Think About It

Is human intelligence related to brain size?

Are IQ scores stable over time?

Do IQ tests predict anything useful?

Are IQ tests biased against certain minority groups?

Are all intelligent people creative?

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If you were to see Chris Langan on the street, you'd almost surely pass right by him. Now in his early sixties, Langan's face is unfamiliar to the overwhelming majority of the general public. Yet according to some psychologists, Langan may be the smartest person in the United States (Gladwell, 2008). Like many geniuses, Langan was a *child prodigy*: someone who displays astounding intellectual achievements at an early age (Morelock & Feldman, 1993). According to reports, he began speaking at 6 months of age and taught himself to read by age 3. When tested on a standard intelligence test, his approximate IQ—intelligence quotient—was an astonishing 195; the psychologist who examined him had to estimate it because the scores on standard IQ tests don't go up that high. Langan received a perfect score of 1600 on his SAT, a widely used college admissions test, and he dropped out of two colleges in part because he felt that he knew more than his professors—he may have been right. In 2008, Langan won $250,000 on NBC's game show "1 vs. 100." In his spare time, he wrote a book introducing his "Cognitive-Theoretical Model of the Universe," a comprehensive theory linking the mind to reality, which contains sentences like "No matter what else happens in this evolving universe, it must be temporally embedded in this dualistic self-inclusion operation" (no, we don't understand it, either).

What, you might ask, does Chris Langan do for a living? Is he a laboratory scientist, a university professor, or a famous computer programmer? If you guessed any of these three, you'd be wrong. For about 20 years, Chris Langan worked as a bar bouncer while holding other jobs, including construction worker and firefighter. Today, he works on a farm in Missouri with his wife. Even though Langan long yearned to earn a doctoral degree and to become a great scientist, he never got close. Why? He seemed to have a knack for offending others, including his college professors, without intending to. Moreover, he appeared unwilling to tolerate the minor bureaucratic frustrations of academic life. To this day, Langan's grand theory remains obscure, as he's never submitted it to a peer-reviewed journal.

How do people like Chris Langan achieve stratospheric levels of IQ? And how can we explain why Langan, in contrast to many others with extremely high IQs, failed to achieve great academic success? In this chapter, we won't find definitive answers, but we'll uncover a few tantalizing cues.

What Is Intelligence? Definitional Confusion

9.1 Identify different models and types of intelligence.

9.2 Describe the connection between intelligence and brain size and efficiency.

One of the problems that renders psychology so challenging—and at times exasperating—is the lack of clear-cut definitions for many of its concepts. No area of psychology illustrates this ongoing challenge better than does the field of intelligence. Even today, psychologists can't agree on the precise definition of intelligence (Sternberg, 2003b; Sternberg & Detterman, 1986).

Psychologist Edwin Boring (1923) discovered an easy way around the nagging question of what intelligence is. According to Boring, intelligence is whatever intelligence tests measure. Yes, it's that simple. Some modern psychologists have embraced this definition, which lets us off the hook from having to figure out what intelligence is. Yet because this definition sidesteps the central question of what makes some people smarter than others—or whether some people are actually smarter than others across the board—it doesn't really get us all that far. The definition of intelligence must go beyond Boring's definition. With that point in mind, let's examine the most influential attempts to define and understand intelligence.

Watch in **MyPsychLab** the **Video:** The Basics: Theories of Intelligence

Intelligence as Sensory Capacity: Out of Sight, Out of Mind

Sir Francis Galton (1822–1911) was a prominent scientist, inventor, and cousin of the great biologist Charles Darwin, co-developer of the theory of evolution by natural selection. Following in the footsteps of his cousin, Galton—himself a creative genius in many

respects—was interested in the potential adaptive advantages of high intellect. Perhaps as a consequence of his own exceptional intelligence, he was fascinated by the question of what makes some people especially smart.

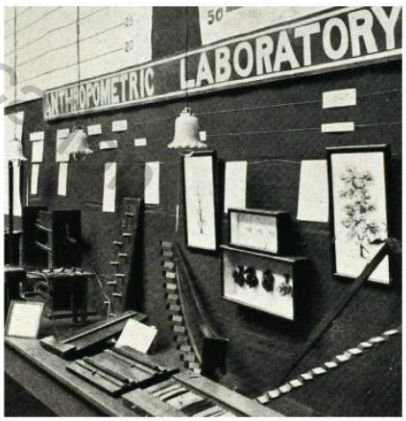
Galton proposed a radical hypothesis: Intelligence is the by-product of sensory capacity. He reasoned that most knowledge first comes through the senses, especially vision and hearing. Therefore, he assumed, people with superior sensory capacities, like better eyesight, should acquire more knowledge than will other people.

For a six-year period beginning in 1884, Galton set up a laboratory at a museum in London, England. There, he administered a battery of 17 sensory tests to more than 9,000 visitors (Gillham, 2001). He measured just about everything under the sun relating to sensory ability: the highest and lowest pitch of sounds that individuals could detect; their reaction times to various stimuli; and their ability to discriminate the weights of similar objects. James McKeen Cattell, who worked under Galton, imported Galton's tests to America, administering them to thousands of college students to find out what they were measuring. Like his teacher, Cattell assumed that intelligence was a matter of raw sensory ability.

