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Cognition and Language
At the Braefield School for the Deaf, I met Joseph, a boy of eleven who had just entered school for the first time—an eleven-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 was bad, 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. Joseph seemed to have no sense of the past, and was unable to imagine or hypothesize. Reviewing the past, contemplating the future, and thinking about possibilities are key elements of human cognition, by which psychologists mean all the processes whereby we acquire and use information. We have already considered several cognitive processes, including perception, learning, and memory. In later chapters, we examine cognition’s crucial relation to intelligence, coping and adjustment, abnormal behavior, and interpersonal relations. In this chapter, our main focus will be on a family of cognitive processes known as “directed thinking,” or how we “use our heads”—and, to a significant degree, language—to solve problems and make decisions.

We begin this chapter by looking at the building blocks of thought—at how we use language, imagery, and concepts to give structure and meaning to our experiences. We then consider whether language and cognition are unique to human beings. Last we turn to problem solving and decision making, focusing on common strategies for dealing with life’s puzzles.
Chapter 7  •  Cognition and Language

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

Phonemes  The basic sound units of a language that indicate changes in meaning.

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  The rules for arranging words into grammatical phrases and sentences.

The Building Blocks of Thought

When we think, are we simply talking to ourselves?

The phone rings, and it’s your friend Sherryl. “I was just thinking about you!” you exclaim. What exactly do you mean when you say you were thinking about her? You may have been talking silently to yourself about her as you unpacked a bag of groceries, thoughts such as “I want to call Sherryl tonight” or “I wish I could be more like her.” An image of her might have crossed your mind—probably her face, but perhaps also the sound of her voice. You may have been comparing Sherryl to another friend, using various concepts or categories such as woman, kind, funny, strong, caring, dynamic, gentle. Language, images, and concepts are the main building blocks of thought.

Language

Human language is a flexible system of symbols that enables us to communicate our ideas, thoughts, and feelings. Unlike nonhuman communication, human language is semantic, or meaningful: We can exchange detailed information about all kinds of objects and events, feelings, and ideas. We can tell others not only, “Watch out!” but also why. Human language is also characterized by displacement: it frees us from the here-and-now so we can communicate over time and space to people who have never been to the place or had the experience we are describing. Faced with a problem, we can contemplate alternative solutions, estimate their consequences, and weigh the costs and benefits of different actions in our head before we actually do anything. In short, language allows us to conduct mental experiments: If . . . then. Finally, human language is productive: we can combine sounds to make new words, arrange words into phrases, and string phrases into sentences—the possibilities are almost infinite.

The Structure of Language

Sound and Meaning  Spoken language is based on universal sound units called phonemes that indicate changed meaning. There are about 45 phonemes in English, and as many as 85 in some languages (Bourne, Dominowski, Loftus, & Healy, 1986). In English, /z/ and /s/ are phonemes: The sounds z and s have no inherent meaning, but phonemes can be grouped together to form words, or parts of words. The word zip has a different meaning from the word sip. Morphemes, meaningful combinations of phonemes, are the smallest units of meaning in a language. This term can be applied to whole words (red, calm, or hot) or to parts of words that carry meaning. The suffix -ed signifies “in the past” (as in walked or liked or cared). The prefix pre- reflects the idea of “before” (as in preview or predetermined). We can use the same sounds (phonemes) to produce different words (morphemes): For example, the phonemes e, n, and d produce the morphemes end, den, and Ned. And we can combine morphemes to make up complex words that represent quite complex ideas, such as pre-exist-ing, un-excell-ed, and psycho-logy.

Grammar  In turn, words can be joined into even more complex thoughts. Just as there are rules for combining phonemes and morphemes, there are also rules for structuring sentences and their meaning. These rules are what linguists call 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. The linguist Noam Chomsky (1957) greatly influenced psychologists’ understanding of syntax and semantics (Chomsky, Place, & Schoneberger, 2000). When we are thinking about something—say, the ocean—our ideas usually 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 various different surface structures:

The ocean is unusually calm tonight.

Tonight the ocean is particularly calm.

Compared to most nights, tonight the ocean is calm.

Syntax and semantics enable speakers and listeners to perform what Chomsky calls transformations between the surface and the deep structure. According to Chomsky, 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. Speaking requires top-down processing, and you can see from the left arrow in Figure 7–1 that the movement is indeed from top to bottom. 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. This is called bottom-up processing, as shown by the right arrow in Figure 7–1.

Words, phrases, and sentences are among the building blocks of thought. Images are another, as we will see in the next portion of the chapter.

Images

Think for a moment about Abraham Lincoln. Your thoughts of Lincoln may include such phrases as “wrote the Gettysburg Address,” “president during the Civil War,” and “assassinated by John Wilkes Booth.” But you probably also have mental

**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.
We can use visual and auditory images to think about things, such as this famous “I Have A Dream” speech by Martin Luther King, Jr. delivered at the Lincoln Memorial in Washington DC on August 28, 1963.

Images, or nonverbal (visual, auditory, olfactory) mental representations, can be exceptionally powerful. We can visualize the Statue of Liberty or people we know; we can smell Thanksgiving dinner; we can hear Martin Luther King, Jr., saying “I have a dream!” In short, we can think about things using images. Albert Einstein relied heavily on his powers of visualization to understand phenomena that he later described in complex mathematical formulas. Einstein believed that his skill in visualizing abstract concepts led to his extraordinary insights (Miller, 1992; Shepard, 1978). Although few can match Einstein’s brilliance, we all use imagery to think about and solve problems.

Not only do we visualize things in order to think about them, but we can also manipulate these mental images (Stylianou, 2002). Shepard and Metzler (1971) presented people with pairs of geometrical patterns (see Figure 7–2). In some cases, the two pictures were of the same pattern rotated to provide different views (see Figures 7–2A and 7–2B). In other cases, the two pictures were of different patterns (see Figure 7–2C). People were asked to determine whether each pair of patterns was the same or different. The researchers discovered that people invariably rotated the image of one pattern in their minds until they could see both patterns from the same perspective. Then they tried to see whether the mental image of one pattern matched the other pattern. Subsequent studies have supported these findings (e.g., Kosslyn & Sussman, 1995).

Concepts

Concepts are mental categories for classifying specific people, things, or events (Komatsu, 1992). Dogs, books, and cars are all concepts that let us categorize objects in the world around us. Fast, strong, and interesting are also concepts that can classify things, events, or people. Concepts provide a way of grouping or categorizing experiences so that encounters with something new need not be a surprise. We know, to some extent, what to think, and do not have to create a new word for every new experience. Instead, we draw on concepts that we have already formed, and we place the new object or event into the appropriate categories. In the process, we may modify some of our concepts to better match our experience. Consider, for example, the concept of professor. No doubt you had some concept of professor before you attended any college classes. After you took your first college courses and actually met some
professors, your concept probably changed. Your concept will become fuller as you add new information about professors based on your experiences at college. In the future, because you have formed a concept of professor, you will not have to respond to each new professor as a totally new experience.

Equally important, concepts can be organized in hierarchies, with the narrowest, most specific category at the bottom and the most general at the top (Reed, 1996). For example, collie is a subset of the category dog, and dog is a subset of the category

When you think about the concept bird, you don’t think about every different kind of bird you know, nor do you imagine a list of features that all birds share (wings, feathers, beak, two feet, egg-laying). Instead you think of a prototype of a “typical” bird, which probably looks like this bluebird. A penguin doesn’t match this prototype very well, but you can still tell it is a bird by its degree of category membership.

Figure 7–2
Examples of the pairs of geometrical patterns used in Shepard and Metzler’s (1971) experiment.
The researchers found that participants first rotated an image of one pattern in their minds until they could see both patterns from the same perspective. They then matched the mental images of the pairs of patterns to decide whether they were the same (A and B) or different (C).
animal. Likewise, maple is a subset of the category tree, and tree is a subset of the category plant. The hierarchical nature of concepts helps us to think about things efficiently and how they relate to one another.

