chapter nine

Language and Thinking

CHAPTER OUTLINE

Myth or Reality?

Dyslexia Is a "Reading Backwards" Disorder (page 307)

According to a popular stereotype, if you had dyslexia and read the sentence "It was a nice day," you might end up reading it as "It saw a nice bay" because reading letters or words backwards is the primary feature of dyslexia. Is it?

Figure 9.1

The "Miracle on the Hudson."
The successful ditching of U.S. Airways Flight 1549 in the Hudson River was a tribute to the power of human reasoning, language, and problem solving.

For the 150 passengers and 5 crew members aboard U.S. Airways Flight 1549 on January 15, 2009, their journey from New York City to Charlotte was about to become a dramatic test of human resourcefulness, with survival at stake. Ascending after takeoff from LaGuardia airport on that frigid afternoon, the Airbus collided with a flock of Canada geese, damaging both engines and causing them to lose thrust. Inside the cockpit, Captain Chesley Sullenberger and First Officer Jeff Skiles knew that the plane had little time to remain aloft. Quickly, they had to formulate a plan.

Sullenberger had to determine whether he or Skiles would pilot the crippled plane. "Typically what's done these days is for the first officer to be the pilot flying and for the captain to be the pilot monitoring, analyzing and managing the situation," Sullenberger later noted. "There wasn't time for that" (Shiner, 2009, para. 10). Although both pilots had similar total flying hours, Sullenberger knew that he was more experienced flying this aircraft. He also recognized that his side of the cockpit offered the better view of important flight path landmarks and that Skiles—due to more recent yearly flight-simulator training—would be faster at locating the proper emergency checklists from within a handbook kept in the cockpit. Sullenberger decided he would fly the plane and communicate with air traffic control; Skiles would focus on restarting the engines. The engines, however, wouldn't restart.

About 35 seconds after the bird strike, Sullenberger decided not to attempt a landing at LaGuardia or another nearby airport but instead to ditch the plane in the Hudson River.

> I could tell . . . that neither [airport] was a viable option. I also thought that I could not afford to choose wrongly. I could not afford to attempt to make it to a runway that in fact I could not make. Landing short, even by a little bit, can have catastrophic consequences. (Shiner, 2009, para. 16)

To increase the odds of a fast rescue, Sullenberger decided to ditch the plane where boats would be operating nearby. Flight attendants shouted emergency-landing instructions to the passengers, and the plane ditched merely 6 minutes after takeoff (Figure 9.1). As it slowly took on water, flight attendants communicated evacuation instructions. Eventually, all aboard were rescued alive. Two days after this "Miracle on the Hudson," a National Transportation Safety Board member called it "the most successful ditching in aviation history" (Olshan & Livingston, 2009).

Incidents like this one vividly illustrate the power of communication, reasoning, and problem solving—cognitive skills that underlie adaptive behavior. Whether it's a pilot talking with air traffic controllers, or flight attendants giving evacuation instructions to passengers, scientists would want to identify the building blocks of language and examine how people are able to understand what others say. Likewise, scientists would want to determine factors that contribute to or hinder effective reasoning and decision making. These are among the many topics we'll explore in this chapter.

We humans dominate our world because we communicate more effectively and think better than other animals do, skills that reflect our remarkable ability to create *mental representations* (Simon, 1990). **Mental representations** *include images, ideas, concepts, and principles*. At this very moment, through the printed words you are reading, mental representations are being transferred from our minds to yours. Indeed, the process of education is all about transferring mental representations from one mind to another.

LANGUAGE

Language has been called "the jewel in the crown of cognition" (Pinker, 2000) and "the human essence" (Chomsky, 1972). Much of our thinking, reasoning, and problem solving involves the use of **language:** *a system of symbols and rules for combining these symbols in ways that can generate an infinite number of possible messages and meanings*. To most of us, using our native language comes as naturally as breathing. Yet using language actually involves a host of complex skills. **Psycholinguistics** *is the scientific study of the psychological aspects of language*, such as how people understand, produce, and acquire language. Before delving into these topics, let's consider some functions of language.

Adaptive Functions of Language

According to anthropologists, the human brain probably achieved its present form some 50,000 years ago (Pilbeam, 1984). Yet it took another 35,000 years before lifelike paintings began to appear on cave walls and another 12,000 years before humans developed a way to store knowledge in the form of writing (Kottak, 2000). These time lags tell us that thought and language depend on more than the brain's physical structure; although the brain may not have physically evolved much over the past 50,000 years, human cognitive and linguistic skills clearly have.

Some evolutionary theorists believe that language use evolved as humans adopted a more socially oriented lifestyle and formed larger social units (Flinn, 1997). As the social environment became more complex, new survival problems emerged: the need to create divisions of labor and cooperative social systems, to develop social customs and communicate thoughts, and to pass on knowledge. Language made it easier for humans to adapt to these environmental demands (Bjorklund & Pellegrini, 2002).

"GOT IDEA. TALK BETTER. COMBINE WORDS. MAKE SENTENCES."

Figure 9.2

According to many theorists, the development of language was a major milestone in human evolution. Source: Copyright © 2004 by Sidney Harris. ScienceCartoonsPlus.com. Reprinted with permission.

It is no coincidence, then, that every human culture has developed language and that the human brain seems to have an inborn capacity to acquire any of the roughly 5,000 to 6,000 languages spoken across the globe. We have evolved into highly social creatures who need to communicate, and we have the physical characteristics (e.g., a highly developed brain, a vocal tract) to do so in the most flexible way known: through language (Figure 9.2).

Language underlies so much of what we do that it's almost impossible to imagine functioning without it. Conscious thinking often takes the form of inner speech. Through language, we can share our thoughts, feelings, goals, intentions, desires, needs, and memories with other people. Language also is a powerful learning mechanism. To get somewhere new, you don't have to drive or walk aimlessly. Instead, you ask for directions, Google a map, or listen to your GPS device. Through storytelling, books, instruction, mass media, and the Internet—language puts the knowledge accrued over generations at your fingertips.

Properties of Language

What captures your attention first when someone uses a foreign language that you don't speak: how different it sounds or looks when written, or simply how incomprehensible it seems? Yet what is striking about the world's languages is not their differences but their underlying similarities. Across the globe, there are four properties essential to any language: symbols, structure, meaning, and generativity. We will also describe a fifth property: displacement.

Language Is Symbolic and Structured

Language uses sounds, written characters, or some other system of symbols (e.g., hand signs) to represent objects, events, ideas, feelings, and actions. The symbols used in any given language are arbitrary. For example, the Spanish, French, and German words for *dog* are *perro*, *chien*, and *hund*, respectively. Nothing about how any one of these words looks or sounds makes it intrinsically correct for representing the concept of "dog." In English, *gerk, woof, professor*, or other words could be used to represent what we call a *dog*. But they aren't (even though "No Professors Allowed on the Lawn" has a certain ring to it). Regardless of how the word *dog* came into being, it has an agreed-on meaning. The same holds true for all the other words we use.

Language also has a rule-governed structure. A language's **grammar** *is the set of rules that dictates how symbols can be combined to create meaningful units of communication*. Thus if we ask you whether *zpflrovc* is an English word, you will almost certainly say "No." Why? Because it violates a rule of the English language: five consonants (*z, p, f, l, r*) cannot be put in an unbroken sequence. Likewise, if we ask you whether "Bananas have sale for I" is an appropriate English sentence, you will say "No. It should read: 'I have bananas for sale.'" In this case, "Bananas have sale for I" violates a portion of English grammar called **syntax,** *the rules that govern the order of words*. Even if you can't verbalize the grammatical rules violated in these examples, you know them implicitly.

The grammars of all languages share common functions, such as providing rules for how to change present tense ("I am walking the dog") into the past tense ("I walked the dog") or a negative ("I didn't walk the dog"). Yet just as symbols (e.g., words) vary across languages, so do grammatical rules. In English, for example, we say *green salad* and *big river,* which follow the rule that adjectives almost always come before the nouns they modify. In French and Spanish, however, adjectives often follow nouns (*salade verte, rio grande*). Although language changes over time, with new words and phrases appearing regularly, they need to conform to the basic rules of that language.

Language Conveys Meaning

Once people learn the symbols and rules of a language, they can form and then transfer mental representations to other people. Thus you can tell a friend about your courses, favorite foods, feelings, and so on. Your friend will then extract meaning—hopefully, your intended meaning—from what you've said. But understanding **semantics,** *the meaning of words and sentences*, is a tricky business. For example, when you ask a friend "How did you do on the test?" and the reply is "I nailed it," you know that your friend is not saying "I hammered the test to the desk with a nail." Someone familiar with English knows not to interpret this expression literally; someone just beginning to learn English might find this expression perplexing.

Language Is Generative and Permits Displacement

Generativity *means that the symbols of language can be combined to generate an infinite number of messages that have novel meaning*. The English language, for example, has only 26 letters, but they can be combined into more than half a million words, which in turn can be combined to create a virtually limitless number of sentences. Thus you can create and understand a sentence like "Why is that sparrow standing underneath my pancake?" even though you are unlikely to have heard anything like it before.

Displacement *refers to the fact that language allows us to communicate about events and objects that are not physically present*. You can discuss the past and the future, as well as people, objects, and events that exist or take place elsewhere. You can even discuss imaginary situations, such as a sparrow standing underneath a pancake.

The Structure of Language

Psycholinguists describe language as having a *surface structure* and a *deep structure*. Language also has a hierarchical structure, in which smaller elements are combined into larger ones. Let's examine these issues.

Surface Structure and Deep Structure

When you read, listen to, or produce a sentence, its **surface structure** *consists of the symbols that are used and their order.* As noted earlier, syntax provides the rules for ordering words properly. In contrast, a sentence's **deep structure** *refers to the* *underlying meaning of the combined symbols*, which returns us to the issue of semantics.

Sentences can differ in surface structure but have the same deep structure. Consider:

1. Sam ate the cake.
2. The cake was eaten by Sam.
3. Eaten by Sam the cake was.

Each sentence conveys the same underlying meaning. Notice that the third has incorrect syntax. English isn't spoken this way, except perhaps by the fictional *Star Wars* character Yoda. Still, its meaning is clear enough.

Sometimes, a single surface structure gives rise to two deep structures, as occurs when people speak or write ambiguous sentences. Consider:

The police must stop drinking after midnight.

This sentence could mean that police officers need to enforce a curfew to prevent citizens from drinking alcohol after midnight. Or, it could mean that if police officers go out for drinks after work, they need to finish their drinking by midnight.

At times, people intentionally use words or phrases to create a *double entendre* (French for "double meaning") to convey two possible deep structures, one of which is often socially inappropriate. For example, in the movie *The Silence of the Lambs*, serial killer Hannibal Lecter tells FBI agent Clarice Starling "I do wish we could chat longer, but I'm having an old friend for dinner." The phrase "having an old friend for dinner" normally elicits only a single deep meaning, but because Lecter is "Hannibal the Cannibal," who eats his victims after killing them, the phrase was intentionally used to convey a second, more sinister deep structure.

In everyday life, when you read or hear speech, you are moving from the surface structure to deep structure—from the way a sentence looks or sounds to its deeper level of meaning. In contrast, when you express your thoughts to other people, you must transform deep structure (the meaning that you want to communicate) into a surface structure that others can understand.

thinking **critically**

DISCERNING THE DEEP STRUCTURE OF LANGUAGE

Figure 9.3 shows a grave marker in the Boothill Graveyard in Tombstone, Arizona, where many notorious outlaws and gunfighters are buried. Analyze the marker carefully, and then identify two possible meanings for the inscription. Think about it, then see page 330.

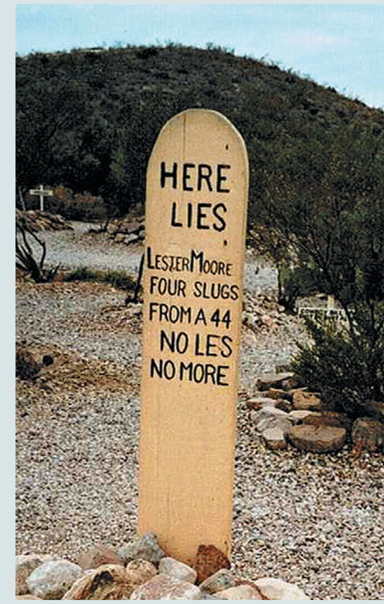


Figure 9.3

This grave marker in Boothill Graveyard illustrates an interesting relation between surface structure and deep structure.

The Hierarchical Structure of Language

The most elementary building block of human language is the **phoneme,** *the smallest unit of speech sound in a language that can signal a difference in meaning*. Humans can produce about 100 phonemes, including the clicking sounds in some African languages, but no language uses them all. Some languages employ as few as 15 phonemes, and others more than 80. English uses about 40 phonemes, consisting of vowel and consonant sounds, as well as certain letter combinations such as *th* and *sh*. Thus sounds associated with *th*, *a*, and *t* can be combined to form the three-phoneme word *that*.

Phonemes have no inherent meaning, but they alter meaning when combined with other elements. For example, the phoneme *d* creates a different meaning from the phoneme *l* when it precedes *og* (i.e., *dog* versus *log*). At the next level of the hierarchy, phonemes are combined into **morphemes,** *the smallest units of meaning in a language*. Thus *dog*, *log*, and *ball* are all morphemes, as are prefixes and suffixes such as *pre-*, *un-*, *-ed*, and *-ous*. Notice in Figure 9.4 that morphemes are not always syllables. For example, in English *s* is not a syllable, but the final *s* on a noun is a morpheme that means "plural." Thus the word *fans* has one syllable but two morphemes. In every language, rules determine how phonemes can be combined into morphemes. English's 40 phonemes can be combined into more than 100,000 morphemes.

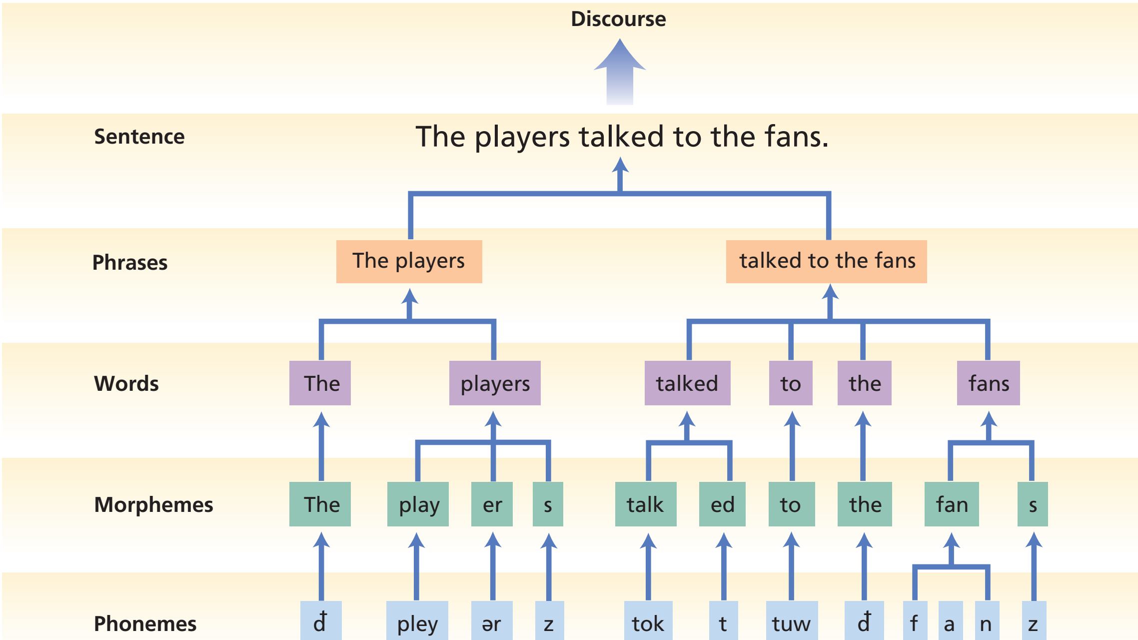


Figure 9.4

The hierarchical structure of language.
Human language is structured hierarchically, with phonemes being the most basic unit. The row of phonemes contains symbols used by linguists to denote particular sounds.

Morphemes, in turn, are the stuff of which words are formed. English morphemes can be combined into over 500,000 words, words into countless phrases, and phrases into an infinite number of sentences. Thus we have a five-step language hierarchy, beyond which lies the sixth and most comprehensive level, **discourse,** *in which sentences are combined into paragraphs, articles, books, conversations, and so forth.*

test yourself — Properties and Structure of Language

Match each numbered concept to the correct definition on the right.

1. grammar	a. smallest unit of meaning in a language
2. phoneme	b. the meaning of words and sentences
3. semantics	c. in a sentence, the symbols used and their order
4. surface structure	d. rules for combining the symbols in a language
5. displacement	e. ability to communicate about things that aren't physically present
6. morpheme	f. smallest unit of speech sound that signals a change in meaning

ANSWERS: 1-d, 2-f, 3-b, 4-c, 5-e, 6-a

Understanding and Producing Language

Here's a true story. A man answers a phone call, listens for 5 seconds, and hangs up. "It was a prerecorded telemarketing call," he tells his wife. "Some company called Pressgrits." "Pressgrits. That's a weird name," she says. Then it dawns on her. She is expecting an automated call from a company called Express Scripts to confirm an order. This was indeed the confirmation call.

How can a voice on the phone say "Express Scripts" and the husband hear it as "Pressgrits"? Did he need to clean out his ears? Hardly. He simply failed to perceive the morpheme *ex*, which left *press* for the first word. By saying "Press Scripts" rapidly, as the prerecorded voice did, you'll realize that phonetically, *pressscripts* and *pressgrits* are not far apart. Additionally, her husband had no context for interpreting the message. Context, as you'll see, plays a key role in understanding language.

The Role of Bottom-Up Processing

To understand language, your brain must recognize and interpret patterns of stimuli—the sounds of speech, shapes of letters, movements that create hand signs, or tactile patterns of dots used in Braille—that are detected by your sensory systems. And just like other perceptual tasks, extracting information from linguistic stimuli involves the joint influence of bottom-up and top-down processing. In **bottom-up processing,** *individual elements of a stimulus are analyzed and then combined to form a unified perception*. Analyzing the hierarchical structure of spoken language as a set of building blocks that uses phonemes to create morphemes and then morphemes to create words reflects a bottom-up approach.