Yet later research showed that one exceptional sense, like heightened hearing, doesn't bear much of a relation to other exceptional senses, like heightened vision (Acton & Schroeder, 2001). Nor are measures of sensory ability highly correlated with overall intelligence (Li, Jordanova, & Lindenberger, 1998). These findings falsify Galton's claim that intelligence equals sensory ability. Whatever intelligence is, it's more than just good eyesight, hearing, and smell. A moment's reflection reveals that this must be the case: According to Galton, Helen Keller, the blind and deaf woman who became a brilliant author and social critic (see Chapter 8), would almost by definition have had mental retardation. Galton's definition can't be right.

FALSIFIABILITY
Can the claim be disproved?

Still, as we'll learn later, Galton may have been onto something. Recent research suggests that some forms of sensory ability relate modestly to intelligence, although these two concepts clearly aren't identical.



Galton's laboratory on display at the International Health Exhibition in London in 1884. The exhibit later moved to the South Kensington Museum where, between 1886 and 1890, thousands of visitors took a battery of 17 sensory tests.

Intelligence as Abstract Thinking

Early in the last century, the French government wanted to find a way to identify children in need of special educational assistance. In 1904, the Minister of Public Instruction in Paris tapped two individuals, Alfred Binet (pronounced "Bee-NAY") and Théodore Simon (pronounced "See-MOAN"), to develop an objective psychological test that would separate "slower" learners from other children without having to rely on the subjective judgments of teachers.

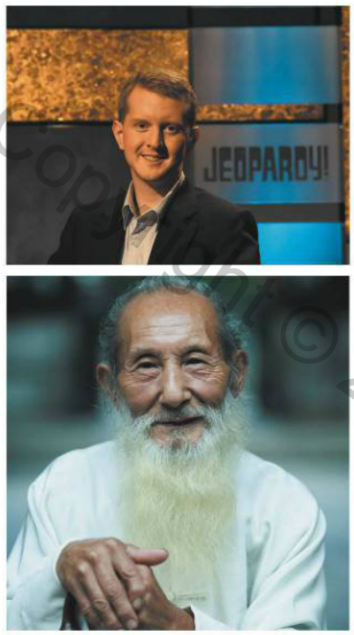
Binet and Simon experimented with many different items (an item is a question on a measure, including an intelligence or personality test) designed to distinguish students whom teachers perceived as plodding learners from other students. In 1905, they developed what most psychologists regard as the first **intelligence test**, a diagnostic tool designed to measure overall thinking ability.

Their items were remarkably diverse in content. They involved naming objects, generating the meanings of words, drawing pictures from memory, completing incomplete sentences ("The man wrote a letter using his _____."), determining the similarities between two objects ("In what way are a dog and a rose alike?"), and constructing a sentence from three words (*woman*, *house*, and *walked*). Despite the superficial differences among these items, they had one thing in common that Binet and Simon (1905) recognized: *higher mental processes*. These processes included reasoning, understanding, and judgment (Siegler, 1992). In this respect, their items differed sharply from those of Galton, which had relied solely on sensation. Virtually all items on modern intelligence tests have followed Binet and Simon's lead.

Indeed, most experts agree that whatever intelligence is, it has something to do with **abstract thinking**: the capacity to understand hypothetical concepts, rather than concepts in the here and now (Gottfredson, 1997; Sternberg, 2003b). In 1921, a panel of

intelligence test
diagnostic tool designed to measure overall thinking ability

abstract thinking
capacity to understand hypothetical concepts



Ken Jennings *(top)*, who broke the record for winnings on the game show *Jeopardy!*, would be regarded as especially intelligent by most individuals in Western culture. In contrast, a village elder *(bottom)* who can impart wisdom would be regarded as especially intelligent by many individuals in Chinese culture.

REPLICABILITY ▶
Can the results be duplicated in other studies?

14 American experts generated a list of definitions of intelligence. They didn't succeed in hammering out a single definition, but they mostly agreed that intelligence consists of the abilities to:

- Reason abstractly.
- Learn to adapt to novel environmental circumstances.
- Acquire knowledge.
- Benefit from experience.

Interestingly, research on how laypeople view intelligence yields similar conclusions, at least in the United States. Most Americans view intelligence as consisting of the capacity to reason well and reason quickly ("to think on one's feet"), as well as to amass large amounts of knowledge in brief periods of time (Sternberg et al., 1981). In contrast, in some non-Western countries, laypersons view intelligence as reflecting people's wisdom and judgment more than their intellectual brilliance (Baral & Das, 2003). For example, in China, people tend to view intelligent individuals as those who perform actions for the greater good of the society and are humble (Yang & Sternberg, 1997). Geniuses who "toot their own horns" might be showered with fame and fortune in the United States, but they might be viewed as hopeless braggarts in the eyes of many Chinese. This difference is consistent with findings that Chinese culture tends to be more focused on group harmony than is American culture (Triandis, 2001; see Chapter 10).