Prototypes  We may be tempted to think of concepts as simple and clear-cut. But many concepts are neither simple nor unambiguous, they are “fuzzy.” They overlap one another and are often poorly defined. For example, most people can tell a mouse from a rat, but few can produce an accurate list of the critical differences between mice and rats (Rosch, 1973, 1978, 1998, 2002). If we cannot explain the difference between mouse and rat, how can we use these fuzzy concepts in our thinking? One possibility is that we construct a model, or prototype, of a representative mouse and one of a representative rat; we then use those prototypes in our thinking. Rosch argued that our concept of bird, for example, does not consist only of a list of key attributes such as “feathers,” “wings,” “two feet,” and “lives in trees.” Instead, most of us also have a model bird, or prototype, in mind—such as a bluebird or a sparrow—that captures for us the essence of bird. When we encounter new animals or drawings of animals, we compare them to these prototypes using what Rosch called degree of category membership to determine whether they are, in fact, mice or rats. That is, we decide what is most probable or most sensible given the facts at hand. For example, a sparrow and a mouse both have two eyes. But unlike a mouse the sparrow has wings and feathers, only two legs, and no whiskers, all of which indicate that it is quite unlike our prototype for a mouse and much more like our prototype for a bird. Similarly, if we were to encounter a three-legged mouse with no whiskers, we would in all likelihood still recognize it as a mouse.

We have seen that language, images, and concepts form important building blocks for thought. To what extent do they shape the kinds of things people can think about and the ways they think about them? And to what extent do people who speak different languages and come from different cultures think differently? In the next section of the chapter we will explore those issues.

CHECK YOUR UNDERSTANDING

1. Language and concepts are two of the three most important building blocks of thought. What is the third?
   ___a. prototypes
   ___b. displacement
   ___c. images

2. Meaningful sentences are constructed according to the rules of _____?
   ___a. grammar
   ___b. semantics
   ___c. category membership

3. Universal sound units found in every language are called
   ___a. morphemes
   ___b. phonemes
   ___c. transformations

Prototype According to Rosch, a mental model containing the most typical features of a concept.
Language, Thought, and Culture

Does the language you speak affect what you can think about?

ENDURING ISSUES diversity universality

Do We All Think Alike?

For at least 100 years, a fundamental assumption in psychology as well as philosophy was that the basic processes of human cognition are universal. It was accepted that cultural differences affect what people think about—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, whatever the cultural setting (Goode, 2000a). In this section, we will examine the validity of these viewpoints.

Language and Cognition

We have seen that language is closely tied to the expression and understanding of thoughts. Because our language determines not only the words we use but also the way in which we combine those words into sentences, can language also determine what we can think about? Some theorists believe that it does indeed. Recall that in Chapter 6, Memory, we noted that language affects long-term memory. As Lindsay and Norman (1977) point out, “memory for single perceptual experiences is directly related to the ease with which language can communicate that experience” (p. 483). In a study of this effect, participants looked at color patches and assigned each one a name (Brown & Lenneberg, 1954). Colors that were quickly and easily named (such as blue) were remembered more easily than were those that took longer to name and were given less common labels (such as sky blue or pale blue).

If language affects our ability to store and retrieve information, it should also affect our ability to think about things. Benjamin Whorf (1956) was an early spokesperson for this position which is called linguistic determinism. Whorf noted, for example, that the Hopi, a Native American people of the southwestern United States, have only two nouns for everything that flies. One noun refers to birds; the other is used for everything else, whether airplanes, kites, or dragonflies. Thus, according to linguistic determinism, the Hopi would interpret all flying things in terms of either of these two nouns—something in the air would be either a bird or a nonbird.

Linguistic determinism has intuitive appeal, but when it is tested in the field a rather different picture emerges. For example, cultures vary in the number of colors their language identifies. Nonetheless, people can perceive color distinctions for which their language has no words. The Dani, a people who live in the highlands of New Guinea, use only two color terms, which correspond roughly to “light” and “dark,” and have no words for geometric shapes. Nonetheless, they remember basic colors such as red, green, and yellow. In addition, the Dani, and people from other cultures with limited color naming terminology, judge the similarity of colors much as English-speaking people do (Heider & Oliver, 1972; Roberson, Davies, & Jules, 2000; Rosch, 1973). Thus, people from different cultures with very different patterns of thinking are determined by the specific language one speaks.
languages think about some things, such as color, in very similar ways, even if their language contains no words for those things. Language may indeed influence thought, but it doesn’t seem to restrict thought to the extent that some linguistic determinists believed.

Moreover, experience and thought actually influence language. For example, English-speaking skiers, realizing that different textures of snow can affect their downhill run, have coined such differentiated words for snow as powder, corn, and ice. The growth of personal computers and the Internet has inspired a vocabulary of its own, such as hard drive, RAM, gigabytes, software, online, and CD-ROM. In short, people create new words when they need them—experience shapes language. If the Hopi had been subjected to air raids, they would probably have created words to distinguish a butterfly from a bomber!

Psychologists and linguists have not dismissed linguistic determinism altogether, but rather have softened it. Clearly, language, thought, and culture are intertwined (Matsumoto, 1996). People create words to capture important aspects of their experiences, and to some extent words shape how people think and what they think about. But people also can think about things for which they have no words. Experience shapes language, and language, in turn, affects subsequent experience.

Is Our Language Male-Dominated?

The English language has traditionally used masculine terms such as “man” and “he” to refer to all people, female as well as male. Does this affect the way that English speakers think? Several studies suggest that it does indeed. Hyde (1984a) asked children to complete stories after she gave them a first line such as, “When a kid goes to school, _____ often feels excited on the first day.” When Hyde filled in the blank with “he,” the children nearly always composed stories about boys. When she used “he or she” in the blank, a third of the children made up stories about girls.

In another study, Hyde (1984b) discovered that the use of “he” or “she” to describe a factory worker who made “wudges” (imaginary plastic parts for video games) affected how children thought male and female wudgemakers would perform their jobs. Those children who heard wudgemakers described by the masculine pronoun “he” rated women wudgemakers poorly; children who heard wudgemakers identified by the pronoun “she” judged female wudgemakers most positively; and the ratings of children who heard gender-neutral descriptions of wudgemakers fell in between those of the two other groups. All the groups of children, however, viewed male wudgemakers equally positively.

More recent research has focused on the unconscious, automatic nature of gender stereotyping and language (Greenwald & Banaji, 1995). In an experiment that required men and women to respond rapidly to gender-neutral and gender-specific pronouns, both sexes responded more quickly to stimuli that contained traditional gender stereotypes (e.g., nurse/she) than to stimuli that contained nontraditional gender stereotypes (e.g., nurse/he). This occurred even among participants who were explicitly opposed to gender stereotyping (Banaji & Hardin, 1996).

From research such as this, it appears that 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 occupations for women, not men (Christie, 2003).
Culture and Cognition

All known cultures use categories to help form concepts, but what information gets included in a given category, and how the categories are shaped by experience, can differ substantially from one culture to another (Rogoff & Chavajay, 1995). Cross-cultural psychologist David Matsumoto provides an amusing example of how cultural differences can affect perception, cognition, and behavior:

We have probably all seen imported, handmade, brass pitchers of various designs and sizes. Once, after dinner with a Persian friend at an American’s home, we all gathered in the living room. After a moment, our Persian friend turned red, giggled, and looked embarrassed, but didn’t say anything. When the host left the room a few minutes later, the Persian pointed out a large ornate brass pitcher with a long spout that was sitting on a coffee table as a decoration. It had been made in the Middle East where toilet paper is scarce and people clean themselves after going to the bathroom by using such pitchers to pour water on themselves. So what was a prized decoration to our host was an embarrassment to my friend. (Matsumoto, 1995, p. 52)

As this example illustrates, two people perceiving the same object may assign it to very different categories!

Anthropologists and other Westerners who have spent time in Asia often say that Eastern and Western cultures are worlds apart—that people in these cultures not

ON THE CUTTING EDGE

CULTURE AND COGNITION

Richard Nisbett and his colleagues conducted a series of rigorous, controlled experiments to determine whether subjective impressions about the ways Easterners and Westerners think are valid. Their comparisons of American to Japanese, Chinese, and Korean cognitive styles indicate that this is a case in which stereotypes are largely accurate. 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; most American participants described the biggest, brightest, fastest fish. (In psychological terms, the Japanese were “field dependent” and the Americans, “field independent”; see Chapter 3, Sensation and Perception).

This different attitude toward contexts carried over into social perceptions. In group decision-making situations, Chinese students generally preferred compromise to conflict; their American counterparts were more likely to focus on differences of opinion and to hold out until one side won or the other lost. Similarly, when presented with examples of interpersonal conflict—for example, between a mother and daughter—American students typically sided with one or the other and made comments such as “The mother is too controlling” or “The daughter is out of control.” Chinese students often saw merits on both sides and came to such conclusions as, “Both the mother and daughter have failed to understand each other.” Many Americans were bothered by this tendency to see both sides of a story and irritated by such Chinese proverbs as “Too modest is half boastful.”