Likewise, as you read this sentence, specialized cell groups in your brain are (1) analyzing the basic elements (e.g., contours, angles of lines) of the printed visual patterns that you see and (2) feeding this information to other cell groups that lead you to perceive these patterns as letters. We then recognize the words, which in turn become the building blocks for sentences, and sentences the building blocks for discourse. But at every step in this bottom-up sequence, including pattern recognition, our understanding of language also is influenced by top-down processing.

The Role of Top-Down Processing

In a Seattle farmers' market, there used to be a store called The Bead Store. The owners sold beads for making jewelry. Tourists would often walk by and ask "Where's the bread?" The store's sign said *Bead,* but many people perceived the word as *Bread*, a function perhaps of their perceptual set (i.e., a perceptual expectation) that they were in a farmers' market that sold food. Eventually, the owners put up a sign saying "We Don't Sell Bread."

In **top-down processing,** *sensory information is interpreted in light of existing knowledge, concepts, ideas, and expectations*. In Chapter 5 we discussed how people's unconscious expectations (i.e., perceptual sets) literally shape what they visually perceive. As the bead store example illustrates, people looked at a stimulus pattern on a store sign that said *Bead*, but *Bread* is what they saw.

Language by its very nature involves top-down processing, because the words you write, read, speak, or hear activate and draw upon your knowledge of vocabulary, grammar, and other linguistic rules that are stored in your long-term memory. That's why if we write "Bill g_ve th_ pe_cil to h_s fr__nd," you can probably interpret the words with little difficulty ("Bill gave the pencil to his friend"), despite the absence of several bottom-up elements.

Let's consider another example. Have you ever listened to someone speak a foreign language in which you aren't fluent and found that it was difficult to tell where one word ended and the next began? Conversely, non-English speakers would have the same problem listening to you speak. How is it, then, that in your native language this process of **speech segmentation**—*perceiving where each word within a spoken sentence begins and ends*—seems to occur automatically? When you read a sentence, the spaces between words make segmentation easy. But when people speak, they don't pause in between each pair of words. In fact, when people utter sentences, there is often more of a drop in sound energy between the segments within a word than between adjacent words. To illustrate, say "We hope you have a nice day" out loud. Did you distinctly segment each whole word, creating a sound energy break between each one? Or were your segments more like "We ho pew ha va nice day"? Moreover, in English about 40 percent of words consist of two or more syllables that are vocally stressed (i.e., emphasized) when spoken (Mattys, 2000). Thus in these and other words, the auditory breaks that we hear in speech often don't correspond well to the physical breaks produced by the spaces in written sentences.

Psycholinguists have discovered that we use several top-down cues to tell when one spoken word ends and another begins (Cunillera et al., 2006). For example, through experience we learn that certain sequences of phonemes are unlikely to occur within a single word, so when we hear these sounds in sequence we are more likely to perceive them as a word ending and the beginning of an adjacent word. We also use the context provided by the other words in a sentence to interpret the meaning of any individual word. Thus when people listen to a single spoken word (e.g., *ice*) and have to identify it based on its sound alone, they perform more poorly than when they listen to the same word spoken within two- to four-word segments (e.g., "covered in ice"; Pollack & Pickett, 1964).

Pragmatics: The Social Context of Language

Imagine that a passerby on the street asks you "Do you have the time?" You say "10:20" and part ways.

In this case, the question really is shorthand for "I'm not wearing a watch, so please tell me what time it is right now." You wouldn't respond to someone's request "Do you have the time?" merely by saying "Yes, I do" and then walking away. Likewise, if a friend says "I need you to explain this material to me. Do you have the time?" you wouldn't say "10:20" and walk away. In this context, you understand that "Do you have the time?" means "Can you take a few minutes to help me?"

These examples illustrate that it takes more than having a vocabulary and arranging words grammatically to understand language and communicate effectively. It also involves **pragmatics,** *a knowledge of the practical aspects of using language* (Cummings, 2005). Language occurs in a social context, and pragmatic knowledge not only helps you understand what other people are really saying, it helps you make sure that other people get the point of what you're communicating. Pragmatics is another example of how top-down processing influences language use.

Many social rules guide communication between people (Arundale, 2005; Grice, 1975). One rule states that messages should be as clear as possible (Figure 9.5). Depending on whether you're talking with an adult or a young child, you usually adjust your choice of words and sentence complexity. Pragmatics also depend on other aspects of the social context. When you write a term paper, you normally would use a more formal tone than when writing an e-mail to friends. Thus when a college student sent an e-mail to her instructor (it wasn't to one of us) that read "I can't find tomorrow's assignment could you pleeeeez send it to me pleeeeez, could ya, could ya?" the instructor sternly let the student know about her violation of pragmatics, namely, that the style of the message was inappropriate for the context.

thinking **critically**

THE SLEEPING POLICEMAN

You're on vacation in England, driving to a countryside bed-and-breakfast to spend the night. You stop in a small town to get directions. A storekeeper tells you to take a left turn a mile up the road, drive "until you come to the sleeping policeman," and then take a right. What do you imagine "the sleeping policeman" (or "The Sleeping Policeman") might be? Think about it, then see page 331.

Language Functions, the Brain, and Sex Differences

Language functions are distributed in many areas of the brain, but the regions shown in Figure 9.6 are especially significant. As discussed in Chapter 4, Broca's area, located in the left hemisphere's frontal lobe, is most centrally involved in word production (lower-right brain scan). Wernicke's area, in the rear portion of the temporal lobe, is more centrally involved in speech comprehension (upper-left scan). People with damage in one or both areas typically suffer from **aphasia,** *an impairment in speech comprehension and/or production* that can be permanent or temporary (LaPointe, 2005). The visual area of the cortex is also involved in processing written words.

Years ago, scientists noted that men who suffer left-hemisphere strokes are more likely than women to show severe aphasic symptoms. In female stroke victims with left-hemisphere damage, language functions are more likely to be spared, suggesting that more of their language function is shared with the right hemisphere.

Brain-imaging research by Susan Rossell and coworkers (2002) supports this hypothesis.

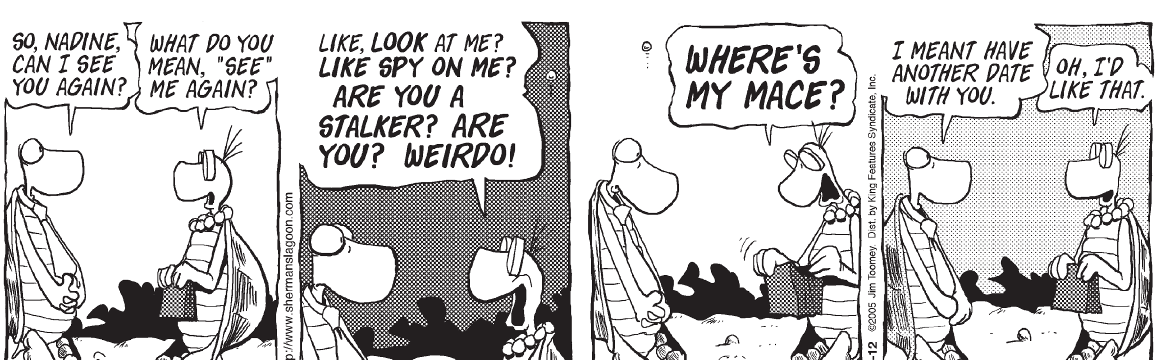


Figure 9.5

A breakdown of pragmatics.

Although most of us might understand the underlying meaning of "Can I see you again?" it seems that in this case our suitor made an error in his choice of words.

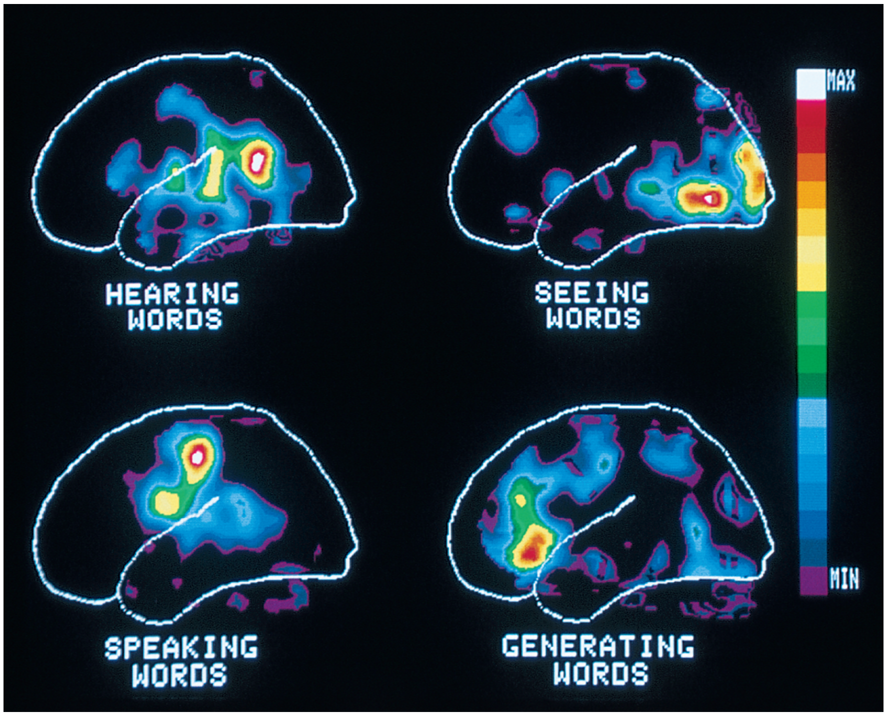


Figure 9.6

Brain areas involved in various aspects of language.
In these PET scans, regions of white, red, and yellow show the greatest activity. Notice in the upper-left image that Wernicke's area (in the temporal lobe) is especially active when we hear words, and in the lower-right image that Broca's area (located in the frontal lobe) is especially active when we generate words.

In their study, men and women engaged in a language task in which words and nonwords were presented on each side of a computer screen. Participants had to identify which was the real word as quickly as possible by pressing one of two computer keys. Functional MRIs (fMRIs) were recorded during the task and during a nonlanguage control task. Men exhibited greater left-hemisphere activation during the language task, whereas women's brain activation occurred in both the left and right hemispheres. Maximum activation occurred in regions corresponding to Broca's area and Wernicke's area.

Neural systems involved in several aspects of language may be organized differently in women than in men, but because this finding has been successfully replicated in some studies but not others, more research is needed to sort out why these inconsistencies occur (Démonet et al., 2005). Further, as a critical thinker, you should recognize that if men's and women's brains differ overall in some aspects of language processing, this finding does not establish by itself whether the source of those differences lies in our genes or possible gender-differences in language socialization (Kaiser et al., 2009).

Acquiring a First Language

Language acquisition is one of the most striking events in human cognitive development. It represents the joint influences of biology (nature) and environment (nurture). Many language experts believe that humans are born linguists, inheriting a biological readiness to recognize and eventually produce the sounds and structure of whatever language they are exposed to (Chomsky, 1986; Pinker, 2000).

Biological Foundations

Linguist Noam Chomsky proposes that from birth, our genetic endowment innately leads us to "interpret part of the environment as linguistic experience" (2005, p. 266). He has argued that we are born with a brain mechanism already "prewired" to understand general grammatical rules common to all languages (which he terms "universal grammar"), such as the principle that languages contain elements that are arranged in particular ways (Chomsky, 1986). Chomsky's views have generated much debate, including disagreements about whether we are born with brain systems specifically dedicated to language or instead have more general inborn cognitive capabilities (e.g., memory, learning) that by themselves can account for language acquisition (Valin, 2009).

Several facts suggest a biological basis for language acquisition. First, human children, despite their limited thinking skills, begin to master language early in life without any formal instruction. For example, whether born in Toledo, Taiwan, or Tanzania, young infants can perceive the entire range of phonemes found in the world's languages. Between 6 and 12 months of age, however, they begin to discriminate only those sounds that are specific to their native tongue. For example, Japanese children lose the ability to distinguish between the *r* and *l* sounds because their language does not make this phonetic distinction, but children exposed to English continue to discriminate these sounds as they mature. Likewise, Japanese-speaking children learn the syntactic rule to put the object before the verb ("Ichiro the ball hit"), whereas English-speaking children learn the syntactic rule that the verb comes before the object ("Ichiro hit the ball").

Moreover, despite their differences at the phoneme level, all adult languages throughout the world—including sign languages for the deaf, which developed independently in different parts of the world—seem to have common underlying structural characteristics. Language acquisition appears to represent the unfolding of a biologically primed process within a social learning environment (Aitchison, 1998; Chomsky, 2005).

Social Learning Processes

Given the required biological foundation, social learning plays a central role in acquiring a language (Pruden et al., 2006). Early on, caregivers attract children's attention and maintain their interest by conversing with them in what has been termed *child-directed speech,* a high-pitched intonation that seems to be used all over the world (Fernald et al., 1989). Caregivers also teach their children words by naming objects, reading aloud, and responding to the never-ending question "What dat?" (Figure 9.7).

The behaviorist B. F. Skinner (1957) developed an operant conditioning explanation for language acquisition. His basic premise was that children's language development is strongly governed by adults' positive reinforcement of appropriate language and nonreinforcement or correction of inappropriate verbalizations. Most modern psycholinguists doubt that operant learning principles alone can account for language development. For one thing, children learn so much so quickly. By grade 2 in elementary school, children have acquired about 5,000 to 6,000 words (Biemiller & Slonim, 2001). Observational studies also show that parents do *not* typically correct their children's grammar as language skills are developing. Rather, parents' corrections focus primarily on the "truth value" (or deep structure) of what the child is trying to communicate. They are less likely, for example, to correct a young child who says "I have two foots" than they are to correct one who says "I have four feet," even though the latter statement is grammatically correct (Brown, 1973). Further, much of children's language is different from that of their parents, and thus it can't be explained simply as an imitative process. Nonetheless, social learning is a crucial contributor to language acquisition, and language development reflects an interplay of biological and environmental factors.

Figure 9.7

Language development depends not only on the brain's biological programming device but also on exposure to one's language. Childhood is an important sensitive period for such exposure.

Developmental Timetable

Language acquisition proceeds according to a developmental timetable that is common to all cultures. As Table 9.1 highlights, children progress from reflexive crying at birth through stages of cooing, babbling, and one-word utterances. By 2 years of age, children are uttering sentences, called *telegraphic speech*, that at first consist of a noun and a verb (e.g., "Want cookie"), with nonessential words left out. Soon, additional words may be added (e.g., "Daddy go car"). From that point on, speech development accelerates as vocabulary increases and sentences become more grammatically correct. In the short span of 5 years, an initially nonverbal creature has come to understand and produce a complex language.

In Chapter 5 we saw how normal perceptual development requires certain kinds of sensory input early in life. Many linguists believe there is also a critical period, or at least a sensitive period, from infancy to puberty during which the brain is optimally responsive to language input from the environment (Arshavsky, 2009; Long, 2005). If exposure to language is delayed beyond this period, then normal language acquisition either will not occur (the "critical period" hypothesis) or will still be possible but much more difficult to achieve (the "sensitive period" hypothesis). Support for at least a sensitive period comes from studies of children who lived by themselves in the wild or who were isolated from human contact by deranged parents. One such child, found when she was 6 years old, immediately received language training

Table 9.1 Course of Normal Language Development in Children

Age	Speech Characteristics
1–3 months	Infant can distinguish speech from nonspeech sounds and prefers speech sounds (phonemes). Undifferentiated crying gives way to cooing when happy.
4–6 months	Babbling sounds begin to occur. Child vocalizes in response to verbalizations of others.
7–11 months	Perception of phonemes narrows to include only the phonemes heard in the language spoken by others in the environment. Child moves tongue with vocalizations ("lalling"). Child discriminates between some words without understanding their meaning and begins to imitate word sounds heard from others.
12 months	First recognizable words typically spoken as one-word utterances to name familiar people and objects (e.g., *da-da* or *block*).
12–18 months	Child increases knowledge of word meanings and begins to use single words to express whole phrases or requests (e.g., *out* to express a desire to get out of the crib); primarily uses nouns.
18–24 months	Vocabulary expands to between 50 and 100 words. First rudimentary sentences appear, usually consisting of two words (e.g., *more milk*) with little or no use of articles (*the, a*), conjunctions (*and*), or auxiliary verbs (*can, will*). This condensed, or telegraphic, speech is characteristic of first sentences throughout the world.
2–4 years	Vocabulary expands rapidly at the rate of several hundred words every 6 months. Two-word sentences give way to longer sentences that, though often grammatically incorrect, exhibit basic language syntax. Child begins to express concepts with words and to use language to describe imaginary objects and ideas. Sentences become more correct syntactically.
4–5 years	Child has learned the basic grammatical rules for combining nouns, adjectives, articles, conjunctions, and verbs into meaningful sentences.

and seemed to develop normal language abilities (Brown, 1958). In contrast, language-deprived children who were found when they were past puberty acquired only limited language skills, despite extensive training (Clarke & Clarke, 2000; Curtiss, 1977).

The importance of early language exposure applies to any language, not just spoken language. Because sign languages share the deep-structure characteristics of spoken languages, deaf children who learn sign language before puberty develop normal linguistic and cognitive abilities without having ever heard a spoken word (Marschark & Mayer, 1998). In contrast, deaf people who are not exposed to sign language before age 12 show language-learning deficits later in life (Morford, 2003).

test yourself — Understanding, Producing, and Acquiring Language

True or false?

1. Bottom-up processing occurs when our brain analyzes the visual patterns (e.g., contours) of written letters and words.
2. In English, we segment speech entirely by hearing the auditory breaks that occur when people speak.
3. Knowing when "it's cool" means "it's OK" rather than "it's a cool temperature" illustrates pragmatics.
4. Aphasia is an impairment in producing or understanding speech.
5. Social learning contributes to language development but can't fully explain it.

ANSWERS: 1-true, 2-false, 3-true, 4-true, 5-true

Bilingualism

For those of us trying to learn a second language, there are inspirational models. M. D. Berlitz, inventor of a well-known system for teaching foreign languages, spoke 58 of them. Sir John Bowring, a former British governor of Hong Kong who reputedly could speak 100 languages and read 100 more, noted that "it is scarcely more difficult to acquire five languages than one" (Bowring, 1877, p. 91).

