7

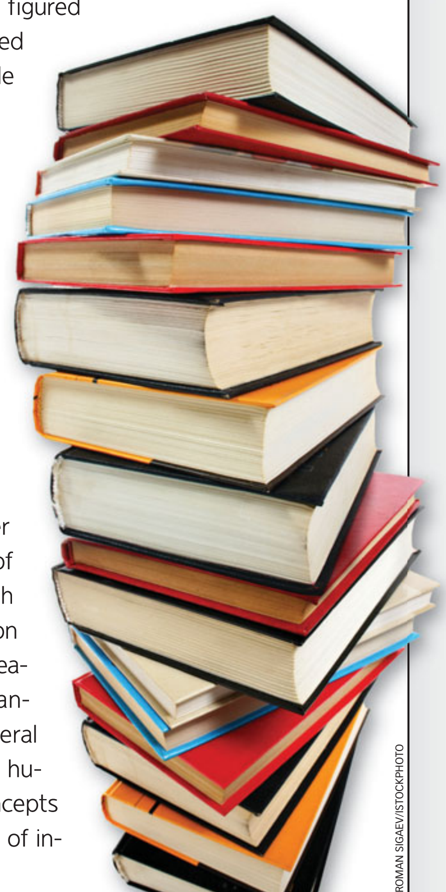
CHAPTER SEVEN

Language, Thought, and Intelligence

AN ENGLISH BOY NAMED CHRISTOPHER showed an amazing talent for languages. By the age of 6, he had learned French from his sister's schoolbooks; he acquired Greek from a textbook in only 3 months. His talent was so prodigious that grown-up Christopher could converse fluently in 16 languages. When tested on English-French translations, he scored as well as a native French speaker. Presented with a made-up language, he figured out the complex rules easily, even though advanced language students found them virtually impossible to decipher (Smith & Tsimpli, 1995).

If you've concluded that Christopher is extremely smart, perhaps even a genius, you're wrong. His scores on standard intelligence tests are far below normal. He fails simple cognitive tests that 4-year-old children pass with ease, and he cannot even learn the rules for simple games like tic-tac-toe. Despite his dazzling talent, Christopher lives in a halfway house because he does not have the cognitive capacity to make decisions, reason, or solve problems in a way that would allow him to live independently.

Christopher's strengths and weaknesses offer compelling evidence that cognition is composed of distinct abilities. People who learn languages with lightning speed are not necessarily gifted at decision making or problem solving. People who excel at reasoning may have no special ability to master languages. In this chapter, you will learn about several higher cognitive functions that distinguish us as humans: acquiring and using language, forming concepts and categories, making decisions: the components of intelligence itself. ■

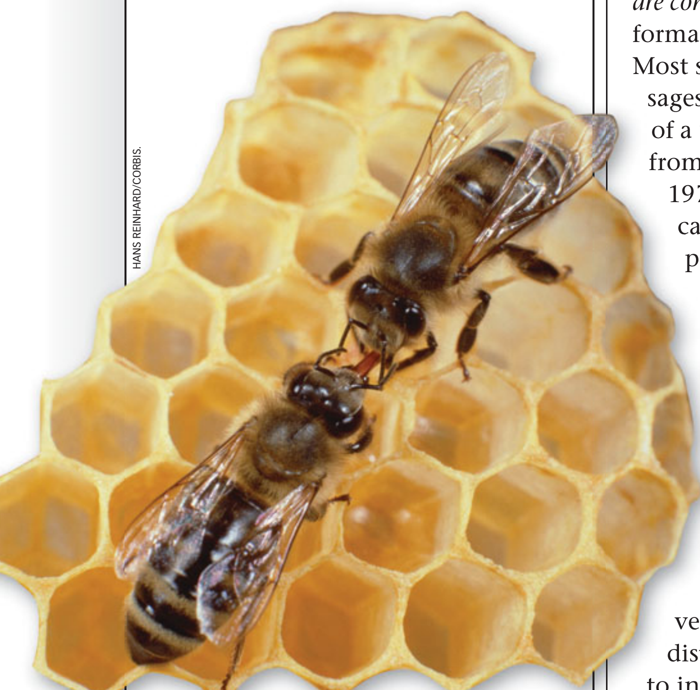


ROMAN SIGAEV/ISTOCKPHOTO

Christopher absorbed languages quickly from textbooks, yet he completely failed simple tests of other cognitive abilities

Language and Communication: Nothing's More Personal

Language is *a system for communicating with others using signals that convey meaning and are combined according to rules of grammar.* Language allows individuals to exchange information about the world, coordinate group action, and form strong social bonds. Most social species have systems of communication that allow them to transmit messages to each other. Honeybees communicate the location of food sources by means of a "waggle dance" that indicates both the direction and distance of the food source from the hive (Kirchner & Towne, 1994; Von Frisch, 1974). Vervet monkeys have three different warning calls that uniquely signal the presence of their main predators: a leopard, an eagle, and a snake (Cheney & Seyfarth, 1990). A leopard call provokes them to climb higher into a tree; an eagle call makes them look up into the sky. Each different warning call conveys a particular meaning and functions like a word in a simple language.



HANS REINHARD/CORBIS.

• *Honeybees communicate with each other about the location of food by doing a waggle dance that indicates the direction and distance of food from the hive.*

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The Complex Structure of Human Language

Human language may have evolved from signaling systems used by other species. However, three striking differences distinguish human language from vervet monkey yelps, for example. First, the complex structure of human language distinguishes it from simpler signaling systems. Second, humans use words to refer to intangible things, such as *unicorn* or *democracy.* These words could not have originated as simple alarm calls. Third, we use language to name, categorize, and describe things to ourselves when we think. It's doubtful that honeybees consciously think, *I'll fly north today to find more honey so the queen will be impressed!*

• What do all languages have in common?

Compared with other forms of communication, human language is a relatively recent evolutionary phenomenon, emerging as a spoken system no more than 1 to 3 million years ago and as a written system as little as 6,000 years ago. There are approximately 4,000 human languages, which linguists have grouped into about 50 language families (Nadasdy, 1995). Despite their differences, all of these languages share a basic structure involving a set of sounds and rules for combining those sounds to produce meanings.

Basic Characteristics

The smallest unit of sound that is recognizable as speech rather than as random noise is the **phoneme.** For example, *b* and *p* are classified as phonemes in English, meaning that they can be used as building blocks for spoken language. Different languages use different phonemes. For example, the language spoken by the !Kung population of Namibia and Angola includes a clicking sound, a phoneme that does not appear in English.

Phonemes are combined to make **morphemes,** *the smallest meaningful units of language* (see **FIGURE 7.1** on page 199). For example, your brain recognizes the *p* sound you make at the beginning of *pat* as a speech sound, but it carries no particular meaning. The morpheme *pat,* in contrast, is recognized as an element of speech that carries meaning. Morphemes can be complete words (e.g., *pat,* or *eat*) or they can be elements that are combined to form words (e.g., *-ing* or *–ed*).

All languages have a **grammar,** *a set of rules that specifies how the units of language can be combined to produce meaningful messages.* These rules generally fall into two categories: *rules of morphology,* which indicate how morphemes can be combined to form words (for example, *eat* + *ing* = *eating*), and *rules of syntax*, which indicate how words can be combined to form phrases and sentences.

language A system for communicating with others using signals that convey meaning and are combined according to rules of grammar.

phoneme The smallest unit of sound that is recognizable as speech rather than as random noise.

morphemes The smallest meaningful units of language.

grammar A set of rules that specify how the units of language can be combined to produce meaningful messages.

deep structure The meaning of a sentence.

surface structure How a sentence is worded.

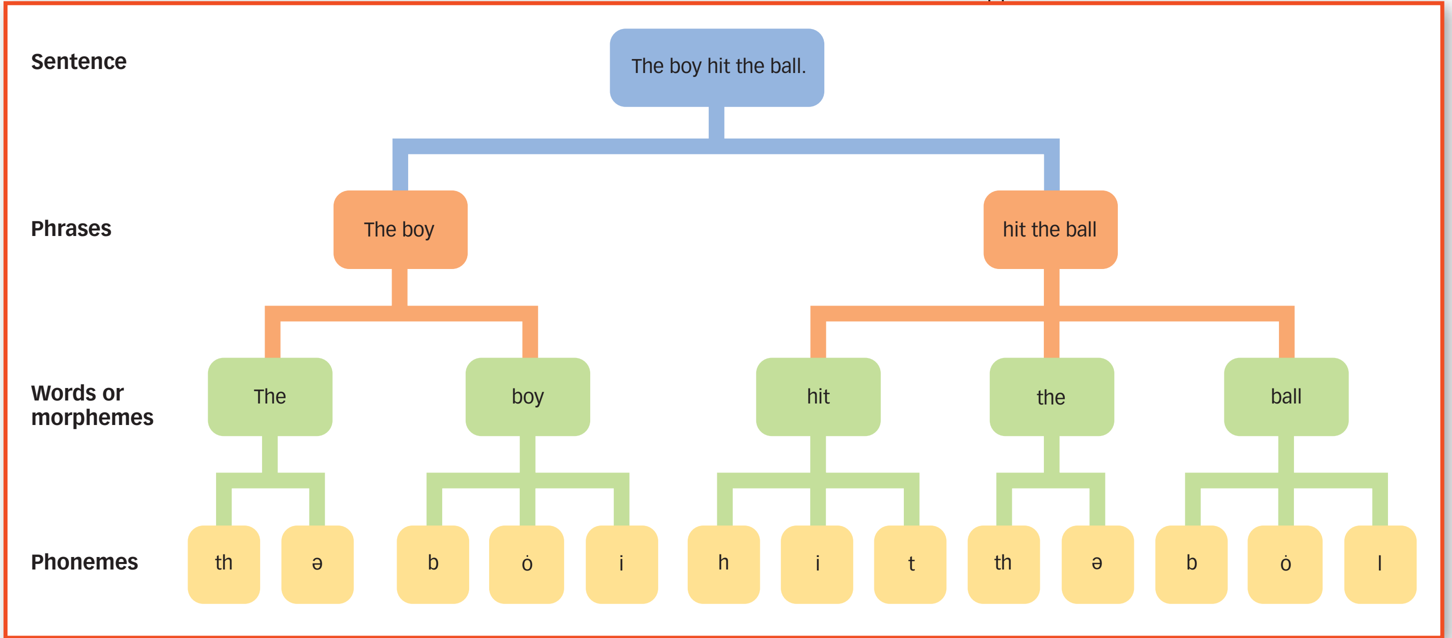


FIGURE 7.1 **Units of Language** *A sentence—the largest unit of language—can be broken down into progressively smaller units: phrases, morphemes, and phonemes. In all languages, phonemes and morphemes form words, which can be combined into phrases and ultimately into sentences.*

Deep Structure versus Surface Structure

Language, like other features of the human mind, is not perfect. Everyday experience shows us how often misunderstandings occur. These mindbugs sometimes result from differences between the deep structure of sentences and their surface structure (Chomsky, 1957). **Deep structure** refers to *the meaning of a sentence*. **Surface structure** refers to *how a sentence is worded*. The sentences "The dog chased the cat" and "The cat was chased by the dog" mean the same thing (they have the same deep structure) even though on the surface their structures are different.

To generate a sentence, you begin with a deep structure (the meaning of the sentence) and create a surface structure (the particular words) to convey that meaning. When you comprehend a sentence, you do the reverse, processing the surface structure in order to extract the deep structure. After the deep structure is extracted, the surface structure is usually forgotten (Jarvella, 1970, 1971). In one study, researchers played tape-recorded stories to volunteers and then asked them to pick the sentences they had heard (Sachs, 1967). Participants frequently confused sentences they heard with sentences that had the same deep structure but a different surface structure. For example, if they heard the sentence "He struck John on the shoulder," they often mistakenly claimed they had heard "John was struck on the shoulder by him." In contrast, they rarely misidentified "John struck him on the shoulder" because this sentence has a different deep structure from the original sentence.

● Is the meaning or wording of a sentence more memorable?

Language Development

Language is a complex cognitive skill, yet we learn to speak and understand with little effort. We can carry on complex conversations with playmates and family before we begin school. Three characteristics of language development are worth bearing in mind. First, children learn language at an astonishingly rapid rate. The average 1-year-old has a vocabulary of 10 words. This tiny vocabulary expands to over *10,000* words in the next 4 years, requiring the child to learn, on average, about six or seven new words *every day.* Second, children make few errors while learning to speak, and the errors they do make

ELLEN B. SENISI/THE IMAGE WORKS

• *Infants enjoy sucking on pacifiers a lot more than you do. Psychologists figured out how to use this natural tendency to learn about speech processing.*

usually respect grammatical rules. This is an extraordinary feat. There are over 3 *million* ways to rearrange the words in any 10-word sentence, but only a few of these arrangements will be both grammatically correct and meaningful (Bickerton, 1990). Third, at every stage of development, children's *passive mastery* of language (their ability to understand) develops faster than their *active mastery* (their ability to speak).

Distinguishing Speech Sounds

At birth, infants can distinguish among all of the contrasting sounds that occur in all human languages. Within the first 6 months of life, they lose this ability and, like their parents, can only distinguish among the contrasting sounds in the language they hear being spoken around them. For example, two distinct sounds in English are the *l* sound and the *r* sound, as in *lead* and *read*. These sounds are not distinguished in Japanese; instead, the *l* and *r* sounds fall within the same phoneme. Japanese adults cannot hear the difference between these two phonemes, but American adults can distinguish between them easily—and so can Japanese infants. In one study, researchers constructed a tape of a voice saying "la-la-la" or "ra-ra-ra" repeatedly (Eimas et al., 1971). They rigged a pacifier so that whenever an infant sucked on it, a tape player that broadcasted the "la-la" tape was activated. When the *la-la* sound began playing in response to their sucking, the babies were delighted and kept sucking on the pacifier to keep the *la-la* sound playing. After a while, they began to lose interest, and sucking frequency declined to about half of its initial rate. At this point, the experiments switched the tape so that the voice now said "ra-ra-ra" repeatedly. The Japanese infants began sucking again with vigor, indicating that they could hear the difference between the old, boring *la* sound and the new, interesting *ra* sound.

• **What language ability do babies have that adults do not?**

Studies like these help explain why it is so difficult to learn a second language as an adult. You might not be able to even *hear* some of the speech sounds that carry crucial information in the language you want to learn, much less pronounce them properly. In a very real sense, your brain has become too specialized for your native language!

Infants can distinguish among speech sounds, but they cannot produce them reliably, relying mostly on cooing, cries, laughs, and other vocalizations to communicate. Between the ages of about 4 and 6 months, they begin to babble speech sounds. Regardless of the language they hear spoken, all infants go through the same babbling sequence. For example, *d* and *t* appear in infant babbling before *m* and *n*. Even deaf babies babble sounds they've never heard, and they do so in the same order as hearing babies do (Ollers & Eilers, 1988). This is evidence that babies aren't simply imitating the sounds they hear. Deaf babies don't babble as much, however, and their babbling is delayed relative to hearing babies (11 months rather than 6).

• *Deaf infants who learn sign language from their parents start babbling with their hands around the same time that hearing infants babble vocally.*

CHRISTINA KENNEDY/ALAMY

In order for vocal babbling to continue, however, babies must be able to hear themselves. In fact, delayed babbling or the cessation of babbling merits testing for possible hearing difficulties. Babbling problems can lead to speech impairments, but they do not necessarily prevent language acquisition. Deaf infants whose parents communicate using American Sign Language (ASL) begin to babble with their hands at the same age that hearing children begin to babble vocally—between 4 and 6 months (Petitto & Marentette, 1991). Their babbling consists of sign language syllables that are the fundamental components of ASL.

Language Milestones

At about 10 to 12 months of age, babies begin to utter (or sign) their first words. By 18 months, they can say about 50 words and can understand several times more than that. Toddlers generally learn nouns before verbs, and the nouns they learn first are names for everyday, concrete objects (e.g., chair, table, milk) (see **TABLE 7.1**). At about this time, their vocabularies undergo explosive growth. By the time the average child begins school, a vocabulary of 10,000 words is not unusual. By fifth grade, the average child knows the meanings of 40,000 words. By college, the average student's vocabulary is about 200,000 words. **Fast mapping**, in which *children map a word onto an underlying concept after only a single exposure,* enables them to learn at this rapid pace (Mervis & Bertrand, 1994). This astonishingly easy process contrasts dramatically with the effort required later to learn other concepts and skills, such as arithmetic or writing.