Intelligence as General versus Specific Abilities

There was one other crucial way that Binet and Simon's items differed from Galton's. When researchers looked at the correlations among these items, they were in for a surprise. Even though Binet and Simon's items differed enormously in content, the correlations among them were all positive: People who got one item correct were more likely than chance to get the others correct. Admittedly, most of these correlations were fairly low, say .2 or .3 (as we learned in Chapter 2, correlations have a maximum value of 1.0), but they were almost never zero or negative. Interestingly, this finding has held up with items on modern IQ tests (Alliger, 1988; Carroll, 1993). Given that some of Binet and Simon's items assessed vocabulary, others assessed spatial ability, and still others assessed verbal reasoning, this finding was puzzling.

The phenomenon of positive correlations among intelligence test items caught the attention of psychologist Charles Spearman (1927). To account for these correlations, Spearman hypothesized the existence of a single shared factor across all these aspects—***g* (general intelligence)**—that explained the overall differences in intellect among people. All intelligence test items are positively correlated, he believed, because they reflect the influence of overall intelligence.

Spearman wasn't sure what produces individual differences in *g*, although he speculated that it has something to do with "mental energy" (Sternberg, 2003b). For Spearman, *g* corresponds to the strength of our mental engines. Just as some cars possess more powerful engines than others, he thought, some people have more "powerful"—more effective and efficient—brains than others. They have more *g*.

The meaning of *g* remains exceedingly controversial (Gould, 1981; Herrnstein & Murray, 1994; Jensen, 1998). All because of this little letter, some intelligence researchers are barely on speaking terms. Why? Because *g* implies that some people are just plain smarter than others. Many people find this view distasteful, because it smacks of elitism. Others, like the late Stephen Jay Gould, have argued that *g* is merely a statistical artifact. In his influential book *The Mismeasure of Man*, Gould (1981) maintained that the idea that all people can be ranked along a single dimension of general intelligence is mistaken. Yet Gould's critics have responded that *g* is unlikely to be a statistical illusion, because scientists have consistently found that intelligence test items are positively correlated with each other regardless of their content (Gottfredson, 2009). Spearman (1927) didn't believe that *g* tells the whole story about intelligence. For every intelligence test item, He also proposed

g (general intelligence)
hypothetical factor that accounts for overall differences in intellect among people

the existence of a factor called ***s* (specific abilities)**, that is unique to each item. According to Spearman, how well we perform on a given mental task depends not only on our general smarts (*g*), but also on our particular skills in narrow domains (*s*). For example, our ability to solve the spatial problem in **FIGURE 9.1** is due not only to our general problem-solving ability, but also to our specific talents with spatial tests, tasks examining the location of objects in physical space. Even if we're really smart—high in overall *g*—we might flunk this item because we have a specific deficiency when it comes to spatial problems. That deficiency may mean either that we're not inherently adept at spatial tasks or that we haven't had much experience with them.

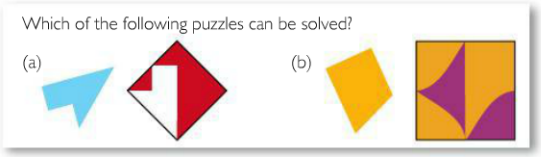


FIGURE 9.1 Spatial Task. Try it! For each of the two puzzles shown, try to complete the figure using the shape on the left.

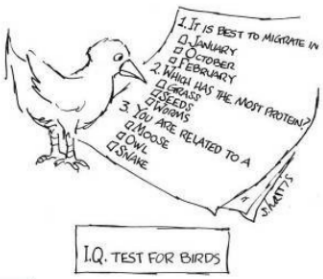
Fluid and Crystallized Intelligence

Later researchers found that Spearman's *g* wasn't as uniform as he'd believed (Carroll, 1993; Vernon, 1971). In the 1930s, Louis Thurstone (1938) discovered that some intelligence test items relate more highly to each other than do other items: These items form clumps corresponding to different intellectual capacities. Later, Raymond Cattell (no relation to James McKeen Cattell) and John Horn distinguished fluid from crystallized intelligence, arguing that what we call "intelligence" is actually a mixture of two capacities.

Fluid intelligence refers to the capacity to learn new ways of solving problems. We depend on our fluid intelligence the first time we try to solve a puzzle we've never seen or the first time we try to operate an apparatus, like a new type of cell phone, we've never used. In contrast, **crystallized intelligence** refers to the accumulated knowledge of the world we acquire over time (Cattell, 1971; Ghisletta et al., 2012; Horn, 1994). We rely on our crystallized intelligence to answer questions such as What's the capital of Italy? or How many justices sit on the U.S. Supreme Court? According to Cattell and Horn, knowledge from newly learned tasks "flows" into our long-term memories, "crystallizing" into lasting knowledge (see **FIGURE 9.2**). Most modern researchers don't believe that the existence of fluid and crystallized intelligence undermines the existence of *g*. Instead, they view them as "facets" or more specific aspects of *g* (Messick, 1992).

FIGURE 9.2 Knowledge "Flowing" into a Flask. According to Cattell and Horn's model, there are two kinds of intelligence, fluid and crystallized. Fluid intelligence "flows" into crystallized intelligence over time.