Bilingualism, *the regular use of two languages,* is common throughout the world (Fabbro, 2001). Officially, Canada is a bilingual country. French is the official language of the province of Quebec, English is the official language elsewhere, and the federal government promotes both languages. But individually, only about 18 percent of Canadians (including 41 percent of those living in Quebec) speak both English and French (Statistics Canada, 2002). English is the sole official language in the United States, but as in Canada and other countries, a history of immigration means that many languages and bilingual combinations are spoken (Table 9.2).

Table 9.2 Most Commonly Spoken Languages at Home in the United States*

Language	Number of Homes
1. English	216,176,111
2. Spanish**	32,184,293
3. Chinese	2,300,467
4. French**	1,932,418
5. Tagalog***	1,376,632
6. Vietnamese	1,142,328
7. German	1,120,256
8. Korean	983,954
9. Russian	812,404
10. Italian	802,436
11. Arabic	686,986
12. Portuguese**	661,990
13. Polish	607,585
14. Hindi	462,371
15. Japanese	457,836

*Includes Americans who are at least 5 years old.

**Includes people who speak a Spanish, French, or Portuguese creole. A *creolized* language is a version of an original language (say, French) that has been blended with some characteristics of another language (say, English) and that evolves into the native language of people living in a certain area.

***Tagalog is native to the Philippines.

Source: U.S. Census Bureau, 2005c.

Does Bilingualism Affect Other Cognitive Abilities and First-Language Learning?

In childhood, does learning a second language influence the development of other cognitive abilities or affect acquisition of one's native language? Causation is difficult to establish, because researchers typically don't get to randomly assign children to bilingual or monolingual classrooms. Nevertheless, research suggests that bilingualism is associated with greater thinking flexibility, higher performance on nonverbal intelligence tests, and better performance on perceptual tasks that require people to inhibit attention to irrelevant information and pay attention to relevant information (Bialystok & Viswanathan, 2009; Kovacs, 2009).

For example, suppose you sit in front of a computer screen that displays an image like the one shown in Figure 9.8 (Bialystok & Martin, 2004). There's a box in the lower-left corner with a red square above it and a box in the lower-right corner with a blue circle above it. Next, a stimulus appears at the top of the screen—either a blue square or a red circle. At first, your task is to place the stimulus into the box that has the same color. If a blue square appears, you hit the letter O on the keyboard to drop it into the lower-right box. If a red circle appears, you hit the X key to drop it into the lower-left box. After several trials, however, we switch the rule. Now your task is to sort each stimulus by its shape, not by its color: drop blue squares into the left box and red circles into the right box. This new rule requires you to ignore the color of each stimulus, which just a moment ago was foremost in your mind, and instead to selectively focus your attention on the shape of the stimulus.

According to psychologist Ellen Bialystok (2009), one reason bilingual people perform better

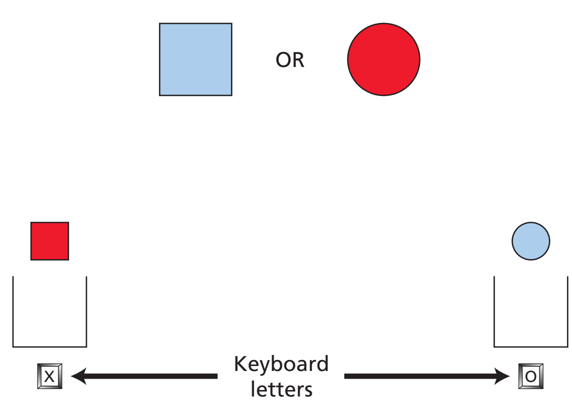


Figure 9.8

Measuring your ability to ignore irrelevant details. This figure shows one of the attention-inhibition tasks used by Bialystok & Martin (2004).

than monolingual people on tasks like this is that in learning a second language, they gain continuous experience in using selective attention to focus on relevant information and ignore information that interferes with a task. For example, while speaking in their second language, bilinguals must ignore the more familiar words of their first language. Bilingual children also gain experience in frequently switching languages, which may contribute to their greater cognitive flexibility than monolingual children. Tasks like the one in Figure 9.8 require participants to switch decision-making strategies when the experimenter provides new instructions.

Bilingualism, however, may also have a linguistic cost. When children are raised learning two languages, they develop a somewhat smaller vocabulary in each language than do their monolingual age peers, and this vocabulary size difference also is found among bilingual adults (Bialystok & Feng, 2009; Portocarrero et al., 2007). At present, research suggests that in general, compared to monolinguals, bilinguals tend to perform more poorly on several linguistic tasks but display superior performance on other types of cognitive tasks (Bialystok, 2009; Kharkhurin, 2008).

The Bilingual Brain: Two Language Systems or One?

Is a second language represented in the same parts of the brain as the native language? One intriguing set of findings comes from studies of bilingual people who experience a brain trauma (e.g., from a tumor or stroke) and subsequently develop an aphasia. In some bilingual patients, the same linguistic ability—such as understanding the meaning of words—may be impaired to different degrees in each language or impaired in one language and not the other (Fabbro, 2001). Moreover, when brain damage produces similar impairments in both languages, patients may experience some simultaneous recovery in both languages or recovery in one language but not the other. These findings suggest that there is variability in how bilingual abilities are represented in the brain, and also that in some cases, each language is represented by at least partially distinct neural networks.

The question "Are there two language systems or one?" is far more complicated than it looks. The answer may depend on the aspect of language examined (e.g., word recognition, grammar), the age and proficiency of second-language learning, the degree of exposure, similarity of the two languages, and other factors. Still, brain-imaging studies shed some interesting light on this issue. The most consistent finding is that when people acquire a second language early in life, both languages use a common neural network (Abutalebi, 2008; Bloch et al., 2009). In contrast, people who learn a second language only moderately well later in life, such as in adolescence or adulthood, typically show more variability in their neural activation patterns. At least for some language functions, their specific brain areas that process each language are partly distinct (Abutalebi, 2008; Bloch et al., 2009). Further, even for some cortical areas involved in processing both languages among older bilingual learners, greater activation tends to occur when the person uses the second language. This suggests that the person may have to exert more conscious effort to process the less dominant, second language.

Age and Second-Language Fluency

Many people start to learn a second language during high school or college or after emigrating to a foreign country during late adolescence or adulthood. Can these "late learners" achieve the fluency of native speakers? The answer is often tied to the hypothesis that there is a biologically based critical period for acquiring a second language—typically proposed to end by late childhood to the mid-teenage years—after which the capacity for true nativelike acquisition is essentially lost. In a nutshell, some psycholinguists believe the evidence supports a critical period hypothesis, others don't, and still others believe there are critical periods for acquiring some aspects of a second language (e.g., speaking without a "foreign" accent) but not other aspects (e.g., learning grammar; Rothman, 2008).

One finding is clear: overall, people who start learning a second language in late adolescence or adulthood achieve less proficiency than younger learners. Importantly, this occurs even when the various age groups have similar amounts of exposure to the second language. Figure 9.9a shows the results of two studies that examined people who had emigrated at various ages to the United States and whose native language was either Korean or Chinese (Johnson & Newport, 1989) or Spanish (Birdsong & Molis, 2001). In both studies, late-arriving immigrants (arrival after age 16) displayed the poorest grammar proficiency, despite having similar exposure to English as the earlier-arriving immigrants. Further, among the 55 late-arriving immigrants combined across both studies, only one achieved nativelike grammar proficiency, though a few others almost did. In

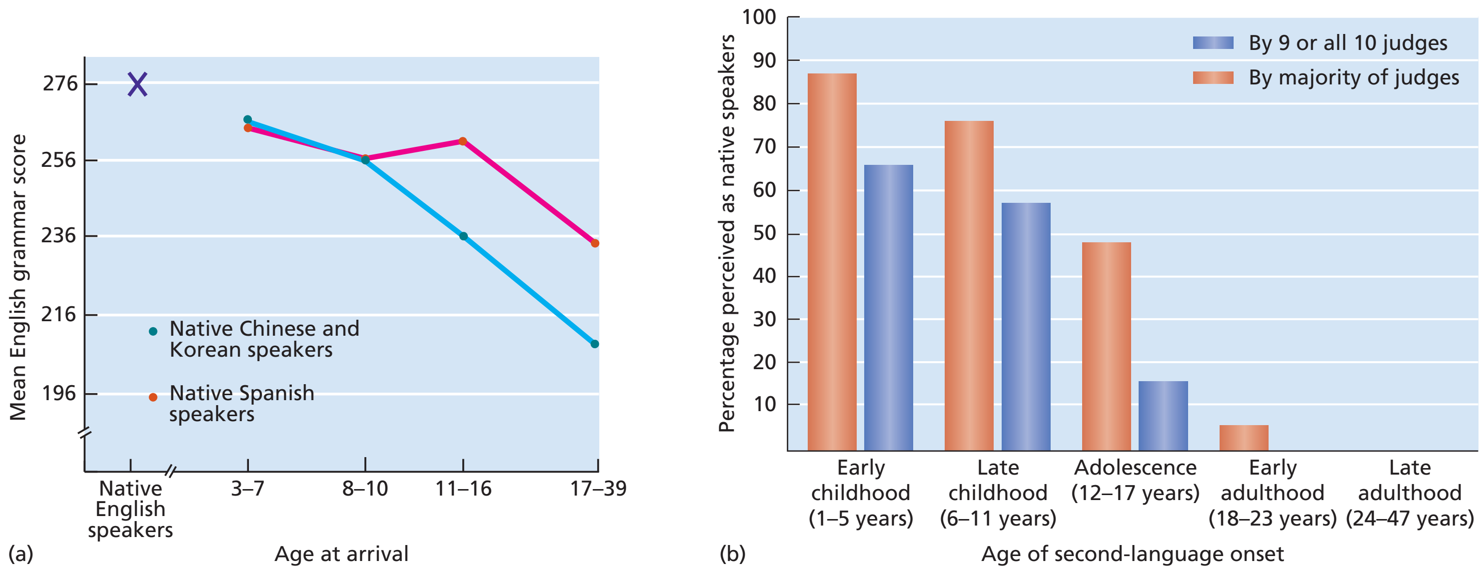


Figure 9.9

Age and proficiency of learning a second language.

(a) The X represents the average grammar score of native-born Americans. The blue line shows the grammar performance of Korean and Chinese individuals of various ages on a 276-item test of English grammar, The red line shows the grammar performance of native Spanish speakers of various ages on a 274-item version of the same grammar test. (b) Percentage of native Spanish speakers perceived to have nativelike Swedish fluency by native Swedish speakers. SOURCES: (a) Based on data from Johnson & Newport, 1989; Birdsong & Molis, 2001. (b) Abrahamsson & Hyltenstam, 2009.

contrast, most 3- to 7-year-olds achieved nativelike grammar proficiency.

But how can we reconcile these and similar findings with those of other studies that generally report that about 5 to 20 percent of adult second-language learners achieve nativelike proficiency on various language tasks (Birdsong, 2005). Recent research by Niclas Abrahamsson and Kenneth Hyltenstam (2009) illustrates how answers to questions such as "Can adult second-language learners achieve nativelike proficiency?" depend strongly on how "nativelike proficiency" is defined and measured. First, they identified 195 native Spanish speakers who began learning Swedish at various ages and who considered themselves to have nativelike Swedish proficiency. Next, native Swedish speakers acted as judges and listened to speech samples from these participants and from a control group of native Swedish speakers. Based solely on the speech samples, 10 judges classified each participant as being a "nonnative" or "native Swedish speaker." Lastly, the researchers administered a battery of Swedish language tests to native Swedish speakers and to a sample of bilingual participants classified by a majority of judges as being native Swedish speakers.

The judges correctly identified all the native Swedish speakers. Figure 9.9b shows the percentage of native Spanish speakers identified as being native Swedish speakers either by a majority of judges (liberal criterion) or by 9 or 10 judges (conservative criterion). Although all the bilingual participants believed they spoke Swedish with nativelike fluency, the judges thought otherwise, especially among the adolescent and adult participants. Further, only 7 percent of bilingual participants demonstrated nativelike proficiency on the entire battery of 10 language tests, and these all came from the childhood learner groups. Based on the test results, Abrahamsson and Kenneth Hyltenstam (2009) argue that to attain nativelike second-language proficiency, acquisition must start in childhood, and even that may not be sufficient. Other psycholinguists argue that criteria for judging nativelike proficiency can be too stringent, and thus the debate continues.

Reading

Typically, as long as we are exposed to an environment rich in spoken language, we will learn to produce and understand speech. Reading is a different animal: it requires extensive instruction (Carreiras et al., 2009). If written language came to humans as naturally as spoken language, there wouldn't be almost 759 million nonliterate adults across the globe (Watkins et al., 2008).

Learning to Read

Reading has been called "one of the most cognitively complex tasks that we will ever learn to do" (Pammer, 2009, p. 266). In the English language, for example, we must first learn to visually recognize a set of basic symbols—26 letters—that constitute the alphabet, as well as other visual elements such as punctuation marks and number symbols. We also learn names for these symbols (our "ABCs").

One of the most intricate steps in learning to read (and write) an alphabetic language such as English is making connections between how letters and letter combinations look when written and how they sound when spoken. For example, note how the letter *a* is voiced differently in each of the following five words: *mat, may, marble, mall,* and *mean* (in which the *a* is silent). Likewise, *e* is voiced differently in *met, meet,* and *ache*, as are various letter combinations such as *ch* in "*channel*" versus *ache*. If you are fluent in reading English, these phonological variations pose no problem. When learning to read, however, they frustrate attempts to apply simple rules such as "the letter *a* always sounds like *ay* and the letter *e* always sounds like *ee*."

This ability to translate print into sound—to have a mental map that connects written symbols to phonemes—is itself dependent on more basic understandings about the properties of language. As children acquire speech, they not only learn how to manipulate phonemes to produce different words, but also become aware that words are constructed from sequences of sounds and, thus, that words can be decoded into more basic sound elements. Psycholinguists use the term **phonological awareness** *to refer to this overall awareness of the sound structure of one's language*, and it is an important predictor of young children's subsequent reading ability (Furnes & Samuelsson, 2009).

Recognizing Written Words

Fluent reading involves rapid word recognition. In Chapter 1, we discussed a claim that

> . . . it deosn't mttaer waht oredr the ltteers in a wrod are, the olny iprmoatnt tihng is taht the frist and lsat ltteres are at the rghit pclae. . . . Tihs is bcuseae we do not raed ervey lteter by istlef but the wrod as a wlohe. (Anonymous, 2003)

We saw that the "letter ordering" claim, as an absolute conclusion, was false: words with interior jumbled letters can be very difficult to read. So, what's the validity of the claim that we don't read individual letters but instead read words "as a whole"?

One way we might recognize words as a "whole" is from their overall shape. The basic idea of the century-old *word shape hypothesis* is that words have a holistic form, or "envelop," based on their pattern of letters (Cattell, 1886; Haber et al., 1983). For example, consider the different envelops created by *brook* and *spark* in Figure 9.10a.

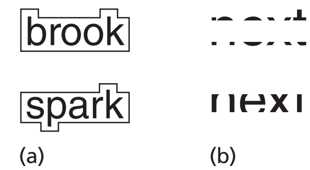


Figure 9.10

(a) Two words with a "shape envelop" drawn around each one. (b) Outer and inner portions of letters within words. Source: Webb et al., 2006.

Several types of evidence have been offered to support this hypothesis, including the iNtErEsTiNg finding that mixing lowercase and uppercase letters—which disrupts a word's typical shape—slows down word rEcOgNiTiOn. But mixed casing has other negative effects, such as making it more difficult to perceive some lowercase letters, and these—rather than overall shape disruption—appear to cause the reading impairment (Mayall et al., 1997). Overall, there is substantial evidence against this simple word-shape "envelop" hypothesis (Grainger, 2008), although visual information contained near the boundaries of letters—in the upper and lower portions of letters as illustrated in Figure 9.10b—may contribute more to word recognition than visual information in the middle portion (Beech & Mayall, 2005).

How then do fluent readers recognize written words? The issue isn't settled, but several lines of evidence point to at least one key component: the parallel processing of letter information within words (Beech & Mayall, 2005; Grainger, 2008). At a basic visual level, the brain simultaneously analyzes the features of multiple letters, acquiring information about individual letters and letter groupings, and coding their location. Some psycholinguists propose that our brain directly processes this visual information to determine the meaning of a word, while others contend that our brain also phonologically recodes printed text to help determine word meaning (Coltheart et al., 2001; Lee, 2009). But in any event, the notion that fluent reading does not involve visual processing at the level of individual letters appears to be wrong (Pelli et al., 2003).

Our brain also is processing other information as we read. Without conscious awareness, as in listening to speech, prior written words create top-down context effects that help prepare us for recognizing the words we're about to read. Additionally, our eye movements while reading are not smooth and continuous. We alternate between briefly fixating on a word, typically for a quarter second or less, and then making a rapid, distinct jump—called a *saccade*—to another word (and some of these saccades are backwards, e.g., right to left, when reading English). During fixations, our brain is receiving information from our visual periphery about the spacing of upcoming words, which helps to determine how large our next eye movement will be (Larson, 2004).

You can see that reading is a complex process. It depends on many brain areas, including ones specialized for detecting and recognizing visual features of objects, coding the identity of letters and their positions within words, processing the phonological aspects of language, and encoding the meaning of words (Pammer, 2009). For fluent readers, all this machinery exists under the radar screen. It seems effortless. Unfortunately, many children and adults struggle with reading, and as our "Myth or Reality?" feature discusses, this includes people diagnosed with *dyslexia*.

Myth or Reality? Dyslexia Is a "Reading Backwards" Disorder

Harvey Hubbell V was diagnosed in the second grade as having dyslexia. Decades later, as director of *Dislecksia: The Movie*, Hubbell took to the streets of New York City and asked people, "What is dyslexia?" Most didn't know; some believed it was a sleep disorder or sexually transmitted disease (Hubbell, 2009).

Children and adults throughout the world have dyslexia, and about 5 to 17 percent of American schoolchildren are dyslexic (International Dyslexia Association, 2008; Shaywitz et al., 2008). You may know that dyslexia is a specific learning disability that affects people's ability to read, write, and spell. But what do you believe is its core feature? If your answer is along the lines of "reading backwards," or "seeing letters and words in reverse," you're not alone. This is a common belief that periodically gets reinforced in the popular media. Indeed, in 1984 an ABC television special (nominated for an Emmy Award) was titled *Backwards: The Riddle of Dyslexia*. And in a study of 250 faculty members, graduate students, and undergraduates in the education department at a large university, 70 percent believed that "word reversal is the major criterion in the identification of dyslexia" (Wadlington & Wadlington, 2005, p. 27).