The researchers also found evidence of different styles of reasoning. Participants were presented with logical sequences such as this syllogism: “All animals with fur hibernate. Rabbits have fur. Therefore rabbits hibernate.” Americans were more likely to accept an argument on logical grounds (if the first two premises are correct, the conclusion must be true); Asians more often rejected abstract, logical reasoning in favor of concrete or empirical knowledge (in this case, the fact that all animals with fur do not hibernate).

Nisbett and his colleagues conclude that these studies reflect fundamental, qualitative differences in how Easterners and Westerners, Orientals and Occidentals, perceive and think about the world. They also emphasize that these differences are cultural, not genetic, in origin because the cognitive approach of Asian Americans born in the United States is indistinguishable from that of European Americans (Peng & Nisbett, 1999; Nisbett et al., 2001; Nisbett & Norenzayan, 2002).
only think about different things but also differ in how they think. The impression is that Easterners think “holistically”: They pay more attention to contexts and relationships than to individuals, put more faith in knowledge acquired through experience than in abstract reasoning, and are more comfortable with contradictions. In contrast, Westerners are seen as more “analytical”: They view actors and objects as independent of context, rely more on formal logic, and are uncomfortable with inconsistencies. Some recent research has confirmed these and other cultural differences in ways of thinking (see On the Cutting Edge: Culture and Cognition).

**CHECK YOUR UNDERSTANDING**

1. Benjamin Whorf championed the idea that patterns of thinking are determined by
   ___a. a person’s grasp of correct grammar
   ___b. the language a person speaks
   ___c. a person’s grasp of semantics

2. Psychologists and linguists have softened the theory of linguistic determinism by suggesting that ____ also has an effect on language.
   ___a. culture
   ___b. experience
   ___c. a and b
   ___d. none of the above

**Nonhuman Thought and Language**

*Can scientists learn what is on an animal’s mind?*

Can animals think? Ask people who live with pets, and they almost certainly will answer yes—and follow with stories about a cat who jumped out of a car miles from home yet found the way back, a dog that saved its owner’s life, and other amazing feats. Ask someone who does not live with, or particularly like, pets and you may well get a sarcastic reply: “Does a bullfrog have wings?” Ask psychologists, and their most likely response will be a thoughtful pause, and then, “That’s a difficult question.”

In evaluating research on nonhuman animals, scientists seek to avoid anthropomorphism—the all-too-human tendency to attribute human characteristics to other animals (Mitchell, Thompson, & Miles, 1997). Yet they are also conscious of the opposite tendency, anthropocentrism—the equally human tendency to view our own species as unique, overlooking our own evolutionary heritage as well as abilities in other species (Fouts, 1997). Questions about animal intelligence are probably as old as human intelligence, but only recently have psychologists developed scientific techniques for learning how other animals use their brains and identifying the similarities and differences between human and nonhuman thought (Boysen & Himes, 1999).

**Animal Cognition**

Numerous studies indicate that other animals have some humanlike cognitive capacities. Parrots, for example, are known to be exceptionally good vocal mimics. Every schoolchild knows the expression “Polly wanna cracker?” But do parrots...
know what they are saying? According to Irene Pepperberg (2000, 2002) Alex, an African gray parrot, does. Pepperberg, who has worked with Alex for more than two decades, reports that he can count to six; identify more than 50 different objects; and classify objects according to color, shape, material, and relative size. For example, if given a tray full of different colored objects, Alex can accurately count the number of blue blocks or green wool balls without being distracted by the other objects on the tray. He recognizes that the same object (a green triangle) can have several different attributes (a rudimentary form of abstract thought), correctly answering the questions “What shape?” and “What color?” When asked “What color is corn?” Alex answers, “Yellow” even when no corn is present. Based on her studies, Professor Pepperberg believes that Alex is demonstrating more than simple mimicry in these behaviors. Indeed she argues that his actions reflect reasoning, choice, and to some extent thinking.

Researchers have also taught dolphins to respond to requests—in the form of human hand and arm gestures or computer-generated whistles—to bring a Frisbee to a surfboard on the right or the left (Herman, Richards, & Wolz, 1984; Rumbaugh, 1990) and to select which of two objects is identical to a sample object—the basis of the concepts same and different (Harley, Roitblat, & Nachtigall, 1996; Roitblat, Penner, & Nachtigall, 1990). Recent studies have shown that rhesus monkeys can learn the concept of numeration (the capacity to use numbers) and serialization (the ability to place objects in a specific order based on a concept) (Brannon & Terrace, 1998; Terrace, Son, & Brannon, 2003). In short, it appears that humans are not totally unique in their ability to form concepts.

The great apes—chimpanzees, gorillas, and orangutans—are of special interest in studies of nonhuman cognition (and language). Apes are our closest kin: We share 97 to 99 percent of our genes with them (which means we are more closely related to them than a lion is to a tiger, or a zebra is to a horse). We also have many characteristics in common. If any other animal thinks like we do, great apes are the most likely candidates. In fact, apes have demonstrated sophisticated problem-solving skills. For example, in Chapter 5 (Learning) we saw that chimpanzees figured out various ways to retrieve a bunch of bananas out of their reach. In more recent studies, chimpanzees provided with computer keyboards have learned to use symbols to make and respond to complex requests (Premack, 1971, 1976), to identify and categorize objects (especially food), to place objects in order (Kawai & Matsuzawa, 2000), and even to solve analogies similar to those found on college entrance tests, such as “Symbol A is to symbol B as symbol C is to what symbol?” (Cook, 1993).

But do the chimps and dolphins and parrots know what they know? In other words, do nonhuman animals have a sense of self (Blumberg & Wasserman, 1995)? George Gallup (1985, 1998) at the Tulane University primate research center noticed that after a few days’ exposure, chimpanzees began using a mirror to make faces and to examine and groom parts of their body that they had never seen before. To test whether the animals actually understood that they were looking at themselves, he anesthetized the chimpanzees and painted a bright red mark above their eyebrow ridge and on the top of one ear. If, the first time they looked at the mirror after awakening, they reached up and touched the red marks, presumably they recognized themselves.

The mirror test has been used by hundreds of researchers, with many other animals, for three decades. Only two nonhuman species consistently show signs of self-awareness, even after extended exposure to mirrors—chimpanzees and orangutans (Boysen & Himes, 1999; Gallup, 1985; Vauclair, 1996). For that matter, even human infants do not demonstrate mirror-recognition until they reach 18 to 24 months of age.

If chimpanzees possess self-awareness, do they understand that others have information, thoughts, and emotions that may be different from their own?
Observational studies suggest they do have at least a limited sense of other-awareness (de Waal, 1989; Goodall, 1971; Menzel, 1974; 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 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.

The Question of Language

In one way or another, all animals communicate. Birds do it, bees do it, whales and chimpanzees do it (to paraphrase Cole Porter's song). The forms of animal communications vary widely. Honeybees enact an intricate waggle dance that tells their hive mates exactly where to find pollen (von Frisch, 1974), and the quality of the pollen at that location (Waddington, Nelson, & Page, 1998). Humpback whales perform haunting solos, ranging from deep basso rumblings to high soprano squeaks and continuing for as long as a half hour. In the wild, chimpanzees communicate by means of some three dozen vocalizations plus an array of gestures, postures, and facial expressions. The technical term for such messages is **signs**, general or global statements about the animal’s *current* state.

To be sure, human beings also use signs. We utter exclamations—such as “Help!” or “Yippee”—that are not much different from a chimpanzee’s *waaaa* (for danger) or *hoot* (for excitement) and use body language to supplement or substitute for words. But fixed, stereotyped signals are a far cry from language. The distinguishing features of language, as described earlier, are *meaningfulness* (or semantics), *displacement* (communication about objects and events not present in the here and now), and *productivity* (the ability to produce and understand new and unique expressions). Using these criteria, as far as we know, no other species has its own language.

Early attempts to teach chimpanzees to speak (Hayes & Hayes, 1951; Kellogg, 1968) met with little success, for the (now) obvious reason that chimpanzees do not have the vocal equipment to produce speechlike sounds. Then R. A. Gardner and B. Gardner attempted to teach American Sign Language (ASL) to a chimpanzee named Washoe whom they acquired as an infant (1969, 1975, 1977). The Gardners raised Washoe as if she were a deaf child, communicating with her (and other humans in her presence) only by signing. They used modeling and shaping to teach her gestures, rewarding her for correct responses. Washoe learned 38 signs by age 2, 85 by age 4, and 160 by age 5. She combined one-word signs into simple two-word sentences (such as “more milk”) similar to the *telegraphic speech* of 1- and 2-year-old human toddlers. Also like small children, Washoe generalized signs (such as “open”) to a variety of objects and situations (containers, bottles, and even the door to outside). Moreover, she invented sign combinations for new situations (simple productivity), such as “water bird” the first time she saw a swan and “black bug” the first time she encountered another chimpanzee (Fouts, 1973)!