There's some evidence for the fluid–crystallized distinction. Fluid abilities are more likely to decline with age than are crystallized abilities (Nisbett et al., 2012; see Chapter 10). In fact, some researchers have found that crystallized abilities often increase with age, including old age (Salthouse, 1996; Schaie, 1996). In addition, fluid abilities are more highly related to *g* than are crystallized abilities (Blair, 2006; Gustafsson, 1988). This finding suggests that of the two abilities, fluid intelligence may better capture the power of the "mental engine" to which Spearman referred.



? According to Cattell and Horn, would this bird IQ test primarily be a measure of (a) fluid or (b) crystallized intelligence? Why? (See answer upside down on bottom of page.)

Crystallized intelligence, but not fluid intelligence, is moderately and positively associated (a correlation of about .3) with a personality trait we'll encounter in Chapter 14: *openness to experience* (Ackerman & Heggestad, 1997; DeYoung, Peterson, & Higgins, 2005; Gignac, Stough, & Loukomitis, 2004). People with high levels of openness to experience are imaginative; intellectually curious; and excited about exploring new ideas, places, and things (Goldberg, 1993; Nusbaum & Silvia, 2011). We don't fully understand the causal direction here. Higher crystallized intelligence could give rise to greater openness to experience, as people who know more things to begin with may find learning new things to be easier and therefore more enjoyable. Alternatively, greater openness to experience could give rise to greater crystallized intelligence, as people who are intellectually curious may expose themselves to more knowledge and learn more things (Ziegler et al., 2012).

s (specific abilities)
particular ability level in a narrow domain

fluid intelligence
capacity to learn new ways of solving problems

crystallized intelligence
accumulated knowledge of the world acquired over time

◀ **CORRELATION VS. CAUSATION**
Can we be sure that A causes B?

Answer: Crystallized, because it assesses accumulated knowledge of the world.

(a)

(b)

(c)

According to Gardner, individuals vary in the types of intelligence at which they excel. (a) Martin Luther King, Jr., was a great orator with high linguistic (and probably interpersonal) intelligence; (b) Taylor Swift is a musician with renowned musical intelligence; and (c) professional tennis player Serena Williams has impressive bodily-kinesthetic intelligence.

Multiple Intelligences: Different Ways of Being Smart

Up to this point, we've been talking about "intelligence" as though it were only one overarching intellectual ability. But in recent decades, several prominent psychologists have argued for the existence of **multiple intelligences**: entirely different domains of intellectual skill. According to them, the concept of *g* is wrong, or at least incomplete. For them, we need multiple intelligences to explain the story of people like Chris Langan, who are extremely successful in some intellectual domains yet unsuccessful in others. Moreover, these psychologists maintain that we can't simply say that Sally is smarter than Bill, because there are many ways of being smart (Guilford, 1967). Even Spearman's concept of *s* is a partial acknowledgement of the existence of multiple intelligences, because it recognizes that people with equal levels of *g* can have different intellectual strengths and weaknesses. But in contrast to Spearman, most proponents of multiple intelligences insist that *g* is only one component of intelligence.

FRAMES OF MIND. Howard Gardner's (1983, 1999) theory of multiple intelligences has been enormously influential in educational practice and theory over the past two decades. According to Gardner, there are numerous "frames of mind," or different ways of thinking about the world. Each frame of mind is a different and fully independent intelligence in its own right.

Gardner (1983) outlined a number of criteria for determining whether a mental ability is a separate intelligence. Among other things, researchers must demonstrate that different intelligences can be isolated from one another in studies of people with brain damage; people with damage to a specific brain region must show deficits in one intelligence but not others. In addition, different intelligences should be especially pronounced in people with exceptional talents. For example, Gardner believed that the existence of *autistic savants*, about whom we learned in Chapter 7, provides evidence for multiple intelligences. These individuals show remarkable abilities in one or two narrow domains, such as knowing the precise batting averages of all active baseball players, but not in most other domains. Gardner also suggested that different intelligences should make sense from an evolutionary standpoint: They should help organisms survive or make it easier for them to meet future mates.

Gardner (1999) proposed eight different intelligences ranging from linguistic and spatial to musical and interpersonal, as described in **TABLE 9.1**. He also tentatively proposed the existence of a ninth intelligence, called *existential* intelligence: the ability to grasp deep philosophical ideas like the meaning of life.

Gardner's model has inspired thousands of teachers to tailor their lesson plans around children's individual profiles of multiple intelligences (Armstrong, 2009). For example, in a class of students with high levels of bodily-kinesthetic intelligence but low levels of logico-mathematical intelligence, a teacher might encourage students to learn arithmetic problems like 3 + 4 = 7 by dividing them into groups of three and four, having them stand in front of the class, and all join hands to form a bigger group of seven.

TABLE 9.1 Howard Gardner's Multiple Intelligences.