It's a myth, however, that dyslexia is a "reading backwards" disorder. Dyslexics don't see or read everything in reverse when looking at a sentence. It's true that dyslexic individuals (children in particular) sometimes reverse letters, such as substituting *d* for *b* or *p* for *q*. They also may reverse individual words (e.g., *pat* for *tap*) or transpose letters within words (e.g., *wrap* for *warp*). But dyslexic children also make other linguistic errors that don't involve letter or word reversals, and importantly, children who are not dyslexic make letter and word reversal errors. Although dyslexic children make linguistic errors more frequently than other children, by late childhood some of these differences may shrink (Wolff & Melngailis, 1996). Older children, adolescents, and adults who have dyslexia may develop strategies that enable them to accurately read and spell individual words but still have trouble reading and writing fluently (Shaywitz et al., 2008). Thus letter and word reversals are not the hallmarks of dyslexia. They are only two among several manifestations of deeper language difficulties.

What are those difficulties? Most experts believe that dyslexia typically results from deficits in *phonological awareness* (Hanly & Vandenberg, 2010; Shaywitz et al., 2008). This may include difficulty in recognizing phonemes and poorer general awareness that words can be broken down into basic phonological elements. Perhaps most centrally, when it comes time to read, write, and spell, children and adults with dyslexia struggle more than their peers in making connections between the "look" and "sound" of letters and letter combinations (Goswami, 2008; Lyon et al., 2003).

Some studies have found that dyslexics are more likely than other people to display atypical eye movements on certain reading tasks, such as fixating longer on words or making more back-and-forth eye movements. However, these eye movement patterns appear to be the result of language processing deficits, not their cause (American Academy of Ophthalmology, 2009). An ongoing area of research—with mixed results thus far—is examining whether impaired coordination of the two eyes on reading tasks might contribute to causing some people's dyslexia (Kapoula et al., 2009; Kirby et al., 2008).

Two Other Myths and One Reality Related to Dyslexia

1. *Vision therapy is an effective treatment for dyslexia.* According to the American Academy of Ophthalmology, "scientific evidence does not support the efficacy of eye exercises, behavioral vision therapy, or special tinted filters or lenses for improving . . . long-term educational performance" (2009, para. 2).
2. *Most children with dyslexia eventually outgrow it.* Not so; dyslexia persists into adolescence and adulthood, and thus early diagnosis and intervention are important (Schatschneider & Torgesen, 2004).
3. *Dyslexia often has other negative psychological effects.* Sadly, this is true. For example, a British study found that overall, compared to other schoolchildren, children with dyslexia had more negative perceptions of how their peers and teachers felt about them, felt more stress about their academic performance, and had a poorer academic self-concept (Alexander-Passe, 2008). Hopefully, intervention programs designed to increase educators' awareness about dyslexia, coupled with greater investment in early diagnosis and treatment, will reduce the struggles and emotional pain felt by many people who have dyslexia (Shaywitz, 2008; Wadlington et al., 2008).

Can Other Animals Acquire Human Language?

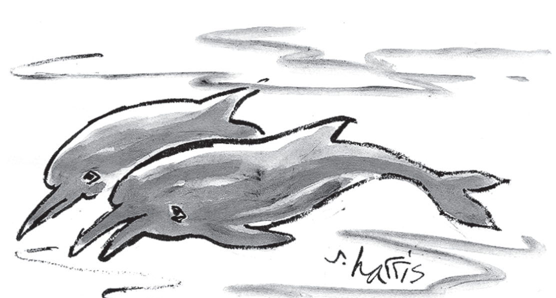
Nonhuman species communicate in diverse ways. Chimpanzees grunt, bark, scream, and make gestures to other chimps. Dolphins make clicking sounds and high-pitched vocalizations (Figure 9.11). Many species use special calls to warn of predators and to attract mates (Alcock, 2005).

In some species, communication shows interesting parallels to human language. Just as humans have different languages, each songbird species has its own songs. And just as humans have a sensitive period in childhood for language acquisition, some songbirds will not sing normally in adulthood unless they hear the songs of their species while growing up (Wilbrecht & Nottebohm, 2003).

Although other species communicate, the capacity to use full-fledged language has long been regarded as the sole province of humans. Some scientists have attempted to challenge this assumption by teaching other species, such as apes and gray parrots, to use human language (Pepperberg, 2007). We'll focus here on the ape research, which has a more extensive history.

Washoe: Early Signs of Success

At first, investigators tried to teach chimpanzees to speak verbally, but chimps lack a vocal system that permits humanlike speech. A breakthrough came in 1966 when Allen Gardner and Beatrice Gardner (1969) took advantage of chimps' hand and finger dexterity and began teaching American Sign Language to a 10-month-old chimp named Washoe. They *cross-fostered* Washoe, raising her at home and treating her like a human child. By age 5, Washoe had learned 160 signs. More important, at times she combined signs (e.g., "more fruit," "you tickle Washoe") in novel ways. Other researchers also had success. For example, a gorilla named Koko learned more than 600 signs (Bonvillian & Patterson, 1997).



"Although humans make sounds with their mouths and occasionally look at each other, there is no solid evidence that they actually communicate with each other."

Figure 9.11

Human scientists debate whether dolphins and other animals use language. Could the opposite also be occurring? SOURCE: Copyright © 2004 by Sidney Harris. ScienceCartoonsPlus.com. Reprinted with permission.

Project Nim: Dissent from Within

At Columbia University, behaviorist Herbert Terrace (1979) taught sign language to a chimp he named Nim Chimpsky—a play on the name of linguist Noam Chomsky. But after years of work and videotape analysis of Nim's "conversations," Terrace concluded that when Nim combined symbols into longer sequences, he was either imitating his trainer's previous signs or "running on" with his hands until he got what he wanted. Moreover, Nim spontaneously signed only when he wanted something, which is not how humans use language. Terrace concluded that Nim had not learned language.

Some ape-language researchers disputed Terrace's conclusions. They agreed that although Washoe and other cross-fostered apes signed mainly to request things, other types of communication also occurred. At Central Washington University, Roger Fouts and Deborah Fouts continued working with Washoe and other cross-fostered chimps. They refrained from signing in front of Loulis, Washoe's adopted son, and found that Loulis acquired over 50 signs by observing other chimps communicate (Fouts et al., 1989). The chimps also signed with each other when humans weren't present, and signing occurred across various contexts, such as when they were playing and fighting (Cianelli & Fouts, 1998).

Kanzi: Chimp versus Child

Sue Savage-Rumbaugh of Georgia State University has worked extensively with a chimpanzee species called the *bonobo* (Figure 9.12). At age $1\frac{1}{2}$, a bonobo named Kanzi spontaneously showed an interest in using plastic geometric symbols that were associated with words. By age 4, with only informal training during social interactions, Kanzi had learned more than 80 symbols and produced a number of two- and three-word communications. Kanzi typically combined gestures and symbols that he pointed to on a laminated board or typed on a specially designed keyboard (see Figure 9.12a). For example, Kanzi created the combinations "Person chase Kanzi," "Kanzi chase person," and "Person chase person" to designate who should chase whom during play. Kanzi also responded to spoken English commands.

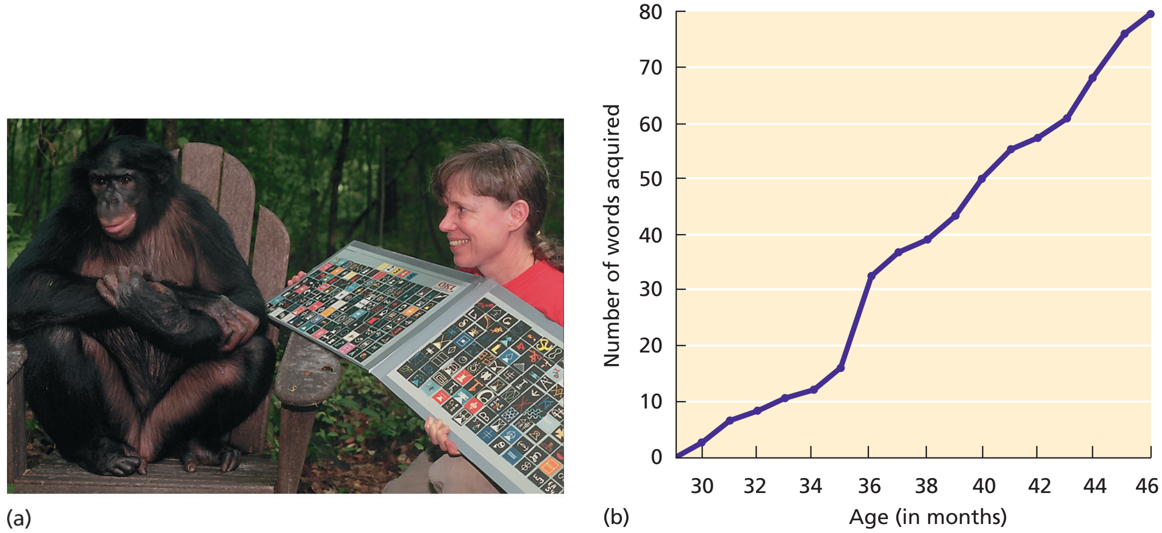


Figure 9.12

Can a chimpanzee acquire language?

(a) Using complex symbols, a bonobo communicates with psychologist Sue Savage-Rumbaugh. (b) This graph shows the rate of Kanzi's symbol acquisition over 17 months of informal training. Source: Adapted from Savage-Rumbaugh et al., 1986.

Savage-Rumbaugh and her coworkers (1993; Segerdahl et al., 2006) also tested Kanzi's ability to understand unfamiliar spoken sentences under controlled conditions. For example, when told "Give the doggie a shot," Kanzi picked up a toy dog, grabbed a toy hypodermic needle, and gave the dog a shot. For comparison, one of the researcher's daughters, Alia, was tested under the same conditions between the ages of 2 and $2\frac{1}{2}$. Kanzi correctly responded to 74 percent of the novel requests and Alia to 65 percent. In short, Kanzi was comprehending speech at the level of a human toddler.

Is It Language?

Recall that human language is symbolic and structured, conveys meaning, is generative, and permits displacement. Apes are capable of communicating with a small vocabulary of symbols and hand signs. They can convey meaning by using one- or two-symbol communications (e.g., "banana" or "give banana"), and have also produced some longer symbol strings that convey meaning. As for structure, there are examples of how apes follow—and violate—rules of grammar, but overall the evidence for "ape grammar" has been disappointing (Givón & Savage-Rumbaugh, 2009). Lastly, the evidence for generativity and displacement is limited and controversial.

Critics—even those impressed by Kanzi's feats—are not persuaded that apes are displaying language (Wynne, 2007). Some believe that ambiguous ape communications are interpreted as language because the researchers erroneously assume what must be going on inside the apes' minds. Conversely, proponents believe the data show that apes can acquire rudimentary language skills, a so-called "protolanguage" that lacks major qualities of true human language (Greenfield et al., 2008). If nothing else, this intriguing scientific work should remind us to appreciate something that we often take for granted, namely, the seemingly natural ease with which humans acquire full-blown language.

Language, Culture, and Thinking

Does the language we speak shape how we think? The linguist Benjamin Lee Whorf (1956) took an extreme position on this matter, contending in his **linguistic relativity hypothesis** *that language not only influences but also determines what we are capable of thinking*.

If the linguistic relativity hypothesis is correct, then people whose cultures have only a few words for colors should have greater difficulty in perceiving the spectrum of colors than do people whose languages have many color words. To test this proposition, Eleanor Rosch (1973) studied the Dani of New Guinea, who have only two color words in their language, one for bright warm colors and the other for dark cool ones. She found that contrary to what strict linguistic determinism would suggest, the Dani could discriminate among and remember a wide assortment of hues in much the same manner as can speakers of the English language, which contains many color names. Similarly, in the Amazon, the language of the Mundurukú people contains few words for geometric or spatial concepts, yet Mundurukú children perform as well on many geometric and spatial tasks as American children (Dehaene et al., 2006).

Other research, however, comparing English children and Himba children from Namibia, suggests that color categories in a given language have a greater influence on color perception than Rosch's study of the Dani suggested (Davidoff, 2004). The English language contains 11 basic color terms, whereas the Himba language has only 5. Himba children made fewer distinctions among colored tiles than did English children. For example, Himba children categorized under the color term *zoozu* a variety of dark colors, such as dark shades of blue, green, brown, purple, red, and the color black. English children distinguished among these colors and remembered the different hues better when retested on which ones they had seen earlier.

Still, most psycholinguists do not agree with Whorf's strong assertion that language *determines* how we think. They would say instead that language can *influence* how we think, categorize information, make decisions, and perceive our experiences (Newcombe & Uttal, 2006). Consider, for example, the ability of sexist language to evoke gender stereotypes (Figure 9.13). In one study, college students read one of the following statements:

> The psychologist believes in the dignity and worth of the individual human being. He is committed to increasing man's understanding of himself and others.

> Psychologists believe in the dignity and worth of the individual human being. They are committed to increasing people's understanding of themselves and others.

The students then were asked to rate the attractiveness of a career in psychology for men and women. Those who had read the first statement rated psychology as a less attractive profession for women than did the students who read the second statement, written in gender-neutral language (Briere & Lanktree, 1983). Apparently, the first statement implied that psychology is a male profession (when, actually, the majority of psychology doctorates awarded over the past decade went to women). In such ways, language can help create and maintain stereotypes.

Figure 9.13

Sexist language influences our perceptions, our decisions, and the conclusions we draw. Which of these people would you assume is the chairperson of this committee? Might you consider the question differently if we said "Which of these people would you assume is the *chairman* of the committee?"

test yourself

Bilingualism, Reading, and Language and Thought

True or False?

1. Bilingualism is associated with enhanced performance on some other cognitive tasks.
2. Typically, when people learn two languages proficiently at a young age, those languages share a common neural network.
3. Fluent readers recognize words by their overall shape, not by processing information about individual letters.
4. Seeing letters and words backwards is the primary cause of dyslexia.
5. Language influences how we categorize information and perceive our experiences.

ANSWERS: 1-true, 2-true, 3-false, 4-false, 5-true

Levels of Analysis

Language

We've seen that language is a complex cognitive activity jointly shaped by biology and the social environment. Let's consider how some of the factors we have discussed represent the biological, psychological, and environmental levels of analysis.

BIOLOGICAL LEVEL

- Acquiring language depends on brain maturation and follows a similar developmental timetable across the globe.
- There appears to be a maturational critical or sensitive period for acquiring normal language capabilities.
- Using language involves a network of brain structures; among bilingual speakers, whether the two languages share the same network depends on age of acquisition and other factors.
- Hemispheric lateralization for language may differ between men and women.

ENVIRONMENTAL LEVEL

- Social learning experiences guide language acquisition, beginning with early caretaker speech that exposes infants to the phonemes of a particular language.
- Formal educational experiences facilitate language development and are integral to learning to read.
- Extensive exposure to a bilingual environment influences the number of languages that children acquire.
- There are cultural variations in word use, such as in the number of words used to identify colors or the degree of sexist language.

PSYCHOLOGICAL LEVEL

- Cognitive processes (e.g., attention, memory) are involved in learning a language's symbols and grammatical rules.
- Bottom-up and top-down processes influence our ability to recognize speech and to read.
- Bilingualism appears to influence other cognitive abilities.
- Language influences how we think.

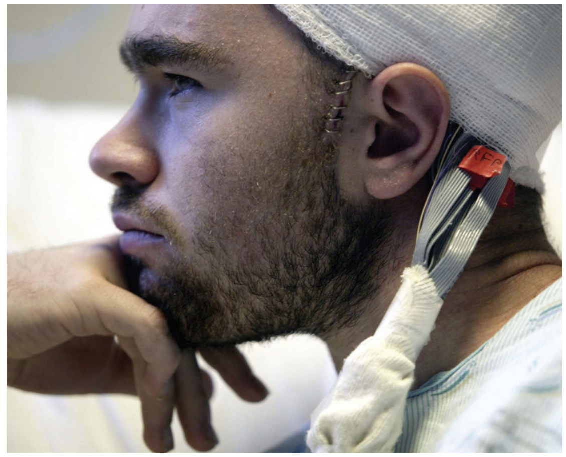
Consider this possible interaction among the three levels of analysis. Suppose a highly proficient bilingual speaker, raised from birth in a bilingual home, studies a third language in college and eventually learns it well. Would you expect all three languages to share a common brain network?

THINKING

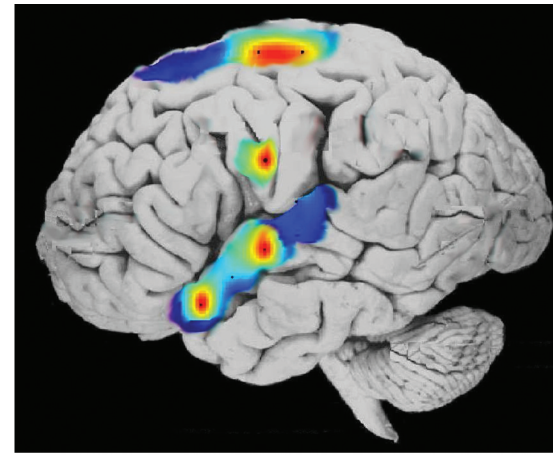
Can pure thought move mountains? Perhaps not, but it can play a video game. Without speaking a word or lifting a finger, 19-year-old Tristan Lundemo looks at a video screen and makes a red electronic cursor (similar to the paddle in the video game *Pong*) move up, down, to the left, or to the right, merely by thinking it (Paulson, 2004). In this literal mind game, Lundemo tries to move the cursor quickly enough to strike rectangular targets that pop up and then disappear from random locations on the video screen.

Thought, Brain, and Mind

Lundemo is a patient with epilepsy who agreed to participate in a brain-computer interface study while undergoing diagnostic tests at Seattle's Harborview Medical Center (Figure 9.14). During a session, researchers attach 72 electrodes to Lundemo's scalp to record his brain's electrical activity. A computer analyzes the patterns and intensity of these brain signals and uses that information to control the movement of the cursor on the video screen. It's not that simple, however, as computer and human have to adapt to each other and learn the precise thought patterns that will



(a)



(b)

Figure 9.14

The power of pure thought.