TABLE 7.1

Language Milestones

Average Age	Language Milestones
0–4 months	Can tell the difference between speech sounds (phonemes). Cooing, especially in response to speech.
4–6 months	Babbles consonants.
6–10 months	Understands some words and simple requests.
10–12 months	Begins to use single words.
12–18 months	Vocabulary of 30–50 words (simple nouns, adjectives, and action words).
18–24 months	Two-word phrases ordered according to the syntactic rules. Vocabulary of 50–200 words. Understands rules.
24–36 months	Vocabulary of about 1,000 words. Production of phrases and incomplete sentences.
36–60 months	Vocabulary grows to more than 10,000 words; production of full sentences; mastery of grammatical morphemes (such as -ed for past tense) and function words (such as *the, and, but*). Can form questions and negations.

Around 24 months, children begin to form two-word sentences and phrases, such as "more milk" or "throw ball." Such sentences are referred to as *telegraphic speech* because they tend to consist of nouns and verbs, without the other elements, such as prepositions or articles, we normally use to link our speech together. Yet these two-word sentences tend to be grammatical; the words are ordered in a manner consistent with the syntactical rules of the language children are learning to speak. So, for example, toddlers will say "throw ball" rather than "ball throw" when they want you to throw the ball to them and "more milk" rather than "milk more" when they want you to give them more milk. With these seemingly primitive expressions, 2-year-olds show that they have already acquired an appreciation of the grammatical rules of the language they are learning.

The Emergence of Grammatical Rules

Evidence of the ease with which children acquire grammatical rules comes from some interesting developmental mindbugs: errors that children make while forming sentences. If you listen to average 2- or 3-year-old children speaking, you may notice that they use the correct past-tense versions of common verbs, as in the expressions "I ran" and "You ate." By the age of 4 or 5, the same children will be using incorrect forms of these verbs, saying such things as "I runned" or "You eated"—forms most children are unlikely to have ever heard (Prasada & Pinker, 1993). The reason is that very young children memorize the particular sounds (i.e., words) that express what they want to communicate. But as children acquire the grammatical rules of their language, they tend to *overgeneralize*. For example, if a child overgeneralizes the rule that past tense is indicated by *-ed,* then *run* becomes *runned* instead of *ran.*

Why is it unlikely that children are using imitation to pick up language?

These errors show that language acquisition is not simply a matter of imitating adult speech. Instead, children acquire grammatical rules by listening to the speech around them and using the rules to create verbal forms they've never heard. They manage this without explicit awareness of the grammatical rules they've learned. In fact, few children or adults can articulate the grammatical rules of their native language, yet the speech they produce obeys these rules.

By about 3 years of age, children begin to generate complete simple sentences that include prepositions and articles (e.g., "Give me *the* ball" and "That belongs *to* me"). The sentences increase in complexity over the next 2 years. By the time the child is 4 to 5 years of age, many aspects of the language acquisition process are complete. As children

fast mapping The fact that children can map a word onto an underlying concept after only a single exposure.

continue to mature, their language skills become more refined, with added appreciation of subtler communicative uses of language, such as humor, sarcasm, or irony.

Theories of Language Development

We know a good deal about how language develops, but the underlying acquisition processes have been the subject of considerable controversy and (at times) angry exchanges among theoreticians. As you learned in Chapter 1, Skinner used principles of reinforcement to argue that we learn language the way he thought we learn everything—through imitation, instruction, and trial-and-error learning. But in the 1950s, linguist Noam Chomsky published a blistering critique of this behaviorist explanation, arguing that language-learning capacities are built into the brain, which is specialized to rapidly acquire language through simple exposure to speech. Let's look at each theory and then examine more recent accounts of language development.

Behaviorist Explanations

According to behaviorists, children acquire language through simple principles of operant conditioning (Skinner, 1957), which you learned about in Chapter 6. As infants mature, they begin to vocalize. Those vocalizations that are not reinforced gradually diminish, and those that are reinforced remain in the developing child's repertoire. So, for example, when an infant gurgles "prah," most English-speaking parents are pretty indifferent. However, a sound that even remotely resembles "da-da" is likely to be reinforced with smiles, whoops, and cackles of "Good baby!" by doting parents. Maturing children also imitate the speech patterns they hear. Then parents or other adults shape those speech patterns by reinforcing those that are grammatical and ignoring or punishing those that are ungrammatical. "I no want milk" is likely to be squelched by parental clucks and titters, whereas "No milk for me, thanks" will probably be reinforced. According to Skinner, then, we learn to talk in the same way we learn any other skill: through reinforcement, shaping, extinction, and the other basic principles of operant conditioning.

The behavioral explanation is attractive because it offers a simple account of language development, but the theory cannot account for many fundamental characteristics of language development (Chomsky, 1986; Pinker, 1994; Pinker & Bloom, 1990).

- First, parents don't spend much time teaching their children to speak grammatically. So, for example, when a child expresses a sentiment such as "Nobody like me," his or her mother will typically respond with something like "Why do you think that?" rather than "Now, listen carefully and repeat after me: Nobody likes me" (Brown & Hanlon, 1970).
- Second, children generate many more grammatical sentences than they ever hear. This shows that children don't just imitate; they learn the rules for generating sentences.
- Third, as you read earlier in this chapter, the errors children make when learning to speak tend to be overgeneralizations of grammatical rules. The behaviorist explanation would not predict these overgeneralizations if children were learning through trial and error or simply imitating what they hear.

Nativist Explanations

Contrary to Skinner's behaviorist theory of language acquisition, Chomsky and others have argued that humans have a particular ability for language that is separate from general intelligence. This **nativist theory** holds that *language development is best explained as an innate, biological capacity.* According to Chomsky, the human brain is equipped with a **language acquisition device (LAD)**—*a collection of processes that facilitate language learning.* Language processes naturally emerge as the infant matures, provided the infant receives adequate input to maintain the acquisition process.

nativist theory The view that language development is best explained as an innate, biological capacity.

language acquisition device (LAD) A collection of processes that facilitate language learning.

genetic dysphasia A syndrome characterized by an inability to learn the grammatical structure of language despite having otherwise normal intelligence.

Christopher's story is consistent with the nativist view of language development: His genius for language acquisition, despite his low overall intelligence, indicates that language capacity can be distinct from other mental capacities. Other individuals show the opposite pattern: People with normal or near-normal intelligence can find certain aspects of human language difficult or impossible to learn. This condition is known **genetic dysphasia,** *a syndrome characterized by an inability to learn the grammatical structure of language despite having otherwise normal intelligence.* Consider some sentences generated by children with the disorder:

She remembered when she hurts herself the other day.

Carol is cry in the church.

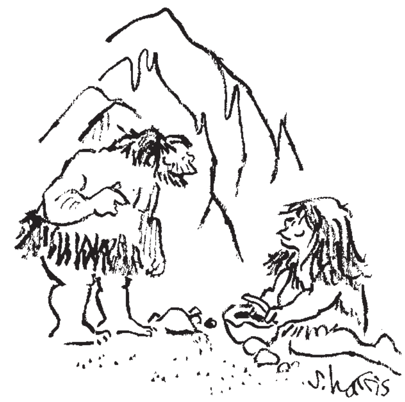
Notice that the ideas these children are trying to communicate are intelligent. The problem lies in their inability to grasp syntactical rules. These problems persist even if the children receive special language training. When asked to describe what she did over the weekend, one child wrote, "On Saturday I watch TV." Her teacher corrected the sentence to "On Saturday, I watch*ed* TV," drawing attention to the *-ed* rule for describing past events. The following week, the child was asked to write another account of what she did over the weekend. She wrote, "On Saturday I wash myself and I watched TV and I went to bed." Notice that although she had memorized the past tense forms *watched* and *went,* she could not generalize the rule to form the past tense of another word (*washed*).

As predicted by the nativist view, studies of people with genetic dysphasia suggest that normal children learn the grammatical rules of human language with ease in part because they are "wired" to do so. Also consistent with the nativist view is evidence that language can be acquired only during a restricted period of development, as has been observed with songbirds. If young songbirds are prevented from hearing adult birds sing during a particular period in their early lives, they do not learn to sing. A similar mechanism seems to affect human language learning, as illustrated by the tragic case of Genie (Curtiss, 1977). At the age of 20 months, Genie was tied to a chair by her parents and kept in virtual isolation. Her father forbade Genie's mother and brother to speak to her, and he himself only growled and barked at her. She remained in this brutal state until the age of 13, when she was removed from the house. Genie's life improved substantially, and she received years of language instruction. But it was too late. Her language skills remained extremely primitive. She developed a basic vocabulary and could communicate her ideas, but she could not grasp the grammatical rules of English.

Similar cases have been reported, with a common theme: Once puberty is reached, acquiring language becomes extremely difficult (Brown, 1958). Data from studies of language acquisition in immigrants support this conclusion. In one study, researchers found that the proficiency with which immigrants spoke English depended not on how long they'd lived in the United States but on their age at immigration (Johnson & Newport, 1989). Those who arrived as children were the most proficient, whereas among those who immigrated after puberty, proficiency showed a significant decline regardless of the number of years in their new country. Given these data, it is unfortunate that most U.S. schools do not offer training in other languages until middle school or high school.

Interactionist Explanations

Nativist theories are often criticized because they do not explain *how* language develops. A complete theory of



"Got Idea. Talk Better. Combine words. Make Sentences."

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Immigrants who learn English as a second language are more proficient if they start to learn English before puberty rather than after.

MICHAEL NEWMAN/PHOTOEDIT

A group of deaf children in Nicaragua created their own sign language, complete with grammatical rules, without receiving formal instruction. The language has evolved and matured over the past 25 years.

language acquisition requires an explanation of the processes by which the innate, biological capacity for language combines with environmental experience. This is just what interactionist accounts of language acquisition do. Interactionists point out that parents tailor their verbal interactions with children in ways that simplify the language acquisition process: They speak slowly, enunciate clearly, and use simpler sentences than they do when speaking with adults (Bruner, 1983; Farrar, 1990). This observation supports the interactionist notion that although infants are born with an innate ability to acquire language, social interactions play a crucial role in language.

Further evidence of the interaction of biology and experience comes from a fascinating study of deaf children's creation of a new language (Senghas, Kita, & Ozyurek, 2004). Prior to about 1980, deaf children in Nicaragua stayed at home and usually had little contact with other deaf individuals. In 1981, some deaf children began to attend a new vocational school. At first, the school did not teach a formal sign language, and none of the children had learned to sign at home, but the children gradually began to communicate using hand signals that they invented.

Over the past 25 years, their sign language has developed considerably, and researchers have studied this new language for the telltale characteristics of languages that have evolved over much longer periods. For instance, mature languages typically break down experience into separate components. When we describe something in motion, such as a rock rolling down a hill, our language separates the type of movement (rolling) and the direction of movement (down). If we simply made a gesture, however, we would use a single continuous downward movement to indicate this motion. This is exactly what the first children to develop the Nicaraguan sign language did. But younger groups of children, who have developed the sign language further, use separate signs to describe the direction and the type of movement—a defining characteristic of mature languages. That the younger children did not merely copy the signs from the older users suggests that a predisposition exists to use language to dissect our experiences. Thus, their acts of creation nicely illustrate the interplay of nativism (the predisposition to use language) and experience (growing up in an insulated deaf culture).

● How does the interactionist theory of language acquisition differ from behaviorist and nativist theories?

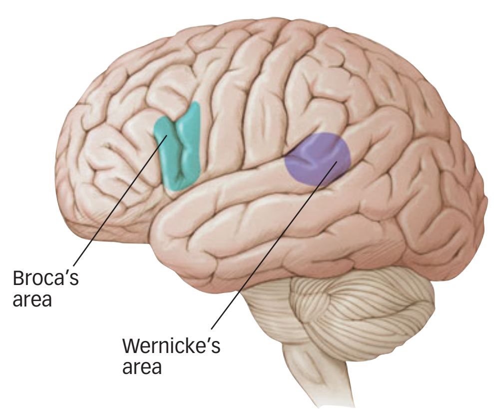


FIGURE 7.2

Broca's and Wernicke's Areas *Neuroscientists study people with brain damage in order to better understand how the brain normally operates. When Broca's area is damaged, patients have a hard time producing sentences. When Wernicke's area is damaged, patients can produce sentences, but they tend to be meaningless.*

The Neurological Specialization That Allows Language to Develop

As the brain matures, specialization of specific neurological structures takes place, and this allows language to develop. In early infancy, language processing is distributed across many areas of the brain. But language processing gradually becomes more and more concentrated in two areas, sometimes referred to as the language centers of the brain. The first, *Broca's area,* is located in the left frontal cortex; it is involved in the production of the sequential patterns in vocal and sign languages (see FIGURE 7.2). The second, *Wernicke's area,* located in the left temporal cortex, is involved in language comprehension (whether spoken or signed). As the brain matures, these areas become increasingly specialized for language, so much so that damage to them results in a serious condition called **aphasia**, defined as *difficulty in producing or comprehending language.*

● How does language processing change in the brain as the child matures?

As you saw in Chapter 1, patients with damage to Broca's area can understand language relatively well, although they have increasing comprehension difficulty as grammatical structures get more complex (Broca, 1861, 1863). But their real struggle is with speech production. Typically, they speak in short, staccato phrases and grammatical structure is impaired. A person with the condition might say something like "Ah, Monday, uh, Casey park. Two, uh, friends, and, uh, 30 minutes."

In contrast, patients with damage to Wernicke's area can produce grammatical speech, but it tends to be meaningless, and they have considerable difficulty comprehending language (Wernicke, 1874). Such a patient might say something like "I feel very well. In other words, I used to be able to work cigarettes. I don't know how. Things I couldn't hear from are here."

In normal language processing, Wernicke's area is highly active when we make judgments about word meaning, and damage to this area impairs comprehension of spoken and signed language although the ability to identify nonlanguage sounds is unimpaired. For example, Japanese can be written using symbols that, like the English alphabet, represent speech sounds, or by using pictographs that, like Chinese pictographs, represent ideas. Japanese patients who suffer from Wernicke's aphasia encounter difficulties in writing and understanding the symbols that represent speech sounds but not pictographs.

In normal language development, Broca's area and Wernicke's area become specialized for processing and producing language as long as the developing child is exposed to spoken or signed language. As the case of Genie shows, there is a critical period during which this specialization occurs; and if the developing brain does not receive adequate language input, this process can be permanently disrupted.

Culture & Community

Does Bilingual Education Slow Cognitive Development?

Question: What do you call someone who speaks more than one language?
Answer: A polyglot.
Question: What do you call someone who speaks only one language?
Answer: An American.

In most of the world, bilingualism is the norm, not the exception. In fact nearly half of the world's population speaks more than one language (Hakuta, 1999). Despite this, bilingualism is the source of considerable controversy in the American educational system. Detractors argue that bilingual instruction can slow the cognitive development of children—a perspective supported by early research but contradicted in recent studies.

New findings show that monolingual and bilingual students show similar rates of language development. Bilingual students even exceed monolingual students in cognitive flexibility and analytic reasoning (Bialystok, 1999) and, in fact, show increased ability of the left parietal lobe to handle linguistic demands (Mechelli et al., 2004).

summary quiz [7.1]

1. The sentences "The dog chased the cat" and "The cat was chased by the dog" have _____ deep structure and _____ surface structure.

a. different; different
b. the same; different
c. different; the same
d. the same; the same

2. On the day 2 year-old Isabel helped her father build bookshelves, she added the words *board, measuring tape,* and *dowel* to her vocabulary after her first encounter with these objects. This is an example of

a. a language acquisition device.
b. fast mapping.
c. telegraphic speed.
d. linguistic relativity.

3. A collection of processes that facilitate language learning is called

a. a language acquisition device.
b. fast mapping.
c. an exemplar.
d. a deep structure.