INTELLIGENCE TYPE	CHARACTERISTICS OF HIGH SCORERS
Linguistic	Speak and write well
Logico-mathematical	Use logic and mathematical skills to solve problems such as scientific questions
Spatial	Think and reason about objects in three-dimensional space
Musical	Perform, understand, and enjoy music
Bodily-kinesthetic	Manipulate the body in sports, dance, or other physical endeavors
Interpersonal	Understand and interact effectively with others
Intrapersonal	Understand and possess insight into self
Naturalistic	Recognize, identify, and understand animals, plants, and other living things

multiple intelligences
idea that people vary in their ability levels across different domains of intellectual skill

Yet this approach may not be a good idea, and even Gardner himself has said he isn't entirely comfortable with it (Willingham, 2004). After all, if a child has a weakness in a specific skill domain like vocabulary or mathematics, it may make more sense to try to teach "to" that domain rather than "away" from it. Otherwise, we may allow the child's already poor skills to decay, much like a weak muscle we choose not to exercise. In addition, as we learned in Chapter 6, research hasn't supported the claim that matching teaching styles to students' learning styles enhances learning outcomes (Reiner & Willingham, 2010; Stahl, 1999).

The scientific reaction to Gardner's model has been mixed. All researchers agree with Gardner that we vary in our intellectual strengths and weaknesses. Gardner also deserves credit for highlighting the point that all intelligent people aren't smart in the same way. But much of Gardner's model is vague and difficult to test. In particular, it's not clear why certain mental abilities, but not others, qualify as multiple intelligences. According to Gardner's criteria, there should probably also be "humor" and "memory" intelligences (Willingham, 2004). Or given Gardner's emphasis on evolutionary adaptiveness, why not "romantic" intelligence, the ability to attract sexual partners? It's also not clear that all of Gardner's "intelligences" are genuinely related to intelligence. Some, such as bodily-kinesthetic intelligence, seem much closer to talents that depend heavily on nonmental abilities like athletic skills (Scarr, 1985; Sternberg, 1988b).

Moreover, because Gardner hasn't developed formal tests to measure his intelligences, his model is difficult to falsify (Klein, 1998). In particular, there's no good evidence that his multiple intelligences are truly independent, as he claims (Lubinski & Benbow, 1995). If measures of these intelligences were all positively correlated, that could suggest that they're all manifestations of *g*, just as Spearman argued. Even research on autistic savants doesn't clearly support Gardner's model, because autistic savants tend to score higher on measures of general intelligence than do other individuals with autism (Miller, 1999). This finding suggests that their highly specialized abilities are due at least partly to *g*.

FALSIFIABILITY
Can the claim be disproved?

THE TRIARCHIC MODEL. Like Gardner, Robert Sternberg has argued that there's more to intelligence than *g*. Sternberg's (1983, 1988b) **triarchic model** posits the existence of three largely distinct intelligences (see **FIGURE 9.3**). Moreover, in conjunction with the College Board, he's been developing measures of the second and third intelligence, which he believes are largely unrepresented in standard IQ tests (Gillies, 2011; Hunt 2010). These three intelligences are:

1. **Analytical intelligence:** the ability to reason logically. In essence, analytical intelligence is "book smarts." It's the kind of intelligence we need to do well on traditional IQ tests and college admissions exams, the kind of intelligence possessed by Chris Langan. According to Sternberg, this form of intelligence is closely related to *g*. But for him, it's only one component of intelligence and not necessarily the most crucial. Indeed, Sternberg has long complained about a "*g*-ocentric" view of intelligence, one in which school-related smarts is the only kind of intelligence that psychologists value (Sternberg & Wagner, 1993).
2. **Practical intelligence:** also called "tacit intelligence," the ability to solve real-world problems, especially those involving other people. In contrast to analytical intelligence, this form of intelligence is akin to "street smarts." It's the kind of smarts we need to "size up" people we've just met or figure out how to get ahead on the job. Practical intelligence also relates to what some researchers call *social intelligence,* or the capacity to understand others (Guilford, 1967). Sternberg and his colleagues have developed measures of practical intelligence to assess how well employees and bosses perform in business settings, how well soldiers perform in military settings, and so on.
3. **Creative intelligence:** also called "creativity," our ability to come up with novel and effective answers to questions. It's the kind of intelligence we need to find new and effective solutions to problems, like composing an emotionally moving poem or exquisite piece of music. Sternberg argues that practical and creative intelligences predict outcomes, like job performance, that analytical intelligence doesn't (Sternberg & Wagner, 1993; Sternberg et al., 1995).

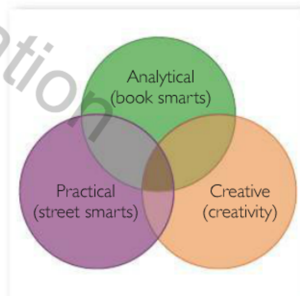


FIGURE 9.3 Sternberg's Triarchic Model of Intelligence. Sternberg's model proposes three kinds of intelligence: analytical, practical, and creative.

Watch in **MyPsychLab** the **Video:** Practical Intelligence

triarchic model
model of intelligence proposed by Robert Sternberg positing three distinct types of intelligence: analytical, practical, and creative

Our intuitions tell us that these three types of intellect don't always go hand in hand. We can all think of people who are extremely book smart but who possess all of the social skills of a block of concrete. Similarly, we can think of people who have high levels of street smarts but who do poorly on school-related tests.