Research with the other great apes has found similar capabilities. Francine Patterson (Bonvillian & Patterson, 1997; Patterson, 1978, 1980, 1981) reared Koko, a lowland gorilla much like Washoe, and has worked with her for two decades. By age 5, Koko had a working vocabulary of 500 signs—about the same level as a 5-year-old deaf child who uses sign language, though...
far lower than a hearing, speaking child’s vocabulary of 1,000 to 5,000 words (Patterson & Cohn, 1990). Now in her mid-20s, Koko reportedly signs about her own and her companions’ emotions, such as happy, sad, or angry. Most interesting, Koko refers 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 have been quick to point out potential flaws in these sign language studies. Gestures are subject to varied interpretations: Skeptics argue that these researchers were reading meaning and intentions into simple gestures. Moreover, as we will see in Chapter 10 (Life Span Development), human children learn language effortlessly and swiftly without deliberate, explicit adult instruction. In contrast, these apes required intensive training and constant reinforcement to develop very limited language skills (Limber, 1977). One of the most outspoken critics, Herbert Terrace (1979, 1985), attempted to teach sign language to “Nim Chimpsky” (respectfully named for the cognitive linguist Noam Chomsky, who proposed a specifically human language acquisition device), and concluded that the apes’ accomplishments reflected simple operant conditioning, not linguistic aptitude. Terrace argued that apes do not understand syntax—the rules for combining words in meaningful orders, so that “Nim eat banana” means something quite different from “Banana eat Nim.” The result, as Terrace put it, was “word salad” (Savage-Rumbaugh & Lewin, 1994, p. 131). Noam Chomsky emphatically agrees (Johnson, 1995).

To reduce the ambiguity of hand signs, other researchers began using computer keyboards to teach and record communications with apes (Rumbaugh, 1977; Rumbaugh & Savage-Rumbaugh, 1978; Rumbaugh, von Glaserfeld, Warner, Pisani, & Gill, 1974); to document behavior with and without humans on camera; to use double-blind procedures; and also to study another ape species, bonobos (formerly called “pygmy chimpanzees”). Most impressive—and surprising—was a bonobo named Kanzi (Savage-Rumbaugh & Lewin, 1994). When brought to the Language Research Center near Atlanta, Kanzi was adopted by an older female who was unable (or unwilling) to use a keyboard. Some months later, the researchers discovered that Kanzi, who accompanied his mother to lessons, was learning keyboard

Chimpanzees, our closest living relative, use a wide repertoire of gestures, facial expressions, and vocalizations to communicate.
symbols and spoken English on his own, *without formal training*, much as children do. Sue Savage-Rumbaugh decided to continue this naturalistic education through social interaction, expanding his horizons with walks around the Center’s grounds. Kanzi understands spoken English and more than 200 keyboard symbols. He responds to vocal and keyboard requests that he has not heard before (such as, “Put the key in the refrigerator”), and uses the keyboard to make requests, comment on his surroundings, state his intentions, and—sometimes—to indicate what he is thinking about.

Washoe, now in her thirties, lives with four other chimpanzees at the Chimpanzee and Human Communications Institute in Washington state. Her caretakers, Roger and Deborah Fouts, who communicate only in sign language in the compound, report that the chimpanzees use signs to communicate with each other (even when they are alone, as recorded by hidden cameras) as well as with humans. Washoe’s adopted son, Loulis, learned signs not from human trainers (who did not sign in his presence) but from the other chimpanzees. What do they sign about? The usual stuff: “Wanna play?” is most common among young males. With Loulis, Washoe has more motherly concerns, especially discipline and comfort. This possible anthropomorphism aside, Loulis is the only ape to learn signs exclusively from other apes.

The studies of Kanzi and Loulis answer one criticism—that apes learn signs only through intensive training and to win favor and obtain rewards from human trainers. But the second criticism—that even if apes can learn to use signs and symbols, they do not grasp the deep structure (or underlying rules) of language—is far from resolved (Blumberg & Wasserman, 1995). At most, apes have reached the linguistic level of a 2- to 2-1/2-year-old child. Not surprisingly, critics see this as evidence of severe limitations, whereas their trainers (and others) see this as an extraordinary accomplishment.

Ultimately, research on nonhuman language raises as many questions as it answers. Are humans and great apes separated by an unbridgeable divide, or are the differences between us a matter of degree? If, as many scientists believe, humans and great apes are descended from a common ancestor—and if, as some scientists...
conclude, great apes have at least a rudimentary capacity for symbolic communication—why didn’t they develop a language of their own? Equally significant, why did we?

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.

CHECK YOUR UNDERSTANDING

1. Chimpanzees and orangutans 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

Problem Solving

Sometimes we are totally stumped by a problem or puzzle. When we learn the answer, it seems so obvious we can’t believe we didn’t see it right away. Why?

Our minds do not passively record information from the environment just as it is presented to the senses; rather, they actively select and interpret sensory data. Typically, we transform and reorganize external data so that they fit our existing mental framework (including our concepts, images, and language); sometimes, however, we need to modify our mental structures to accommodate new data and new ways of thinking. Nowhere is the transformational nature of cognition more apparent than in problem solving.

Let’s begin with some problems.

1. **Problem 1.** You have three measuring spoons (Figure 7–3). 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.

2. **Problem 2.** You have a 5-minute hourglass and a 9-minute hourglass (Figure 7–4), How can you use them to time a 14-minute barbecue? (Adapted from Sternberg, 1986)

Most people find these easy to solve. But now consider more elaborate versions of the same three problems:
1. **Problem 3.** You have three measuring spoons (Figure 7–5). 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.

2. **Problem 4.** You have a 5-minute hourglass and a 9-minute hourglass (Figure 7–4). How can you use them to time a 13-minute barbecue? (Adapted from Sternberg, 1986)

Most people find the last two problems much more difficult than the first two. (The answers to these and other numbered problems appear at the end of the chapter.) Why? The answer lies in interpretation, strategy, and evaluation. Problems 1 and 2 are considered trivial because it’s so easy to interpret what is called for, the strategies for solving them are simple, and you can effortlessly verify that each step you take moves you closer to a solution. Problems 3 and 4, in contrast, require some thought to interpret what is called for, the strategies for solving them are not immediately apparent, and it is harder to evaluate whether any given step has actually made progress toward your goal. These three aspects of problem solving—interpretation, strategy, and evaluation—provide a useful framework for investigating this topic.

## The Interpretation of Problems

The first step in solving a problem is called **problem representation:** interpreting or defining the problem. 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 the problem would be to figure out ways to boost profits—by cutting costs, by increasing income, or both. To see the importance of problem representation, consider these two problems.

1. **Problem 5.** You have four pieces of chain, each of which is made up of three links (Figure 7–6). All links are closed at the beginning of the problem. It costs two cents to open a link and three cents to close a link. How can you join all 12 links together into a single, continuous circle without paying more than 15 cents?

2. **Problem 6.** Arrange six kitchen matches into four equilateral triangles (Figure 7–7). Each side of every triangle must be only one match in length.
These two problems are difficult because people tend to represent them in ways that impede solutions. For example, in Problem 5, most 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 almost immediately obvious. Similarly, for the kitchen match problem, most people assume that they can work only in two dimensions—that is, that the triangles must lie flat on a surface—or that one match cannot serve as the side of two triangles. When the problem is represented differently, the solution becomes much easier. (The solutions to both of these problems appear at the end of this chapter.)

If you have successfully interpreted Problems 5 and 6, give number 7 a try:

1. **Problem 7.** 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 his ascent, he travels at various speeds and stops often to rest. He spends the night engaged in meditation and 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.

Another aspect of successfully representing a problem is deciding which category the problem belongs to. Properly categorizing a problem can provide clues about how to solve it. In fact, once a problem has been properly categorized, its solution may be very easy. Quite often, people who seem to have a knack for solving problems are actually just very skilled at categorizing them in effective ways. Star chess players, for example, can readily categorize a game situation by comparing it with various standard situations stored in their long-term memories. This strategy helps them interpret the current pattern of chess pieces with greater speed and precision than the novice chess player can. Similarly, a seasoned football coach may quickly call for a particular play because the coach has interpreted a situation on the field in terms of familiar categories. Gaining expertise in any field, from football to physics, consists primarily of increasing your ability to represent and categorize problems so that they can be solved quickly and effectively (Haberlandt, 1997).