4. Damage to Wernicke's area results in

a. failure to produce grammatical speech.
b. great difficulty in understanding language.
c. genetic dysphasia.
d. great difficulty in identifying nonlanguage sounds.

aphasia Difficulty in producing or comprehending language.

concept A mental representation that groups or categorizes shared features of related objects, events, or other stimuli.

category-specific deficit A neurological syndrome that is characterized by an inability to recognize objects that belong to a particular category while leaving the ability to recognize objects outside the category undisturbed.

family resemblance theory Members of a category have features that appear to be characteristic of category members but may not be possessed by every member.

Concepts and Categories: How We Think

A **concept** is a *mental representation that groups or categorizes shared features of related objects, events, or other stimuli.* For example, your concept of a chair might include such features as sturdiness, relative flatness, an object that you can sit on. That set of attributes defines a category of objects in the world including desk chairs, recliner chairs, flat rocks, bar stools, and so on.

● **Why are concepts useful to us?**

Concepts are fundamental to our ability to think and make sense of the world. As with other aspects of cognition, we can gain insight into how concepts are organized by looking at some instances in which they are rather disorganized. Some mindbugs in the form of unusual disorders help us understand how concepts are normally organized in the brain.

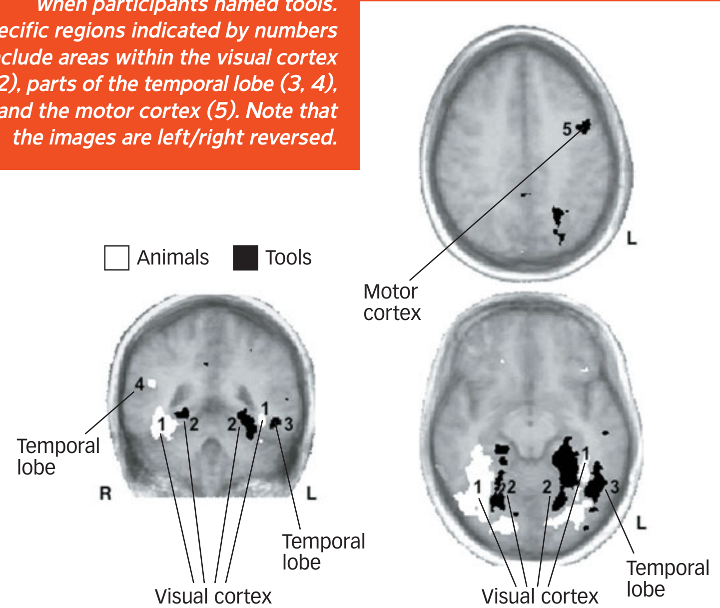
The Organization of Concepts and Category-Specific Deficits

Over 20 years ago, two neuropsychologists described a mindbug resulting from brain injury that had major implications for understanding how concepts are organized (Warrington & McCarthy, 1983). Their patient could not recognize a variety of human-made objects or retrieve any information about them, but his knowledge of living things and foods was perfectly normal. In the following year, the two neuropsychologists reported four patients who exhibited the reverse pattern: They could recognize information about human-made objects, but their ability to recognize information about living things and foods was severely impaired (Warrington & Shallice, 1984). Since the publication of these pioneering studies, over 100 similar cases have been reported (Martin & Caramazza, 2003). The syndrome is called **category-specific deficit**, *an inability to recognize objects that belong to a particular category while leaving the ability to recognize objects outside the category undisturbed.*

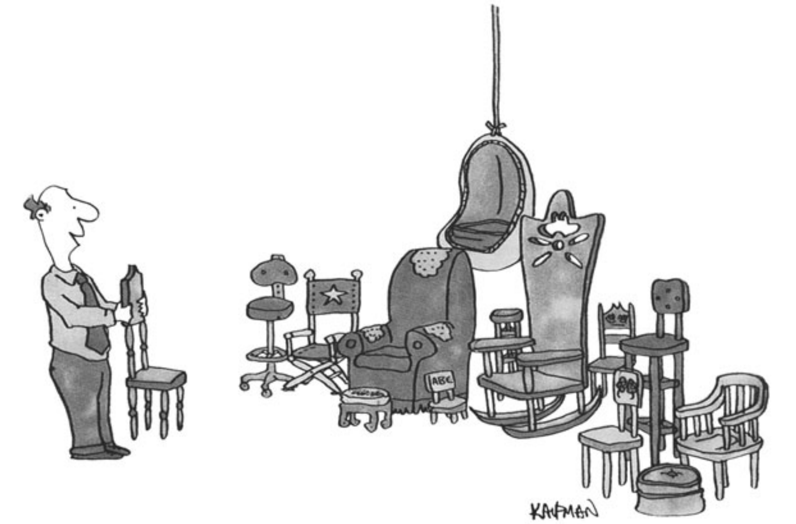
Category-specific deficits like these have been observed even when the brain trauma that produces them occurs shortly after birth. Two researchers reported the case of Adam, a 16-year-old boy who suffered a stroke a day after he was born (Farah & Rabinowitz, 2003). Adam has severe difficulty recognizing faces and other biological objects. When shown a picture of a cherry, he identified it as "a Chinese yo-yo." When shown a picture of a mouse, he identified it as an owl. He made errors like these on 79% of the animal pictures and 54% of the plant pictures he was shown. In contrast, he made only 15% errors when identifying pictures of nonliving things, such as spatulas, brooms, and cigars. The fact that 16-year-old Adam exhibited category-specific deficits despite suffering his stroke when he was only 1 day old strongly suggests that the brain is "prewired" to organize perceptual and sensory inputs into broad-based categories, such as living and nonliving things.

The type of category-specific deficit suffered depends on where the brain is damaged. Deficits usually result when an individual suffers a stroke or other trauma to areas in the left hemisphere of the cerebral cortex (Martin & Caramazza, 2003). Damage to the front part of the left temporal lobe results in difficulty identifying humans, damage to the lower left temporal lobe results in difficulty identifying animals, and damage to the region where the temporal lobe meets the occipital and parietal lobes impairs the ability to retrieve names of tools (Damasio et al., 1996). Similarly, imaging studies of healthy people have demonstrated that the same regions of the brain are more active during naming of tools than animals and vice versa, as shown in **FIGURE 7.3** (Martin & Chao, 2001).

FIGURE 7.3 **Brain Areas Involved in Category-Specific Processing** *Participants were asked to silently name pictures of animals and tools while they were scanned with fMRI. The fMRIs revealed greater activity in the areas in white when participants named animals, and areas in black showed greater activity when participants named tools. Specific regions indicated by numbers include areas within the visual cortex (1, 2), parts of the temporal lobe (3, 4), and the motor cortex (5). Note that the images are left/right reversed.*



ALEX MARTIN AND LINDA CHAO, 2001, CURRENT OPINIONS NEUROBIOL., 11: 194–201.



"Attention, everyone! I'd like to introduce the newest member of our family."

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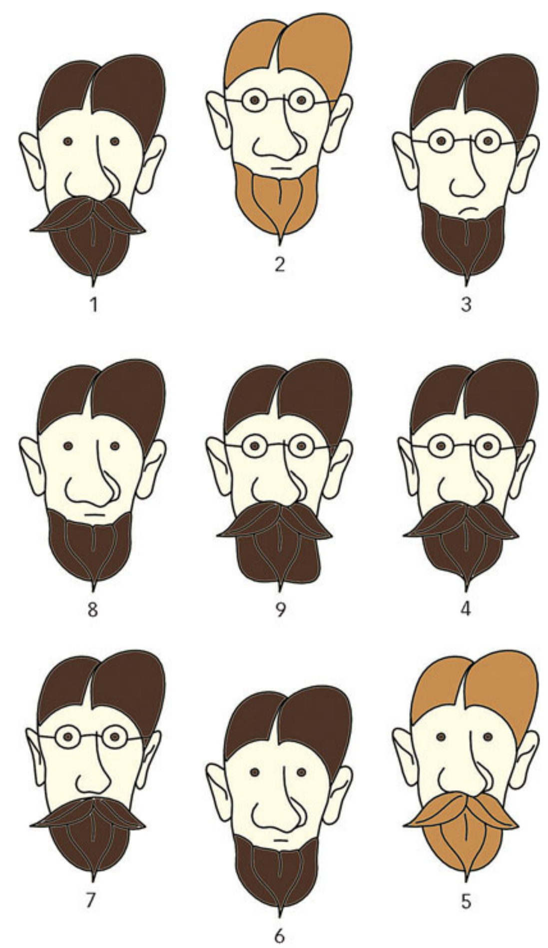
FIGURE 7.4 **Family Resemblance Theory** *The family resemblance here is unmistakable, even though no two Smith brothers share all the family features. The prototype is brother 9. He has it all: brown hair, large ears, large nose, mustache, and glasses.*



Cases of category-specific deficit provide new insights into how the brain organizes our concepts about the world, classifying them into categories based on shared similarities. Our category for "dog" may be something like "small, four-footed animal with fur that wags its tail and barks." Our category for "bird" may be something like "small, winged, beaked creature that flies." We form these categories in large part by noticing similarities among objects and events that we experience in everyday life. A stroke or trauma that damaged the particular place in your brain that stores your "dog" category would wipe out your ability to recognize dogs or remember anything about them.

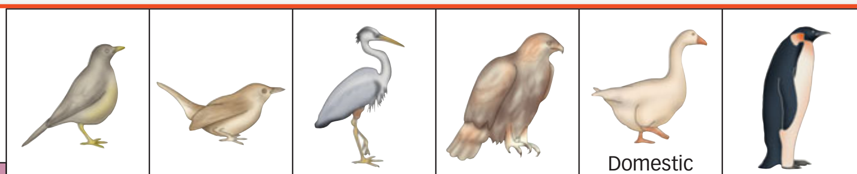
● How does the brain organize our concepts of the world?

Psychological Theories of Concepts and Categories

Psychologists have investigated the nature of human concepts, how they are acquired, and how they are used to make decisions and guide actions. For example, what is your definition of "dog"? Can you come up with a rule of "dogship" that includes all dogs and excludes all nondogs? Most people can't, but they still use the term *dog* intelligently, easily classifying objects as dogs or nondogs. Several theories seek to explain how people perform these acts of categorization.

Family Resemblance Theory

Eleanor Rosch developed a theory of concepts based on **family resemblance**—that is, *features that appear to be characteristic of category members but may not be possessed by every member* (Rosch, 1973, 1975; Rosch & Mervis, 1975; Wittgenstein, 1953/1999). For example, you and your brother may have your mother's eyes, although you and your sister may have your father's high cheekbones. There is a strong family resemblance among you, your parents, and your siblings despite the fact that there is no necessarily defining feature that you all have in common. Similarly, many members of the "bird" category have feathers and wings, so these are the characteristic features. Anything that has these features is likely to be classified as a bird because of this "family resemblance" to other members of the bird category. **FIGURE 7.4** illustrates family resemblance theory.



Properties	Generic bird	Wren	Blue heron	Golden eagle	Domestic goose	Penguin
Flies regularly	✓	✓	✓	✓		
Sings	✓	✓	✓			
Lays eggs	✓	✓	✓	✓	✓	✓
is small	✓	✓				
Nests in trees	✓	✓				

FIGURE 7.5
Critical Features of a Category *We tend to think of a generic bird as possessing a number of critical features, but not every bird possesses all of those features. In North America, a wren is a "better example" of a bird than a penguin or an ostrich.*

Prototype Theory

Building on the idea of family resemblance, Rosch also proposed that psychological categories (those that we form naturally) are best described as organized around a **prototype**, which is *the "best" or "most typical member" of the category.* A prototype possesses most (or all) of the most characteristic features of the category. For North Americans, the prototype of the bird category would be something like a robin: a small animal with feathers and wings that flies through the air, lays eggs, and migrates (see FIGURE 7.5, above). (If you lived in Antarctica, your prototype of a bird might be a penguin: a small animal that has flippers, swims, and lays eggs.) According to *prototype theory,* if your prototypical bird is a robin, then a canary would be considered a better example of a bird than would an ostrich because a canary has more features in common with a robin than an ostrich does. People make category judgments by comparing new instances to the category's prototype. This contrasts with the classical approach to concepts in which something either is or is not an example of a concept (i.e., it either does or does not belong in the category "dog" or "bird").

BLEND IMAGES/SUPERSTOCK

There is family resemblance between family members despite the fact that there is no defining feature that they all have in common. Instead, there are shared common features. Someone who also shares some of those features may be categorized as belonging to the family.

Exemplar Theory

In contrast to prototype theory, **exemplar theory** holds that *we make category judgments by comparing a new instance with stored memories for other instances of the category* (Medin & Schaffer, 1978). Imagine that you're out walking in the woods, and from the corner of your eye you spot a four-legged animal that might be a wolf or coyote but that reminds you of your cousin's German shepherd. You figure it must be a dog and continue to enjoy your walk rather than fleeing in a panic. You probably categorized this new animal as a dog because it bore a striking resemblance to examples (or *exemplars*) of other dogs you've encountered. Exemplar theory does a better job than prototype theory in accounting for certain aspects of categorization, especially in that we recall not only what a *prototypical* dog looks like but also what *specific* dogs look like.

● **How do prototypes and exemplars relate to each other?**

Researchers have concluded that we use both prototypes and exemplars when forming concepts and categories. In other words, when we see a new four-legged animal, we decide whether it is a dog both by comparing it against our prototype of a generic dog and also by comparing it against specific exemplars of dogs we have encountered. Neuroimaging shows that the visual cortex is involved in forming prototypes, whereas the prefrontal cortex and basal ganglia are involved in learning exemplars (Ashby & Ell, 2001). This evidence suggests that exemplar-based learning involves analysis and decision making (prefrontal cortex), whereas prototype formation is a more holistic process involving image processing (visual cortex).

summary quiz [7.2]

5. An inability to recognize objects that belong to a particular category while leaving the ability to recognize objects outside the category is called

a. genetic dysphasia.
b. Broca's aphasia.
c. category-specific deficit.
d. Wernicke's aphasia.

6. The "best" or "most typical member" of a category is called a(n)

a. concept.
b. prototype.
c. exemplar.
d. heuristic.

7. A theory of categorization that says we make category judgments by comparing a new instance with stored memories for other instances of the category is called

a. exemplar theory.
b. family resemblance theory.
c. prototype theory.
d. linguistic relativity hypothesis.

Judging, Valuing, and Deciding: Sometimes We're Logical, Sometimes Not

We use categories and concepts to guide the hundreds of decisions and judgments we make during the course of an average day. Some decisions are easy—what to wear, what to eat for breakfast, and whether to walk or ride to class—and some are more difficult—which car to buy, which apartment to rent, and which job to take after graduation.

Decision making, like other cognitive activities, is vulnerable to mindbugs—many of little consequence. Had you really thought through your decision to go out with Marge, you might instead have called Emily, who's a lot more fun, but all in all, your decision about the evening was okay. The same kinds of slips in the decision-making process can have tragic results, however. In one experiment, a large group of physicians were asked to predict the incidence of breast cancer among women whose mammogram screening tests showed possible evidence of breast cancer. The physicians were told to take into consideration the rarity of breast cancer (1% of the population at the time the study was done) and radiologists' record in diagnosing the condition (correctly recognized only 79% of the time and falsely diagnosed almost 10% of the time). Most of the physicians estimated the probability that cancer was present to be about 75%. The correct answer is 8%! The physicians apparently experienced difficulty taking so much information into account when making their decision (Eddy, 1982). Similar dismal results have been reported with a number of medical screening tests (Hoffrage & Gigerenzer, 1996; Windeler & Kobberling, 1986). Such mistakes can lead to tragic consequences: In one case, a well-meaning surgeon urged many of his "high-risk" female patients to undergo a mastectomy in order to avoid developing breast cancer—even though the vast majority of these women (85 out of 90) were not expected to develop breast cancer at all (Gigerenzer, 2002).

Before you conclude that humans are poorly equipped to make important decisions, note that our success rate often depends on the nature of the task. Let's find out why this is so.

Decision Making: Rational and Otherwise

Economists contend that if we are rational and free to make our own decisions, we will behave as predicted by **rational choice theory:** *We make decisions by determining how likely something is to happen, judging the value of the outcome, and then multiplying the two*

prototype The "best" or "most typical member" of a category.

exemplar theory A theory of categorization that argues that we make category judgments by comparing a new instance with stored memories for other instances of the category.

rational choice theory The classical view that we make decisions by determining how likely something is to happen, judging the value of the outcome, and then multiplying the two.