Yet, like virtually all anecdotes (see Chapter 1), such examples have their limitations. Indeed, some scientists have questioned the bases of Sternberg's claims. In particular, Sternberg hasn't demonstrated convincingly that practical intelligence is independent of *g* (Gottfredson, 2003; Jensen, 1993). Like crystallized intelligence, it may merely be one specialized subtype of *g*. Furthermore, Sternberg's work-related measures of practical intelligence may actually be measures of job knowledge. Not surprisingly, people who know the most about a job tend to perform it the best (Schmidt & Hunter, 1993). Moreover, the causal direction of this correlation isn't clear. Although more practical knowledge may lead to better job performance, better job performance may lead to more practical knowledge (Brody, 1992). Moreover, even creative intelligence is probably not independent of g. As we'll learn later in the chapter, measures of these two constructs tend to be at least moderately correlated (Preckel, Holling, & Wiese, 2006).

CORRELATION VS. CAUSATION ▶
Can we be sure that A causes B?

Thus, the concept of multiple intelligences remains controversial. Unquestionably, we all possess different intellectual strengths and weaknesses, but it's not clear that they're as independent of each other as Gardner and Sternberg assert. So there may still be a general intelligence dimension after all.

Revisiting Chris Langan, we can see how Spearman, on the one hand, and Gardner and Sternberg, on the other, would conceptualize his genius. Spearman would have viewed Langan as possessing extremely high *g*, as well as high specific abilities (*s*) in language, theoretical understanding, and other mental capacities. Gardner and Sternberg, while acknowledging that Langan has remarkable analytical abilities—book smarts—and perhaps even creative abilities, might emphasize that he appears to have difficulty understanding others and therefore may be below average in interpersonal (Gardner) or practical (Sternberg) intelligence.

Biological Bases of Intelligence

One popular notion about intelligence is that it's related positively to brain size. We speak of smart people as "brainy" or having "lots of marbles upstairs." But to what extent is intelligence related to the brain's size and efficiency?

INTELLIGENCE AND BRAIN STRUCTURE AND FUNCTION. For years, almost all psychology textbooks informed students that although brain size correlates with intelligence *across* species, it's uncorrelated with intelligence *within* species, including humans. Yet several studies demonstrate that brain volume, as measured by structural MRI scans (see Chapter 3), correlates positively—between .3 and .4—with measured intelligence (McDaniel, 2005; Willerman et al., 1991). So when we refer to the supersmart kid in class as a "brain,"—the one who gets 100s on all of his exams without studying—we may not be entirely off base. Still, the correlation between brain volume and IQ is complicated and may hold more for verbal than for spatial abilities (Witelson, Beresh, & Kiger, 2006).

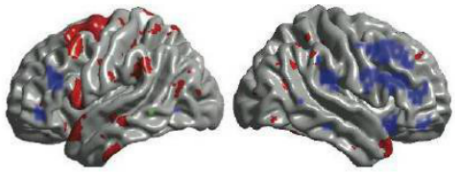
CORRELATION VS. CAUSATION ▶
Can we be sure that A causes B?

Moreover, we don't know whether these findings reflect a direct causal association. Perhaps bigger brains contribute to higher intelligence. Or perhaps some third variable, like better nutrition before or shortly after birth, leads to both. In addition, a correlation of less than .4 tells us that the association between brain size and intelligence is far less than perfect. For example, Albert Einstein's brain actually weighed about 1230 grams, slightly less than the average brain. Interestingly, though, the lower part of Einstein's parietal cortex, an area that becomes active during spatial reasoning tasks, was 15 percent wider than normal (Witelson, Kigar, & Harvey, 1999). This finding may explain Einstein's remarkable capacity for visual imagery (Falk, 2009). In addition, Einstein's brain also had an unusually high density of neurons and glial cells (see Chapter 3), suggesting that his brain packed more mass than the average brain (Anderson & Harvey, 1996).

Recent studies on brain development suggest that there may be more to the story. A study using structural MRI revealed that highly intelligent (IQs in the top 10 percent) 7-year-olds have a *thinner* cerebral cortex than do other children. The cortexes of these children then thicken rapidly, peaking at about age 12 (Shaw et al., 2006). We don't yet know what these findings mean, and independent investigators haven't replicated them. But they may indicate that, like fine wines, intelligent brains take longer to mature than others.

Functional brain imaging and laboratory studies of information processing offer intriguing clues regarding what intelligence is and where in the brain it resides. Over the span of about a month, Richard Haier and his colleagues (Haier et al., 1992) taught a group of eight undergraduates to play the computer video game Tetris. All participants improved over time, and those with the highest scores on a measure of intelligence improved the most. Surprisingly, participants with higher levels of intelligence exhibited *less* brain activity in many areas than participants with lower levels of intelligence (Haier et al., 2009). Haier's explanation? The brains of the more intelligent students were especially efficient. Much like well-conditioned athletes who barely break a sweat while running a five-mile race, they could afford to slack off a bit while learning the task (Haier, 2009). Admittedly, not all researchers have replicated Haier's results (Fidelman, 1993), but these findings raise the possibility that intelligence in part reflects efficiency of mental processing (Langer et al., 2011).