(a) With electrodes attached to his scalp underneath the bandage, Tristan Lundemo uses his thoughts to control the movement of a cursor on a video screen. (b) Various brain regions become active when Lundemo moves the cursor in a particular direction.

make the cursor move. Lundemo is a fast study (as is the computer); he masters the task in two days. Electric mind over electronic matter.

Figure 9.14b shows that several brain regions become most active when Lundemo's thought moves the cursor in a particular direction. The pattern of brain activity changes when he has a thought that moves the cursor in a different direction. Researchers hope that this technology eventually will improve the lives of people who have lost limbs or are paralyzed.

Recall from Chapter 6 that according to some neuroscientists, conscious thought arises from the unified activity of different brain areas. In essence, of the many brain regions and circuits that are active at any instant, a particular subset joins in unified activity that is strong enough to become a conscious thought or perception (Koch, 2004). The specific brain activity pattern that composes this dominant subset varies from moment to moment as we experience different thoughts and respond to changing stimuli. Even altering one's thought from "move up" to "move down" produces a different pattern of brain activity. Although we're still far from understanding exactly how the brain produces thought, from a biological level of analysis, thought exists as patterns of neural activity.

Subjectively, at the psychological level, thinking may seem to be the internal language of the mind—akin to "inner speech"—but it actually includes several mental activities. One mode of thought indeed takes the form of verbal statements that we "say in our minds." This is called **propositional thought** *because it expresses a proposition, or statement,* such as "I'm hungry" or "It's almost time for dinner." Another thought mode, **imaginal thought,** *consists of images that we can see, hear, or feel in our mind*. A third mode, **motoric thought,** *relates to mental representations of motor movements*, such as throwing an object. In this chapter, we'll focus on propositional and imaginal thought.

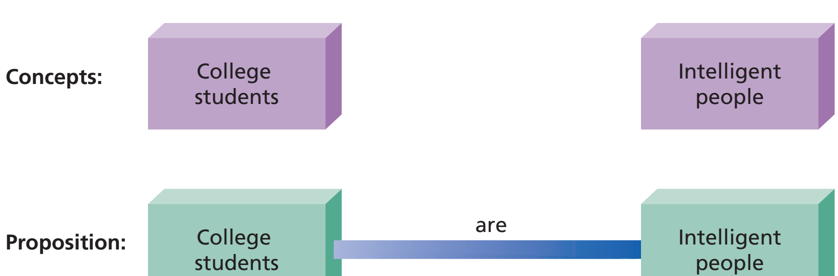


Figure 9.15

Concepts are building blocks of thinking and reasoning.

Concepts can be combined into propositions to create simple and complex thoughts, and the propositions can serve as the basis for reasoning and discourse.

Concepts and Propositions

Much of our thinking occurs in the form of **propositions,** *statements that express ideas*. All propositions consist of concepts combined in a particular way. For example, "college students are intelligent people" is a proposition in which the concepts "college students" and "intelligent people" are linked by the verb *are* (Figure 9.15). **Concepts** *are basic units of semantic memory—mental categories into which we place objects, activities, abstractions* (such as "liberal" and "conservative"), *and events that have essential features in common*. Concepts can be acquired through explicit instruction or through our own observations of similarities and differences among various objects and events.

Many concepts are difficult to define explicitly. For example, although you might have difficulty defining what a vegetable is, you can quickly think of examples of vegetables, such as broccoli or carrots. According to Eleanor Rosch (1977), many concepts are defined by **prototypes,** *the most typical and familiar members of a category or class*. Rosch suggests that we often decide which category something belongs to by its degree of resemblance to the prototype.

Consider the following questions:

Is an eagle a bird?

Is a penguin a bird?

Is a bat a bird?

According to the prototype view, you should have come to a quicker decision on the first question than on the last two. Why? Because an eagle fits most people's "bird" prototype better than does a penguin (which is a bird, but cannot fly) or a bat (which is not a bird, but can fly). Experiments measuring how quickly participants responded yes or no to the preceding questions have found that it does indeed take most people longer to decide whether penguins or bats are birds (Rips, 1997).

Using prototypes is an elementary method of forming concepts. It requires only that we note similarities among objects. Thus children's early concepts are based on prototypes of the objects and people they encounter personally. They then decide if new objects are similar enough to the prototype to be a "Mommy," a "cookie," a "doggie," and so on (Smith & Zarate, 1992).

Reasoning

Reasoning is one aspect of intelligent thinking. It helps us acquire knowledge, make sound decisions, solve problems, and avoid the hazards and time-consuming efforts of trial and error. For example, people often solve problems by developing solutions in their minds before applying them in the external world.

Deductive Reasoning

Two types of reasoning underlie many of our attempts to make decisions and solve problems (Figure 9.16). In **deductive reasoning,** *we reason from the top down, that is, from general principles to a conclusion about a specific case*. When people reason deductively, they begin with a set of *premises* (propositions assumed to be true) and determine what the premises imply about a specific situation. Deductive reasoning is the basis of formal mathematics and logic. Logicians regard it as the strongest and most valid form of reasoning because the conclusion *cannot be false* if the premises (factual statements) are true. More formally, the underlying deductive principle may be stated: given the general proposition "if X then Y," if X occurs, then you can infer Y. Thus, to use a classic deductive argument, or *syllogism,*

If all humans are mortal (first premise), and

if Socrates is a human (second premise),

then Socrates must be mortal (conclusion).

Inductive Reasoning

In **inductive reasoning,** *we reason from the bottom up, starting with specific facts and trying to develop a general principle.* Scientists use induction when they observe specific instances of a phenomenon and then form a general principle. After Ivan Pavlov observed repeatedly that the dogs in his laboratory began to salivate when approached by the experimenter who fed them, he began to think in terms of a general principle that eventually became the foundation of classical conditioning (repeated conditioned stimulus–unconditioned stimulus pairings produce a conditioned response).

A key difference between deductive and inductive reasoning lies in the certainty of the results. Deductive conclusions are certain to be true *if* the premises are true, but inductive reasoning leads to likelihood rather than certainty. Even if we reason inductively in a flawless manner, the possibility of error always remains because some

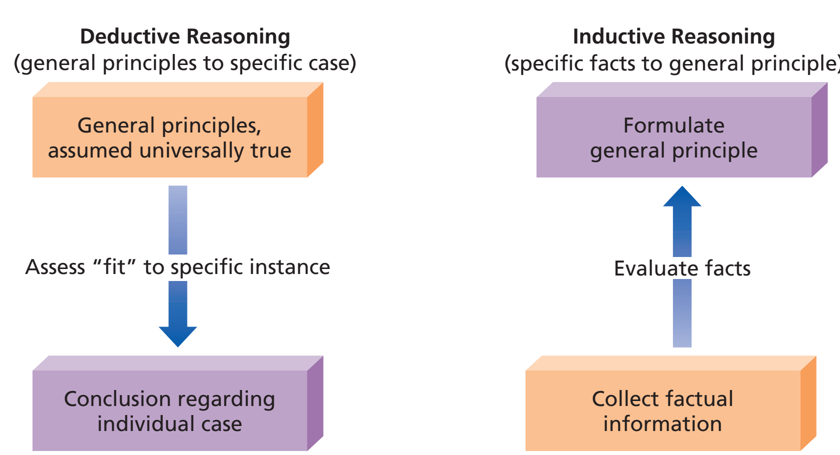


Figure 9.16

A comparison of deductive and inductive reasoning.

new observation may disprove our conclusion. Thus you may observe that every person named Jordan you have ever met has blue eyes, but it would obviously be inaccurate to reason that, therefore, all people named Jordan have blue eyes.

In daily life and in science, inductive and deductive reasoning may be used at different points in problem solving and decision making. For example, suppose you're ill and describe your symptoms to a physician. Based on specific facts from your description and an initial examination, the doctor uses inductive reasoning to formulate a tentative, general conclusion: "you have disease X." Of course, this inductive conclusion could be wrong. So, using deductive reasoning, the doctor may run further medical tests: "if you have disease X, then medical tests A and B should come back positive." If the test results don't come back positive, then the physician has to reconsider the diagnosis. Likewise, scientists use specific facts and findings to develop general explanations (e.g., theories). This represents inductive reasoning. Then they use those general explanations to derive new, specific predictions (e.g., hypotheses). This is deductive reasoning. If new research fails to support those predictions, then scientists—like the physician—need to reconsider the validity of their general explanations.

Stumbling Blocks in Reasoning

The ability to reason effectively is a key factor in critical thinking, making sound decisions, and solving problems. Unfortunately, several factors may impair effective reasoning.

Distraction by Irrelevant Information Distinguishing relevant from irrelevant information can be challenging. Consider the following problem. As you solve it, analyze the mental steps you take, and do not read on until you have decided on an answer.

> Your drawer contains 19 black socks and 13 blue socks. Without turning on the light, how many socks do you have to pull out of the drawer to have a matching pair?

As you solved the problem, what information entered into your reasoning? Did you take into account the fact that there were 19 black socks and 13 blue ones? If so, you're like many students who do the same thing, thereby making the problem more difficult than it should be (Sternberg, 1988). All that matters is how many *colors* of socks there are. In this case, with two colors, once you have selected any three socks, you are bound to have at least two of the same color. People often fail to solve problems because they focus on irrelevant information.

Belief Bias **Belief bias** *is the tendency to abandon logical rules in favor of our own personal beliefs*. To illustrate, consider an experiment in which college students judged whether conclusions followed logically from syllogisms like the following:

> All things that are smoked are good for one's health.
>
> Cigarettes are smoked.
>
> Therefore cigarettes are good for one's health.

What do you think? Is the logic correct? Actually, it is. If we accept (for the moment) that the premises are true, then the conclusion *does* follow logically from the premises. Yet students in one study frequently claimed that the conclusion was not logically correct because they disagreed with the first premise that all things smoked are good for one's health. In this case, their beliefs about the harmful effects of smoking got in the way of their logic. When the same syllogism was presented with a nonsense word such as *ramadians* substituted for *cigarettes*, the errors in logic were markedly reduced (Markovits & Nantel, 1989). Incidentally, we agree that the conclusion that cigarettes are good for one's health is factually false. However, it is false because the first premise is false, not because the logic is faulty. Unfortunately, many people confuse factual correctness with logical correctness. The two are not the same.

Emotions and Framing When evaluating problems or making decisions, we may abandon logical reasoning in favor of relying on our emotions—"trusting our gut"—to guide us (Slovic & Peters, 2006). Reasoning also can be affected by the particular way that information is presented to us, or "framed." **Framing** *refers to the idea that the same information, problem, or options can be structured and presented in different ways*. For example, in one classic study, college students who were told that a cancer treatment had a 50 percent success rate judged the treatment to be significantly more effective and expressed a greater willingness to have it administered to a family member than did participants who were told that the treatment had a 50 percent failure rate (Kahneman & Tversky, 1979).

Representing outcomes in terms of positives or negatives has this effect because people tend to assign greater costs to negative outcomes (such as losing $100) than they assign value to equivalent positive outcomes (finding $100). The proposition that "there is a 50 percent chance of failure" evokes thoughts about the patient's dying and causes the 50-50 treatment to appear riskier. Similarly, graphs or other visual displays can be designed to make identical information "look different" and thus influence people's judgments and decisions (Diacon & Hasseldine, 2007).

Framing can interfere with logical reasoning. This may be especially so when choices are framed to highlight potential positive or negative outcomes, thereby triggering emotions—such as fear, anger, or sadness—that may alter our perceptions of the risks associated with various choice options (Slovic & Peters, 2006). Framing also can enhance reasoning, as we'll now see.

Problem Solving and Decision Making

Humans have an unmatched ability to solve problems. Recalling the "Miracle on the Hudson," the cockpit crew's excellent problem-solving abilities enabled them to rapidly implement and execute a plan for successfully ditching U.S. Airways Flight 1549 and saving the terrified passengers' lives.

Steps in Problem Solving

In accomplishing that astonishing feat, the pilot and copilot had to rapidly gain an understanding of the problems they were facing (e.g., loss of thrust, airspeed, and altitude; too great a distance from the airport), generate solutions (e.g., maintain sufficient airspeed, restart engines, ditch the plane in the river), test those solutions (e.g., force the plane's nose downward to maintain sufficient airspeed; implement engine restart procedures), and then evaluate the results (e.g., engines won't restart; ditching successful). Problem solving typically proceeds through these four stages, and how well we carry out each stage affects our success (Figure 9.17).

Understanding, or Framing, the Problem Have you ever been totally frustrated in attempting to solve a problem, then someone suggests a new way of looking at it, and the solution suddenly becomes obvious? How we mentally *frame* a problem can make a huge difference. Consider this example (Figure 9.18):

> Train A leaves Baltimore for its 50-mile trip to Washington, D.C., at a constant speed of 25 mph. At the same time, train B leaves Washington, bound for Baltimore at the same speed of 25 mph. The world's fastest crow leaves Baltimore at the same time as train A, flying above the tracks toward Washington at a speed of 60 mph. When the crow encounters train B, it turns and flies back to train A, then instantly reverses its direction and flies back to train B. The supercharged bird continues this sequence until trains A and B meet midway between Baltimore and Washington. Try to solve this problem before reading on: what is the total distance the bird will have traveled in its excursions between trains A and B?

Many people approach this as a distance problem. That's natural, because the question is stated in terms of distance. They try to compute how far the bird will fly during each flight segment between trains A and B, sometimes filling up pages with frenzied computations. But suppose you approach the problem by asking not how far the bird will fly but *how long* it will take the trains to meet. The crow will have flown the same period of time at 60 mph. Now that you have reframed it as a time problem, the problem becomes easier to solve.

Our initial understanding of a problem is a key step toward solving it successfully. Framing a problem poorly can lead us into blind alleys and ineffective solutions. Framing it optimally gives us a chance to generate an effective solution. A knack for framing problems in effective ways that differ from conventional expectations has been called *outside-the-box thinking*.

Generating Potential Solutions Once we have interpreted the problem, we can begin to formulate potential solutions. Ideally, we might proceed in the following fashion:

1. Determine the procedures and strategies that will be considered.

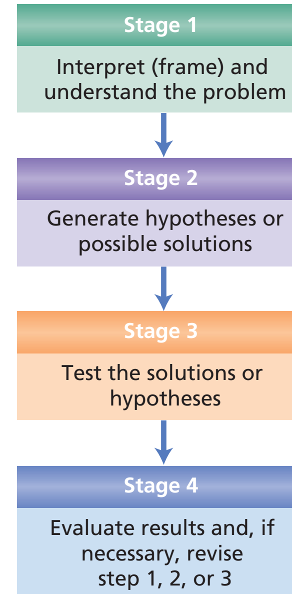


Figure 9.17

The stages of problem solving.

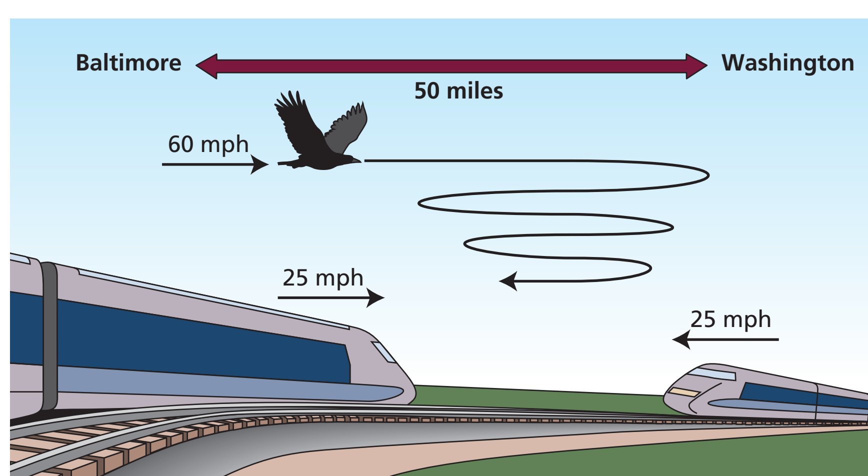
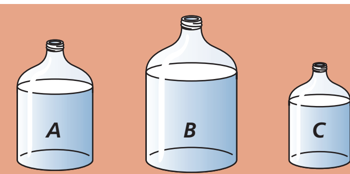


Figure 9.18

The crow-and-trains problem.
(The answer appears on page 331.)



Problem	Given jugs of these sizes A	B	C	Measure out this much water
1	21	127	3	100
2	14	46	5	22
3	18	43	10	5
4	7	42	6	23
5	20	57	4	29
6	23	49	3	20
7	15	39	3	18

Figure 9.19

Luchins's water jugs problems. Using containers A, B, and C with the capacities shown in the table, how would you measure out the volumes indicated in the right-hand column? You may discover a general problem-solving schema that fits all seven problems.

2. Determine which solutions are consistent with the evidence that has been observed thus far. Rule out any solutions that do not fit the evidence.

Testing the Solutions Consider the possible solutions that remain. If a solution requires you to choose between specific options, ask if there is any test that should give one result if one option is correct and another result if a different option is correct. If so, evaluate the options again in light of the new evidence from that test. In essence, this is what scientists do when they gather evidence.

Let's consider a common difficulty in discovering and applying solutions to problems. Consider problem 1 in Figure 9.19:

> You have a 21-cup jug, a 127-cup jug, and a 3-cup jug. Drawing and discarding as much water as you like, how will you measure out exactly 100 cups of water?

Try to solve all seven problems in Figure 9.19 in order, and write down your calculations for each one before reading on. Does a common solution emerge? If so, can you specify what it is?

As you worked the problems, you probably discovered that they are all solvable by the same formula, namely, $B - A - (2 \times C) =$ desired amount. In problem 1, for example, $127 - 21 - (2 \times 3) = 100$. If you discovered this, it gave you a logical formula that you could apply to the rest of the problems. And it worked, didn't it? However, by applying this successful formula to problems 6 and 7, you may have missed even easier solutions for these last two problems, namely, $A - C$ for problem 6 and $A + C$ for problem 7.

Abraham Luchins (1942) developed the water jugs problems to demonstrate how a **mental set**—*the tendency to stick to solutions that have worked in the past*—can result in less effective problem solving. Luchins found that most people who worked on problems 6 and 7 were blinded by the mental set they had developed by working the first five problems. In contrast, people who had not worked on problems 1 through 5 almost always applied the simple solutions to problems 6 and 7. Sometimes, reliance on problem-solving concepts or solutions that have worked in the past can prevent us from exploring or recognizing solutions that are even better (Bilalić et al., 2008).