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People don't always make rational choices. When a lottery jackpot is larger than usual, more people will buy lottery tickets, thinking that they might well "win big." However, more people buying lottery tickets reduces the likelihood of any one person's winning the lottery. Ironically, people have a better chance at winning a lottery with a relatively small jackpot.

(Edwards, 1955). This means that our judgments will vary depending on the value we assign to the possible outcomes. Suppose, for example, you were asked to choose between a 10% opportunity to gain $500 and a 20% chance of gaining $2,000. The rational person would choose the second alternative because the expected payoff is $400 ($2,000 × 20%), whereas the first offers an expected gain of only $50 ($500 × 10%). Selecting the option with the highest expected value seems so straightforward that many economists accepted the basic ideas in rational choice theory. But how well does this theory describe decision making in our everyday lives? In many cases, the answer is "not very well."

As you learned earlier in the chapter, humans easily group events and objects into categories based on similarity, and they classify new events and objects by deciding how similar they are to categories that have already been learned. However, these strengths of human decision making can turn into weaknesses when certain tasks inadvertently activate these skills. In other words, the same principles that allow cognition to occur easily and accurately can pop up as mindbugs to bedevil our decision making. Here are three examples of such mindbugs.

● **How do we fail as rational decision makers?**

Judging Frequencies and Probabilities

Consider the following list of words:

block table block pen telephone block disk glass table block telephone block watch table candy

You probably noticed that the words *block* and *table* occurred more frequently than the other words did. In fact, studies have shown that people are quite good at estimating the frequency with which things occur (Barsalou & Ross, 1986; Gallistel & Gelman, 1992; Hasher & Zacks, 1984).

This skill matters quite a bit when it comes to decision making. As you'll remember, physicians performed dismally when they were asked to estimate the true probability of breast cancer among women who showed possible evidence of the disease. However, dramatically different results were obtained when the study was repeated using *frequency* information instead of *probability* information. Stating the problem as "10 out of every 1,000 women actually have breast cancer" instead of "1% of women actually have breast cancer" led 46% of the physicians to derive the right answer, compared to only 8% who came up with right answer when the problem was presented using probabilities (Hoffrage & Gigerenzer, 1998). This finding suggests at a minimum that when seeking advice—even from a highly skilled decision maker—you'd be well served to make sure that your problem is described using frequencies rather than probabilities.

The Conjunction Fallacy

Consider the following description:

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

ONLY HUMAN

NOW, LET ME CALCULATE HOW LIKELY IT IS WE'LL WALK AWAY FROM THIS. . . . Some of the 280 survivors (out of 340) of a Dutch charter plane that crashed in a wind gust in the resort town of Faro, Portugal, gathered to tell their stories to reporters. Wim Kodman, 27, who is a botanist, said he was trying to calm a friend during the wind turbulence by appealing to logic. Said Kodman, "I told him, 'I'm a scientist; we're objective.' I told him a crash was improbable. I was trying to remember the exact probability when we smashed into the ground."

conjunction fallacy When people think that two events are more likely to occur together than either individual event.

framing effects When people give different answers to the same problem depending on how the problem is phrased (or framed).

sunk-cost fallacy A framing effect in which people make decisions about a current situation based on what they have previously invested in the situation.

Which state of affairs is more probable?

a. Linda is a bank teller.
b. Linda is a bank teller and is active in the feminist movement.

In one study, 89% of participants rated option **b** as more probable than option **a** (Tversky & Kahneman, 1983), although that's logically impossible. This mindbug is called the **conjunction fallacy** because *people think that two events are more likely to occur together than either individual event.* In fact, the joint probability that *two* things are true is always mathematically less than the independent probability of each event; therefore, it's always *more* probable that any one state of affairs is true than is a set of events simultaneously (FIGURE 7.6).

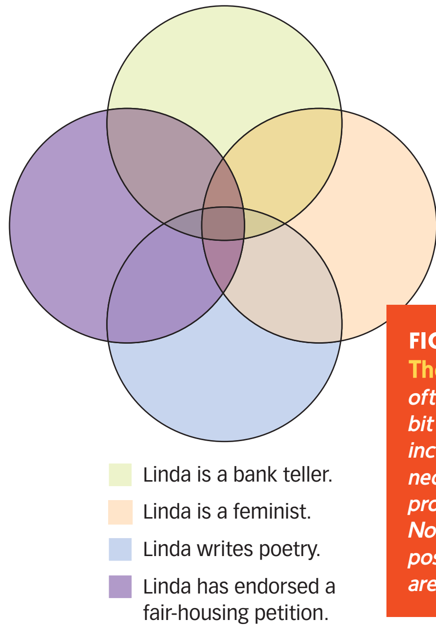


FIGURE 7.6 **The Conjunction Fallacy** *People often think that which each additional bit of information, the probability increases that all the facts are simultaneously true of a person. In fact, the probability decreases dramatically. Notice how the intersection of all these possibilities is much smaller than the area of any one possibility alone.*

Framing Effects

You've seen that, according to rational choice theory, our judgments will vary depending on the value we place on the expected outcome. So how effective are we at assigning value to our choices? Not surprisingly, a mindbug can affect this situation. Studies show that **framing effects**, which occur when *people give different answers to the same problem depending on how the problem is phrased (or framed),* can influence the assignment of value.

For example, if people are told that a particular drug has a 70% effectiveness rate, they're usually pretty impressed: 70% of the time the drug cures what ails you sounds like a good deal. Tell them instead that a drug has a 30% failure rate—30% of the time it does no good—and they typically perceive it as risky, potentially harmful, something to be avoided. Notice that the information is the same: A 70% effectiveness rate means that 30% of the time, it's ineffective. The way the information is framed, however, leads to substantially different conclusions (Tversky & Kahneman, 1981).

● **Why does a 70% success rate sound better than a 30% failure rate?**

One of the most striking framing effects is the **sunk-cost fallacy,** which occurs when *people make decisions about a current situation based on what they have previously invested in the situation.* Imagine waiting in line for 3 hours, paying $100 for a ticket to see your favorite bands, and waking on the day of the outdoor concert to find that it's bitterly cold and rainy. If you go, you'll feel miserable. But if you stay home, the $100 you paid for the ticket and the time you spent in line will have been wasted.

Notice that you have two choices: (1) spend $100 and stay comfortably at home or (2) spend $100 and endure many uncomfortable hours in the rain. The $100 is gone in either case; it's a sunk cost, irretrievable now. But the way you framed the problem creates a mindbug: Because you invested time and money, you probably feel obligated to follow through, even though it's something you no longer want. If you can turn off the mindbug and ask, "Would I rather spend $100 to be comfortable or spend it to be miserable?" the smart choice is clear: Stay home and listen to the podcast!

Even the National Basketball Association (NBA) is guilty of a sunk-cost fallacy. Coaches should play their most productive players and keep them on the team longer. But they don't. The most *expensive* players are given more time on court and are kept on the team longer than cheaper players, even if the costly players are not performing up to par (Staw & Hoang, 1995). Coaches act to justify their team's investment in an expensive player rather than recognize the loss. Mindbugs can be costly!

ANDY ALTENBURGER/ICON SMI

Worth the cost? Sports teams sometimes try to justify their investment in an expensive player who is underperforming—an example of a sunk-cost effect. Adrián Beltré is a highly paid baseball player, but his performance has not always lived up to his salary.

Prospect Theory

As you have seen, everyday decision making seems riddled with errors and shortcomings. Our decisions vary wildly depending on how a problem is presented (e.g., frequencies versus probabilities or framed in terms of losses rather than savings), and we seem to be prone to fallacies, such as the sunk-cost fallacy or the conjunction fallacy.

According to a totally rational model of inference, people should make decisions that maximize value; in other words, they should seek to increase what psychologists and economists call *expected utility*. We face decisions like this every day. If you are making a decision that involves money, and if money is what you value, then you should choose the outcome that is likely to bring you the most money. So, for example, when deciding which of two apartments to rent, you'd compare the monthly expenses for each and choose the one that leaves more money in your pocket.

● **Why will most people take more risks to avoid losses than to make gains?**

As you have seen, however, people often make decisions that are inconsistent with this simple principle. The question is, why? To explain these effects, Amos Tversky and Daniel Kahneman (1992) developed **prospect theory**, which argues that *people choose to take on risk when evaluating potential losses and avoid risks when evaluating potential gains*. These decision processes take place in two phases.

- First, people *simplify* available information. So, in a task like choosing an apartment, they tend to ignore a lot of potentially useful information because apartments differ in so many ways (the closeness of restaurants, the presence of a swimming pool, the color of the carpet, etc.). Comparing each apartment on each factor is simply too much work; focusing only on differences that matter is more efficient.
- In the second phase, people choose the prospect that they believe offers the *best value*. This value is personal and may differ from an objective measure of "best value." For example, you might choose the apartment with higher rent because you can walk to eight great bars and restaurants.

Prospect theory makes other assumptions that account for people's choice patterns. One assumption, called the *certainty* effect, suggests that when making decisions, people give greater weight to outcomes that are a sure thing. When deciding between playing a lottery with an 80% chance of winning $4,000 or receiving $3,000 outright, most people choose the $3,000, even though the expected value of the first choice is $200 more ($4,000 × 80% = $3,200)! Apparently, people weigh certainty much more heavily than expected payoffs when making choices.

Prospect theory also assumes that in evaluating choices, people compare them to a *reference point*. For example, suppose you're still torn between two apartments. The $400 monthly rent for apartment A is discounted $10 if you pay before the fifth of the month. A $10 surcharge is tacked onto the $390 per month rent for apartment B if you pay after the fifth of the month. Although the apartments are objectively identical in terms of cost, different reference points may make apartment A seem psychologically more appealing than B.

Prospect theory also assumes that people are *more willing to take risks to avoid losses than to achieve gains*. Given a choice between a definite $300 rebate on your first month's rent or spinning a wheel that offers an 80% chance of getting a $400 rebate, you'll most likely choose the lower sure payoff over the higher potential payoff ($400 × 80% = $320). However, given a choice between a sure fine of $300 for damaging an apartment or a spinning of a wheel that has an 80% chance of a $400 fine, most people will choose the higher potential loss over the sure loss. This asymmetry in risk preferences shows that we are willing to take on risk if we think it will ward off a loss, but we're risk-averse if we expect to lose some benefits.

prospect theory Proposes that people choose to take on risk when evaluating potential losses and avoid risks when evaluating potential gains.

intelligence A hypothetical mental ability that enables people to direct their thinking, adapt to their circumstances, and learn from their experiences.

summary quiz [7.3]

8. Consider the following description: Paula is 42 years old, married, and extremely intelligent. In college, she majored in English and served as a writing tutor. Which state of affairs is most probable?
a. Paula works in a bookstore.
b. Paula works in a bookstore and writes poetry.
c. Paula works in a bookstore, writes poetry, and does crossword puzzles.
d. Paula works in a bookstore, writes poetry, does crossword puzzles, and is active in the antiwar movement.

9. Claire spent $100 for a nonrefundable ticket to a play. Then she found out her granddaughter's first dance recital was that day. Claire really wanted to go to the recital but felt obligated to go to the play. She was displaying
a. the representative heuristic.
b. the sunk-cost fallacy.
c. functional fixedness.
d. the availability bias.

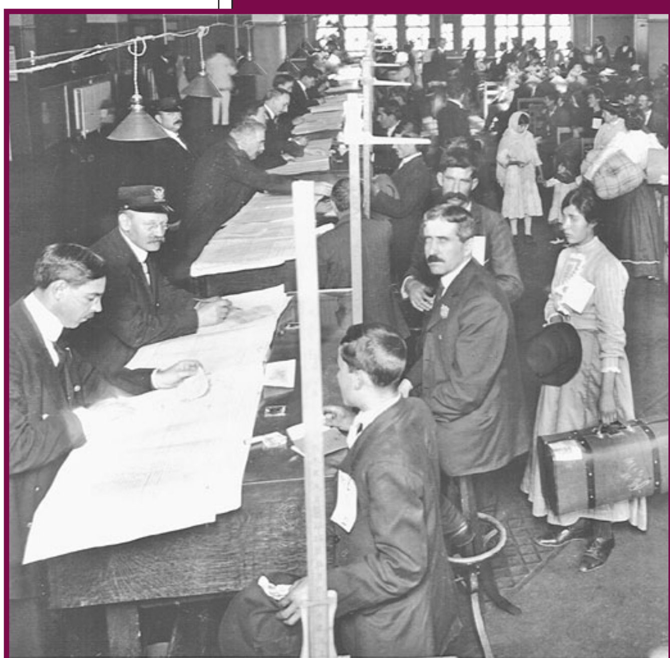
10. Which view states that people choose to take on risks when evaluating potential losses and avoid risks when evaluating potential gains?
a. the frequency format hypothesis
b. prospect theory
c. means-end analysis
d. belief bias

Intelligence

Let's return for a moment to Christopher, the boy who could learn languages but not tic-tac-toe. Would you call him intelligent? That's a difficult question. It seems odd to say that someone is intelligent when he or she can't master a simple game, but it seems equally odd to say that someone is unintelligent when he or she can master 16 languages. In a world of Albert Einsteins and Homer Simpsons, we'd have no trouble distinguishing the geniuses from the dullards. But ours is a world of people like Christopher and people like us—people who are sometimes brilliant, typically competent, and occasionally dimmer than broccoli. This forces us to ask hard questions: What exactly is intelligence? How can it be measured? Where does it come from? Can it be improved?

Psychologists have been asking such questions for more than a century. They agree that intelligence involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, and learn from experience. It not just the product of "book learning" but also the ability to "figure things out." Psychologists generally define **intelligence** as *a mental ability that enables people to direct their thinking, adapt to their circumstances, and learn from their experiences*. Clearly, intelligence is a good thing to have. So how do we measure it?

When immigrants arrived at Ellis Island in the 1920s, they were given intelligence tests, which supposedly revealed that Jews, Hungarians, Italians, and Russians were "feebleminded."



NATIONAL PARK SERVICE

The Measurement of Intelligence: Highly Classified

Few things are more dangerous than a man with a mission. In the 1920s, psychologist Henry Goddard administered intelligence tests to arriving immigrants at Ellis Island and concluded that the overwhelming majority of Jews, Hungarians, Italians, and Russians were "feebleminded." Goddard also used his tests to identify feebleminded

ratio IQ A statistic obtained by dividing a person's mental age by the person's physical age and then multiplying the quotient by 100 (see *deviation IQ*).

deviation IQ A statistic obtained by dividing a person's test score by the average test score of people in the same age group and then multiplying the quotient by 100 (see *ratio IQ*).

American families (who, he claimed, were largely responsible for the nation's social problems) and suggested that the government should segregate them in isolated colonies and "take away from these people the power of procreation" (Goddard, 1913, p. 107). The United States subsequently passed laws restricting the immigration of people from Southern and Eastern Europe, and 27 states passed laws requiring the sterilization of "mental defectives."

The Invention of IQ

From Goddard's day to our own, intelligence tests have been used to rationalize prejudice and legitimate discrimination against people of different races, religions, and nationalities. While intelligence testing has achieved many notable successes, its history is marred by more than its share of fraud and disgrace (Chorover, 1980; Lewontin, Rose, & Kamin, 1984). The fact that intelligence tests have occasionally been used to further detestable ends is especially ironic because such tests were originally developed for the noble purpose of helping poor children prosper, learn, and grow. When France instituted a sweeping set of education reforms in the 19th century that made a primary school education available to children of every social class, French classrooms were suddenly filled with a diverse group of children who differed dramatically in their readiness to learn. The French government called on psychologist Alfred Binet and physician Theophile Simon to create a test that would allow educators to develop remedial programs for those children who lagged behind their peers. "Before these children could be educated," Binet (1909) wrote, "they had to be selected. How could this be done?"

● What was the original goal of the IQ test?

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Binet and Simon set out to develop an objective test that would provide an unbiased measure of a child's ability. They began, sensibly enough, by looking for tasks that the best students in a class could perform and that the worst students could not. The tasks they tried included solving logic problems; remembering words; copying pictures; distinguishing edible and inedible foods; making rhymes; and answering questions such as "When anyone has offended you and asks you to excuse him, what ought you to do?" Binet and Simon settled on 30 of these tasks and assembled them into a test that they claimed could measure a child's "natural intelligence," meaning a child's *aptitude* for learning independent of the child's prior educational *achievement*. Binet and Simon suggested that teachers could use their test to estimate a child's "mental age" simply by computing the average test score of children in different age groups and then finding the age group whose average test score was most like that of the child's. For example, a child who was 10 years old but whose score was about the same as the score of the average 8-year-old was considered to have a mental age of 8 and thus to need remedial education.