**Producing Strategies and Evaluating Progress**

Once you have properly interpreted a problem, the next steps needed are selecting a solution strategy and evaluating 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 there are only limited choices. 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 garage door. In most cases, however, trial and error wastes time because there are so many different options to test. It is better to eliminate unproductive approaches and to zero in on an approach that will work. Let’s consider some alternative strategies.

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.

Information Retrieval  One approach is to retrieve from long-term memory information 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  More complex problems require more 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 numbers according to the rules of multiplication (the algorithm). If we do it accurately, we are guaranteed to get the right answer. Similarly, to convert temperatures from Fahrenheit to Celsius, we use the algorithm \( C = \frac{5}{9} (F - 32) \).

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. Part of problem solving is to decide which heuristic is most appropriate for a given problem (Bourne et al., 1986).

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. In trying to balance a budget, each reduction in expenses brings you closer to the goal and leaves you with a smaller deficit.

Another problem-solving heuristic is to create subgoals. By setting subgoals, we break a problem into smaller, more manageable pieces, each of which is easier to solve than the problem as a whole (Reed, 1996). Consider the problem of the Hobbits and the Orcs:

1. **Problem 8.** 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?

   The solution to this problem may be found 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 8, you might want to try Problem 9, which is considerably more difficult (the answers to both problems are at the end of the chapter):

   1. **Problem 9.** This problem is identical to Problem 8, 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 and taking notes, preparing an outline, writing the first draft, editing, rewriting, and so on. Even the subgoals can sometimes be broken down into separate tasks: Writing the first draft of the paper 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. Although the overall purpose of setting subgoals is still to reach the ultimate goal, this tactic allows us to set our sights on closer, more manageable objectives.

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.

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 (Bourne et al., 1986). 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

In everyday life, 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 9, 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. Set determines which information we tend to retrieve from memory to help us find a solution. Set can be helpful if we have learned operations that we can apply to the present situation. Much of our formal education involves learning sets and ways to solve problems (that is, learning heuristics and algorithms). But sets can also create obstacles, especially when a novel approach is needed. The most successful problem solvers have many different sets to choose from and can judge when to change sets or when to abandon them entirely. Great ideas and inventions come out of such flexibility.

One type of set that can seriously hinder problem solving is called functional fixedness. Consider Figure 7–8. Do you see a way to mount the candle on the wall? If not, you are probably stymied by functional fixedness. The more you use an object in only one way, the harder it is to see new uses for it, because you have “assigned” the object to a fixed function. To some extent, part of the learning process is to assign correct functions to objects—this is how we form concepts. But we need to be open to seeing that an object can be used for an entirely different function. (The solution to this problem appears at the end of the chapter.) (See Applying Psychology: Becoming a More Skillful Problem Solver for techniques that will improve your problem-solving skills.)
Because creative problem solving requires thinking up original ideas, deliberate strategies don’t always help. Solutions to many problems rely on insight (Novick & Sherman, 2003), often a seemingly arbitrary flash “out of the blue.” (See Chapter 5, Learning.) But you can’t always sit back and wait for a flash of insight to solve a problem. When you need a quick solution, you can do some things that encourage creative answers. Sometimes we get so enmeshed in the details of a problem that we lose sight of the obvious. If we stop thinking about the problem for a while, we may return to it from a new angle (H. G. Murray & Denny, 1969). Then we may be able to redefine the problem, circumventing an unproductive mind-set.

The value of looking for new ways to represent a difficult problem cannot be overstressed. Ask yourself, “What is the real problem here? Can the problem be interpreted in other ways?” Also 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: generating a lot of ideas before you review and evaluate them.

Finally, people often become more creative when exposed to creative peers and teachers (Amabile, 1983). Although some creative people work well alone, many others are stimulated by working in teams with other creative people.

**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.

**Where Does Creativity Come From?**

It is tempting to think that creativity arises from within the individual—that some people are simply more creative than others. And some evidence suggests that this
**APPLYING PSYCHOLOGY**

**BECOMING A MORE SKILLFUL PROBLEM SOLVER**

Even the best problem solvers occasionally get stumped, but by applying the principles described in this chapter, 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. First, list all the possible solutions you can think of, and then discard all the solutions that seem to lead in the wrong direction. Now examine the list more closely. Some solutions seem to be ineffective but on closer examination may turn out to be good.

2. **Visualize a solution.** Sometimes people who are stumped by a problem can find a solution by using a basic building block of thought: visual images. Visualizing often involves diagramming courses of action. For example, in the Hobbit and Orc problem, 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 can help you grasp what a problem calls for. You also can visualize mentally.

3. **Develop expertise.** People get stumped on problems because they 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. Many problems require some original thinking. For example, how many unusual uses can you think of for a brick? 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. You should not be surprised to learn that many business and engineering schools stress divergent thinking skills to encourage more creative problem solving.

Even the best problem solvers occasionally get stumped, but by applying the principles described in this chapter, 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.

view is correct, as we will see in the next chapter. But there is also some intriguing evidence that creative solutions come from posing creative problems—in other words, that creative problems “draw out” creative responses from people who otherwise would not be particularly creative. Hackman and Morris (1975) gave small groups a variety of tasks. Some groups were asked to discuss issues, come to a consensus, and write down their position. For example:

Come to an agreement as to what your group feels is the best meaning of the word *intellectual*, and write a paragraph or two summing up your ideas.

Other groups were asked to solve problems, such as:

In recent years the increasing population of the United States has resulted in overcrowded classrooms. Write a proposal, about a paragraph long, outlining a program to resolve this problem. Be specific.

Still others were asked to be creative. This last group were posed such tasks as:

METHALAGALOGIMUS. The task for your group is to write a story involving in some way the word above. This story should be as original and creative as possible. It must contain a title, a beginning, a middle, and an end.

Independent judges rated the creativity of each group’s work on a seven-point scale. The groups that received problems to solve averaged 2.49; the groups that discussed issues averaged 2.72; the group that received the creative tasks averaged 4.76. In other words, the task itself had a profound effect on creativity: Groups that received creative tasks were far more likely than other groups to come up with a
creative result, even though the members of those groups were no more or less creative than the members of the other groups.

**Experience and Expertise**

Numerous studies have found qualitative differences in the way experts and beginners approach and solve problems. We have already seen that experts, when presented with a problem in their field, are likely to recognize it as belonging to a familiar set of problems they have solved before and thus solve it much more quickly than beginners. Research also shows that experts think in larger units, or “chunks,” that include many pieces of information, algorithms, and heuristics and that are so welded together that they require no further thought (see discussion of chunking in Chapter 6, Memory.) These chunks are extensively interconnected, much like a cross-referencing system in a library (Bédard & Chi, 1992). Beginners work through a problem one step at a time. Chunking enables experts to approach a problem with many more potentially relevant ideas than a novice would. It also reduces the mental time and energy required to process basic data, allowing an expert to devote more attention to selecting problem-solving strategies, monitoring their effectiveness, and carrying out other higher-level activities. Given the same problem, experts take fewer but much larger steps than novices.

Chess masters are the classic example of chunking (Huffman, Mathews, & Gagne, 2001). When shown a board for five seconds and asked to recreate the positions a few minutes later, grand masters and masters rarely make a mistake; other players (including experts) get more positions wrong than right. The reason is not that chess masters have “better visual memory”; when shown a board with positions that would never occur in an actual game, they perform as poorly as novices. Their expertise is based on their conceptual grasp of chess, not memory of visual patterns (Waters, Gobet, & Leyden, 2002). The most important difference between chess masters and novices is not that the masters can conceive a greater number of moves; rather, the chess masters recognize the significance of various board positions that have little or no meaning to novices (Bédard & Chi, 1992). Recognizing a situation as familiar, in turn, enables them to generate a good next move more quickly (Klein, Wolf, Militello, & Zsambok, 1995).

Chunking plays a role in the development of any skill. The novice typist pecks slowly and laboriously, one letter at a time; skilled typists know the entire keyboard, common groups of letters, words, and even phrases so well that they don’t even look at the keyboard. Making a turn, a beginning driver struggles to coordinate slowing down, clicking the turn signal, turning the wheel, and stepping on the gas: Each step requires conscious attention. The experienced driver performs such operations with hardly a thought. One way to understand the power of chunking is to try teaching a child or other beginner how to ride a bicycle or perform long division. You’ve learned the entire procedure so well that it requires effort to remember—much less explain—what operations are required!

Expertise has limits, however. Under some circumstances, it may even become a hindrance (Bédard & Chi, 1992; Wiley, 1998). For example, expertise in one area (e.g., medicine) often does not transfer very well to another domain (e.g., interpersonal skills). Moreover, an expert may become so accustomed to handling problems a certain way that a novice performs better when a novel or creative response is required.