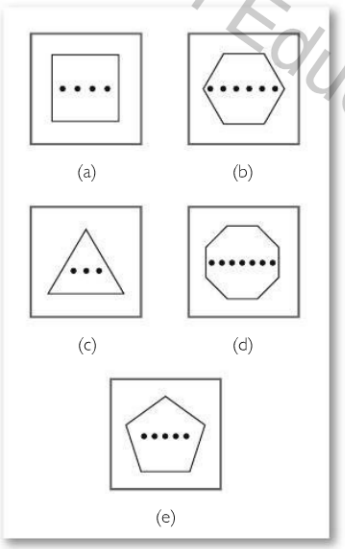
◀ **REPLICABILITY**
Can the results be duplicated in other studies?



? Here are functional brain images of two people who've been playing the computer game Tetris. As is standard in brain images, red depicts high levels of brain activation; blue, low levels of brain activation. **According to research by Richard Haier and colleagues, which brain is likely to come from someone with a high IQ? Why?** (See answer upside down on bottom of page.)

◀ **REPLICABILITY**
Can the results be duplicated in other studies?

THE LOCATION OF INTELLIGENCE. Where in the brain is intelligence located? This may seem like a silly question, as it's unlikely that a neurosurgeon can point to a specific region of the brain and say "Right there . . . that's what makes us smart." Yet intelligence is more localized to certain areas of the cortex than others. One group of investigators administered a number of reasoning tasks that are highly "g-loaded"—substantially related to general intelligence (see **FIGURE 9.4**). These tasks all activated the prefrontal cortex (Duncan et al., 2000), a brain region that plays key roles in planning, impulse control, and short-term memory (see Chapter 3). More recent evidence demonstrates that intelligence is associated with the density of neural connections between the prefrontal cortex (especially on the left side of the brain) and other brain regions, suggesting that the prefrontal cortex may be a "command and control center" that pulls together information from other parts of the brain to help us think (Cole, Yarkoni, Repovs, Anticevic, & Braver, 2012).



? **FIGURE 9.4** Sample Task (a Highly g-Loaded Item). This sample item is similar to items that researchers have identified as highly "g-loaded," meaning that it's a good predictor of general intelligence. In this item, one of the five choices differs from the others. **Can you figure out which one it is?** (The answer is printed upside down at the bottom of the page.)

Nevertheless, the prefrontal cortex doesn't tell the whole story when it comes to intelligence. For example, regions of the parietal lobe, which is intimately involved in spatial abilities (see Chapter 3), also appear to be associated with intelligence (Haier, 2009; Jung & Haier, 2007).

INTELLIGENCE AND REACTION TIME. When speaking loosely, we sometimes refer to people who don't seem as intelligent as other people as "slow." Psychologists have transported this folk belief to the laboratory by studying the relation of intelligence to *reaction time*, or the speed of responding to a stimulus (Jensen, 2006). Imagine being seated in front of the reaction time box shown in **FIGURE 9.5** (Hick, 1952), which features a semicircle of eight buttons, with lights alongside them. On each trial, anywhere from one to eight of the

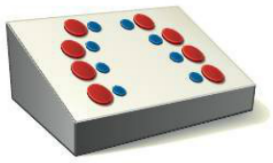


FIGURE 9.5 Reaction-Time Apparatus. Psychologists have used a reaction-time box to study the relation between intelligence and response to simple stimuli. Typically, the red lights turn on, and then as soon as one turns off, the participant tries as quickly as possible to press the blue button next to the unlit light.

Answer to Figure 9.4: d

Answer: The brain on the right; people with high IQs tend to have more efficient brains, which in turn need to work less hard.

lights turn on, and then one of them suddenly turns off. Your job is to hit the button next to the light that turned off—and to do so as quickly as possible. The results of numerous studies indicate that measured intelligence correlates negatively (about –.3 to –.4) with reaction time on this task (Deary, Der, & Ford, 2001; Detterman, 1987): People with higher intelligence react more quickly than other people do when the light turns off (Brody, 1992). So Galton may not have been completely wrong in believing that speed of sensory processing contributes to intelligence, although these two concepts clearly aren't identical.

INTELLIGENCE AND MEMORY. Intelligence also bears an intimate connection to memory capacity. Many researchers have examined the relation of tasks that assess "working memory" to intelligence. As we learned in Chapter 7, this type of memory is closely related to short-term memory, and it reflects especially our ability to juggle multiple bits of information in our minds at the same time. A typical working memory task might require particpants to perform a test of digit span (see Chapter 7) while trying to figure out the meaning of a proverb (such as "What does the saying 'A bird in the hand is worth two in the bush' mean?"). Scores on working memory tasks are moderately correlated (about .5) with scores on intelligence tests (Ackerman, Beier, & Boyle, 2005; Engle, 2002; Kane, Hambrick, & Conway, 2005). Indeed, an increasing number of researchers argue that differences among people in their working memory may help to explain why some people process information more quickly than others, and hence score better on standard measures of IQ (Conway, Getz, Macnamara, & Engel de Abreu, 2011; Redick, Unsworth, Kelly, & Engle, 2012).

In light of the findings we have just reviewed, several commercial companies now market computerized products, like *BrainTwister* and *BrainFitness Pro*, to boost working memory (say, by teaching them to recognize when a number in a sequence matches a previous number in that sequence). These companies claim that by doing so they can increase IQ. Yet controlled studies suggest that although these products may increase working memory, they don't increase IQ (Redick et al., 2012; Shipstead, Redick, & Engle, 2012). So although working memory and IQ are correlated, these findings remind us that one can't assume that improving working memory will *cause* increases in general intelligence.

CORRELATION VS. CAUSATION ▶
Can we be sure that A causes B?

PULLING IT ALL TOGETHER. If there's one central theme to these diverse findings, it's that intelligence is related to efficiency or speed of information processing (Schmiedek et al., 2007; Vernon, 1987). So here, common sense may be partly correct: People who are rapid thinkers tend to be especially intelligent. Still, the associations are far less than a perfect correlation of 1.0, which tells us that whatever intelligence, it's more than quickness of thinking. These results also suggest that the capacity to retrieve short-term information—and to keep this information active while we process it online—is related to intelligence, although the causal direction of this association isn't clear.

Assess Your Knowledge FACT or FICTION?

1. Most research suggests that intelligence is almost entirely a function of sensory ability. **True / False**
2. All or almost all items on modern intelligence tests tend to be positively correlated with each other. **True / False**
3. According to Sternberg, practical intelligence is essentially the same thing as book smarts. **True / False**
4. Within humans, brain size tends to be moderately positively correlated with measured intelligence. **True / False**
5. Intelligence is unrelated to reaction time. **True / False**

Answers: 1. F (p. 323); 2. T (p. 324); 3. F (p. 327); 4. T (p. 328); 5. F (p. 330)

Intelligence Testing: The Good, the Bad, and the Ugly

9.3 Determine how psychologists calculate IQ.

9.4 Explain the history of misuse of intelligence tests in the United States.

9.5 Describe tests of intelligence used today and evaluate the reliability and validity of IQ scores.

9.6 Distinguish the unique characteristics of mental retardation and genius.

Psychologists have long struggled with the thorny question of how to measure people's intelligence. The simplest way to do so, of course, would be to ask them "How smart are you?" Tempting as this approach might be, it's unlikely to work. Self-estimates of IQ correlate only .2 to .3 with objective measures of intelligence (Hansford & Hattie, 1982; Paulhus, Lysy, & Yik, 1998). Making matters more complicated, evidence suggests that people with poor cognitive skills are especially likely to overestimate their intellectual abilities (Dunning, Heath, & Suls, 2004; Kruger & Dunning, 1999). This curse may explain why some people perform poorly in school and on the job, even though they're convinced they're performing well. It may also help to explain the embarrassing behavior of some singers on television shows like *American Idol*, who seem utterly oblivious of the fact that they have no more musical talent than the average person off the street. *Metacognitive skills* play a key role in this phenomenon (Koriat & Bjork, 2005). Metacognition refers to knowledge of our own knowledge (see Chapter 8). People with poor metacognitive skills in a given domain may overestimate their performance, because they don't know what they don't know (Dunning et al., 2004; Sinkavich, 1995).

These findings confirm the intuitions of Binet, Simon, and other psychologists that we need systematic tests to measure intelligence, because self-assessments of intelligence won't do. When Binet and Simon created the first intelligence test more than a century ago, however, they had no inkling that they'd alter the landscape of psychology. Yet their invention has changed how we select people for schools, jobs, and the military; it's changed schooling and social policies; and it's changed how we think about ourselves. The history of intelligence testing begins where Binet and Simon left off.

Stanford-Binet IQ test
intelligence test based on the measure developed by Binet and Simon, adapted by Lewis Terman of Stanford University

intelligence quotient (IQ)
systematic means of quantifying differences among people in their intelligence

mental age
age corresponding to the average individual's performance on an intelligence test

Watch in **MyPsychLab** the **Video:** Special Topics: Intelligence Testing, Then and Now

How We Calculate IQ

Shortly after Binet and Simon introduced their test to France, Lewis Terman of Stanford University developed a modified and translated version called the **Stanford-Binet IQ test**, first published in 1916 and still used today in its revised fifth edition. Originally developed for children but since extended to adults, the Stanford-Binet consists of a wide variety of tasks like those Binet and Simon used, such as measures that involve testing vocabulary and memory for pictures, naming familiar objects, repeating sentences, and following commands (Janda, 1998). Terman's great achievement was to establish a set of *norms*, baseline scores in the general population from which we can compare each individual's score. Using norms, we can ask whether a given person's score on intelligence test items are above or below those of similar-aged people and by how much. All modern intelligence tests contain norms for different age groups, such as adults between 30 and 54 and between 55 and 69.

Watch in **MyPsychLab** the **Video:** Classic Footage of Language Assessment Portions of Stanford-Binet Intelligence Scale

Shortly before World War I, German psychologist Wilhelm Stern (1912) invented the formula for the **intelligence quotient**, which will forever be known by two letters: *IQ*. Stern's formula for computing IQ was simple: Divide *mental age* by *chronological age* and multiply the resulting number by 100. **Mental age**, a concept introduced by Binet, is the age corresponding to the average person's performance on an intelligence test. A girl who takes an IQ test and does as well as the average 6-year-old has a mental age of 6, regardless of her actual age. Her chronological age is simply her actual age in years. So if a 10-year-old child does as well on an IQ test