Evaluating Results The final stage of problem solving is to evaluate the solutions. As we saw in the water jugs problems, even solutions that prove successful may not be the easiest or the best. Thus, after solving a problem, we should ask ourselves, "Would there have been an easier or more effective way to accomplish the same objective?" This can lead to the development of additional problem-solving principles that may be applicable to future problems.

Algorithms and Heuristics

Algorithms and *heuristics* are two broad approaches to solving problems. **Algorithms** *are formulas or precise sequences of procedures that automatically generate solutions* (Beilock & DeCaro, 2007). Mathematical formulas are algorithms, and if you use them properly, you will always get the correct answer. Consider another example, which illustrates a "brute force" algorithm. If the letters of a word are randomly scrambled to produce an anagram like *kabr,* we can always identify the word by rearranging the four letters in all 24 possible orders. Likewise, this algorithm will guarantee success with an eight-letter scrambled word, such as *rtyleibr*, but because there are 40,320 possible orders, using the "all possible orders" algorithm in this situation would be inefficient. Instead, you might use some rule-of-thumb strategy, such as trying out only consonants in the first and last positions, because you know that more words begin and end in consonants than in vowels. When we adopt rule-of-thumb approaches like this, we are using heuristics.

Heuristics *are general problem-solving strategies, similar to mental rules-of-thumb, that we apply to certain classes of situations*. One common heuristic, **means-ends analysis,** *involves identifying differences between the present situation and a desired goal, and then making changes that reduce these differences* (MacGregor & Omerand, 2001; Newell & Simon, 1972). Suppose that you have a 30-page paper due at the end of the term and have not begun working on it yet. The present situation is no pages written; the desired end goal is a 30-page paper. What, specifically, needs to be done to reduce that discrepancy, and how are you going to do it?

To answer these questions, you could use another heuristic called **subgoal analysis:** *formulating subgoals, or intermediate steps, toward a solution* (Houser-Marko & Sheldon, 2008). You would break down the task of writing a paper into subgoals, such as (1) choosing a topic, (2) doing library and Internet research to get the facts you need, (3) organizing the facts within a general outline of the paper, (4) writing a first draft of specific sections, (5) reorganizing and refining the first draft, and so on. In so doing, a huge task becomes a series of smaller and more manageable tasks, each with a subgoal that leads you toward the ultimate goal of a quality 30-page paper.

The Tower-of-Hanoi problem, explained in Figure 9.20, illustrates the value of setting subgoals. The first subgoal is to get ring C to the bottom of peg 3. The second subgoal is to get ring B over to peg 3. With these subgoals accomplished, the final subgoal of getting ring A to peg 3 is easy.

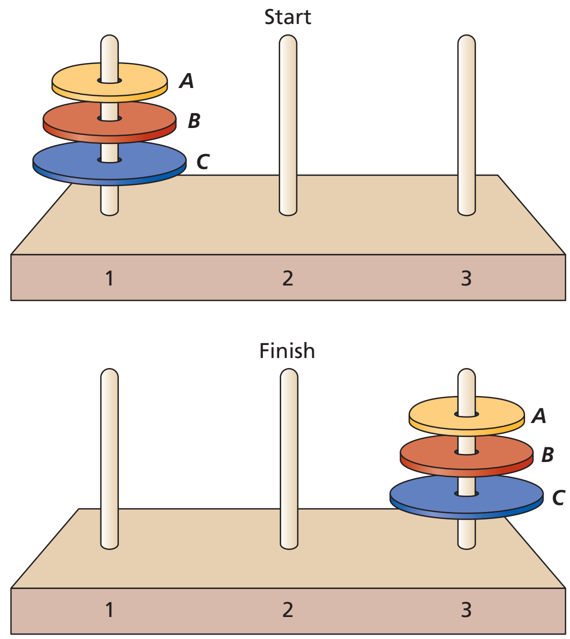


Figure 9.20

The Tower-of-Hanoi problem. The object is to move the rings one at a time from peg 1 to peg 3 in no more than seven moves. Only the top ring on a peg can be moved, and a larger ring can never be placed on top of a smaller one. (The answer appears on page 331.)

Uncertainty, Heuristics, and Decision Making

We use heuristics not only to solve problems but also to make a wide range of judgments and decisions, from judgments about our own health to decisions about purchases (Katapodi et al., 2005). In everyday life, our judgments and decisions typically involve outcome uncertainty. Often, the best we can hope for is that they will yield a high probability of a positive outcome. But because we seldom know what the exact probabilities are (for example, that a college course will be interesting or that a new dating relationship will become permanent), we often apply heuristics to form judgments about the likelihood of particular events or outcomes. Such heuristics often serve us very well, but they can also contribute to errors in judgment (Kahneman & Klein, 2009).

Many of our judgments and decisions focus on what other people are like. Suppose you receive the following description of a young woman:

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and she also participated in antinuclear demonstrations.

Now rate the likelihood that each of the following hypotheses is true. Use 1 to indicate the most likely statement, 8 to indicate the least likely statement, and any number between 2 and 7 to rate the likelihood of the second most likely statement.

__ Hypothesis A: Linda is active in the feminist movement.

__ Hypothesis B: Linda is a bank teller.

__ Hypothesis C: Linda is active in the feminist movement and is a bank teller.

Cognitive psychologists Amos Tversky and Daniel Kahneman (1982) used this problem in a series of classic experiments that studied the role of heuristics in judgment and decision making. They showed that certain heuristics underlie much of our inductive decision making (drawing conclusions from facts) and that misusing these heuristics results in many of our thinking errors. Let us examine how that occurs.

The Representativeness Heuristic "Will this be a good or bad course?" "Is this person nice or strange, geeky or cool?" Tversky, Kahneman, and their colleagues proposed that one way we judge the likelihood of something is by using the **representativeness heuristic:** *we think about how closely something fits our prototype for that particular concept, or class, and therefore how likely it is to be a member of that class* (Kahneman & Frederick, 2005; Tversky & Kahneman, 1982). In Linda's case, we ask "How closely does her description fit the prototype of a 'feminist' and of a 'bank teller'?" This is a reasonable question to ask, but sometimes our use of representativeness can cause us to make decisions that fly in the face of logic.

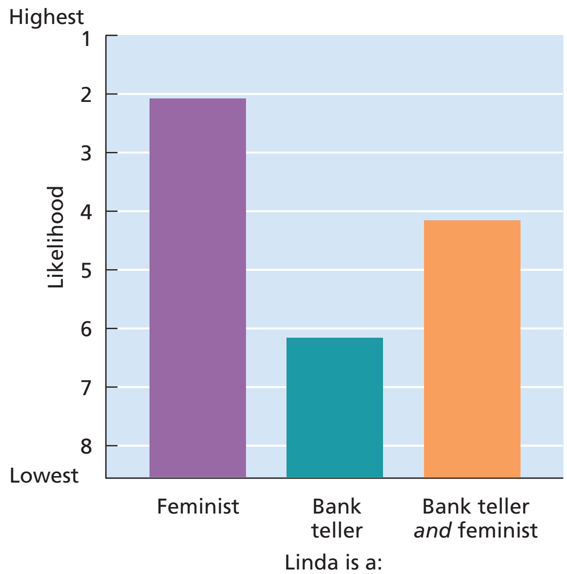


Figure 9.21

Illogical judgments.

This graph shows the mean likelihood judgments made by participants on the basis of the description of Linda (top left column). Overall, people judge it to be more likely that Linda is a bank teller and a feminist rather than just a bank teller. Logically, this is impossible.
SOURCE: Based on Tversky & Kahneman, 1982.

How did you order the three likelihood hypotheses? Figure 9.21 shows the mean likelihood estimates that college students attached to each statement. First, hypothesis A (Linda is a feminist) is rated as most likely. This is not surprising; the description does make her sound like a feminist. Second, the significant finding is that hypothesis C (Linda is a feminist bank teller) was favored over hypothesis B (Linda is a bank teller). But this cannot possibly be correct. Why not? Because (1) everyone who is both a feminist and a bank teller is also *simply* a bank teller, and (2) there are many bank tellers who are not feminists, and Linda could be one of them. Stated differently, any individual person is more likely to be simply a bank teller than to be a bank teller *and* a feminist—or, for that matter, a bank teller and anything else. People who say that hypothesis C is more likely than hypothesis B (and about 85 percent of people given this problem do so) violate the logical principle that the intersection of two events (e.g., at an ice cream parlor, the ice cream a customer orders is vanilla and is served on a cone) cannot be more likely than either event alone (the ice cream is vanilla; the ice cream is served on a cone). We equate the likelihood of something with how well it fits our prototype for that particular concept.

Tversky and Kahneman (1982) proposed that the reason people make this sort of error is that they confuse representativeness with probability. Linda represents our prototype for a feminist bank teller better than she fits our prototype for a bank teller. Therefore, we erroneously think the former is more likely than the latter. In other words, if Linda is to be a bank teller at all, we think she must be a feminist bank teller.

The Availability Heuristic Another heuristic that sometimes leads us astray is the **availability heuristic,** *in which people base judgments and decisions on how easily information is available in memory*. We tend to remember events that are most important and significant to us. Usually that principle serves us well, keeping important information at the forefront in our memories, ready to be applied. But if something easily comes to mind, we may exaggerate the likelihood that it could occur. For example, consider each of the following pairs and choose the more likely cause of death:

- murder or suicide?
- botulism or lightning?
- asthma or tornadoes?

When Paul Slovic and coworkers (1988) asked people to make these judgments, 80 percent chose murder over suicide as the more likely cause of death, 63 percent chose botulism over lightning, and 43 percent chose tornadoes over asthma. In actuality, public health statistics showed that people were 25 percent less likely to be murdered than to kill themselves, that lightning killed 53 times more people than botulism did, and that death by asthma was 21 times more likely than death as a result of a tornado. Yet murder, botulism, and tornadoes are more highly and dramatically publicized when they do occur and thus are more likely to come to mind.

Recent memorable events can increase people's belief that they may suffer a similar fate. After the terrorist hijackings of September 11, 2001, airline bookings and tourism declined dramatically within the United States for a significant period. Similarly, in the summer of 1975, when Steven Spielberg's movie *Jaws* burned into people's memories graphic images of a great white shark devouring swimmers at a New England seaside town, beach attendance all over the country decreased. The images available in memory—even though the movie was clearly fiction—increased people's perceived likelihood that they, too, could become shark bait.

Thus at times the representativeness and availability heuristics can lead us astray by distorting our estimates of how likely an event really is. In other words, they can blind us to the *base rates*, or actual frequencies, at which things occur.

In general, it's always best to find out what the actual probabilities are and make judgments on that basis; that's the strategy that allows insurance companies to flourish.

The availability heuristic also can influence the judgments we make about our own qualities. Suppose we ask you to recall two instances in which you behaved assertively; then we ask you to rate how assertive a person you are. Now imagine that we had asked you instead to recall eight such instances, rather than only two, and then rate your assertiveness. You might expect that thinking of eight instances when you behaved assertively would lead you to rate yourself as more assertive. After all, it's a larger amount of evidence. But when psychologist Eugene Caruso (2008) conducted such an experiment, the randomly assigned students who were asked to recall only two assertive instances rated themselves as significantly more assertive than students who were asked to recall eight instances. Why? Coming up with two assertive instances is an easier task (and was rated as easier by the students) than having to recall eight instances, and "Hey, if it was easy for me to think of examples when I was assertive, then it must be because I'm a relatively assertive person."

Confirmation Bias and Overconfidence

When we test a solution, idea, or hypothesis, what's the best type of evidence to gather? Here is a principle that may seem puzzling to you (it harkens back to the concept of *falsifiability* that we discussed in Chapter 2): the best thing we can do to test our ideas is to seek evidence that will *disconfirm* them, rather than only look for evidence that confirms them. Why? Disconfirming evidence has the potential to conclusively prove that our idea *cannot* be true in its current form. For example, consider the hypothesis "If a person waits until adulthood to start learning a second language, it will be impossible to achieve full native fluency." Because this statement is expressed in absolute terms, it could be proven untrue by finding people who became bilingual in adulthood and speak both languages with native fluency.

In contrast, confirming evidence doesn't establish absolute certainty. Even if we study 1 million adult bilingual learners and find that none speaks a second language with native fluency, we have obtained evidence that *supports* our hypothesis but doesn't *prove* it. Why doesn't this provide absolute proof? Because it is always possible that future studies may find adult bilingual learners who speak both languages with native fluency.

Following this disconfirmation principle is easier said than done, because people are often unwilling to challenge their cherished beliefs. Instead, they are prone to fall into a trap called **confirmation bias,** *tending to look for evidence that will confirm what they currently believe rather than looking for evidence that could disconfirm their beliefs* (Hart et al., 2009). Often, when people have strong beliefs about something, they are very selective in the kinds of information they expose themselves to. They seek out like-minded people, compatible mass media sources and Internet sites, and recall information that confirms their beliefs. Because they find it difficult to test and challenge their ideas, particularly those to which they are strongly committed, they often fail to get the evidence needed to make a correct decision.

Confirmation bias can contribute to **overconfidence,** *the tendency to overestimate one's correctness in factual knowledge, beliefs, and decisions*. Overconfidence, like confirmation bias, is widespread. In one study, college students were asked at the beginning of the academic year to make predictions about how likely it was (from 0 percent to 100 percent) that they would experience various personal events, such as dropping a course, breaking up with a romantic partner, or joining a fraternity or sorority. They also indicated how confident they were—how likely it was that they would be correct. Then, at the end of the academic year, they indicated which events had in fact occurred. Figure 9.22, shows that, overall, students' confidence exceeded their accuracy, and this overconfidence was equally great when the students were 100 percent sure of their predictions (Vallone et al., 1990). Studies of investment and business professionals, military strategists, weather forecasters, novice drivers, and other populations have found overconfidence effects (McKenzie et al., 2008; Mynttinen et al., 2009).

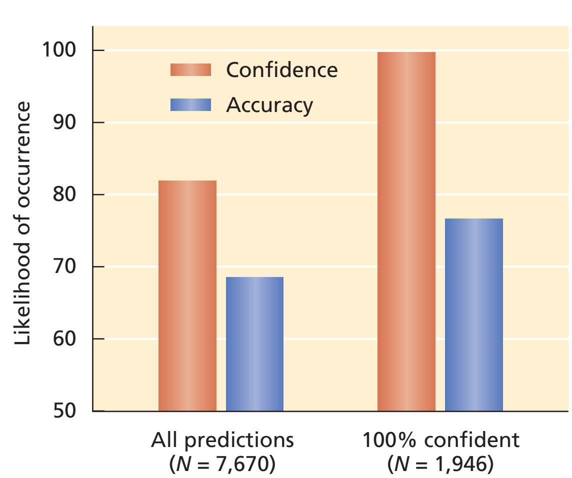


Figure 9.22

Displaying overconfidence. Overconfidence is illustrated in the discrepancy between the accuracy with which students predicted that specific events would occur to them during the coming academic year and the degree of confidence that they had in their predictions. Overall, accuracy was considerably lower than confidence level, even for those events for which the students expressed complete certainty. SOURCE: Based on Vallone et al., 1990.

Overconfidence and confirmation bias can be potent adversaries in our search for correct predictions and decisions. When we're confident in the correctness of our views and reluctant to seek evidence that could prove them wrong, we can easily be blinded to the truth or to better and sometimes more creative ways of solving problems. Our "Applying Psychological Science" feature discusses some aspects of creative problem solving.

Applying Psychological Science

Guidelines for Creative Problem Solving

Creativity *is the ability to produce something that is both new and valuable* (Sternberg, 2006b). The product may be virtually anything, from a creative painting to a novel approach to solving a problem. Here, we'll be concerned with creative problem solving.

Research on reasoning offers insights into how effective and creative problem solvers think and how they approach problems. One component of creativity is the ability to break away from conventional approaches when the occasion demands it and to engage in **divergent thinking,** *the generation of novel ideas that depart from the norm* (Guilford, 1959; Silvia et al., 2009). In part, this means being able to apply concepts or propositions from one domain to another unrelated domain in a manner that produces a new insight. It also means refusing to be constrained by traditional approaches to a problem (Sternberg, 2006b). Creative people are, in this respect, intellectual rebels. The constraints created by the tried-and-true can be difficult to overcome.

Consider, for example, the nine-dot problem in Figure 9.23. Many people have difficulty solving this problem. Did you? If so, it may be because you imposed a traditional but unnecessary constraint on yourself and tried to stay within the boundary formed by the dots. But nothing in the statement of the problem forced you to do so. To solve the problem, try thinking outside the box.

Creative problem solvers are often able to ask themselves questions like the following to stimulate divergent thinking (Simonton, 1999):

- What would work instead?
- Are there new ways to use this? How else could it be used if I modified it in some way? By adding, subtracting, or rearranging parts, or by modifying the sequence in which things are done, could I make it more useful?

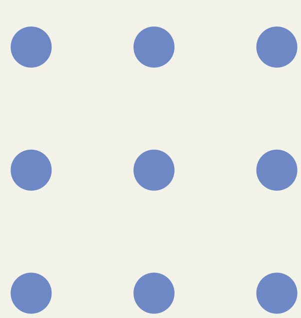


Figure 9.23

The nine-dot problem.
Without lifting your pencil from the paper, draw no more than four straight lines that will pass through all nine dots. (The answer appears on page 331.)

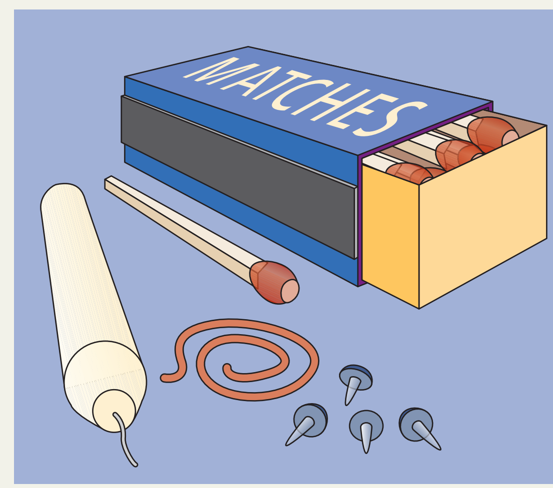


Figure 9.24

The candlestick problem.
Using these objects, find a way to mount the candle on a wall so it functions like a lamp. (The answer appears on page 331.)

- Do the elements remind me of anything else? What else is like this?

Use some of these questions when trying to solve the candlestick problem illustrated in Figure 9.24.