**THINKING CRITICALLY**

**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?
Chapter 7 • Cognition and Language

The ability quickly to recognize and respond to the situation on a basketball court, as well as to visualize complex new plays, are just two of the factors that give expert basketball players an edge over beginners.

CHECK YOUR UNDERSTANDING

1. Match the problem-solving strategy with the appropriate definition.
   ___ algorithm a. rule-of-thumb approach
   ___ heuristic b. each step moves you closer to a solution
   ___ hill climbing c. step-by-step method
   ___ means-end analysis d. moving from the goal to the starting point
   ___ working backward e. reducing the discrepancy between the situation and the goal at a number of intermediate points
   ___ subgoal creation f. breaking down the problem to smaller, more manageable steps

2. The first step in solving a problem is called
   ___ a. trial and error
   ___ b. problem representation
   ___ c. information retrieval

3. Mental set can ____ problem solving.
   ___ a. help
   ___ b. hinder
   ___ c. a and b
   ___ d. none of the above

4. What minimizes the effect of mental sets?
   ___ a. brainstorming
   ___ b. heuristics
   ___ c. trial and error

Answers: 1. algorithm—c; heuristic—a; hill climbing—b; means-end analysis—e; working backward—d; subgoal creation—f, 2.b, 3.c, 4.a

Decision Making

People spend considerable time wondering about “what might have been” if only they had made a different decision. Is this time well spent?

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 or the choice that comes closest to meeting your needs and goals. Decisions range from trivial matters, such as what to wear or where to have dinner, to such major decisions as where to go to college or whether to buy a house, to matters of life and death. Individuals may know exactly what they want or have only a vague idea; they may have hundreds of choices or only two. They may have a great deal of information at their disposal or very little; they may arrive at a decision quickly or become mired in indecision. Whereas some problems have one solution and you know whether you have answered correctly or not, decisions are more often based on probabilities. You cannot predict the outcome of one or another decision, and often have no clear way to measure whether a decision was the right one. How do you make decisions in the face of these uncertainties?

Right now, this child has to think about every aspect of riding a bike—how to keep her balance, when to start and stop pedaling, when to turn the handlebars. Before long, however, she will develop expertise that will enable her to perform this skill automatically and effortlessly.
Logical Decision Making

You want to buy a car and, after shopping around, have identified a number of possible choices within your budget. How do you make a decision? The logical way to proceed is to decide on a set of criteria (factors that are most important); rate each of the available choices according to these criteria; and then add up the pros and cons to see how well each choice matches your criteria. Each choice will probably have attractive features that offset or compensate for unattractive features; thus, this approach is called the compensated model of decision making.

Table 7–1 illustrates one of the most useful compensatory models, applied to the car decision. The buyer has three criteria, which are weighted in terms of importance: price (not weighted heavily), gas mileage, and service record (both weighted more heavily). Each car is then rated from 1 (poor) to 5 (excellent) on each of the criteria. You can see that Car 1 has an excellent price (5) but relatively poor gas mileage (2) and service record (1); 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). Then ratings are added to give a total for each car. Clearly Car 2 is the better choice: It has a less desirable price, but that is offset by the fact that its mileage and service record are better, and these two criteria are more important than price to this particular buyer.

Using a table like this one allows individuals to evaluate a large number of choices on a large number of criteria. If the criteria are weighted properly and the choices rated correctly, the alternative with the highest total score is the most rational choice, given the information available. Does this mean that most day-to-day decision making is rational? Not necessarily. In many instances we don’t have all of the relevant information; it’s impossible to quantify the pros and cons; the decisions are equally attractive (or unattractive); and the consequences of one or another decision are a matter of probabilities, not certainties. In short, many if not most everyday decisions involve a high degree of ambiguity (Mellers, Schwartz, & Cooke, 1998). In such cases, we must often rely on heuristics.

Decision-Making Heuristics

Research has identified a number of common heuristics that people use to make decisions. We use these because, for the most part, they have worked in the past and because they simplify decision making, even though they may lead to less-than-optimal 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.” A good illustration of representativeness is a study conducted by Tversky and Kahneman.

### Table 7-1 COMPENSATORY DECISION TABLE FOR PURCHASING A NEW CAR

<table>
<thead>
<tr>
<th></th>
<th>Price (weight = 4)</th>
<th>Gas Mileage (weight = 8)</th>
<th>Service Record (weight = 10)</th>
<th>Weighted Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Car 1</strong></td>
<td>5(20)</td>
<td>2(16)</td>
<td>1(10)</td>
<td>(46)</td>
</tr>
<tr>
<td><strong>Car 2</strong></td>
<td>1(4)</td>
<td>4(32)</td>
<td>4(40)</td>
<td>(76)</td>
</tr>
<tr>
<td><strong>Ratings:</strong></td>
<td>5 = Excellent</td>
<td>1 = Poor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(1973) in which students at a particular university were asked to choose whether a student who was described as “neat and tidy,” “dull and mechanical,” and a “poor writer” was a computer science major or a humanities major. More than 95 percent chose computer science as the student’s major. Even after they were told that more than 80 percent of the students at their school were majoring in humanities, the estimates remained virtually unchanged. Thus, although representativeness enables us to make decisions quickly, it will also lead us to make mistakes in some situations.

Another common heuristic is availability. In the absence of full and accurate information, we often base decisions on whatever information is most readily available to memory, even though this information may not be accurate. In one experiment, for example, the participants were asked whether the letter \( r \) appears more frequently as the first or third letter in English words (Tversky & Kahneman, 1973). Most guessed that \( r \) was usually the first letter; in fact, the opposite is true. The participants answered the question by trying to think of words that begin with \( r \) (red, round, right) and words in which it is the third letter (car, strong, dare, bird). Because it’s much easier to remember words beginning with \( r \), participants assumed that words beginning with \( r \) are more common.

A familiar example of the availability heuristic is the so-called subway effect (Gilovich, 1991). 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 you want to go. Similarly, if you need a taxi in a hurry, inevitably an unusually long string of occupied or off-duty taxis will pass by. The problem here is that once a subway train or a taxi does come along, we leave the scene, so we never get to see the opposite situation: several subway trains going in our direction before one comes the other way, or a long string of empty taxis. As a result, we tend to assume that those situations seldom or never occur and make our decisions accordingly.

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 (Myers, 1996). 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, some historians still report that President William Henry Harrison caught a case of fatal pneumonia on the day of his inaugural speech because he delivered it in a freezing rain. In fact, a virus, not exposure to inclement weather, causes pneumonia. Many people still believe that chocolate causes acne to flare up in susceptible teenagers, yet this myth was disproved almost half a century ago; acne is a bacterial infection, although the tendency to get acne has a strong genetic component (Kolata, 1996a). Many parents strongly believe that sugar may cause hyperactivity in children—despite research evidence to the contrary. The list of commonsense beliefs that persist in the face of contrary evidence is long.

Nonetheless, for the most part people are reasonably satisfied with the decisions they make in the real world (Kleinmuntz, 1991). In part, this is so because decisions often can be revised if an initial choice does not work out as expected. Moreover, many real-world decisions don’t have to be ideal, as long as the results are acceptable. A financial investment that returns a 15 percent profit in one year is still an excellent investment, even if another investment might have returned 20 percent or 25 percent. However, some decisions have serious consequences, and they must be made quickly without all the facts. In the next section we will see how people go about making decisions in those difficult situations.

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

**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 or phrasing of information that is used to make a decision.

Framing

One way in which a decision may be intentionally or unintenionally swayed is by how the information provided to make the decision is presented or framed. Psychologists use the term framing to refer to the perspective or phrasing of information that is used to make a decision. Numerous studies have shown that subtle changes in the way information is presented can dramatically affect the final decision (Detweiler, Bedell, Salovey, Pronin, & Rothman, 1999; Jones, Sinclair, & Courneya, 2003; LeBoeuf & Shafir, 2003; Wolsko, Park, Judd, & Wittenbrink, 2000). A classic study by McNeil, Pauker, Sox, and Tversky (1982) illustrates how framing may 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 information provided to make this choice was manipulated. In the survival frame, the participants were given the statistical outcomes of both procedures in the form of survival statistics and were told that of 100 people who had surgery 90 survived the surgery, 68 were alive a year following surgery, and 34 were alive 5 years after the surgery. With regard to radiation therapy, participants were told that of 100 people receiving radiation therapy, everyone survived the therapy, 77 of the 100 were alive at the end of one year, and 22 of the 100 were alive at the end of 5 years. In the mortality frame, the participants were given the same information, although this time it was presented (or framed) in the form of the mortality statistics associated with each procedure. Thus, the participants were told that of the 100 people who had surgery, 10 died during the procedure, 32 died by the end of the first year, and 66 had died by the end of 5 years. With regard to radiation, the mortality frame informed the participants that of 100 people who had radiation therapy none had died during the treatment, 23 had died by the end of the first year, and 78 had died by the end of 5 years.