This simple idea became the basis for the most common measure of intelligence: the intelligence quotient. To measure the intelligence of a child, psychologists compute a ratio intelligence quotient (or **ratio IQ**) by *dividing the child's mental age by his or her physical age, and then multiplying by 100*. So a 10-year-old whose mental age is 10 has an IQ of (10/10) × 100 = 100, but a 10-year-old who scores like an average 8-year-old and thus has a mental age of 8 has an IQ of (8/10) × 100 = 80. This measure doesn't work well for adults (after all, there's nothing wrong with a 55-year-old who scores like a 45-year-old), and thus psychologists use a slightly different measure called the **deviation IQ**, which is computed by

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● *Alfred Binet (left, 1857–1911) and Theodore Simon (right, 1872–1961) developed the first intelligence test to identify children who needed remedial education.*

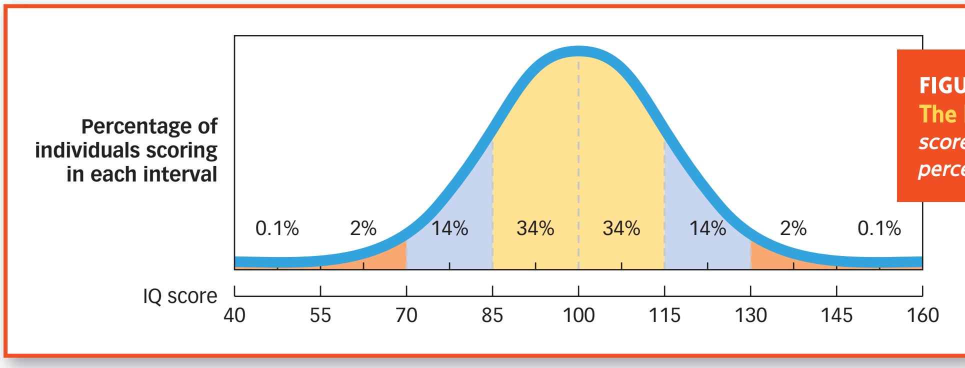


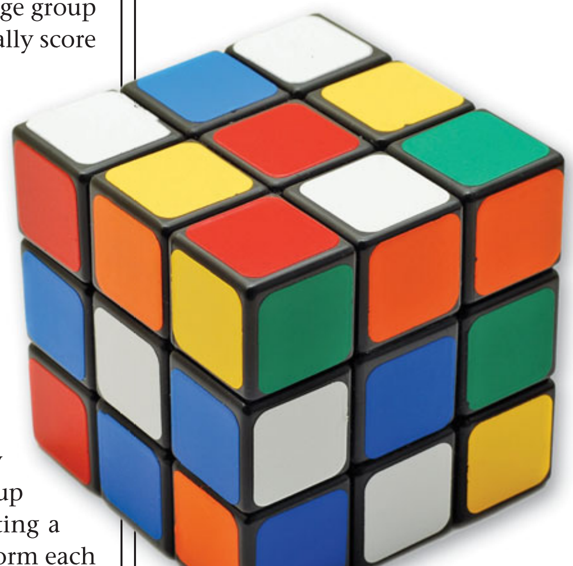
FIGURE 7.7 **The Normal Curve of Intelligence** *Deviation IQ scores produce a normal curve. This chart shows the percentage of people who score in each range of IQ.*

dividing the adult's test score by the average test score of people in the same age group, and then multiplying by 100. Thus, an adult who scores the same as others in the same age group has an IQ of 100. **FIGURE 7.7** (above) shows the percentage of people who typically score at each level of IQ on a standard intelligence test.

The Logic of Intelligence Testing

Binet and Simon's test did a good job of predicting a child's performance in school, and intelligence is surely one of the factors that contributes to that performance. But surely there are others. Affability, motivation, intact hearing, doting parents—all of these seem likely to influence a child's scholastic performance. Binet and Simon's test identified students who were likely to perform poorly in school, but was it a test of intelligence?

As you learned in Chapter 2, psychological research typically involves generating an operational definition of a hypothetical property that one wishes to measure. To design an intelligence test, we begin with the assumption that a *hypothetical property* called intelligence enables people to perform a wide variety of *consequential behaviors* such as getting good grades in school, becoming a group leader, earning a large income, finding the best route to the gym, or inventing a greaseless burrito (**FIGURE 7.8**, below). Because measuring how well people perform each of these consequential behaviors would be highly impractical, we instead devise an easily administered set of tasks (e.g., a geometric puzzle) and questions (e.g., "*Butterfly* is to *caterpillar* as *woman* is to ____") whose successful completion is known to be correlated with those behaviors. Now, instead of measuring the consequential behaviors (which is difficult to do), we can simply give people our test (which is easy to do). We



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Is a Rubik's cube an intelligence test? Intelligence is a hypothetical property that makes possible consequential behavior such as school achievement and job performance. People who can perform such behaviors can often solve puzzles like this one.

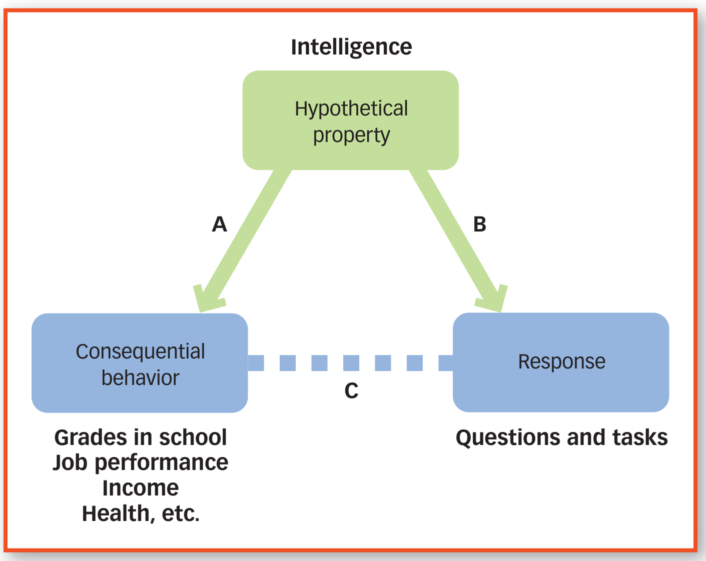


FIGURE 7.8 **The Logic of Intelligence Testing** *An intelligence test is a set of questions and tasks that elicit responses. These responses are correlated with numerous consequential behaviors (path C), presumably because the hypothetical property called intelligence causes both the responses (path B) and the consequential behaviors (path A).*

could call this "an intelligence test" as long as we understood that what we mean by that phrase is "a measurement of responses that are correlated with consequential behaviors that are correlated with intelligence." In other words, intelligence tests do not "measure" intelligence in the same way that thermometers measure temperature. Rather, they measure the ability to answer questions and perform tasks that are highly correlated with the ability to get good grades, solve real-world problems, and so on.

● What do intelligence tests measure?

Finding such questions and tasks isn't easy, and since Binet and Simon's day, psychologists have worked hard to construct intelligence tests that can predict a person's ability to perform the consequential behaviors that intelligence should make possible. Today the most widely used intelligence tests are the *Stanford-Binet* (a test that is based on Binet and Simon's original test but that has been modified and updated many times) and the *WAIS* (the Wechsler Adult Intelligence Scale). Both tests require respondents to answer a variety of questions and solve a variety of problems. For example, the WAIS's 13 subtests involve seeing similarities and differences, drawing inferences, working out and applying rules, remembering and manipulating material, constructing shapes, articulating the meaning of words, recalling general knowledge, explaining practical actions in everyday life, working with numbers, attending to details, and so forth.

So what are the consequential behaviors that the scores on these tests predict? Binet and Simon would be pleased to know that intelligence tests predict school performance better than they predict just about anything else. The correlation between a person's score on a standard intelligence test and his or her academic performance is roughly $r = .5$ across a wide range of people and situations. An intelligence test score is also the best predictor of the number of years of education an individual will receive, which is in part why these scores also predict a person's occupational status and income. For example, a person's score on an intelligence test taken in early adulthood correlates about $r = .4$ with the person's later occupational status (Jencks, 1979). One study of brothers found that the brother who exceeded his sibling by 15 IQ points had, on average, about 17% greater annual earnings. There is also a strong correlation between the average intelligence score of a nation and its overall economic status (Lynn & Vanhanen, 2002). An analysis of the data from thousands of studies revealed that intelligence test scores are among the best predictors of how well employees perform in their jobs (Hunter & Hunter, 1984), and job performance correlates more highly with intelligence ($r = .53$) than with factors such as performance during a job interview ($r = .14$) or education ($r = .10$).

● What do intelligence tests predict?

But intelligence scores don't just predict success at school and work. Intelligence scores also do a reasonably good job of predicting a wide variety of behaviors that most of us think of as "smart" (see The Real World box on page 217). One study identified 320 people with extremely high intelligence test scores at age 13 and followed them for 10 years (Lubinski et al., 2001). Not only were they 50 times more likely than the general population to get graduate degrees and 500 times more likely than the general population to obtain a perfect score on the Graduate Record Examination, but also, at a time when fewer than a quarter of their peers had completed an undergraduate degree, they had already published scientific studies in peer-reviewed journals and stories in leading literary magazines, obtained prestigious scholastic fellowships, written operas, developed successful commercial products, and obtained patents. Intelligence test scores also predict people's performance on a variety of basic cognitive tasks. For instance, when people are briefly exposed to a pair of vertical lines and are asked to determine which is longer, people with high intelligence test

JEOPARDY PRODUCTIONS VIA GETTY IMAGES

● *Intelligence is highly correlated with income. Jeopardy contestant Ken Jennings finally lost on September 7, 2004, after becoming the biggest money winner in TV game show history at the time, earning $2,520,700 over a 74-game run.*

[THE REAL WORLD]

Look Smart

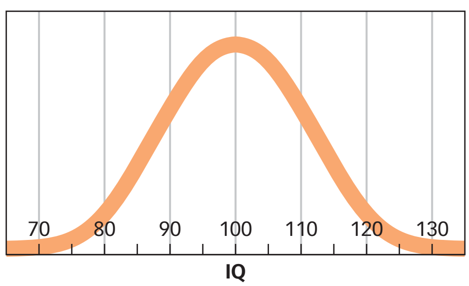
Your interview is in 30 minutes. you've checked your hair twice, eaten your weight in breath mints, combed your résumé for typos, and rehearsed your answers to all the standard questions. Now you have to dazzle them with your intelligence whether you've got it or not. Because intelligence is one of the most valued of all human traits, we are often in the business of trying to make others think we're smart regardless of whether that's true. So we make clever jokes and drop the names of some of the longer books we've read in the hope that prospective employers, prospective dates, prospective customers, and prospective in-laws will be appropriately impressed.

But are we doing the right things, and if so, are we getting the credit we deserve? Research shows that ordinary people are, in fact, reasonably good judges of other people's intelligence (Borkenau & Liebler, 1995). For example, observers can look at a pair of photographs and reliably determine which of the two people in them is smarter (Zebrowitz et al., 2002). When observers watch 1-minute videotapes of different people engaged in social interactions, they can accurately estimate which person has the highest IQ—even if they see the videos without sound (Murphy, Hall, & Colvin, 2003).

How do we do this amazing trick? We notice gaze. As it turns out, intelligent people hold the gaze of their conversation partners both when they are speaking and when they are listening, and observers seem to be tuned into this fact (Murphy et al., 2003). This is especially true when the observers are women (who tend to be better judges of intelligence) and the people being observed are men (whose intelligence tends to be easier to judge).

The bottom line? Breath mints are fine and a little gel on the cowlick certainly can't hurt, but when you get to the interview, don't forget to stare.

scores require less time to get the right answer (Deary & Stough, 1996; Grudnick & Kranzler, 2001; Nettleback & Lally, 1976). The same is true when people attempt to distinguish between colors or between tones (Acton & Schroeder, 2001). People with high intelligence test scores also have faster and less variable reaction times to almost any kind of stimulus (Deary, Der, & Ford, 2001). Clearly, intelligence scores predict many of the behaviors that we would expect intelligent people to perform (see **FIGURE 7.9**, below).



Population Percentages

Total population distribution	5	20	50	20	5
Out of labor force more than 1 month out of year (men)	22	19	15	14	10
Unemployed more than 1 month out of year (men)	12	10	7	7	2
Divorced in 5 years	21	22	23	15	9
Had children outside of marriage (women)	32	17	8	4	2
Lives in poverty	30	16	6	3	2
Ever incarcerated (men)	7	7	3	1	0
Chronic welfare recipient (mothers)	31	17	8	2	0
High school dropout	55	35	6	0.4	0

FIGURE 7.9 **Life Outcomes and Intelligence** *People with lower intelligence test scores typically have poorer life outcomes. This chart shows the percentage of people at different levels of IQ who experience the negative life outcomes listed in the leftmost column. Adapted from Gottfredson (1998).*

factor analysis A statistical technique that explains a large number of correlations in terms of a small number of underlying factors.

two-factor theory of intelligence Spearman's theory suggesting that every task requires a combination of a general ability (which he called *g*) and skills that are specific to the task (which he called *s*).

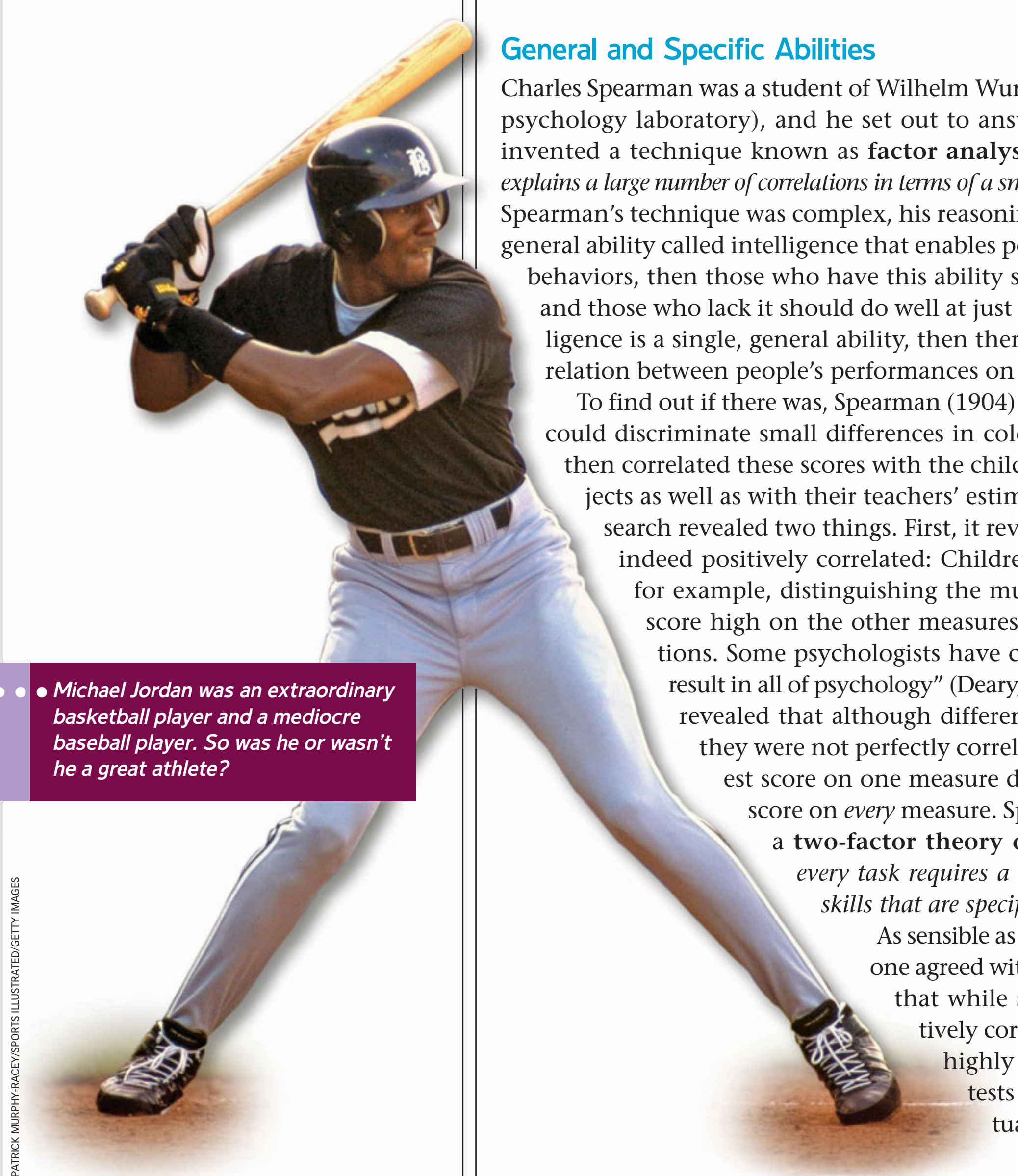
fluid intelligence The ability to process information (see *crystallized intelligence*).

crystallized intelligence The accuracy and amount of information available for processing (see *fluid intelligence*).