Solving the problem requires using some of the objects in unconventional ways. Many people, however, are prevented from doing so because of **functional fixedness,** *the tendency to be so fixed in their perception of the proper function of an object or procedure that they are blinded to new ways of using it.*

Sometimes creative solutions to problems seemingly appear out of the blue, suddenly popping into our mind in a flash of insight after we have temporarily given up and put the problem aside. This phenomenon is called **incubation:** *processing a problem, presumably at a subconscious level, while doing some other activity*. Experiments on incubation suggest that sometimes the best approach when we are stymied by a problem is indeed to put it aside for a while, focus on something else, and gain some psychological distance from it (Beeftink et al., 2008; Ellwood et al., 2009).

As you can see, creative problem solving involves many of the principles discussed earlier in the chapter. We see the operation of means-ends reasoning, the testing of hypotheses, and the need to overcome biases that may cause us to overestimate or underestimate the likelihood of certain outcomes. Here are some other general problem-solving guidelines:

1. When you encounter a new problem, ask yourself if it's similar to problems you've previously solved. Maybe the solution for solving a problem with similar features can be modified to solve this one. Take advantage of the storehouse of knowledge in long-term memory.
2. Make a true effort to test your ideas. Try to find evidence that would disconfirm your ideas, not only evidence that would confirm what you already believe. For example, if you are asked to accept statement X as true, see if you can imagine situations in which X would be false. Beware of the human tendency toward confirmation bias.
3. Make use of the means-ends problem-solving heuristic. Ask yourself what you are trying to accomplish, what the present state of affairs is, and what means you have for reducing the discrepancy.
4. Don't be afraid to use pencil and paper. Orderly notes and schematics can substitute for our rather limited working memory and allow us to have more information at hand to work with.

test yourself **Reasoning, Problem Solving, and Decision Making**

Match each numbered concept to the correct definition on the right.

1. inductive reasoning	a. looking for evidence that supports rather than contradicts one's views
2. deductive reasoning	b. structuring or presenting the same information in different ways
3. confirmation bias	c. using specific facts to come up with a general principle
4. availability heuristic	d. information that's easily recalled disproportionately affects our judgments
5. framing	e. using a general principle to draw conclusions about a specific case
6. belief bias	f. relying on personal opinions rather than logical reasoning

ANSWERS: 1-c, 2-e, 3-a, 4-d, 5-b, 6-f

Knowledge, Expertise, and Wisdom

Each culture passes down knowledge from one generation to the next. This vast library of knowledge, combined with other learning experiences, forms the foundation for expertise and wisdom and supports the reasoning, decision-making, and problem-solving skills that we have been discussing in this chapter.

Acquiring Knowledge: Schemas and Scripts

One way to think about knowledge acquisition is as a process of building schemas. Most broadly, a **schema** *is a mental framework, an organized pattern of thought about some aspect of the world*. Concepts and categories represent types of schemas, and together they help you build a mental framework of your world, such as "interesting versus dull people" or "easy versus hard exams." Algorithms and heuristics also are types of schemas that provide you with mental frameworks for solving certain types of problems.

Another type of schema, called a **script,** *is a mental framework concerning a sequence of events that usually unfolds in a regular, almost standardized order*. For example, if we tell you that "John and Linda went to the movies," these mere seven words convey a lot of information because "going to the movies" is a fairly standardized (i.e., scripted) activity. You can reasonably assume that John and Linda got to the theater, waited in the ticket line and bought tickets (or bought them online), entered the theater where someone checked their tickets, bought a snack, found seats, and so on. The scripts that you learn—"attending class," "shopping," "driving," and so on—provide knowledge


(a)


(b)

Figure 9.25

(a) Chess master Gary Kasparov developed chess schemas that made him a worthy opponent for even the most sophisticated computers, including IBM's Deep Blue.
(b) Experienced snowboarders and skiers learn schemas for various types of snow, and the discriminations made possible by these schemas can affect planning and decision making. This boarder might approach a slope covered with "powder" differently than one covered with "corn" or "hardpack" because of their different effects on the board and potentially on the boarder's safety.

to guide and interpret actions. In sum, your knowledge grows as you acquire new scripts, concepts, and other types of schemas; as your existing schemas become more complex; and as you form connections between schemas.

The Nature of Expertise

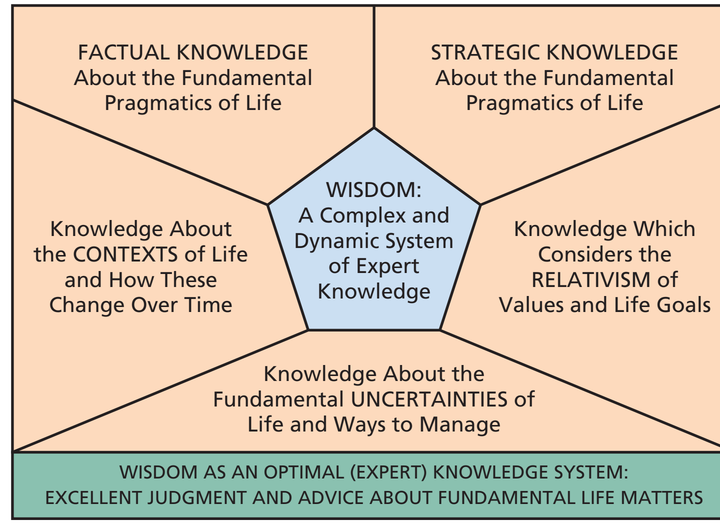
Schemas help explain what it means to be an expert (Bilalić et al., 2008). Masters and grand masters in chess can glance at a chessboard and quickly plan strategies in the heat of competition. The world's best players can remember as many as 50,000 board configurations, including the locations of individual pieces (Chase & Simon, 1973). For years, world chess champion Gary Kasparov's sophisticated schemas enabled him to regularly defeat chess-playing computers that used logical rules, even those capable of logically analyzing up to 100,000 moves per second. It took Deep Blue, a 1.4-ton behemoth capable of calculating at a rate of 200 million positions and 200,000 moves per second, to finally defeat the schemas within Kasparov's 3-pound brain (Figure 9.25a).

Recall that when U.S. Airways Flight 1549 hit a flock of Canada geese shortly after takeoff and lost thrust in both engines, Captain Sullenberger rapidly had to make several critical decisions. This included the decision not to follow the procedure of letting the first officer pilot the plane while the captain monitors the situation. He also decided within 35 seconds of the collision to ditch the plane in the Hudson River rather than attempt an airport landing. Asked by an aviation magazine editor whether he was "calculating the distance" the plane could glide, Sullenberger replied, "It wasn't so much calculating as it was being acutely aware, based upon our energy state and by visually assessing the situation, of what was and what was not possible. There are several ways I used my experience to do that" (Shiner, 2009, para. 15). Sullenberger also was able to instantly draw upon procedural schemas—scripts—to peform the difficult task of pushing the crippled jetliner's nose downward just enough to maintain optimal airspeed and control of plane.

Whether in aviation, chess, sports, medicine, science, or other fields, experts have developed many schemas to guide problem solving in their fields, and they are better than novices at recognizing when a schema should or should not be applied (Figure 9.25b; Montgomery et al., 2005). Further, as you learned in Chapter 8, schemas reside in long-term memory. Because experts rely on learned schemas, they take advantage of their spacious long-term memory. They can quickly analyze a problem deductively, pull the appropriate schema from memory, and apply the schema to solve the problem at hand (Horn & Masunaga, 2000). In contrast, novices who haven't yet learned specialized schemas must use general problem-solving methods that often tax working memory, the space-limited blackboard of the mind.

When people develop expertise, their brain functioning changes in ways that increase processing efficiency. This occurs even in animals. Thus, as macaque monkeys in one study became experts in categorizing objects, brain recordings revealed quicker and stronger activity in the specific neurons that responded to the important features used to categorize the stimuli (Sigala & Logothetis, 2002). Of course, efficient processing and expertise don't always guarantee an optimal decision or solution to a problem. Sometimes the schemas experts use may generate a good solution but inhibit further exploration of potentially better solutions (Bilalić et al., 2008). At other times, experts' reliance on familiar schemas to simplify a situation may lead to a poor or outright "wrong" decision (Kahneman & Klein, 2009).

(a)



(b)

Figure 9.26

Wisdom.
(a) Among the Inuit of the Canadian Arctic, wisdom involves extensive cultural knowledge, involvement in community life, and teaching young people about cultural values. (b) Components of wisdom. SOURCE: Baltes & Smith, 2008.

What Is Wisdom?

Anthropologist Peter Collings (2001) notes that, as in many cultures, the Inuit living in the Arctic of western Canada accord their elders special status and great respect (Figure 9.26). Young and old Inuit alike regard wisdom as a key component of aging successfully. To them, wisdom reflects "the individual's function as a repository of cultural knowledge and his or her involvement in community life by interacting with younger people and talking to them, teaching them about 'traditional' cultural values" (p. 146).

Does the Inuit conception of wisdom coincide with yours? If not, how would you define wisdom? To German psychologist Paul Baltes and his colleagues, **wisdom** *is a system of rich, expert knowledge about fundamental matters of life* (Baltes & Smith, 2008). After examining many cultural, historical, philosophical, religious, and psychological views of wisdom, they concluded that wisdom has five major components:

1. *Factual knowledge about life*, including knowledge about human nature, social relationships, and major life events
2. *Strategic knowledge about life*, including strategies for making decisions, handling conflict, and giving advice
3. *Knowledge about life-span contexts,* including awareness that life involves many contexts, such as family, friends, work, and leisure
4. *Knowledge of the relativism of values and goals,* including awareness that values and goals differ across people and societies
5. *Knowledge about life's uncertainties and how to manage them,* including awareness that the future cannot be fully known (see Figure 9.26)

Although this model links wisdom to expertise, realize that wisdom encompasses a breadth of expertise about life that goes well beyond being an expert in just one or a few areas. These combined qualities of extraordinary scope and truly superior knowledge and judgment make true wisdom hard to achieve (Baltes & Smith, 2008).

Metacognition: Knowing Your Own Cognitive Abilities

Have you ever had a friend or classmate say to you after an exam, "I don't understand why I got this question wrong" or "I don't understand how I got such a low grade—I thought I really knew this stuff"? Have you ever felt that way?

Recognizing What You Do and Don't Know

To cognitive psychologists, the term **metacognition** *refers to your awareness and understanding of your own cognitive abilities.* For example, *comprehension* has to do with understanding something, such as a concept that you just read about. You may *think* you understand the concept, but in actuality you may or may not understand it. Metacognition has to do with truly knowing whether you do or do not understand the concept. The particular component of metacognition that we're discussing in this case is *metacomprehension*. In other words, people who display good metacomprehension are accurate in judging what they do or don't know, whereas people with poor metacomprehension have difficulty judging what they actually do and don't understand. They may typically think they understand things that, in fact, they don't, or they may often think they don't understand things that they actually do.

Metacomprehension is only one aspect of metacognition. Another component, called *metamemory*, represents your awareness and knowledge of your memory capabilities. For example, suppose that you try to memorize a list of definitions or facts. Your ability to accurately judge how well you will be able to remember those items for an upcoming test reflects one aspect of metamemory. Unfortunately, some students may overestimate their ability to recall material in the future due to a belief that "if I can recall an item now, then I've learned it and don't need additional practice" (Karpicke, 2009).

As a student, your ability to effectively monitor what you do and don't know is an important ingredient in studying efficiently (Koriat & Bjork, 2005). Some students excel at this. Unfortunately, many studies have found that when it comes to reading text material, students overall are only mildly to moderately accurate in judging how well they understand what they are reading. Our "Research Close-up" examines one technique for improving students' metacomprehension.

Research Close-up

"Why Did I Get That Wrong?" Improving College Students' Awareness of Whether They Understand Text Material

Source: Keith W. Theide and Mary C. M. Anderson (2003). Summarizing can improve metacomprehension accuracy. *Contemporary Educational Psychology, 28,* 129–160.

INTRODUCTION

According to psychologists Keith Theide and Mary Anderson, this study is the first to examine whether students' metacomprehension for text material can be enhanced by requiring them to write summaries of that material. Theide and Anderson hypothesized that students who write delayed summaries of passages of text material will show better metacomprehension than students who write immediate summaries or no summaries. Presumably, the task of writing delayed rather than immediate summaries taps more powerfully into students' long-term memory and provides them with a better opportunity to assess whether they truly understand what they have read.

METHOD

Ethnically diverse samples of 75 and 90 college students taking introductory psychology participated, respectively, in Experiment 1 and Experiment 2. The students in each experiment read six passages of text material, with each passage focusing on a different topic (e.g., black holes, global warming, genetics, intelligence, Norse settlements). In Experiment 1, the passages were each about 220 words long, whereas in Experiment 2 they were much longer (1,100 to 1,600 words) and more similar in style to material presented in textbooks.

Students in each experiment were randomly assigned to one of three groups. In the no-summary group (control group), they read all six passages and then rated their comprehension of each passage ("How well do you think you understood the passage?") on a scale ranging from 1 ("very poorly") to 7 ("very well"). In the immediate-summary group, students summarized each passage immediately after they read it and then, after finishing all six summaries, rated

RESEARCH DESIGN (Experiments 1 and 2)

Question: Will writing summaries of text material that they have read improve college students' metacomprehension?

Type of Study: *Experimental*

Independent Variable

Writing summaries of text material (random assignment to no-summary, immediate-summary, or delayed-summary groups)

→

Dependent Variables

- Actual comprehension
- Students' perceived comprehension
- Metacomprehension accuracy (degree of association between actual and perceived comprehension)

their comprehension of each one. In the delayed-summary group, students read all six passages before summarizing each one and then rating their comprehension of each passage.

All students, after rating their comprehension, took a multiple-choice comprehension test for each passage that included both factual and conceptual questions. These tests enabled Theide and Anderson to measure how well students' *beliefs* about their comprehension (measured by the rating scales) correlated with their actual comprehension (measured by their test scores). The research design is summarized in the graphic on the preceding page.

RESULTS

The critical finding in both experiments was that students in the delayed-summary group were much more accurate than the other students in judging whether they knew or didn't know the material (Figure 9.27). In contrast, the three groups did not differ overall in their comprehension ratings or in their test performance. In other words, students in the delayed-summary group did not feel that they knew the material better, and in fact they didn't. Rather, summarizing the passages after a time delay helped them become more accurate in distinguishing the material they did know from the material they didn't.

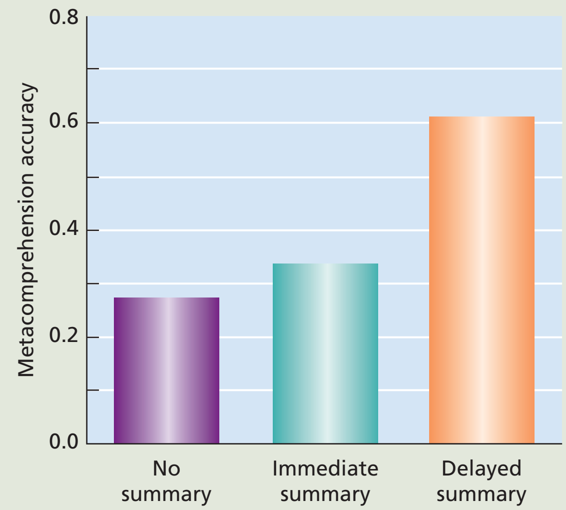


Figure 9.27

Writing summaries helps us recognize what we do and don't know. Students who wrote delayed summaries of text material showed far better metacomprehension than did students who wrote immediate summaries or no summaries.

DISCUSSION

As the researchers predicted, students' ability to accurately determine how well they understood text material improved greatly when they wrote delayed summaries. Because the delayed-summary group did not rate their comprehension higher or perform better on the comprehension tests than the other groups, we want to ensure that you do *not* reach the wrong conclusion of "So what if metacomprehension improved; the students didn't do better on the test."

Realize that the students in this experiment were not allowed to go back and study the text passages again before taking the comprehension tests. Therefore, students in the delayed-summary group did not have the opportunity to act upon their superior metacognitive knowledge (i.e., to bone up on the material that they accurately felt they didn't know). But in real-world test situations, students who better recognize what they know and don't know can indeed put that information to use in preparing for a test. They can allocate more time to studying the material they have found difficult and less time to the material that they already understand. Students with poor metacomprehension may end up allocating their study time less efficiently, ignoring material that they think they know but truly don't.

Further Advice on Improving Metacognition

As a student, you want to be able to accurately assess how well you remember and understand course material *before* it's time to take a test. First, if you buy used textbooks to save money, try to buy copies that don't already contain highlighting or underlining. If that's not possible, ignore what the previous student has done and do your own highlighting or underlining. You don't know whether the prior book owner got an A, C, or F in the course. Some or much of that highlighting may be inappropriate, and research indicates that when students read text passages that are already inappropriately highlighted, this impairs accurate comprehension and leads students to overestimate how well they know the material (Gier et al., 2009).

Second, don't equate "I can recall material now" with "I've learned it and don't need to practice it more," which can impair metamemory (Karpicke, 2009). Keep practicing the material and testing your ability to retrieve it. One way to do this is to take advantage of practice tests, such as those found in study guides. But don't try to memorize specific questions and answers from practice tests, as some students do. This does little to help you assess your broader understanding of the material. Instead, seriously study the material first, and then try to answer the practice questions. For each question, rate how confident you are that your answer is right; this may help you develop a better sense of whether your metacomprehension is good.

Finally, merely being able to recall definitions and facts won't necessarily let you know whether you understand the material on a deeper level. The "Research Close-up" study found that writing delayed summaries improved students' metacomprehension, and other research finds that writing summaries boosts actual comprehension of text material (Winne & Hadwin, 1998). At this textbook's you will find study questions for each chapter. Use these questions as the basis for writing brief, delayed summaries of the text. It's not magic. It takes time and effort. But in writing these summaries, if you find yourself struggling to remember the material or articulate the main concepts, then you have gained the knowledge that you need to restudy the material or seek assistance in trying to understand it.