Interestingly, while 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. Of the participants who were in the survival frame group, only 18 percent chose radiation therapy, whereas 44 percent of the participants in the mortality frame group chose radiation therapy. Generally speaking, then, surgery was viewed as a more attractive option compared to radiation when the participants were read the survival frame compared to the mortality frame. Probably most surprising was that this framing effect was found even when 424 experienced physicians with a specialty in radiology served as the experimental participants!

Decisions Under Pressure

Individuals do not always have the luxury of contemplating different perspectives or the time to think about alternatives, weigh them against each other, and then decide which best fits the situation. At times, individuals have to make immediate, potentially life-or-death, decisions that cannot be reversed later. Such is often the case with police officers, military commanders, and nurses on intensive care units.

In a series of field studies, psychologist Gary Klein (1997) observed how firefighters make decisions in situations that nearly always are dangerous. On one occasion, a fire ground commander pulled his team out of a burning house just minutes before the floor collapsed. When first questioned, the commander couldn’t say why he ordered the evacuation. There were no clear signs of imminent danger. On further questioning, however, he realized that the situation had seemed strange to him; the fire wasn’t behaving like other fires he had seen before. So he decided to pull out and regroup. His decision was based on experience, not careful analysis.

In other professions, the potential for disaster is constant but actual emergencies are rare. For example, Spettle and Liebert (1986) studied decision making among operators at nuclear power plants. They found that the stress of an emergency situation causes decision making to deteriorate, sometimes leading to panic.
1979, during the worst nuclear accident in U.S. history, one of two reactors at the Three Mile Island power plant near Harrisburg, Pennsylvania, came perilously close to a meltdown. During the crisis, so many alarms in the power plant’s control center were sounding and blinking that operators actually turned them off.

Spettle and Liebert suggest that training under simulated emergency conditions can prepare people to use efficient and effective decision-making strategies not only in those particular types of emergency, but also in unanticipated situations where quick and accurate decisions are crucial. Preparatory training is also central to the Outward Bound program. This program was originally developed because British sailors whose boats were torpedoed panicked and died when calm decision making would have ensured their survival. The Outward Bound program puts people in a variety of stressful wilderness situations in the belief that they will learn effective decision-making strategies that can be transferred to a wide variety of everyday situations.

Explaining Our Decisions

Whether a choice is exceptionally good, extraordinarily foolish, or somewhere in between, most people ruminate over their decisions after the fact. Retrospective thinking takes different forms. 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 (Azar, 1999b; Fischoff, 1975; Pohl, Schwarz, Sczesny, & Stahlberg, 2003). For example, physicians remember being more confident about their diagnoses when they learn they were correct than they were at the time of the actual diagnoses. An investor buys a stock on a hunch: If it goes up, she is convinced that she “knew it all along”; if the stock goes down, she is equally convinced that she knew it was a mistake. The phrase “Monday morning quarterback” describes fans who, having watched a football game on Sunday, insist the next day that if they had been making the calls, their team would have won.

According to an old saying, “hindsight is always 20:20.” Psychologists have long viewed the hindsight bias as a cognitive flaw—a self-serving mechanism, conscious or unconscious, that restores our faith in our own judgment (see 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. In a sense, hindsight functions like the “find and replace” function in a word processing program, eliminating extra, time-consuming keystrokes and mental effort.

In addition to hindsight, at times everyone imagines alternatives to reality and mentally plays out the consequences. “What if I had gone to a large university instead of a small college?” “What if I had majored in acting instead of computer science?” “What if I were a great tennis player?” “What if I had asked for her/his phone number?” Psychologists refer to such musings on alternative realities and things that never happened as **counterfactual thinking**—they 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 taken that job”; “If only I had driven straight home.” More directed than daydreams, counterfactual thoughts typically deal with causes and consequences.

Theoretically, the question “What if . . . ?” has no limits. Most of us have far-fetched thoughts from time to time: “What if I had lived in ancient Egypt?” “What if aliens invaded earth?” But research shows that counterfactual thinking usually centers around a small number of themes: reversing a course of events that led to a negative experience; explaining atypical or abnormal events by assigning responsibility to someone or something; and regaining a sense of personal control (Roese, 1997). For example, suppose it’s a bright sunny day, you decide to drive home by
way of a longer but more scenic route, and you have a car accident. A common response is the thought, “If only I had taken my usual route, this wouldn’t have happened” (Mandel & Lehman, 1996). Accidents are, by definition, unpredictable. Yet most people feel more comfortable with the idea that there was a reason for the accident; that it didn’t just happen, even if this means blaming themselves.

Like physical pain, negative counterfactual thinking tells us that something is wrong and prompts us to think about why and perhaps make better decisions in the future. But it can also lead to distortions. Obsessive “If only” thinking may promote feelings of shame, guilt, and regret. It is common for the families and friends of accident victims to have endless “If only” thoughts that exact a high psychological price: “If only I hadn’t delayed him by talking about . . .”, “If only I hadn’t insisted that he drive back tonight,” “If only I’d made a different plane reservation for her” and so on.

The many strategies we use to make decisions—and to rethink decisions—emphasize one of the defining features of human beings: We are a storytelling species.

CHECK YOUR UNDERSTANDING

1. Match each decision-making heuristic with the appropriate definition.

   ___ representativeness heuristic   a. making judgments on the basis of whatever information can be most readily retrieved from memory

   ___ availability heuristic         b. attending to evidence that supports your existing beliefs and ignoring other evidence

   ___ confirmation bias             c. making decisions on the basis of information that matches your model of what is “typical” of a certain category

2. The way that information needed in decision making is presented is called

   ___ a. cause and effect

   ___ b. framing

   ___ c. availability

3. Which type of thinking is often phrased “What if . . .?”

   ___ a. counterfactual

   ___ b. hindsight bias

   ___ c. mortality frame

4. What model of decision making involves selecting a set of criteria, rating each one and adding up the ratings?

   ___ a. framing

   ___ b. heuristic

   ___ c. compensatory

   Answers: 1. representativeness heuristic—c; availability heuristic—b; confirmation bias—a; 2. b, c

Answers to Problems in the Chapter

1. Problem 1. Fill each of the smaller spoons with salt from the larger spoon. That will require four teaspoons of salt, leaving exactly four teaspoons of salt in the larger spoon.
2. **Problem 2.** Turn the 5-minute hourglass over; when it runs out, turn over the 9-minute hourglass. When it, too, runs out, 14 minutes have passed.

3. **Problem 3.** As shown in Figure 7–9, fill spoon C with 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 salt from spoon A (leaving A with only 2 teaspoons of salt, while B and C each have 3). Fill spoon B with salt from spoon C (this leaves 1 teaspoon of salt in spoon C while B has 5 teaspoons and A has only 2). Pour all the salt from spoon B into spoon A (now A has 7 teaspoons of salt and C has 1). Pour all the salt from spoon C into spoon B, and then fill spoon C from spoon A (this leaves 4 teaspoons of salt in A, 1 teaspoon in B, and 3 teaspoons in C). Finally, pour all the salt from spoon C into spoon B (this leaves 4 teaspoons of salt in spoons A and B, which is the solution).

4. **Problem 4.** Start both hourglasses. When the 5-minute hourglass runs out, turn it over to start it again. When the 9-minute hourglass runs out, turn over the 5-minute hourglass. Because there is 1 minute left in the 5-minute hourglass when you turn it over, it will run for only 4 minutes. Those 4 minutes, together with the original 9 minutes, give the required 13 minutes for the barbecue.

5. **Problem 5.** Take one of the short pieces of chain shown in Figure 7–10 and open all three links (this costs six cents). Use those three links to connect the remaining three pieces of chain (closing the three links costs nine cents).

6. **Problem 6.** Join the matches to form a pyramid as shown in Figure 7–11.

7. **Problem 7.** One way to solve this problem is to draw a diagram of the ascent and the descent, as shown in Figure 7–12. 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. and 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.

8. **Problem 8.** This problem has four possible solutions, one of which is shown in Figure 7–14 (the other three solutions differ only slightly from this one).

9. **Problem 9.** This problem has 15 possible solutions, of which this is one: 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 opposite side (making a total of three Orcs on the opposite bank) while one Orc rows back. Now three Hobbits cross the river; two stay on the opposite

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**Figure 7–9**
Solution to Problem 3.

**Figure 7–10**
Solution to Problem 5.
*Step 1: Cut one piece of chain into three open links.*
*Step 2: Use three links to join three remaining pieces of chain.*

**Figure 7–11**
Solution to Problem 6.
side with two Orcs while one Hobbit 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. One of the Orcs then rows back and forth across the river twice to transport the remaining Orcs to the opposite side.
Figure 7–14
Solution to Problem 8.
The term cognition refers to all the processes whereby we acquire and use information. These include thinking and language.

The Building Blocks of Thought

The main building blocks of thought are language, images, and concepts.

Language  Language is a flexible system of symbols that enables us to communicate our ideas, thoughts, and feelings. Human language differs from nonhuman communication in that it is semantic, or meaningful. It is also characterized by displacement (it is not limited to the here-and-now) and productivity (it can produce new words, phrases, and sentences).

The Structure of Language  Spoken language is based on universal sound units called phonemes that indicate changed meaning. Phonemes are combined to form morphemes, the smallest units of meaning in a language, such as words or parts of words, prefixes, and suffixes.

The rules for structuring sentences and their meaning are called grammar. Syntax and semantics are the two major components of grammar. Syntax is the system of rules that governs how we combine words to form meaningful phrases and sentences. Semantics describes how we assign meaning to morphemes, words, phrases, and sentences.

Sentences have both a surface structure (particular words and phrases) and a deep structure (the underlying meaning). Speaking requires top-down processing in which we move from the underlying idea or thought (deep structure) to the words and phrases that express the idea (surface structure). Understanding speech requires bottom-up processing, which requires moving from specific words and phrases to their underlying meaning.

Images  An image is a nonverbal mental representation. Images allow us to think in nonverbal ways. We not only visualize things in order to think about them but also manipulate these mental images.

Concepts  A concept is a mental category for classifying people, things, or events. Concepts provide a way of categorizing experiences so that encounters with something new need not be a surprise. They can be organized in hierarchies, with the most specific category at the bottom and the most general at the top.

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

Language and Cognition  Language is closely tied to the expression and understanding of thought. According to Benjamin Whorf, patterns of thinking are determined by the language one speaks, a process called linguistic determinism. Some critics of this theory maintain that people from cultures with different languages think about some things in similar ways, even if their language contains no words for those things. Others point out that people create new words when they need them.

Is Our 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 occupations for women, not men.

Culture and Cognition  All known cultures use categories to form concepts. What information is included in a given category, and how categories are shaped by experience, vary from culture to culture. For example, recent research confirms that people from Eastern cultures tend to think holistically, whereas Westerners tend to think analytically.

Nonhuman Thought and Language

Animal Cognition  Research indicates that some animals have some humanlike cognitive capacities, such as the ability to form concepts and to reason. Apes have demonstrated sophisticated problem-solving skills. However, only chimpanzees and orangutans consistently show signs of self-awareness and perhaps a limited sense of other-awareness.

The Question of Language  Nonhuman animals communicate primarily through signs: general or global statements about the animal’s current state. No other species has its own language, but chimpanzees have been taught to use American Sign Language. Similar to young children, chimpanzees have been observed using two-word combinations called telegraphic speech during early language acquisition. Nonetheless, the extent to which animals have the ability to acquire and use true language is still not clear. For example, apes do not demonstrate a syntactical use of language—the ability that allows humans to understand and create complex sentences.

Problem Solving

Typically, we transform external data to fit our existing mental framework, but sometimes we need to modify our mental structures to accommodate new data. This is most apparent in problem solving.

The Interpretation of Problems  Problem representation—defining or interpreting the problem—is the first step in problem solving. The importance of problem representation is shown by the fact that a problem represented or categorized in one way may be difficult or impossible to solve, while the same problem represented differently may be solved easily.

Producing Strategies and Evaluating Progress  When there are only a limited number of solutions to a problem, trial and error may be the best way to find the correct one. At other times, a problem may be solved simply by retrieving information. But more complex problems require more complex problem solving strategies. An algorithm is a problem-solving method that guarantees a solution if it fits the problem and is carried out correctly. Solving a mathematical problem
by use of a formula is an example of the use of an algorithm. **Heuristics** are rules of thumb that help simplify problems, though they do not guarantee a solution. **Hill climbing** is a heuristic in which each step moves the problem solver closer to the final goal. Another heuristic is the creation of **subgoals**—intermediate, more manageable goals that may make it easier to reach the final goal. **Means-end analysis**, a heuristic that combines hill climbing and subgoals, aims to reduce the discrepancy between the current situation and the desired goal at a number of intermediate points. **Working backward** involves working from the desired goal back to the given conditions.

**Obstacles to Solving Problems** A factor that can help or hinder problem solving is **mental set**, a tendency to perceive and approach problems in certain ways. Sets enable us to draw on past experience to solve a present problem, but a strong set can also interfere with the ability to use novel approaches to solving a problem. One set that can seriously hamper problem solving is **functional fixedness**, the tendency to assign a fixed function to something we learn to use in a particular way. One way to reduce the effect of mental sets is to stop thinking about the problem for a while and then return to it from a new angle; by redefining the problem, it may be possible to get around the unproductive mind-set. Another 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. In this way, no potential solution is rejected prematurely.

**Experience and Expertise** Expertise in a field increases a person’s ability to interpret a particular problem. Experts not only know more about their subject but also think in larger units that include many interconnected pieces of information, algorithms, and heuristics. Expertise in a field is an asset in solving problems because experts do not need the elaborate preparations required of a beginner. However, an expert may become so accustomed to handling problems a certain way that a novice performs better when a novel or creative response is required.

**Decision Making** Unlike other kinds of problem solving, decision making starts off with knowledge of all the possible solutions or choices.

**Logical Decision Making** A logical approach is to select a set of criteria, rate each of the choices on those criteria, and add up the ratings to see how well each choice matches the criteria. This is called the **compensatory model** of decision making. Although it allows a person to evaluate a large number of alternatives on a large number of criteria and to identify the optimal choice from among those alternatives, it does not work well for many day-to-day decisions where we do not have all of the relevant information, where it is impossible to quantify pros and cons, where the alternatives are equally attractive or unattractive, or where the consequences of some decisions are uncertain. In those cases, decisions are most often made on the basis of heuristics.

**Decision-Making Heuristics** When we lack complete or accurate information about one or more alternatives, we may end up judging a new situation in terms of its resemblance to a more familiar model—the **representativeness** heuristic. Another common heuristic is **availability**, in which we base a judgment or decision on information that is most readily available to memory, whether or not that information is accurate. Another faulty heuristic, **confirmation bias**, involves the tendency to notice and remember evidence that supports our beliefs and to ignore evidence that does not support them. A related phenomenon is the tendency to see connections or patterns of cause and effect where none exist.

In the real world, the use of faulty heuristics does not always spell disaster. This is partly because such decisions are often not final, and partly because we often do not need to make an absolutely perfect decision so long as the results are satisfactory.

**Framing** The term **framing** refers to the perspective or phrasing of information that is used to make a decision. Subtle changes in the way information is presented can dramatically affect the final decision even though the underlying facts remain unchanged.

**Decisions Under Pressure** The stress of an emergency situation may cause decision making to deteriorate. Training under simulated emergency conditions can prepare people to make better decisions under such conditions.

**Explaining Our Decisions** Most people ruminate over their decisions after the fact. The term **hindsight bias** refers to the tendency to view outcomes as inevitable and predictable after they are known. **Counterfactual thinking** refers to thinking about alternative realities that are counter to the facts (“What if. . . .?” or “If only. . . .”) as a way of mentally reversing a course of events that led to a negative experience, explaining atypical or abnormal events by assigning responsibility to someone or something, or regaining a sense of personal control.

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**Key Terms**

- **Cognition**
- **Language**
- **Phonemes**
- **Morphemes**
- **Grammar**
- **Syntax**
- **Semantics**
- **Surface structure**
- **Deep structure**
- **Image**
- **Concept**

- **Prototype**
- **Linguistic determinism**
- **Signs**
- **Telegraphic speech**
- **Problem representation**
- **Algorithm**
- **Heuristics**
- **Hill climbing**
- **Subgoals**
- **Means-end analysis**
- **Working backward**

- **Mental set**
- **Functional fixedness**
- **Brainstorming**
- **Compensatory model**
- **Representativeness**
- **Availability**
- **Confirmation bias**
- **Framing**
- **Hindsight bias**
- **Counterfactual thinking**

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