The Nature of Intelligence: Pluribus or Unum?

During the 1990s, Michael Jordan won the National Basketball Association's Most Valuable Player award five times, led the Chicago Bulls to six league championships, and had the highest regular season scoring average in the history of the game. The Associated Press named him the second-greatest athlete of the century, and ESPN named him the first. So when Jordan quit professional basketball in 1993 to join professional baseball, he was as surprised as anyone to find that compared to his teammates, he—well, there's really no way to say this nicely—sucked. One of his teammates lamented that Jordan "couldn't hit a curveball with an ironing board," and a major league manager called him "a disgrace to the game" (Wulf, 1994).

Michael Jordan's brilliance on the court and his mediocrity on the diamond proved beyond all doubt that basketball and baseball require different abilities that are not necessarily possessed by the same individual. But if these two sports require different abilities, then what does it mean to say that someone is the greatest athlete of the century? Is *athleticism* a meaningless abstraction? The science of intelligence has grappled with a similar question for more than a hundred years. As we have seen, intelligence test scores predict consequential behaviors that hint at the existence of a hypothetical property called intelligence. But is there really such a property, or is intelligence just a meaningless abstraction?



• Michael Jordan was an extraordinary basketball player and a mediocre baseball player. So was he or wasn't he a great athlete?

PATRICK MURPHY-RACEY/SPORTS ILLUSTRATED/GETTY IMAGES

General and Specific Abilities

Charles Spearman was a student of Wilhelm Wundt (who founded the first experimental psychology laboratory), and he set out to answer precisely this question. Spearman invented a technique known as **factor analysis**, which is *a statistical technique that explains a large number of correlations in terms of a small number of underlying factors*. Although Spearman's technique was complex, his reasoning was simple: If there really is a single, general ability called intelligence that enables people to perform a variety of intelligent behaviors, then those who have this ability should do well at just about everything and those who lack it should do well at just about nothing. In other words, if intelligence is a single, general ability, then there should be a very strong, positive correlation between people's performances on all kinds of tests.

To find out if there was, Spearman (1904) measured how well school-age children could discriminate small differences in color, auditory pitch, and weight, and he then correlated these scores with the children's grades in different academic subjects as well as with their teachers' estimates of their intellectual ability. His research revealed two things. First, it revealed that most of these measures were indeed positively correlated: Children who scored high on one measure—for example, distinguishing the musical note C-sharp from D—tended to score high on the other measures—for example, solving algebraic equations. Some psychologists have called this finding "the most replicated result in all of psychology" (Deary, 2000, p. 6). Second, Spearman's research revealed that although different measures were positively correlated, they were not perfectly correlated: The child who had the very highest score on one measure didn't necessarily have the very highest score on *every* measure. Spearman combined these two facts into a **two-factor theory of intelligence**, which suggested that *every task requires a combination of a general ability* (g) *and skills that are specific to the task* (s).

As sensible as Spearman's conclusions were, not everyone agreed with them. Louis Thurstone (1938) noticed that while scores on most tests were indeed positively correlated, scores on verbal tests were more highly correlated with scores on other verbal tests than they were with scores on perceptual tests. Thurstone took this "clustering

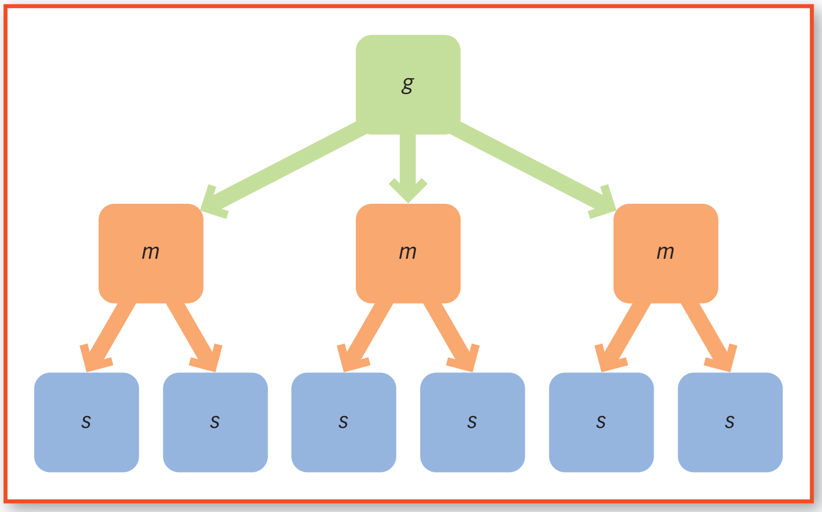
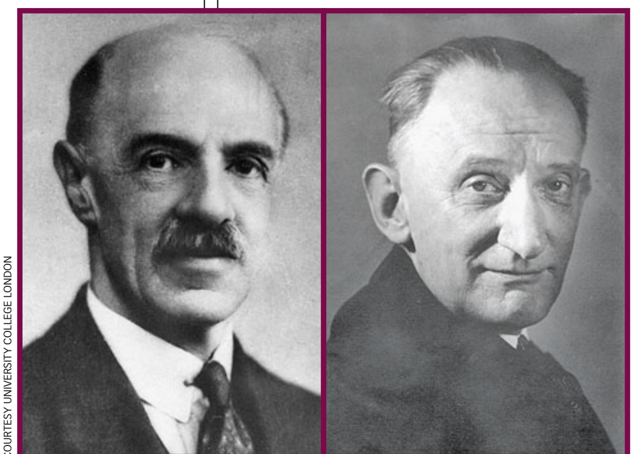


FIGURE 7.10 **A Three-Level Hierarchy** *Most intelligence test data are best described by a three-level hierarchy with general intelligence (g) at the top, specific abilities (s) at the bottom, and a small number of middle-level abilities (m) (sometimes called group factors) in the middle.*

of correlations" to mean that there was actually no such thing as *g* and that there were instead a few stable and independent mental abilities such as perceptual ability, verbal ability, and numerical ability, which he called the *primary mental abilities*. In essence, Thurstone argued that just as we have games called *baseball* and *basketball* but no game called *athletics,* so we have abilities such as verbal ability and perceptual ability but no general ability called intelligence.

● **Why is the three-level hierarchy of abilities a useful way to think about intelligence?**

As it turns out, both Spearman and Thurstone were right. More modern mathematical techniques have revealed that the correlations between scores on different mental ability tests are best described by a three-level hierarchy (see **FIGURE 7.10**, above) with a high-level ability or *general factor* (like Spearman's *g*) at the top, many low-level abilities or *specific factors* (like Spearman's *s*) at the bottom, and a few middle-level abilities or *group factors* (like Thurstone's primary mental abilities) in the middle (Gustafsson, 1984). As this hierarchy suggests, people have a very general ability called intelligence, which is made up of a small set of independent subabilities, which are made up of a large set of specific abilities that are unique to particular tasks.



COURTESY UNIVERSITY COLLEGE LONDON

COURTESY L. L. THURSTONE PSYCHOMETRIC LABORATORY, UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Charles Spearman (left, 1863–1945) discovered that people who did well on one ability test tended to do well on another, which he attributed to a hypothetical property called general intelligence, or g. Louis Thurstone (right, 1887–1955) disagreed with Spearman's interpretation of the data and believed that people had several primary mental abilities and not a single ability called general intelligence.

Middle-Level Abilities

So what are these middle-level abilities? Some psychologists have taken a "bottom-up" approach to answering this question by examining the correlations between people's responses to different items on different intelligence tests, much as Spearman and Thurstone did. For example, psychologist John Carroll conducted a landmark analysis of intelligence test scores from nearly 500 studies conducted over a half century (Carroll, 1993), and he concluded that there are exactly eight independent middle-level abilities: *memory and learning, visual perception, auditory perception, retrieval ability, cognitive speediness, processing speed, crystallized intelligence,* and *fluid intelligence*. Although most of the abilities on this list are self-explanatory, the last two are not. **Fluid intelligence** refers to *the ability to process information,* and **crystallized intelligence** refers to *the accuracy and amount of information available for processing* (Horn & Cattell, 1966). If we think of the brain as a machine that uses old information ("Some spiders don't spin webs" and "All spiders eat insects") as raw material to produce new information ("That means some spiders must stalk their prey rather than trapping them"), then

● **Is fluid intelligence like a processing system or like data? What about crystallized intelligence?**

"I don't have to be smart, because someday I'll just hire lots of smart people to work for me."

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fluid intelligence refers to the way the machine runs, and crystallized intelligence refers to the information it uses and produces (Salthouse, 2000). Whereas crystallized intelligence is generally assessed by tests of vocabulary, factual information, and so on, fluid intelligence is generally assessed by tests that pose novel, abstract problems that must be solved under time pressure.

Other psychologists have taken a "top-down" approach to answering the question about the nature of middle-level abilities. Rather than starting with people's responses on standard intelligence tests, they have started with general theories about the nature of intelligence—some of which are not measured by standard tests. For example, psychologist Robert Sternberg (1988) believes that there are three kinds of intelligence, which he calls *analytic intelligence, creative intelligence,* and *practical intelligence.* Analytical intelligence is the ability to identify and define problems and to find strategies for solving them. Creative intelligence is the ability to generate solutions that other people do not. Practical intelligence is the ability to apply and implement these solutions in everyday settings. Some studies suggest that these different kinds of intelligence are independent. For example, workers at milk-processing plants develop complex strategies for efficiently combining partially filled cases of milk, and not only do they outperform highly educated white-collar workers, but their performance is also unrelated to their scores on intelligence tests, suggesting that practical and analytic intelligence are not the same thing (Scribner, 1984). Sternberg has argued that tests of practical intelligence are better than tests of analytic intelligence at predicting a person's job performance, though such claims have been severely criticized (Brody, 2003; Gottfredson, 2003).

Psychologist Howard Gardner also believes that standard intelligence tests fail to measure some important human abilities. His observations of ordinary people, people with brain damage, **prodigies** (*people of normal intelligence who have an extraordinary ability*), and **savants** (*people of low intelligence who have an extraordinary ability*) led him to conclude that there are eight distinct kinds of intelligence: *linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal, intrapersonal,* and *naturalistic.* Although few data confirm the existence or independence of these eight abilities, Gardner's suggestions are intriguing. Moreover, he argues that standard intelligence tests measure only the first three of these abilities because they are the abilities most valued by Western culture but that other cultures may conceive of intelligence differently. For instance, the Confucian tradition emphasizes the ability to behave properly, the Taoist tradition emphasizes humility and self-knowledge, and the Buddhist tradition emphasizes determination and mental effort (Yang & Sternberg, 1997). Westerners regard people as intelligent when they speak quickly and often, but Africans regard

● Why does intelligence seem to vary between cultures?

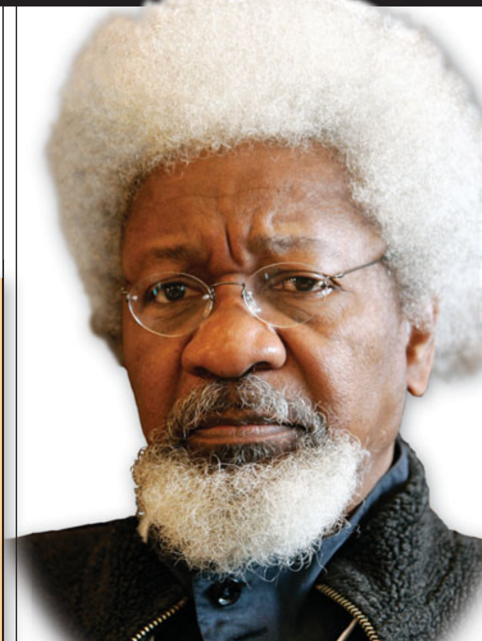
ONLY HUMAN

DON'T TELL PEOPLE THEIR IQ UNLESS THEY ASK In 1997, Daniel Long was fired from his job as a greeter at a Wal-Mart in Des Moines, Iowa, because he told a customer that she had to be "smarter than the cart" to get two shopping carts unstuck.

The 5-year-old who drew the picture on the left is a savant, a "low-functioning" autistic child with a mental age of about 3 years. The picture on the right was drawn by a normal 5-year-old.

SELFE, L., NADIA: A CASE OF EXTRAORDINARY DRAWING ABILITY IN CHILDREN.LONDON: ACADEMIC PRESS, 1977 © ELSEVIER PRESS
FROM THE COLLECTION OF ELLEN WINNER

people as intelligent when they are deliberate and quiet (Irvine, 1978). Unlike Western societies, many African and Asian societies conceive of intelligence as including social responsibility and cooperativeness (Azuma & Kashiwagi, 1987; Serpell, 1974; White & Kirkpatrick, 1985), and the word for *intelligence* in Zimbabwe, *ngware,* means to be wise in social relationships.


AP PHOTO/FRANÇOIS MORI

Unlike Americans, Africans describe people as intelligent when they are deliberate and quiet. "Thought is hallowed in the lean oil of solitude," wrote Nigerian poet Wole Soyinka, who won the Nobel Prize in Literature in 1986.

summary quiz [7.4]

11. Isabel is 3 years old. Her mental age is 5. What is her ratio IQ?
a. 100 b. 120 c. 60 d. 167

12. Intelligence tests predict _______ better than they predict anything else.
a. occupational status
b. income
c. school performance
d. creativity

13. The theory that every task requires combination of a general ability and skills that are specific to the task is known as the _______ theory.
a. general and specific
b. two-factor
c. primary mental abilities
d. fluid and crystallized intelligence

14. The accuracy and amount of information available for processing is called
a. fluid intelligence.
b. crystallized intelligence.
c. creative intelligence.
d. practical intelligence.

The Origins of Intelligence: From SES to DNA

Stanford professor Lewis Terman improved on Binet and Simon's work and produced the intelligence test now known as the Stanford-Binet. Among the things his test revealed was that Whites performed much better than non-Whites. "Are the inferior races really inferior, or are they merely unfortunate in their lack of opportunity to learn?" he asked, and then answered unequivocally: "Their dullness seems to be racial, or at least inherent in the family stocks from which they come." He went on to suggest that "children of this group should be segregated into separate classes . . . [because] they cannot master abstractions but they can often be made into efficient workers" (Terman, 1916).

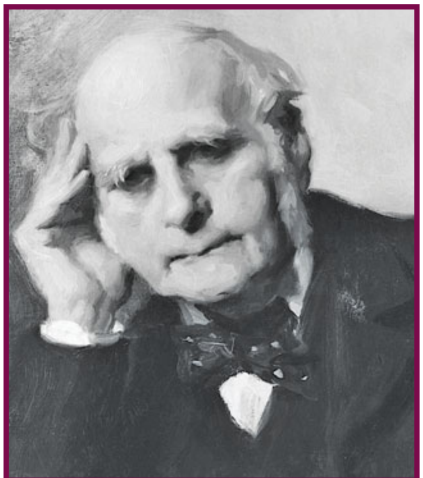
Nearly a century later, these sentences make us cringe, and it is difficult to decide which of Terman's suggestions is the most repugnant. Is it the suggestion that a person's intelligence is a product of his or her genes? Is it the suggestion that members of some racial groups score better than others on intelligence tests? Or is it the suggestion that the groups that score best do so because they are genetically superior? If all of these suggestions seem repugnant to you, then you may be surprised to learn that the first and second suggestions are now widely accepted as facts by most scientists. Intelligence *is* influenced by genes, and some groups *do* perform better than others on intelligence tests. However, the last of Terman's suggestions—that genes *cause* some groups to outperform others—is not a fact. Indeed, it is a highly provocative claim that has been the subject of both passionate and acrimonious debate. Let's examine all three suggestions and see what the facts really are.

Intelligence and Genes

The notion that all people are not born equal is at least two millennia old. In *The Republic,* the philosopher Plato suggested that some people are naturally constituted to

prodigy A person of normal intelligence who has an extraordinary ability.

savant A person of low intelligence who has an extraordinary ability.



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• *Sir Francis Galton (1822–1911) studied the physical and psychological traits that appeared to run in families. In his book* Hereditary Genius, *he concluded that intelligence was largely inherited.*

rule, others to be soldiers, and others to be tradesmen. But it wasn't until late in the 19th century that this suggestion became the subject of scientific inquiry. Sir Francis Galton was a half cousin of Charles Darwin, who became interested in the origins of intelligence (Galton, 1869). He did careful genealogical studies of eminent families, and he collected measurements that ranged from head size to the ability to discriminate tones from over 12,000 people. Based on these measurements, he concluded that intelligence was inherited. Was he right? Intelligence is clearly a function of how and how well the brain works, and given that brains are designed by genes, it would be rather remarkable if genes *didn't* play a role in determining a person's intelligence.

The importance of genes is easy to see when we compare the intelligence test scores of people who do and do not share genes. For example, brothers and sisters share (on average) 50% of their genes, and thus we should expect the intelligence test scores of siblings to be much more similar than the intelligence test scores of unrelated people. And they are—by a country mile. But there is a problem with this kind of comparison, which is that siblings share many things other than genes. For instance, siblings typically grow up in the same house, go to the same schools, read many of the same books, and have many of the same friends. Thus, the similarity of their intelligence test scores may reflect the similarity of their genes, or it may reflect the similarity of their experiences. To solve this problem, psychologists have studied the similarity of the intelligence test scores of people who share genes but not experiences, who share experiences but not genes, or who share both. Who are these people?

• **Why are siblings' intelligence test scores often so similar?**

Identical twins (also called *monozygotic twins*) are *twins who develop from the splitting of a single egg that was fertilized by a single sperm,* and **fraternal twins** (also called *dizygotic twins*) are *twins who develop from two different eggs that were fertilized by two different sperm.* Identical twins are genetic copies of each other, whereas fraternal twins are merely siblings who happened to have spent 9 months together in their mother's womb. Identical twins share 100% of their genes, and fraternal twins (like all siblings who have the same biological mother and father) share on average 50% of their genes. Studies show that the intelligence test scores of identical twins are correlated about $r = .86$ when the twins are raised in the same household and about $r = .78$ when they are raised in different households (e.g., when they are adopted by different families). As you'll notice from **TABLE 7.2** (on page 223), identical twins who are raised apart have more similar intelligence scores than do fraternal twins who are raised together. In other words, people who share all their genes have extremely similar intelligence test scores regardless of whether they share experiences. Indeed, the correlation between the intelligence test scores of identical twins who have never met is about the same as the correlation between the intelligence test scores of a single person who has taken the test twice! By comparison, the intelligence test scores of unrelated people raised in the same household (e.g., two siblings, one or both of whom were adopted) are correlated about $r = .32$ (Bouchard & McGue, 1981). These patterns of correlation clearly suggest that genes play an important role in determining intelligence. Of course, **TABLE 7.2** shows that shared environments play a role, too. Genetic influence can be seen by noting that identical twins raised apart are more similar than fraternal twins raised together, but environmental influence can be seen by noting that unrelated siblings raised together are more similar than related siblings raised apart.

Exactly how powerful is the effect of genes on intelligence? The **heritability coefficient** (commonly denoted as h^2) is *a statistic that describes the proportion of the difference between people's scores that can be explained by differences in their genetic makeup*. When the data from numerous studies of children and adults are analyzed together, the heritability of intelligence is roughly .5, which is to say that about 50% of the difference between people's intelligence test scores is due to genetic differences between them (Plomin & Spinath, 2004). This fact may tempt you to conclude that half your intelligence is due

DEANNE FITZMAURICE

• *Small genetic differences can make a big difference. A single gene on chromosome 15 determines whether a dog will be too small for your pocket or too large for your garage.*

TABLE 7.2

Intelligence Test Correlations between People with Different Relationships

Relationship	Shared Home?	% Shared Genes	Correlation between Intelligence Test Scores (r)
Twins			
Identical twins (n = 4,672)	Yes	100%	.86
Identical twins (n = 93)	No	100%	.78
Fraternal twins (n = 5,533)	Yes	50%	.60
Parents and Children			
Parent-biological child (n = 8,433)	Yes	50%	.42
Parent-biological child (n = 720)	No	50%	.24
Nonbiological parent-adopted child (n = 1,491)	Yes	0%	.19
Siblings			
Biological siblings (2 parents in common) (n = 26,473)	Yes	50%	.47
Nonbiological siblings (no parents in common) (n = 714)	Yes	0%	.32
Biological siblings (2 parents in common) (n = 203)	No	50%	.24

Source: Plomin et al., 2001a, p. 168.

to your genes and half is due to your experiences, but that's not right. To understand why, consider the rectangles in **FIGURE 7.11** (below).

These rectangles clearly differ in size. If you were asked to say what percentage of the difference in their sizes is due to differences in their heights and what percentage is due to differences in their widths, you would quickly and correctly say that 100% of the difference in their sizes is due to differences in their widths and 0% is due to differences in their heights (which are, after all, identical). Good answer. Now, if you were asked to say how much of the size of rectangle A was due to its height and how much was due to its width, you would quickly and correctly say, "That's a dumb question." And it is a dumb question because the size of a single rectangle cannot be due more (or less) to height than to width. Only the *differences* in the sizes of rectangles can. Similarly, if you measured the intelligence of all the people in your psychology class and were then asked to say what percentage of the difference in their intelligences was due to differences in their genes and what percentage was due to differences in their experiences, you would quickly and correctly say that about half was due to each. That's what the heritability coefficient of .5 suggests. If you were next asked to say how much of a particular classmate's intelligence is due to her genes and how much is due to her experiences, you would (we hope) quickly and correctly say, "That's a dumb question." It is a dumb question because the intelligence of a single person cannot be due more (or less) to genes than to experience.

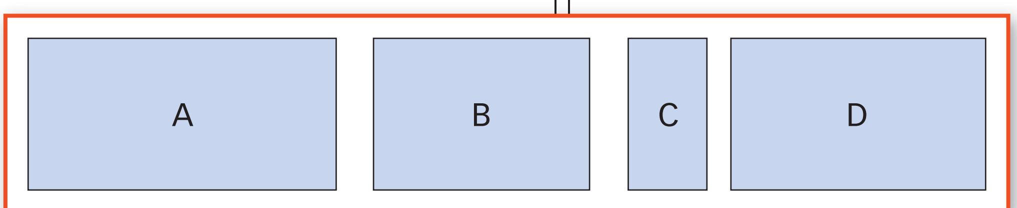


FIGURE 7.11 **How to Ask a Dumb Question** *These four rectangles differ in size. How much of the difference in their sizes is due to differences in their widths, and how much is due to differences in their heights? Answer: 100% and 0%, respectively. Now, how much of rectangle A's size is due to width, and how much is due to height? Answer: That's a dumb question.*

identical twins (also called **monozygotic twins**) Twins who develop from the splitting of a single egg that was fertilized by a single sperm (see *fraternal twins*).

fraternal twins (also called **dizygotic twins**) Twins who develop from two different eggs that were fertilized by two different sperm (see *identical twins*).

heritability coefficient A statistic (commonly denoted as h^2) that describes the proportion of the difference between people's scores that can be explained by differences in their genetic makeup.

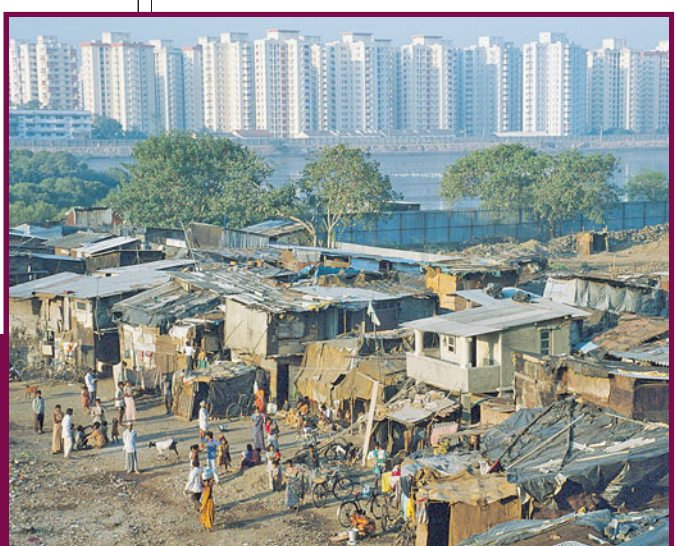
(LEFT): JEFF VINNICK/GETTY IMAGES
(MIDDLE): © REUTERS/CORBIS
(RIGHT): CLIVE BRUNSKILL/GETTY IMAGES

• *Identical twins (such as hockey players Daniel and Henrik Sedin) share 100% of their genes. Fraternal twins (such as swimmer Susie Maroney and her brother, Sean) share about 50% of their genes, as do non-twin siblings (such as tennis players Serena and Venus Williams).*

The heritability coefficient tells us why people in a particular group differ from one another, and thus its value can change depending on the particular group of people we measure. For example, the heritability of intelligence among wealthy children is about .72 and among poor children about .10 (Turkheimer et al., 2003). How can that be? Well, if we assume that wealthy children have fairly similar environments—that is, if they all have nice homes with books, plenty of free time, ample nutrition, and so on—then all the differences in their intelligence must be due to the one and only factor that distinguishes them from each other—namely, their genes. Conversely, if we assume that poor children have fairly different environments—that is, some have books and free time and ample nutrition, while others have some or none of these—then the difference in their intelligences may be due to either of the factors that distinguish them—namely, their genes and their environments.

● **Why is the heritability coefficient higher among children of the wealthy than among children of the poor?**

Heritability coefficients give us some sense of how large a role genes play in explaining differences in intelligence. But whether large or small, exactly *how* do genes play their role? It is tempting to imagine an "intelligence gene" that directly determines a person's brainpower at birth in the same way that, say, the hemoglobin beta gene found on chromosome 11p15.4 directly determines whether a person will be anemic. But a gene that influences intelligence is not necessarily an "intelligence gene" (Posthuma & de Geus, 2006). For instance, a gene that caused someone to enjoy the smell of library dust or to interact successfully with other people would almost surely make that person smarter, but it would be strange to call either of these an "intelligence gene." Although it is tempting to think of genes as the direct causes of traits, they may actually exert some of their most powerful influences by determining the nature of the social, physical, and intellectual environments in which people live their lives (Plomin et al., 2001a). This fact suggests that the distinction between genes and environments—between nature and nurture—is not just simple but simple-minded. Genes and environments interact in complex ways to make us who we are, and although psychologists do not yet know enough to say exactly how these interactions unfold, they do know enough to say that Terman's first suggestion was right: Intelligence is influenced by genes.



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• *A river separates one of the richest and one of the poorest neighborhoods in Bombay, India. Research suggests that intelligence is more heritable in wealthy than poor neighborhoods.*

Intelligence and Groups

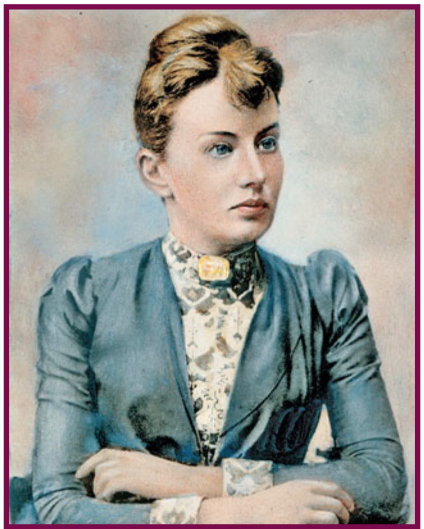
But what of Terman's second suggestion? Are some groups of people more intelligent than others? We should all hope so. If atomic scientists and neurosurgeons aren't a little bit smarter than average, then those of us who live near nuclear power plants or need spinal cord surgery have a lot to worry about. Between-group differences in intelligence are not inherently troubling. No one is troubled by the possibility that Nobel laureates are on average more intelligent than shoe salesmen, and that includes the shoe salesmen. But most of us are extremely troubled by the possibility that people of one gender, race, or nationality are more intelligent than people of another, because intelligence is a valuable commodity, and it just doesn't seem fair for a few groups to corner the market by accidents of birth or geography.

But fair or not, some groups do tend to outscore others on intelligence tests. For example, Asians routinely outscore Whites, who routinely outscore Latinos, who routinely outscore Blacks (Neisser et al., 1996; Rushton, 1995). Women routinely outscore men on tests that require rapid access to and use of semantic information, production and comprehension of complex prose, and fine motor skills, but men routinely outscore women on tests that require transformations in visual or spatial memory, certain motor skills, and fluid reasoning in abstract mathematical and scientific domains (Halpern, 1997). Indeed, group differences in performance on intelligence tests "are among the most thoroughly documented findings in psychology" (Suzuki & Valencia, 1997, p. 1104). Terman's second suggestion was clearly right: Some groups really do perform better than others on intelligence tests. The important questions that follow from this fact are (a) do group differences in intelligence test scores reflect group differences in actual intelligence, and (b) if so, what causes these group differences?

Intelligence tests are, of course, imperfect measures of intelligence. Could those imperfections create an advantage for one group over another? There is little doubt that the earliest intelligence tests were culturally biased; that is, they asked questions whose answers were more likely to be known by members of one culture (usually White Europeans) than another. When Binet and Simon asked students, "When anyone has offended you and asks you to excuse him, what ought you to do?" they were looking for answers such as "Accept the apology graciously." The answer "Demand three goats" would have been counted as wrong. But intelligence tests have come a long way in a century, and one would have to look awfully hard to find questions on a modern intelligence test that have a clear cultural bias (Suzuki & Valencia, 1997). Moreover, group differences emerge even on those portions of intelligence tests that measure nonverbal skills. In short, culturally biased tests are very unlikely to explain group differences in intelligence test scores.

● **How can the testing situation affect people's scores?**

But even when test *questions* are unbiased, testing *situations* may not be. For example, African American students perform more poorly on tests if they are asked to report their race at the top of the answer sheet, presumably because doing so causes them to feel anxious about confirming racial stereotypes, and this anxiety naturally interferes with their test performance (Steele & Aronson, 1995). European American students do not show the same effect when asked to report their race. When Asian American women are reminded of their gender, they perform unusually poorly on tests of mathematical skill, presumably because they are aware of stereotypes suggesting that women can't do math. But when the same women are instead reminded of their ethnicity, they perform unusually well on the same tests, presumably because they are aware of stereotypes suggesting that Asians are especially good at math (Shih, Pittinsky, & Ambady, 1999). Indeed, simply reading an essay suggesting that mathematical ability is strongly influenced by genes causes women to perform more poorly on subsequent tests of mathematical skill (Dar-Nimrod & Heine, 2006)! Findings such as these remind us that the situation in which intelligence tests are administered can affect members of different groups differently and may cause group differences in performance that do not reflect group differences in intelligence.



THE GRANGER COLLECTION

Research suggests that men tend to outperform women in abstract mathematical and scientific domains, and women tend to outperform men on production and comprehension of complex prose. Sonya Kovalevsky (1850–1891), who was regarded as one of the greatest mathematicians of her time, wrote, "It seems to me that the poet must see what others do not see, must look deeper than others look. And the mathematician must do the same thing. As for myself, all my life I have been unable to decide for which I had the greater inclination, mathematics or literature."

MICHAEL J. DOOLITTLE/THE IMAGE WORKS

Can anxiety over racial and gender stereotypes affect individual student performance? Studies show that if these students are asked to list their ethnicities prior to taking the exam, the African American students will score poorer and the Asian American students will score higher than if neither group was asked to list their ethnicity. Interestingly, if Asian American women are asked to list their gender instead of their race, the opposite occurs, and the women will perform unusually poorer than expected on math tests. What can these studies teach us about standardized testing?

Situational biases may explain some of the between-group difference in intelligence test scores but surely not all. If we assume that some of these differences reflect real differences in the abilities that intelligence tests measure, then what could account for these ability differences? The obvious candidates are genes and experiences. Although scientists do not yet know enough about the complex interaction of these two candidates to say which is the more important determinant of between-group differences, this much is clear: Different groups *may* have different genes that influence intelligence, but they *definitely* have different experiences that influence intelligence. For example, in America, the average Black child has lower socioeconomic status (SES) than the average White child. Black children often come from families with less income; attend worse schools; and have lower birth weights, poorer diets, higher rates of chronic illness, lower rates of treatment, and so on (Acevedo-Garcia et al., 2007; National Center for Health Statistics, 2004). All of these factors can affect intelligence. Indeed, for almost a century socioeconomic status has proved to be a better predictor than ethnicity of a child's intelligence test performance. Everyone agrees that *some* percentage of the between-group difference in intelligence is accounted for by experiential differences, and the only question is whether *any* of the between-group difference in intelligence is accounted for by genetic differences.

Some scientists believe that the answer to this question is yes, and others believe the answer is no. Perhaps because the question is so technically difficult to answer or perhaps because the answer has such important social and political repercussions, there is as yet no consensus among those who have carefully studied the data. When the American Psychological Association appointed a special task force to summarize what is known about the cause of the difference between the intelligence test scores of Black and White Americans, the task force concluded, "Culturally based explanations of the Black/White IQ differential have been proposed; some are plausible, but so far none has been conclusively supported. There is even less empirical support for a genetic interpretation. In short, no adequate explanation of the differential between the IQ means of Blacks and Whites is presently available" (Neisser et al., 1996, p. 97). Such is the state of the art.

Changing Intelligence

Americans believe that every individual should have an equal chance to succeed in life, and one of the reasons we bristle when we hear about genetic influences on intelligence is that we mistakenly believe that our genes are our destinies—that *genetic* is a synonym for *unchangeable*. In fact, traits that are influenced by genes are almost always modifiable.

The Dutch were renowned for being short in the 19th century but are now the second-tallest people in the world, and most scientists attribute their dramatic and rapid change in height to changes in diet. Yes, height is a highly heritable trait. But genes do not dictate a person's precise height so much as they dictate the range of heights that a person may achieve (Scarr & McCartney, 1983).

So is intelligence like height in this regard? Can intelligence change? Yes—it can and it does. For example, when people take intelligence tests many years apart, the people who get the best (or worst) scores when they take the test the first time tend to get the best (or worst) scores when they take it the second time. In other words, an individual's *relative intelligence* is likely to be stable over time, and the people who are the most intelligent at age 11 are likely to be the most intelligent at age 80 (Deary et al., 2000, 2004). On the other hand, an individual's *absolute intelligence* typically changes over the course of his or her lifetime (Owens, 1966; Schaie, 1996, 2005; Schwartzman, Gold, & Andres, 1987). How can a person's relative intelligence remain stable if his or her absolute intelligence changes? Well, the shortest person in your 1st grade class was probably not the tallest person in your 10th grade class, which is to say that the relative heights of your classmates probably stayed about the same as they aged. On the other hand, everyone got taller (we hope) between 1st and 10th grade, which is to say that everyone's absolute height changed. Intelligence is like that.

Not only does intelligence change across the lifespan, but it also tends to change across generations. The *Flynn effect* refers to the accidental discovery by James Flynn that the average intelligence test score has been rising by about 0.3% every year, which is to say that the average person today scores about 15 IQ points higher than the average person did 50 years ago (Dickens & Flynn, 2001; Flynn, 1984). Although no one is sure why, researchers have speculated that the effect is due to better nutrition, better parenting, better schooling, better test-taking ability, and even the visual and spatial demands of television and video games (Neisser, 1998).

Intelligence waxes and wanes naturally. But what about intentional efforts to improve it? Modern education is an attempt to do just that on a mass scale, and the correlation between the amount of formal education a person receives and his or her intelligence is quite high—somewhere in the range of $r = .55$ to .90 (Ceci, 1991; Neisser et al., 1996). But is this correlation so high because smart people tend to stay in school or because school makes people smart? The answer, it seems, is both. More intelligent people are indeed more likely to stay in high school and go on to college, but it also

BURSTEIN COLLECTION/CORBIS

Genetic does not mean "unchangeable." In the 19th century, Dutch men such as Vincent van Gogh were renowned for being short. Today the average Dutch man is 6 feet tall.

ANDY NELSON/CHRISTIAN SCIENCE MONITOR VIA GETTY IMAGES

Although their school was burned by attackers in 2006, the students at the Girls High School of Mondrawet in Afghanistan continue to attend. Studies show that education increases intelligence.

appears that staying in school can itself increase IQ (Ceci & Williams, 1997, p. 1052). For instance, the intelligence of schoolchildren declines during the summer, and these declines are most pronounced for children whose summers are spent on the least academically oriented activities (Hayes & Grether, 1983; Heyns, 1978). Furthermore, children born in the first 9 months of a calendar year typically start school an entire year earlier than those born in the last 3 months of the same year, and sure enough, students with late birthdays tend to have lower intelligence test scores than students with early birthdays (Baltes & Reinert, 1969). Although educational programs can reliably increase intelligence, studies suggest that such programs usually have only a minor impact, tend to enhance test-taking ability more than cognitive ability, and have effects that dwindle and vanish within a few years (Perkins & Grotzer, 1997). In other words, educational programs appear to produce increases in intelligence that are smaller, narrower, and shorter-lived than we might wish.

● Can intelligence be improved?

Education is a moderately effective way to increase intelligence, but it is also expensive and time-consuming. Not surprisingly, then, scientists are looking for cheaper, quicker, and more effective ways to boost the national IQ. *Cognitive enhancers* are drugs that produce improvements in the psychological processes that underlie intelligent behavior, such as memory, attention, and executive function. For example, conventional stimulants such as methylphenidate, or Ritalin (Elliott et al., 1997; Halliday et al., 1994; McKetin et al., 1999), can enhance cognitive performance, which is why there has been an alarming increase in their abuse by healthy students over the past few years. Although no one has yet developed a safe and powerful "smart pill," many experts believe that this is likely to happen in the next few years (Farah et al., 2004; Rose, 2002; Turner & Sahakian, 2006). Clearly, we are about to enter a brave new world.

What kind of world will it be? Because people who are above average in intelligence tend to have better health, longer lives, better jobs, and higher incomes than those who are below average, we may be tempted to conclude that the more intelligence we have, the better off we are. In general, this is probably true, but there are some reasons to be cautious. For example, although moderately gifted children (those with IQs of 130 to 150) are as well adjusted as their less intelligent peers, profoundly gifted children (with IQs of 180 or more) have a rate of social and emotional problems that is twice that of an average child (Winner, 1997). This is not all that surprising when you consider how out of step such children are with their peers. Furthermore, it is interesting to note that gifted children are rarely gifted in all departments. Rather, they tend to have very specialized gifts. For example, more than 95% of gifted children show a sharp disparity between their mathematical and verbal abilities (Achter, Lubinski, & Benbow, 1996), suggesting that those who are exceptionally talented in one domain are not quite so talented in the other. Some research suggests that what really distinguishes gifted children is the sheer amount of time they spend engaged in their domain of excellence (Ericsson & Charness, 1999). The essence of nature's "gift" may be the capacity for passionate devotion to a single activity.

summary quiz [7.5]

15. The genetic influence on intelligence is illustrated by the finding that

a. unrelated siblings raised together are more similar than related siblings reared apart.
b. identical twins reared apart are more similar than fraternal twins reared together.
c. parents and biological children living together are more similar than parents and biological children living apart.
d. identical twins living together are more similar than identical twins living apart.

16. Which statement is true?
  a. Half of your best friend's intelligence is due to her genes, and half is due to her experiences.
  b. The heritability of intelligence is about .5 for both poor and rich children.
  c. Across all populations, about 50% of the difference between people's intelligence test scores is due to genetic differences between them.
  d. The heritability coefficient tells us how much of each person's intelligence is due to environment and how much is due to heredity.

17. Female students who are asked their gender before a math test tend to perform more poorly than if they were not asked their gender. According to the textbook, this is because
  a. they are insulted.
  b. they want to please their teacher.
  c. they are reluctant to outperform the boys in their class, so deliberately don't do well.
  d. they feel anxious about confirming gender stereotypes that women can't do math, which interferes with their performance.

18. Which statement is true?
  a. Relative and absolute intelligence both are likely to remain stable over time.
  b. Relative and absolute intelligence both are likely to change over time.
  c. Relative intelligence is likely to be stable over time, whereas absolute intelligence is likely to change.
  d. Relative intelligence is likely to change over time, whereas absolute intelligence is likely to be stable.

WhereDoYouStand?

Making Kids Smart or Making Smart Kids?

Once upon a time, babies were a surprise. Until the day they were born, no one knew if Mom would deliver a girl, a boy, or perhaps one of each. Advances in medicine such as amniocentesis and ultrasound technology have allowed parents to look inside the womb and learn about the gender and health of their children long before they actually meet them. Now parents can do more than just look. For example, IVF (in vitro fertilization) involves creating dozens of human embryos in the laboratory, determining which have genetic abnormalities, and then implanting only the normal embryos in a woman's womb. Gene therapy involves replacing the faulty sections of an embryo's DNA with healthy sections. These and other techniques may (or may soon) be used to reduce a couple's chances of having a child with a devastating illness such as Tay-Sachs disease, early-onset Alzheimer's disease, sickle-cell disease, hemophilia, neurofibromatosis, muscular dystrophy, and Fanconi's anemia. But in the not-too-distant future, they may also enable a couple to increase the odds that their baby will have the traits they value—such as intelligence.

If scientists do find genes that are directly related to intelligence, IVF and gene therapy will provide methods of increasing a couple's chances of having an intelligent—perhaps even an extraordinarily intelligent—child. Those who oppose the selection or manipulation of embryos fear that there is no clear line that separates repairing or selecting genes that cause disease and repairing or deselecting genes that cause normal intelligence. This could ultimately lead to a lot of interesting people never being born. As Shannon Brownlee (2002) of the New America Foundation wryly noted, "Today, Tom Sawyer and Huck Finn would have been diagnosed with attention-deficit disorder and medicated. Tomorrow, they might not be allowed out of the petri dish."

People on the other side of this debate wonder what the fuss is about. After all, many couples are already selecting their offspring for high IQ by mating with the smartest people they can find. And once their babies are born, most parents will work hard to enhance their children's intelligence by giving them everything from vitamins to cello lessons. Science writer Ron Bailey predicted that parents will someday "screen embryos for desirable traits such as tougher immune systems, stronger bodies, and smarter brains. What horrors do such designer babies face? Longer, healthier, smarter, and perhaps even happier lives? It is hard to see any ethical problem with that" (Bailey, 2002).

Should parents be allowed to use genetic screening or gene therapy to increase the odds that they will have intelligent children? Where do you stand?

CHAPTER REVIEW

Summary

Language and Communication: Nothing's More Personal

- Human language is characterized by a complex organization from phonemes to morphemes to words to phrases and sentences.
- Most children follow a pattern of language development that includes milestones such as distinguishing speech sounds (phonemes), followed by babbling, followed by understanding and using single words, and, finally, attaining adult mastery.
- Children appear to be biologically predisposed to process language in ways that allow them to extract grammatical rules from the language they hear.
- In the brain, Broca's area is critical for language production, and Wernicke's area is critical for language comprehension.

Concepts and Categories: How We Think

- We organize knowledge about objects and events by creating concepts and categories.
- Studies of people with brain damage have shown that the brain organizes concepts into distinct categories, such as living things and human-made tools.
- When we encounter a new object, we assess how well it fits in with our existing categories; prototype theory holds that we compare new items against the most "typical" member of the category; exemplar theory holds that we compare new items against other examples from the category.

Judging, Valuing, and Deciding: Sometimes We're Logical, Sometimes Not

- Rational choice theory assumes that humans make decisions based on how likely something is to happen and on the expected value of the outcome.
- However, humans often depart from rational choice; they are much less accurate at judging probabilities than at judging frequencies, and decision making can be led further astray by mindbugs such the conjunction fallacy, and framing effects.
- Prospect theory argues that people are biased to take on risk when evaluating potential losses but to avoid risk when evaluating potential gains.

Intelligence: Highly Classified

- Intelligence is a hypothetical mental ability that allows people to direct their thinking and learn from their experiences.
- Intelligence tests measure responses (to questions and on tasks) that are thought to be correlated with consequential behaviors that are made possible by intelligence. These behaviors include academic performance and job performance.
- Most researchers agree that between *g* (general intelligence) and *s* (specific abilities) are several middle-level abilities, but not all researchers agree about what they are.

The Origins of Intelligence: From SES to DNA

- Both genes and environment influence intelligence.
- The heritability coefficient describes the extent to which differences in the intelligence test scores of different people are due to differences in their genes. It does not describe the extent to which an individual's intelligence is inherited.
- Some ethnic groups score better than others on intelligence tests, but there is no compelling evidence to suggest that these differences are due to genetic factors.
- Intelligence changes naturally over time and can be changed by interventions. Education increases intelligence, though its impact is smaller, narrower, and more short-lived than we might wish.

Key Terms

language (p. 198)
phoneme (p. 198)
morphemes (p. 198)
grammar (p. 198)
deep structure (p. 199)
surface structure (p. 199)
fast mapping (p. 201)
nativist theory (p. 202)
language acquisition device (LAD) (p. 202)
genetic dysphasia (p. 203)
aphasia (p. 204)
concept (p. 206)
category-specific deficit (p. 206)
family resemblance theory (p. 207)
prototype (p. 208)
exemplar theory (p. 208)
rational choice theory (p. 209)
conjunction fallacy (p. 211)
framing effects (p. 211)
sunk-cost fallacy (p. 211)
prospect theory (p. 212)
intelligence (p. 213)
ratio IQ (p. 214)
deviation IQ (p. 214)
factor analysis (p. 218)
two-factor theory of intelligence (p. 218)
fluid intelligence (p. 219)
crystallized intelligence (p. 219)
prodigies (p. 220)
savants (p. 220)
identical twins (p. 222)
fraternal twins (p. 222)
heritability coefficient (p. 222)

Critical Thinking Questions

1. To create a sentence, you have to change the deep structure of an idea into the surface structure of a sentence. The one receiving the message translates the surface structure of the sentence back into the deep structure of the idea.
   With surface structure so important to communication, why are we able to communicate effectively when we quickly forget the surface structure of sentences? Why might this forgetfulness of the surface structure be an evolutionary benefit?
2. In this chapter you read about how deaf children at a school in Nicaragua developed their own sign language. Explain how this supports the interactionist explanation of language development.
3. Rational choice theory posits that people evaluate all options when making a decision and choose the alternative with the greatest benefit to them. However, psychological research shows us that this not always the case. Indeed, we are often forced to make decisions without all the information present. In these conditions, we are often fooled into making a different decision than we normally would because of how the options are presented to us.
   Think to a recent election. How might some political candidates use conjunction fallacy, framing effects, or prospect theory to influence voters' evaluations of their opponents or their opponents' views?
4. Intelligence tests were developed for a noble purpose, but early in their history, they were sometimes used to legitimate prejudice and discrimination. Intelligence test results can also be influenced by features of the testing situation. Given what you learned about what intelligence tests can measure, would you support or oppose the suggestion that intelligence tests should be given to all school children?

Answers to Summary Quizzes

Summary Quiz 7.1
1. b; 2. b; 3. a; 4. b

Summary Quiz 7.2
5. c; 6. b; 7. a

Summary Quiz 7.3
8. a; 9. b; 10. b

Summary Quiz 7.4
11. d; 12. c; 13. b; 14. b

Summary Quiz 7.5
15. b; 16. c; 17. d; 18. c