Mental Imagery

Having spent most of this chapter discussing language and types of thought that we subjectively experience as inner speech, let's turn to another mode of thought: *mental imagery*. A **mental image** *is a representation of a stimulus that originates inside your brain, rather than from external sensory input*. Nighttime dreams are a common form of mental imagery. While awake, we may intentionally create and manipulate mental images to get a break from reality, relieve boredom, or help solve problems. Sir Isaac Newton and Albert Einstein used mental imagery to gain insights that led to the discovery of several laws of physics. In a daydream at age 16:

> Einstein imagined himself running alongside a light beam and asked himself the fateful question: what would the light beam look like? Like Newton visualizing throwing a rock until it orbited the earth like the moon, Einstein's attempt to imagine such a light beam would yield deep and surprising results. (Kaku, 2004, p. 43)

Mental images can represent different sensory modalities, as when we imagine the savory taste or enticing aroma of a favorite food. They can also represent motor movements, as when athletes or dancers use mental imagery to rehearse skills. Such mental images not only subjectively involve tastes, smells, sounds, and so on, but also activate sensorimotor circuits in the brain (Palmiero et al., 2009; Szameitat et al., 2007). Visual mental images are the most common and most thoroughly researched, and we'll focus on them here.

Mental Rotation

Look at the objects in Figure 9.28. In each pair, are the two objects different, or are they the same object that has been rotated to a different orientation? Typically, in this *mental-rotation task*, people rotate one object in their mind's eye until it lines up sufficiently with the other object to permit a same-different judgment.

In 1971, psychologists Roger Shepard and Jacqueline Metzler reported a landmark experiment that helped place the study of mental imagery on the scientific map. Their elegant experiment demonstrated that mental images could be studied by gathering objective data, rather than by relying exclusively on people's subjective self-reports. They presented each research participant with 1,600 pairs of rotated objects, including the objects shown in Figure 9.28. Upon seeing each pair, participants pulled one of two levers to signal whether the two objects were the same or different, and their speed of response was measured. For 800 pairs, the objects within the pair were identical and were rotated from each other

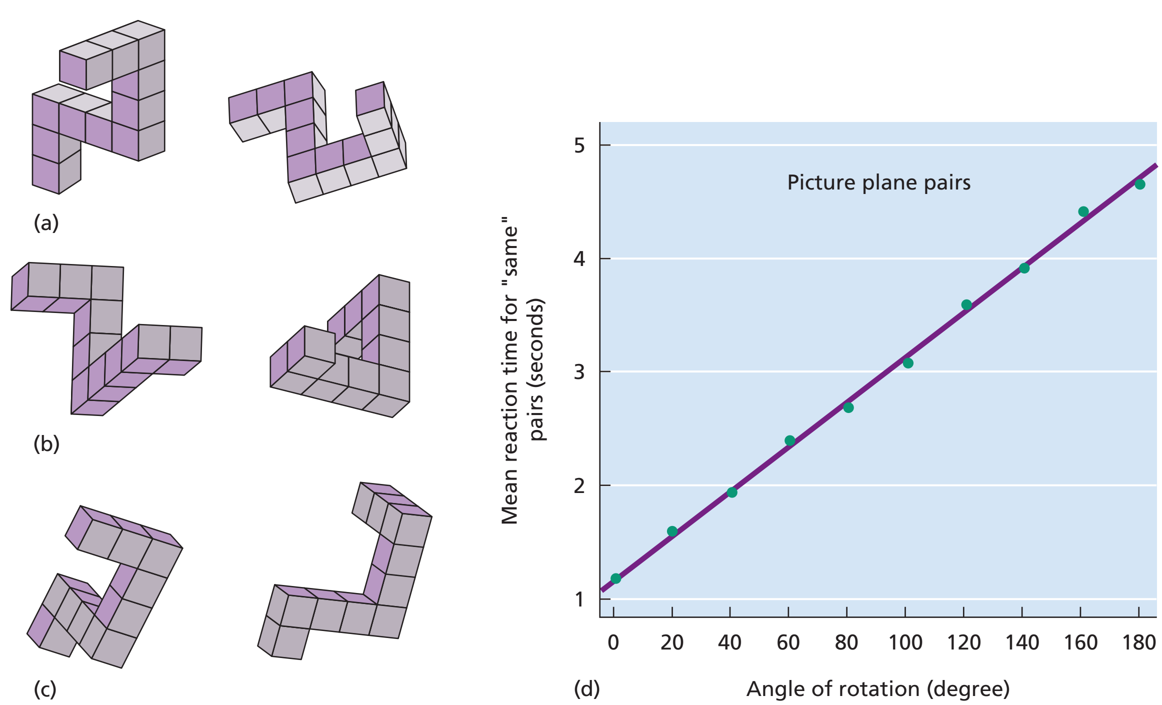


Figure 9.28

Mental rotation.
(a, b, c) These are three of the many pairs of objects used in Shepard and Metzler's (1971) mental-rotation study. (d) This graph shows the average number of seconds it took participants to decide that the two objects in each pair were similar, as a function of the initial angle of rotation. Factoring in the time that it took to make a physical response, participants' speed of mental rotation was approximately 60 degrees per second. In pairs (a) and (b) the objects are the same. In pair (c) they are different.

at an angle of either 0, 20, 40, 60, 80, 100, 120, 140, 160, or 180 degrees. The two objects within pair (a) and within pair (b) in Figure 9.28, for example, are the same and rotated 80 degrees from one another; those in pair (c) are different.

Subjectively, participants reported that they were able to mentally rotate the objects as if the objects existed in three-dimensional space but that the speed of this mental rotation process was limited. Shepard and Metzler's key finding concerned the pairs in which the two objects were the same. On these trials, the greater the difference in rotation between the two pictured objects, the longer it took participants to reach their decision (Figure 9.28d). Shepard and Metzler (1971) concluded that "if we can describe this process as some sort of 'mental rotation in three-dimensional space,' then . . . the average rate at which these particular objects can be thus 'rotated' is roughly 60° per second" (p. 703). Subsequent experiments, though not necessarily replicating the near-perfect linear relation found in Figure 9.28d, support the view that objects can be mentally rotated (Schendan & Lucia, 2009).

Are Mental Images Pictures in the Mind?

Many researchers believe that mental images, while not literally pictures in the mind, function in ways analogous to actual visual images and are represented in the brain as a type of perceptual code (Kosslyn et al., 2006). If this is the case, then mental images should have qualities similar to those that occur when we perceive objects and scenes in the real world. For example, if the objects portrayed in Figure 9.28 were real objects, you would be able to physically rotate them in three-dimensional space. Shepard and Metzler's (1971) experiment suggested that mental images likewise can be rotated within mental space.

Mental Imagery as Perception Let's consider an example that illustrates the perceptual nature of mental imagery. Look at the island in Figure 9.29. Notice that it contains seven landmarks (e.g., a hut, lake, hill, beach), each of which is marked by a red dot. Suppose that after giving you time to memorize this map, we ask you to close your eyes and focus on a mental image of the map. Next, we ask you to (1) focus on a particular landmark (say, the beach), (2) scan the map until you come to the hill, and (3) press a button (which measures your response time) when you find the hill. On another trial, we might ask you to start at the tree and scan the map until you come to the lake. In total, you will end up taking 21 of these mental trips as you scan once between every possible pair of locations.

In the real world, visually scanning between two objects takes longer when they are farther apart. Stephen Kosslyn and his colleagues (1978), who designed this "island" task, conducted an experiment and found that the greater the distance between two locations on the mental image of the map, the longer it took participants to scan and find the second location. This study and other research supports the view that mental images involve a spatial representation (Rinck & Denis, 2004).

Mental Imagery and the Brain

If mental imagery is rooted in perception, then people who experience brain damage that causes perceptual difficulties might also be expected to show similar impairments in forming mental images. In many instances this seems to be the case, but there are also exceptions. Some patients with brain damage have deficits in producing visual mental images, yet their visual perception is intact (Moro et al., 2008). Other cases involve the opposite pattern: the ability to produce mental images despite impaired visual perception (Bartolomeo, 2008). For example, some patients who have damage on one side of the brain (usually the right hemisphere) suffer from a condition called *visual neglect:* they fail to visually perceive objects on the other side (e.g., the left side) of their visual field. If you showed patients who have left-side visual neglect the picture of the island in Figure 9.29 and

Figure 9.29

Imagine an island.
This island is similar to one used in Kosslyn et al.'s (1978) mental imagery scanning study.

asked them to draw a copy of it, they would draw the right side of the island but fail to copy the left side. However, in some cases, if you were to ask the patients to draw the picture from memory (by calling up a mental image of the picture of the island) rather than to copy it (which relies on direct visual perception), they would be able to draw the entire island (Halligan et al., 2003).

Brain-imaging studies of healthy people reveal that many brain regions that become more active when people visually perceive objects also become more active when people form mental images (Kaas et al., 2010). Moreover, researchers have found evidence of *imagery neurons*, which fire in response to a particular stimulus regardless of whether it is visual (a photo of a baseball) or imagined (a mental image of a baseball). Altogether, studies of impaired and healthy brain functioning suggest that while visual mental imagery and visual perception do not activate all of the same neural components, there is considerable overlap between these two processes (Stokes et al., 2009).

Levels of Analysis

Thinking Processes

We have now covered diverse aspects of human thought. The subjective experience of thinking fits squarely within the psychological level of analysis, but as we now recap, research on thinking spans the biological, psychological, and environmental levels of analysis.

Consider this possible interaction between the environmental and psychological levels of analysis. Do you think that educational experiences or training about thinking errors and biases would reduce people's future tendency to display such errors and biases?

test yourself Knowledge, Expertise, Wisdom, Metacognition, and Mental Imagery

True or false?

1. The activity "Carl went to the library to study" is an example of a script.
2. Concepts, categories, algorithms, and heuristics are all examples of schemas.
3. Wisdom and expertise are the same thing.
4. The best way to increase metacomprehension of textbook material is to write a summary of it immediately after reading it.
5. Compared to novices, experts rely more on long-term memory in tasks related to their fields.
6. Mental imagery and visual perception activate entirely different brain areas.

ANSWERS: 1-true, 2-true, 3-false, 4-false, 5-true, 6-false

Chapter Summary

LANGUAGE

- Human language is symbolic and structured, conveys meaning, is generative, and permits displacement. Language facilitates cooperative social systems and knowledge transmission.
- A language's surface structure refers to how symbols are combined; the deep structure refers to the underlying meaning of the symbols. Language elements are hierarchically arranged: from phonemes to morphemes, words, phrases, and sentences.
- Understanding and producing language involves bottom-up and top-down processing.
- Scientists believe that humans have evolved an innate capacity for acquiring language. Infants can perceive all the phonemes that exist in all the languages of the world. Between 6 and 12 months of age, their speech discrimination narrows to include only the sounds specific to their native tongue. By ages 4 to 5, most children have learned basic grammatical rules for combining words into meaningful sentences.
- Language development depends on innate brain mechanisms that permit the learning and production of language, provided that the child is exposed to an appropriate linguistic environment during a sensitive period that extends from early childhood to puberty.
- Compared to monolingual children, bilingual children tend to perform better on cognitive tasks that involve inhibiting attention to irrelevant stimuli, but they develop a smaller vocabulary in each language. In general, when people acquire a second language early in life, both languages share a common neural network.
- Learning to read is more complex than acquiring speech. Poor phonological awareness is a major reason why people with dyslexia have difficulty learning to read.
- Apes have been taught to use hand signs or keyboard symbols to communicate in languagelike fashion. At best, they are capable of communicating with symbols at a level similar to that of a human toddler. Skeptics question whether apes can learn syntax and generate novel ideas.
- Language influences what people think and how effectively they think. Expansion of vocabulary allows people to encode and process information in more sophisticated ways.

THINKING

- Thoughts are propositional, imaginal, or motoric mental representations that exist as patterns of neural activity in the brain. Propositional thought involves the use of concepts in the form of statements. Concepts are mental categories, or classes, that share certain characteristics. Many concepts are based on prototypes.
- In deductive reasoning, we reason from general principles to a conclusion about a specific case. Inductive reasoning involves reasoning from a set of specific facts or observations to a general principle. Deductive conclusions cannot be false if appropriate logical rules are applied and the premises are true. Inductive reasoning cannot yield certainty. Unsuccessful reasoning can result from failure to select relevant information, belief bias, emotional reactions, and framing effects.
- Problem solving proceeds through several steps: (1) understanding the problem, (2) establishing initial hypotheses or potential solutions, (3) testing solutions against existing evidence, and (4) evaluating the results.

- People use several types of problem-solving schemas. Algorithms are formulas or procedures that guarantee correct solutions. Heuristics—such as means-ends analysis, subgoal analysis, the representativeness heuristic, and the availability heuristic—are general strategies that may or may not provide correct solutions.
- Humans exhibit confirmation bias, a tendency to look for facts to support hypotheses rather than to disprove them. They also suffer from overconfidence, a tendency to overestimate their knowledge and the correctness of their beliefs and decisions.
- In some situations, divergent thinking is needed for generating novel ideas. Functional fixedness can blind us to new ways of using an object or procedure, thereby interfering with creative problem solving. Sometimes, an incubation period permits problem solving to proceed subconsciously.
- Knowledge acquisition involves building mental frameworks, called schemas. One type of schema—scripts—provides a framework for understanding regular sequences of events. Compared with novices, experts have more schemas to guide problem solving in their fields and more effective recognition of when each schema should be applied.
- Wisdom is a system of knowledge about the fundamental matters of life. It consists of rich factual knowledge, strategic knowledge, an understanding of life-span contexts, an awareness of the relativism of values and priorities, and the ability to recognize and manage uncertainty.
- Metacognition refers to a person's awareness of her or his own cognitive abilities. One aspect of metacognition, metacomprehension, reflects how accurate people are at judging what they do and do not understand. After reading textbook material, writing summaries of that material after a time delay can increase metacomprehension.
- A mental image is a representation of a stimulus that originates inside the brain, rather than from external sensory input. Mental images of objects seem to have properties that are analogous to the properties of actual objects (e.g., you can rotate them, visually scan them). Brain research suggests that mental images are perceptual in nature.

KEY TERMS AND CONCEPTS

Each term has been boldfaced and defined in the chapter on the page indicated in parentheses.

algorithms (p. 316)
aphasia (p. 299)
availability heuristic (p. 318)
belief bias (p. 314)
bilingualism (p. 303)
bottom-up processing (p. 298)
concept (p. 312)
confirmation bias (p. 319)
creativity (p. 320)
deductive reasoning (p. 313)
deep structure (p. 295)
discourse (p. 297)
displacement (p. 295)
divergent thinking (p. 320)
framing (p. 314)
functional fixedness (p. 320)
generativity (p. 295)
grammar (p. 295)
heuristics (p. 316)
imaginal thought (p. 312)
incubation (p. 320)
inductive reasoning (p. 313)
language (p. 294)
linguistic relativity hypothesis (p. 309)
means-ends analysis (p. 316)
mental image (p. 326)
mental representations (p. 294)
mental set (p. 316)
metacognition (p. 323)
morpheme (p. 296)
motoric thought (p. 312)
overconfidence (p. 319)
phoneme (p. 296)
phonological awareness (p. 306)
pragmatics (p. 299)
proposition (p. 312)
propositional thought (p. 312)
prototype (p. 313)
psycholinguistics (p. 294)
representativeness heuristic (p. 317)
schema (p. 321)
script (p. 321)
semantics (p. 295)
speech segmentation (p. 298)
subgoal analysis (p. 317)
surface structure (p. 295)
syntax (p. 295)
top-down processing (p. 298)
wisdom (p. 323)

thinking **critically**

DISCERNING THE DEEP STRUCTURES OF LANGUAGE (Page 296)

The final words on the grave marker ("No Les No More") consist of a single surface structure with two possible deep structures. First, given the preceding words on the tombstone, the phrase "No Les No More" could be a play on words, which in this case is meant to represent the expression "No Less, No More." In other words, Lester Moore was killed by exactly 4 bullets, no less, no more. Or, the deep structure of "No Les No More" can be interpreted as meaning that Lester is no longer among the living. Thus, like the sentence "The police must stop drinking after midnight," the inscription on this tombstone has an ambiguous deep structure.

Sometimes, interpreting ambiguous sentences yields humorous results. For example, a newspaper headline that reads "Squad Helps Dog Bite Victim" is intended to mean that the squad helps the victim of a dog bite. But another deep structure is that the squad helped the dog to bite the victim!

THE SLEEPING POLICEMAN (Page 299)

This actual event illustrates how top-down processing and pragmatics affect our ability to understand language. First, I (your author, MP) didn't take the storekeeper's words literally; I did not expect to see a police officer sleeping on the side of the road!

Second, in England (and Ireland and Scotland), the taverns often have wonderfully colorful names: The Drunken Duck, The Black Swan, and so on. Given this knowledge, would it change your interpretation of "the sleeping policeman"? Indeed, I assumed that the storekeeper was referring to a pub or perhaps a restaurant—and I interpreted his spoken words as "The Sleeping Policeman."

Unfortunately, driving along the road, I saw nothing but farmland and homes. I returned to town and asked the storekeeper, "When you say 'Sleeping Policeman,' are you referring to a pub?" He chuckled and said, "Oh no, no. You know . . . it's that long thing in the road . . . the thing that slows you down." "Ah," I replied, "at home we call them speed bumps!"

My prior top-down knowledge about the names of English pubs shaped my assumption that "the sleeping policeman" referred to a pub. When I later asked English friends if they had heard of the term *sleeping policeman,* about half said no. Thus the storekeeper made an erroneous assumption as well, namely, that visitors would have the background to understand the meaning of the local idiom *sleeping policeman*. This reflects a breakdown in pragmatics: it violates the rule of clarity. Can you think of idioms (e.g., "give me a hand," "that's cool") that have obvious meaning to you but which may have a literal interpretation that could confuse a foreign visitor?

Answers to Problems in the Text

Figure 9.18 Baltimore and Washington are 50 miles apart. The trains are traveling at the same speed (25 mph). Hence they will meet at the halfway point, which is 25 miles, after 1 hour of travel time. Since the crow is flying at 60 mph, it will have flown a total of 60 miles when the trains meet.

Figure 9.20 Sequence of moves: A to 3, B to 2, A to 2, C to 3, A to 1, B to 3, A to 3.

Figure 9.23 Here are two solutions to the nine-dot problem. Both require you to think outside the box, literally.

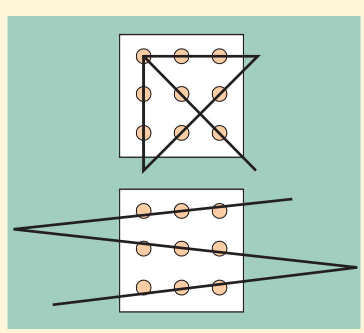


Figure 9.24 Solution to the candlestick problem: