation corresponds to IQ scores from the low 50s to the middle 30s. People with IQ scores between the middle 30s and 20 are considered severely retarded, and the profoundly retarded are those whose scores are below 20. (See **Table 7–3**.)

But a low IQ is not in itself sufficient for diagnosing mental retardation. The person must also be unable to perform the daily tasks needed to function independently (Rust & Wallace, 2004). A person who is able to live independently, for example, is not considered to have mental retardation even if his or her IQ may be extremely low. To fully assess individuals and to place them in appropriate treatment and educational programs, mental health professionals need information on physical health and on emotional and social adjustment (Borthwick-Duffy, 2007).

mental retardation Condition of significantly subaverage intelligence combined with deficiencies in adaptive behavior.

Some people with mental handicaps exhibit remarkable abilities in highly specialized areas, such as numerical computation, memory, art, or music (Pring, Woolf, & Tadic, 2008; Treffert & Wallace, 2002). Probably the most dramatic and intriguing examples involve *savant performance* (Boelte, Uhlig, & Poustka, 2002; L. K. Miller, 2005). Savant performances

Table 7–3 LEVELS OF MENTAL RETARDATION

Type of Retardation	IQ Range	Attainable Skill Level
Mild retardation	Low 50s to low 70s	People may be able to function adequately in society and learn skills comparable to a sixth-grader, but they need special help at times of unusual stress.
Moderate retardation	Mid-30s to low 50s	People profit from vocational training and may be able to travel alone. They learn on a second-grade level and perform skilled work in a sheltered workshop under supervision.
Severe retardation	Low 20s to mid-30s	People do not learn to talk or to practice basic hygiene until after age 6. They cannot learn vocational skills but can perform simple tasks under supervision.
Profound retardation	Below 20 or 25	Constant care is needed. Usually, people have a diagnosed neurological disorder.

Source: Based on APA, *DSM-IV*, 1994.

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include mentally calculating large numbers almost instantly, determining the day of the week for any date over many centuries, and playing back a long musical composition after hearing it played only once.

What causes mental retardation? In most cases, the causes are unknown (Beirne-Smith, Patton, & Ittenbach, 1994; Glidden, 2004)—especially in cases of mild retardation, which account for nearly 90% of all retardation. When causes can be identified, most often they stem from a wide variety of genetic, environmental, social, nutritional, and other risk factors (A. A. Baumeister & Baumeister, 2000; Moser, 2004).

About 25% of cases—especially the more severe forms of retardation—appear to involve genetic or biological disorders. Scientists have identified more than 100 forms of mental retardation caused by single defective genes (Plomin, 1997). One is the genetically based disease *phenylketonuria*, or *PKU*, which occurs in about one person out of 25,000. In people suffering from PKU, the liver fails to produce an enzyme necessary for early brain development. Fortunately, placing a PKU baby on a special diet can prevent mental retardation from developing (Merrick, Aspler, & Schwarz, 2005). In the disorder known as *Down syndrome*, which affects 1 in 600 newborns, an extra 21st chromosome is the cause. Down syndrome, named for the physician who first described its symptoms, is marked by moderate to severe mental retardation.

Biologically caused mental retardation can be moderated through education and training (C. T. Ramey, Ramey, & Lanzi, 2001). The prognosis for those with no underlying physical causes is even better. People whose retardation is due to a history of social and educational deprivation can respond dramatically to appropriate interventions. Today, the majority of children with physical or mental disabilities are educated in local school systems (Doré, Wagner, Doré, & Brunet, 2002), in *inclusion* arrangements (Kavale, 2002) (previously known as *mainstreaming*), which help these students to socialize with their nondisabled peers. The principle of mainstreaming has also been applied successfully to adults with mental retardation, by taking them out of large, impersonal institutions and placing them in smaller community homes that provide more normal life experiences (I. Brown, Buell, Birkan, & Percy, 2007).

Down syndrome is a common biological cause of mental retardation, affecting one in 600 newborns. The prognosis for Down syndrome children today is much better than it was in the past. With adequate support, many children with the affliction can participate in regular classrooms and other childhood activities.

Giftedness At the other extreme of the intelligence scale are "the gifted"—those with exceptional mental abilities, as measured by scores on standard intelligence tests. As with mental retardation, the causes of **giftedness** are largely unknown.

The first and now-classic study of giftedness was begun by Lewis Terman and his colleagues in the early 1920s. They defined giftedness in terms of academic talent and measured it by an IQ score in the top 2 percentile (Terman, 1925). More recently, some experts have sought to broaden the definition of giftedness beyond that of simply high IQ (L. J. Coleman & Cross, 2001; Csikszentmihalyi, Rathunde, & Whalen, 1993; Subotnik & Arnold, 1994). One view is that giftedness is often an interaction of above-average general intelligence, exceptional creativity, and high levels of commitment (Renzulli, 1978). Various criteria can identify gifted students, including scores on intelligence tests, teacher recommendations, and achievement test results. School systems generally use diagnostic testing, interviews, and evaluation of academic and creative work (Sattler, 1992). These selection methods can identify students with a broad range of talent, but they can miss students with specific abilities, such as a talent for mathematics or music (Cramond & Kim, 2008). This is an important factor because research suggests that most gifted individuals display special abilities in only a few areas. "Globally" gifted people are rare (Achter, Lubinski, & Benbow, 1996; Lubinski & Benbow, 2000; Olzewski-Kubilius, 2003; Winner, 1998, 2000).

A common view of gifted people is that they have poor social skills and are emotionally maladjusted. However, research does not support this stereotype (J. Richards, Encel, & Shute, 2003; Robinson & Clinkenbeard, 1998). Indeed, one review (Janos & Robinson, 1985) concluded that "being intellectually gifted, at least at moderate levels of ability, is clearly an asset in terms of psychosocial adjustment in most situations" (p. 181). Nevertheless, children who are exceptionally gifted sometimes do experience difficulty "fitting in" with their peers.

giftedness Refers to superior IQ combined with demonstrated or potential ability in such areas as academic aptitude, creativity, and leadership.

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ENDURING ISSUES

Diversity–Universality Not Everyone Wants to Be Special

Because gifted children sometimes become bored and socially isolated in regular classrooms, some experts recommend that they be offered special programs (Olzewski-Kubilius, 2003). Special classes for the gifted would seem to be something the gifted themselves would want, but this is not always the case. Special classes and special schools can separate gifted students from their friends and neighbors. And stereotypes about the gifted can mean that, once identified as gifted, the student is less likely to be invited to participate in certain school activities, such as dances, plays, and sports. Gifted students also sometimes object to being set apart, labeled "brains," and pressured to perform beyond the ordinary. Many but not all gifted students welcome the opportunities offered by special programs. ■

Any discussion of giftedness inevitably leads to the topic of creativity. The two topics are, indeed, closely related, as we shall see in the next section.

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CHECK YOUR UNDERSTANDING

1. Indicate whether the following statements are true (T) or false (F):
   a. ___ When identical twins are raised apart, their IQ scores are not highly correlated.
   b. ___ Environmental stimulation has little, if any, effect on IQ.
   c. ___ Head Start graduates are more likely than their peers to graduate from college.
2. As psychologists learn more about giftedness, the definition of it has become (broader/narrower) _____.

Answers: a. (F). b. (F). c. (T). 2. broader.

APPLY YOUR UNDERSTANDING

1. Imagine that an adoption agency separates identical twins at birth and places them randomly in very different kinds of homes. Thirty years later, a researcher discovers that the pairs of twins have almost identical scores on IQ tests. Which of the following conclusions is most consistent with that finding?
   a. Heredity has a significant effect on intelligence.
   b. Environment has a significant effect on intelligence.
   c. Heredity provides a starting point, but environment determines our ultimate intelligence.
   d. Because the twins were placed in very different environments, it's not possible to draw any conclusions.
2. Ten-year-old John has an IQ score of 60 on the Wechsler Intelligence Scale for Children. Which of the following would you need to know before you could determine whether John is mildly retarded?
   a. whether his score on the Stanford–Binet Intelligence Scale is also below 70
   b. whether he can perform the daily tasks needed to function independently
   c. whether he has a genetic defect in the X chromosome
   d. whether he suffered from malnutrition before birth

Answers: 1. a. 2. b.

LEARNING OBJECTIVE

- **Describe the relationship between creativity and intelligence, and the ways in which creativity has been measured.**

CREATIVITY

What is creativity?

creativity The ability to produce novel and socially valued ideas or objects.

Creativity is the ability to produce novel and socially valued ideas or objects ranging from philosophy to painting, from music to mousetraps (Mumford & Gustafson, 1988; Runco, 2004; Sternberg, 2001). Sternberg included creativity and insight as

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important elements in human intelligence. Most IQ tests, however, do not measure creativity, and many researchers would argue that intelligence and creativity are not the same thing.

Intelligence and Creativity

How is creativity related to intelligence?

Early studies typically found little or no relationship between creativity and intelligence (for example, Getzels & Jackson, 1962; Wing, 1969), but these studies were concerned only with bright students. Perhaps creativity and intelligence are indeed linked, but only until IQ reaches a certain threshold level, after which higher intelligence isn't associated with higher creativity. There is some evidence for this *threshold theory* (Barron, 1963; Yamamoto & Chimbidis, 1966). However, other studies have failed to provide support (Preckel, Holling, & Wiese, 2006) finding instead that the relationship between intelligence and creativity is best understood only when the individual facets of intelligence (such as crystal versus fluid) and creativity (such as musical or artistic) are considered (K. H. Kim, 2008; Sligh, Conners, & Roskos-Ewoldsen, 2005).

Creative people are often *perceived* as being more intelligent than less creative people who have equivalent IQ scores. But this may be the result of other characteristics that creative people share. For instance, research has shown that creative people also tend to score high on measures of *extraversion*—a personality trait reflecting gregariousness, assertiveness and excitement seeking (Furnham & Bachtiar, 2008; Furnham, Batey, Anand, & Manfield, 2008). (See Chapter 10, "Personality.")

In general, creative people are *problem finders* as well as problem solvers. The more creative people are, the more they like to work on problems that they have set for themselves. Creative scientists (such as Charles Darwin and Albert Einstein) often work for years on a problem that has sprung from their own curiosity (Gruber & Wallace, 2001). Also, "greatness" rests not just on "talent" or "genius"; such people also have intense dedication, ambition, and perseverance (Stokes, 2006). **Simulate** on **MyPsychLab**

Simulation on Creativity at www.mypsychlab.com

Creativity Tests

Can creativity be measured?

Measuring creativity poses special problems (Cramond & Kim, 2008; Naglieri & Kaufman, 2001; Runco, 2008). Because creativity involves original responses to situations, questions that can be answered *true* or *false* or *a* or *b* are not good measures. More open-ended tests are better. Instead of asking for one predetermined answer to a problem, the examiner asks the test takers to let their imaginations run free. Scores are based on the originality of a person's answers and often on the number of responses as well.

In one such test, the *Torrance Test of Creative Thinking*, people must explain what is happening in a picture, how the scene came about, and what its consequences are likely to be. In the *Christensen–Guilford Test*, they are to list as many words containing a given letter as possible, to name things belonging to a certain category (such as "liquids that will burn"), and to write four-word sentences beginning with the letters RDLS—"Rainy days look sad, Red dogs like soup, Renaissance dramas lack symmetry." One of the most widely used creativity tests, S. A. Mednick's (1962) *Remote Associates Test (RAT)*, asks people to relate three apparently unrelated words. For example, a test taker might relate the stimulus words *poke*, *go*, and *molasses* using the word *slow:* "Slowpoke, go slow, slow as molasses." In the newer *Wallach and Kogan Creative Battery*, people form associative groupings. For instance, children are asked to "name all the round things you can think of" and to find similarities between objects, such as between a potato and a carrot.

Although people who do not have high IQs can score well on the Wallach and Kogan test, the Torrance test seems to require a reasonably high IQ for adequate

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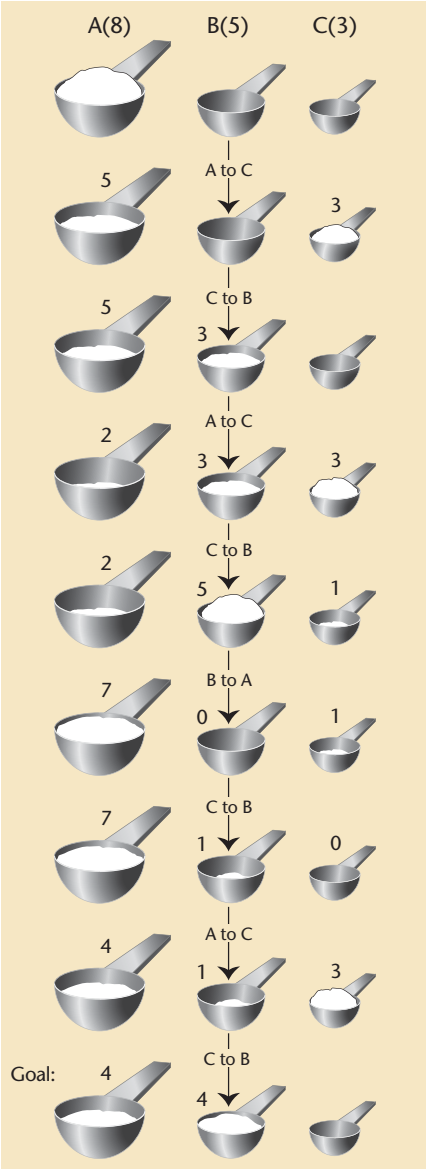

Figure 7–8
Answer to Problem 2.

performance. This finding raises the question of which of these tests is a valid measure of creativity. In general, current tests of creativity do not show a high degree of validity (Baer, 2008; Clapham, 2004), so measurements derived from them must be interpreted with caution.

CHECK YOUR UNDERSTANDING

1. The ability to produce novel and unique ideas or objects, ranging from philosophy to painting, from music to mousetraps, is termed _____.
2. Two important features of creative people are that they
   a. take risks and like to work on problems that they invent themselves.
   b. are perceived as less intelligent and more irresponsible than other people.
   c. excel at art but are poor at science.
3. _____-_____ tests are the best type for measuring creativity.

Answers: 1. creativity. 2. a. 3. Open-ended.

APPLY YOUR UNDERSTANDING

1. You are discussing creativity and intelligence with a friend who says, "Those are two different things. There's no relationship between being intelligent and being creative." Based on what you have learned in this chapter, which of the following would be the most accurate reply?
   a. "You're right. There is no evidence of a relationship between creativity and intelligence."
   b. "You're wrong. There is a relationship between intelligence and creativity but it is complex and is understood only when the individual facets of intelligence and creativity are taken into account."
   c. "That's apparently true only among very bright people. For most people, creativity and intelligence tend to go together."
   d. "That's true for people with IQ scores below about 100, but above that point, intelligence and creativity tend to go together."

Answers: 1. c.

ANSWERS TO PROBLEMS IN THE CHAPTER

PROBLEM 1 Fill each of the smaller spoons with salt from the larger spoon. That step will require 4 teaspoons of salt, leaving exactly 4 teaspoons of salt in the larger spoon.

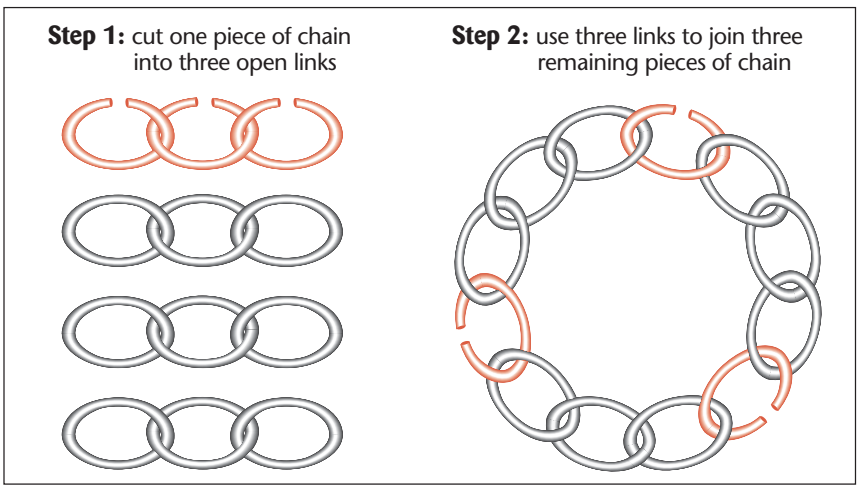

Figure 7–9
Answer to Problem 3.

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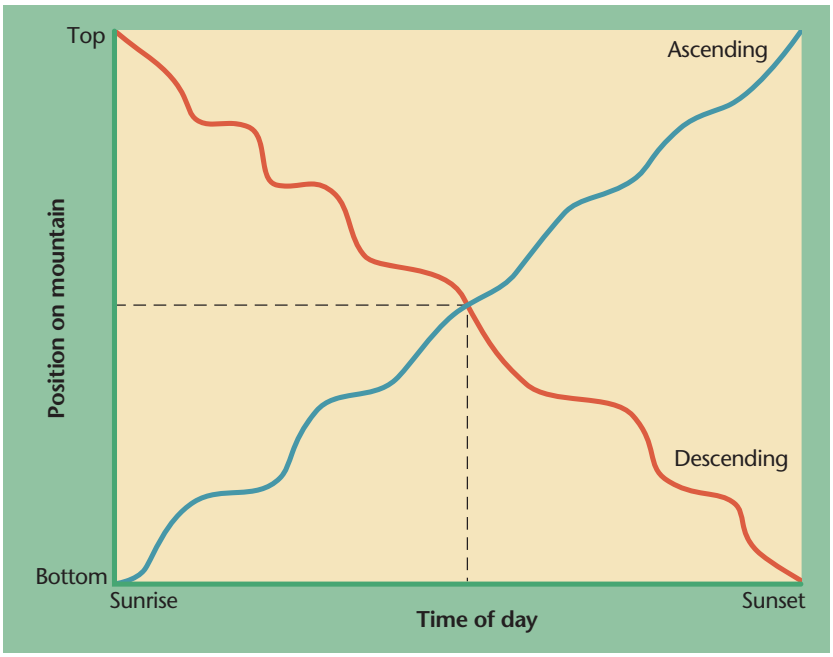

Figure 7–10
Answer to Problem 4.

PROBLEM 2 As shown in **Figure 7–8**, fill spoon C with the salt from spoon A (now A has 5 teaspoons of salt and C has 3). Pour the salt from spoon C into spoon B (now A has 5 teaspoons of salt, and B has 3). Again fill spoon C with the salt from spoon A. (This leaves A with only 2 teaspoons of salt, while B and C each have 3.) Fill spoon B with the salt from spoon C. (This step leaves 1 teaspoon of salt in spoon C, while B has 5 teaspoons, and A has only 2.) Pour all of the salt from spoon B into spoon A. (Now A has 7 teaspoons of salt, and C has 1.) Pour all of the salt from spoon C into spoon B, and then fill spoon C from spoon A. (This step leaves 4 teaspoons of salt in A, 1 teaspoon in B, and 3 teaspoons in C.) Finally, pour all of the salt from spoon C into spoon B. (This step leaves 4 teaspoons of salt in spoons A and B, which is the solution.)

PROBLEM 3 Take one of the short pieces of chain shown in **Figure 7–9**, and open all three links. (This step costs 6 cents.) Use those three links to connect the remaining three pieces of chain. (Hence, closing the three links costs 9 cents.)

PROBLEM 4 One way to solve this problem is to draw a diagram of the ascent and the descent, as in **Figure 7–10**. From this drawing, you can see that indeed there is a point that the monk passes at exactly the same time on both days. Another way to approach this problem is to imagine that there are two monks on the mountain; one starts ascending at 7 A.M., while the other starts descending at 7 A.M. on the same day. Clearly, sometime during the day the monks must meet somewhere along the route.

PROBLEM 5 This problem has four possible solutions, one of which is shown in **Figure 7–11**.

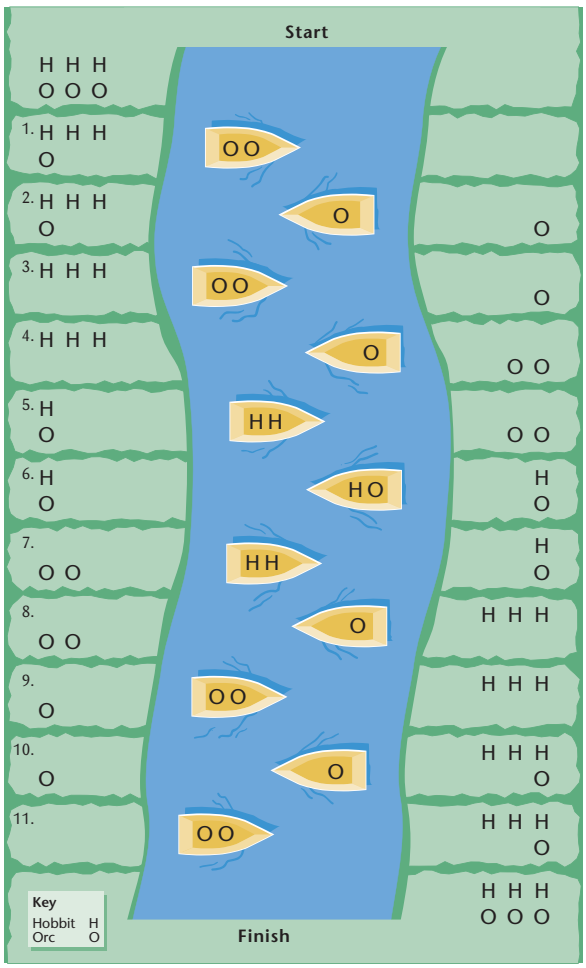

Figure 7–11
Answer to Problem 5.

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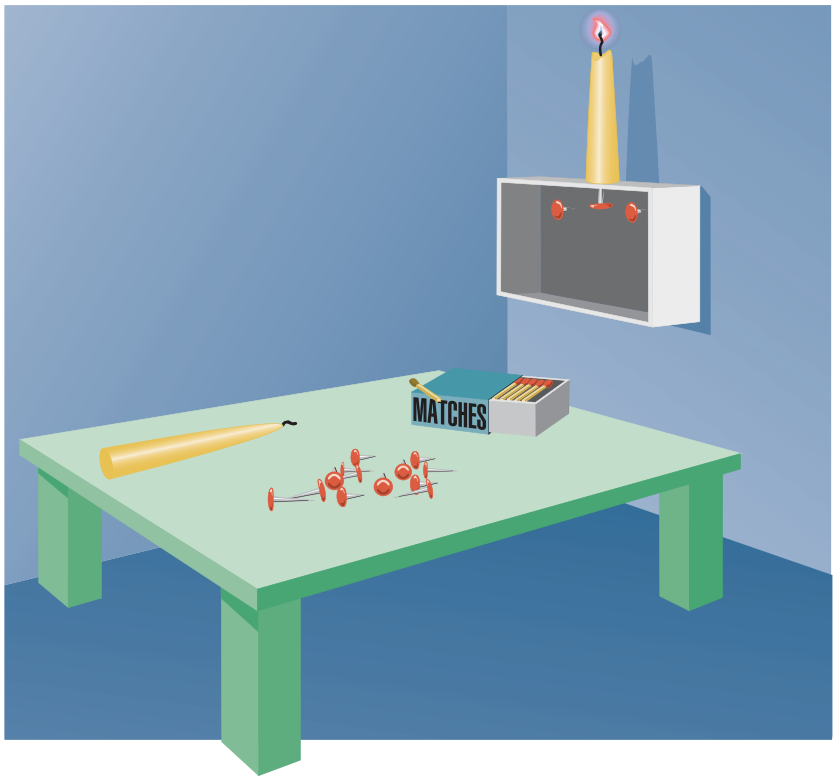

Figure 7–12
Solution to Figure 7–5.
In solving the problem given in **Figure 7–5**, many people have trouble realizing that the box of tacks can also be used as a candleholder, as shown here.

PROBLEM 6 There are 15 possible solutions to this problem, of which this is one: First, one Hobbit and one Orc cross the river in the boat; the Orc remains on the opposite side while the Hobbit rows back. Next, three Orcs cross the river; two of those Orcs remain on the other side (making a total of three Orcs on the opposite bank) while one Orc rows back. Now three Hobbits and one Orc row the boat back. Again, three Hobbits row across the river, at which point all five Hobbits are on the opposite bank with only two Orcs. Then, one of the Orcs rows back and forth across the river twice to transport the remaining Orcs to the opposite side.

ANSWERS TO INTELLIGENCE TEST QUESTIONS

1. *Idleness* refers to the state of being inactive, not busy, unoccupied; *laziness* means an unwillingness or a reluctance to work. Laziness is one possible cause of idleness, but not the only cause.
2. If you face west, your right ear will face north.
3. *Obliterate* means to erase or destroy something completely.
4. Both an hour and a week are measures of time.
5. Alternative (f) is the correct pattern.
6. Seventy-five cents will buy nine pencils.
7. Alternative (d) is correct. A crutch is used to help someone who has difficulty with locomotion; spectacles are used to help someone who has difficulty with vision.
8. Alternative D is correct. The second figure is the same shape and size but with diagonal cross-hatching from upper left to lower right.
9. Figures 3, 4, and 5 can all be completely covered by using some or all of the given pieces.

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phonemes, *p. 218*
morphemes, *p. 218*
grammar, *p. 218*
image, *p. 219*
concepts, *p. 219*
prototype (or model), *p. 219*

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CHAPTER REVIEW

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BUILDING BLOCKS OF THOUGHT

What are the three most important building blocks of thought? The three most important building blocks of thought are language, images, and concepts. As we think, we use words, sensory "snapshots," and categories that classify things.

What steps do we go through to turn a thought into a statement? **Language** is a flexible system of symbols that allows us to communicate ideas to others. When we express thoughts as statements, we must conform to our language's rules. Every language has rules indicating which sounds (or **phonemes**) are part of that particular language, how those sounds can be combined into meaningful units (or **morphemes**), and how those meaningful units can be ordered into phrases and sentences (rules of **grammar**). To communicate an idea, we start with a thought and then choose sounds, words, and phrases that will express the idea clearly. To understand the speech of others, the task is reversed.

What role do images play in thinking? **Images** are mental representations of sensory experiences. Visual images in particular can be powerful aids in thinking about the relationships between things. Picturing things in our mind's eye can sometimes help us solve problems.

How do concepts help us to think more efficiently? **Concepts** are categories for classifying objects, people, and experiences based on their common elements. Without the ability to form concepts, we would need a different name for every new thing we encounter. We draw on concepts to anticipate what new experiences will be like. Many concepts are "fuzzy," lacking clear-cut boundaries. Therefore we often use **prototypes**, mental models of the most typical examples of a concept, to classify new objects.

LANGUAGE, THOUGHT, AND CULTURE

How do language, thought, and culture influence each other? According to Benjamin Whorf's **linguistic relativity hypothesis**, thought is greatly influenced by language. But critics contend that thought and experience can shape and change a language as much as a language can shape and change thought.

Is language male dominated? Some evidence indicates that the use of "man" and "he" to refer to all people affects the way that English speakers think. Referring to doctors, college professors, bankers, and executives by the generic "he" may contribute to the gender stereotyping of these respected occupations as appropriate for men but not for women. In contrast, referring to secretaries and housekeepers as "she" may reinforce the stereotype that those occupations are appropriate for women, not men.

NONHUMAN LANGUAGE AND THOUGHT

Can scientists learn what is on an animal's mind? Nonhuman animals communicate primarily through **signs**: general or global statements about the animal's current state. Using the distinguishing features of language, which include semantics, displacement,

ISBN 1-256-37427-X

and productivity as criteria, no other species has its own language, although chimpanzees have been taught to use American Sign Language. Research indicates that some animals have humanlike cognitive capacities, such as the ability to form concepts and to reason. Apes have demonstrated sophisticated problem-solving skills. However, only chimpanzees, bonobos, and orangutans consistently show signs of self-awareness.

PROBLEM SOLVING

What are three general aspects of the problem-solving process? Interpreting a problem, formulating a strategy, and evaluating progress toward a solution are three general aspects of the problem-solving process. Each in its own way is critical to success at the task.

Why is representing the problem so important to finding an effective solution? **Problem representation**—defining or interpreting the problem—is the first step in problem solving. We must decide whether to view the problem verbally, mathematically, or visually; and to get clues about how to solve it we must categorize it. Some problems require **convergent thinking**, or searching for a single correct solution, while others call for **divergent thinking**, or generating many possible solutions. Representing a problem in an unproductive way can block progress completely.

Why are heuristics usually better for solving problems than is trial and error? Selecting a solution strategy and evaluating progress toward the goal are also important steps in the problem-solving process. A solution strategy can range from trial and error, to information retrieval based on similar problems, to a set of step-by-step procedures guaranteed to work (an **algorithm**), to rule-of-thumb approaches known as **heuristics**. An algorithm is often preferable over trial and error because it guarantees a solution and does not waste time. But because we lack algorithms for so many things, heuristics are vital to human problem solving. Some useful heuristics are **hill climbing**, creating **subgoals**, **means-end analysis**, and **working backward**.

How can a "mental set" both help and hinder problem solving? A **mental set** is a tendency to perceive and approach a problem in a certain way. Although sets can enable us to draw on past experience to help solve problems, a strong set can also prevent us from using essential new approaches. One set that can seriously hamper problem solving is **functional fixedness**—the tendency to perceive only traditional uses for an object. One way to minimize mental sets is the technique of **brainstorming** in which an individual or group collects numerous ideas and evaluates them only after all possible ideas have been collected.

DECISION MAKING

How does decision making differ from problem solving? Decision making is a special kind of problem solving in which all possible solutions or choices are known. The task is not to come up with new solutions, but rather to identify the best one available based on whatever criteria are being used.

How would you go about making a truly logical decision? The logical way to make a decision is to rate each available choice in terms of weighted criteria and then to total the ratings for each choice. This approach is called a **compensatory model** because heavily weighted attractive features can compensate for lightly weighted unattractive ones.

How can heuristic approaches lead us to make bad decisions? Heuristics can save a great deal of time and effort, but they do not always result in the best choices. Errors in judgment may occur based on the **representativeness** heuristic, which involves making decisions based on information that matches our model of the "typical" member of a category. Other examples are overreliance on the **availability** heuristic (making choices based on whatever information we can most easily retrieve from memory, even though it may not be accurate) and the **confirmation bias** (the tendency to seek evidence in support of our existing beliefs and to ignore evidence that contradicts them).

How do we explain to ourselves the decisions we make? **Framing**, or perspective in which a problem is presented, can also affect the outcome of a decision. And regardless of whether a decision proves to be good or bad, we often use **hindsight bias**, which refers to our tendency to view outcomes as inevitable or predictable after we know the outcome to "correct" our memories so that the decision seems to be a good one. **Counterfactual thinking** involves revisiting our decisions by considering "what if" alternatives.

MULTITASKING

Contrary to what many people believe, multitasking often results in reduced speed, decreased accuracy, and increased stress. Numerous studies have shown that driving is particularly affected by multitasking. Talking on a cell phone or texting while driving may be as bad as driving legally drunk.

INTELLIGENCE AND MENTAL ABILITIES

What types of questions are used to measure intelligence? Psychologists who study **intelligence** ask what intelligence entails and how it can be measured. To accomplish this, they use a variety of questions to assess general knowledge, vocabulary, arithmetic reasoning, and spatial manipulation.

What are some of the major theories of intelligence? Intelligence theories fall into two categories: those that argue in favor of a "general intelligence" that affects all aspects of cognitive functioning, and those that say intelligence is composed of many separate abilities, in which a person will not necessarily score high in all. Spearman's theory of intelligence is an example of the first category. Thurstone's theory is an example of the second category, as are Sternberg's **triarchic theory of intelligence** and Gardner's **theory of multiple intelligences**. Goleman's theory of **emotional intelligence** emphasizes skill in social relationships and awareness of others' and one's own emotions.

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What kinds of intelligence tests are in use today? The *Binet–Simon Scale*, developed in France by Alfred Binet and Theodore Simon, was adapted by Stanford University's L. M. Terman to create a test that yields an **intelligence quotient** (**IQ**), the *Stanford–Binet Intelligence Scale*. **The Wechsler Adult Intelligence Scale** and the **Wechsler Intelligence Scale for Children** were the first intelligence tests to yield both a verbal and performance IQ score as well as an overall IQ score. In contrast to these individual intelligence tests, **group tests** of intelligence are administered by one examiner to many people at a time. Alternatives to traditional IQ tests include **performance tests** of mental abilities that exclude the use of language and **culture-fair tests** that reduce cultural bias in a variety of ways.

What are some important characteristics of a good test? **Reliability** refers to the ability of a test to produce consistent and stable scores. Psychologists express reliability in terms of **correlation coefficients**, which measure the relationship between two sets of scores. **Validity** is the ability of a test to measure what it has been designed to measure. **Content validity** exists if a test contains an adequate sample of questions relating to the skills or knowledge it is supposed to measure. **Criterion-related** validity refers to the relationship between test scores and whatever the test is designed to measure. In the case of intelligence, the most common independent measure is academic achievement. Although the reliability of IQ tests is seldom questioned, their validity is questioned. Critics charge that these tests assess a very limited set of mental skills and that some tests may be unfairly biased against minority groups. Also, poor school performance may be *the result of*, rather than caused by, low test scores. Finally, although IQ tests tend to predict occupational success and performance on the job after college, they are not ideally suited to that important task. New tests are being developed to address these concerns.

HEREDITY, ENVIRONMENT, AND INTELLIGENCE

What determines individual differences in intelligence? Why are twin studies useful in studying intelligence? Although there has been extended debate about the extent to which heredity and environment contribute to IQ, studies comparing the IQ scores of identical and fraternal twins raised in the same and different families indicate that approximately 50% of differences in intelligence are due to genetics and the other half due to differences in environment, including education.

What have we learned from early intervention programs about the influence of the environment on intellectual development? With such a sizable percentage of the differences in IQ scores being attributable to the environment and education, many psychologists are strongly in favor of compensatory education programs for young children from disadvantaged homes. Two such programs are the Milwaukee Project and Head Start. Although they may not boost IQ scores greatly in the long run, such programs do seem to have significant educational benefits.

How can the study of plants help us to understand the relationship between heredity and environment? Plants grown in rich soil under ideal environmental conditions generally do better than plants grown in poor soil under less than ideal conditions, thus showing the importance of environment. But differences between plants grown under the same environmental conditions demonstrate the importance of heredity. Similarly, individual differences in human intelligence reflect both the genetic and environmental factors. However, psychologists cannot yet account for the fact that IQ scores on the whole are increasing (the Flynn Effect).

Do culture and gender influence mental abilities? While males and females do not differ in general intelligence, females do tend to have slightly stronger verbal skills while males tend to have slightly stronger visual-spatial skills. Research indicates that these differences emerge in early infancy. As for cultural differences, research does not support the notion that people from certain cultures have a natural tendency to excel at academic skills.

What do psychologists know about the two extremes of human intelligence: very high and very low? The IQs of nearly 70% of the population fall between 85 and 115; and all but 5% have IQs between 70 and 130. **Mental retardation** and **giftedness** are the two extremes of intelligence. About 25% of cases of mental retardation can be traced to biological causes, including Down syndrome, but causes of the remaining 75% are not fully understood; nor are the causes of giftedness. Gifted people do not necessarily excel in all mental abilities.

CREATIVITY

What is creativity? **Creativity** is the ability to produce novel and socially valued ideas or objects.

How is creativity related to intelligence? The threshold theory holds that a minimum level of intelligence is needed for creativity, but above that threshold level, higher intelligence doesn't necessarily make for greater creativity. Apparently factors other than intelligence contribute to creativity.

Can creativity be measured? Creativity tests are scored on the originality of answers and, frequently, on the number of responses (demonstrating divergent thinking). Some psychologists question how valid these tests are, however.

ISBN 1-256-37427-X