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HISTORICAL SURVEY AND THEORIES OF INTELLIGENCE

Philosophy of science without history is empty; history of science without philosophy is blind.

—Immanuel Kant, German metaphysician and philosopher (1724–1804)

It is reasonable to anticipate that in the new century, emerging technologies using computerized administration will offer decisive advantages. Eventually, new tests based on these technologies will replace the individual intelligence test as we know it. Then it will be the job of these new tests to carry on the tradition of mental testing established by the Binet–Simon and Wechsler–Bellevue scales.

—Corwin Boake, American psychologist (1953–)

Goals and Objectives

This chapter is designed to enable you to do the following:

- Identify the 19th- and 20th-century investigators who shaped current theories of intelligence
- Understand definitions of intelligence
- Describe factor analytic approaches to the study of intelligence
- Discuss information-processing approaches to intelligence
- Examine other approaches to the study of intelligence
- Discuss the form intelligence tests may take in the future

This chapter provides a brief history of developments in the field of intelligence testing. It describes the contributions of pioneer and contemporary theorists and test developers, and it summarizes several major definitions of intelligence. Because so many theories are touched on, the main elements of each are summarized at the end of the chapter. We begin our historical survey with 19th-century developments.

NINETEENTH-CENTURY AND EARLY TWENTIETH-CENTURY DEVELOPMENTS

Jean Esquirol (1772–1840) was one of the first modern-day scientists to make a clear distinction between mental incapacity and mental illness. (By "modern day," we mean a scientist working in the last 200 years.) Mental incapacity was defined by Esquirol as a characteristic of "idiots," who never developed their intellectual capacities, whereas mental illness was considered to be a characteristic of "mentally deranged persons," who lost or were unable to use abilities they had once possessed. To differentiate the two groups, Esquirol focused first on physical measurements and then on speech patterns. His descriptions of the verbal characteristics associated with levels of "idiocy" (e.g., no speech at the lowest level, use of monosyllables at the next level, and use of words and short phrases at the next level) can be regarded as the first crude mental test.

It was not until the latter half of the 19th century that psychology emerged as a separate scientific discipline. The psychophysical methods developed by Ernst H. Weber (1795–1878) and Gustav T. Fechner (1801–1887) and the statistical studies of mental processes initiated by Sir Francis Galton (1822–1911) formed the background for much of the progress that would take place in the 20th century. (See the inside front cover of this textbook for a listing of historical landmarks in cognitive and educational assessment.)

Developments in England

Galton's contribution. Sir Francis Galton is regarded as the father of the psychometrically based testing movement. He was the first to use objective techniques, and he developed the statistical concepts of regression to the mean and correlation (see Chapter 4). These concepts enabled researchers to use test scores to study intelligence over time and to examine the relationship between parents' and children's intelligence. Galton's contributions stimulated the development of the field of psychometrics (i.e., psychological measurement).

In 1869, Galton published *Hereditary Genius,* in which he offered a statistical explanation for inherited mental characteristics and estimated the number of "geniuses" that could be expected in a particular sample of people. In his 1883 publication *Inquiries into Human Faculty,* which was a collection of 40 articles written between 1869 and 1883, Galton presented his views on human faculties and considered the problems involved in measuring mental characteristics. In 1884, he set up a psychometric laboratory at the International Health Exhibition; he later reestablished the laboratory at University College, London. The laboratory was open to the public (see Figure 7-1) and provided measures of physical and mental capacities for a small fee. The laboratory measured, for example, height and weight, the ability to discriminate pitch, sensory acuity, and reaction time, generating the first public, large-scale standardized collection of data. Galton assumed that, because human knowledge of the environment reaches us through the senses, people with the highest intelligence should also have the best sensory discrimination abilities. Unfortunately, his tests of sensory discrimination and motor coordination generally proved to be invalid measures of mental ability and did little to further his work on the measurement of intelligence.

Pearson's contribution. Karl Pearson (1857–1936), Galton's close friend and biographer, was a professor of applied mathematics and mechanics at University College, London. Pearson was active in the fields of eugenics, anthro-

ANTHROPOMETRIC

LABORATORY

For the measurement in various ways of Human Form and Faculty.

Entered from the Science Collection of the S. Kensington Museum.

This laboratory is established by Mr. Francis Galton for the following purposes:—

1. For the use of those who desire to be accurately measured in many ways, either to obtain timely warning of remediable faults in development, or to learn their powers.

2. For keeping a methodical register of the principal measurements of each person, of which he may at any future time obtain a copy under reasonable restrictions. His initials and date of birth will be entered in the register, but not his name. The names are indexed in a separate book.

3. For supplying information on the methods, practice, and uses of human measurement.

4. For anthropometric experiment and research, and for obtaining data for statistical discussion.

Charges for making the principal measurements:
THREEPENCE each, to those who are already on the Register.
FOURPENCE each, to those who are not:— one page of the Register will thenceforward be assigned to them, and a few extra measurements will be made, chiefly for future identification.

The Superintendent is charged with the control of the laboratory and with determining in each case, which, if any, of the extra measurements may be made, and under what conditions.

Figure 7-1. An announcement for Galton's Laboratory. Reproduced by permission of the Science Museum, London, England.

pology, and psychology. Furthering Galton's work, Pearson developed numerous statistical procedures, including the product-moment correlation formula for linear correlation, the multiple correlation coefficient, the partial correlation coefficient, the phi coefficient, and the chi-square test, the latter for determining how well a set of empirical observations conforms to an expected distribution (thus measuring "goodness of fit"; see Chapter 4).

Developments in Germany

Wilhelm Wundt (1832–1920) founded the first psychological laboratory in 1879 in Leipzig, Germany. Wundt believed that the aim of psychology was to analyze the contents of consciousness: Psychology should focus on the study of immediate experience, principally by self-observation or introspection. In his laboratory, Wundt studied problems of sensation, attention, reaction time, and feelings or emotions.

Emil Kraepelin (1855–1926), one of Wundt's first pupils, introduced complex tests for measuring mental functioning in adults. Kraepelin worked in the field of psychopathology and based his tests on abilities necessary for daily functioning, devising tests of perception, memory, motor functions, and attention. He recognized the importance of repeated examinations in order to reduce chance variation.

In response to requests from teachers in Breslau, Germany, for help in evaluating their students' academic aptitude, Herman Ebbinghaus (1850–1909) developed tests of memory, computation, and sentence completion. One test was a timed completion test that contained passages with missing words. The examinee's task was to fill in as many missing words as possible within a 5-minute period. This early work was a predecessor of group-administered intelligence tests.

Carl Wernicke (1848–1905), well known in Poland and Germany for his investigations of brain localization, developed a set of questions designed to detect mental retardation. The questions—such as "What is the difference between a ladder and a staircase?"—emphasized conceptual thinking.

In 1908, Theodore Ziehen (1862–1950) published a test battery that contained questions requiring conceptual thinking, such as "What have an eagle, a duck, a goose, and a stork in common?" In Wernicke's and Ziehen's work we see the beginning of a trend away from measuring sensorimotor functions and toward measuring the kinds of cognitive functions emphasized in modern intelligence tests.

Developments in the United States

James McKeen Cattell's contribution. James McKeen Cattell (1860–1944) studied with Wundt at Leipzig. Cattell left Wundt to serve as an assistant in Galton's anthropometric laboratory and was influenced by Galton's theories. Instead of following Wundt's introspective approach to psychology, Cattell, like Galton, focused on the study of individual differences in behavior. On his return to the United States, Cattell established a psychological laboratory at the University of Pennsylvania. In 1890, he published an article in the journal *Mind* in which he first used the term "mental test." He described 50 measures of sensory and motor abilities that differed little from those designed by Galton. In 1891, Cattell moved to Columbia University to continue his work on measurement.

Cattell stressed that psychology must rest on a foundation of measurement and experimentation. Foreseeing the practical application of tests as tools for diagnostic evaluation and for the selection of individuals for training, he compiled a battery of tests for evaluating several skills. Tests in the battery included Dynamometer Pressure, Rate of Movement, Sensation-Areas, Least Noticeable Difference in Weight, Reaction-Time for Sound, Time for Naming Colors, Bisection of a 50-cm Line, Judgment of Ten Seconds' Time, and Number of Letters Remembered on Once Hearing. Although the battery was a crude measure of cognitive ability and was not a good predictor of educational achievement, Cattell's contributions were valuable. He moved the assessment of mental ability out of the field of abstract philosophy and demonstrated that mental ability could be studied empirically and practically.

Other developments in the United States. Psychological tests made their public debut in the United States at the 1893 Chicago World's Fair, where Hugo Münsterberg (1863–1916) and Joseph Jastrow (1863–1944) collaborated on a demonstration testing laboratory. For a small fee, visitors to the laboratory could take tests of "mental anthropometry" to find out how their performance compared to that of others. In Germany, Münsterberg had developed tests for measuring children's perception, memory, reading, and information. Münsterberg moved from Germany to the United States to take over William James's laboratory at Harvard.

In the early 1890s, Franz Boas (1858–1942), at Clark University, and J. Gilbert, at Yale University, studied how children responded to various tests. Boas assessed the validity of simple sensorimotor tests by using teachers' estimates of children's "intellectual acuteness" as a criterion. Gilbert, also studying simple sensorimotor tests, found only two tests—rate of tapping and judgment of distances—that could distinguish "bright" from "dull" children.

Clark Wissler (1870–1947) studied with Cattell. Later, at Columbia University, he investigated the validity of several tests of simple sensory functions that he thought were related to cognitive processes. Using the correlational methods of Galton and Pearson, he found that correlations were low among the test scores themselves and between the test scores and school grades in a sample of college students.

In 1899, Stella Sharp, at Cornell University, reported that tests similar to those used by Binet and Henri in France were unreliable and thus were of little practical use. Sharp, however, studied only seven graduate students; the weak correlations were not surprising for this small, homogeneous sample.

Unfortunately, even though the studies by Wissler and Sharp had serious methodological shortcomings, they temporarily dampened interest in the field of mental measurement.

Developments in France

In France at the end of the 19th century, Alfred Binet (1857–1911), Victor Henri (1872–1940), and Theodore Simon (1873–1961) used tests of higher mental processes, instead of tests of simple sensory functions, to measure intelligence. After being asked by the French government to find a way to identify school-aged children with mental retardation, Binet collaborated with Simon to construct the 30-item 1905 Binet-Simon Scale (see Exhibit 7-1). The scale can be considered to be the first practical and psychometrically based intelligence test—it had relatively precise administration instructions and experimentally tested items ranked by difficulty level.

Unlike previous attempts at developing intelligence tests, the 1905 Binet-Simon Scale included age-based items that implicitly recognized the changes that occur in cognitive growth during development. The Binet-Simon Scale objectively diagnosed degrees of mental retardation and became the prototype for subsequent mental ability scales. Binet and Simon revised their scale in 1908 and again in 1911 by adding items and extending the measurement range. Each revision refined the scale so that users could more precisely compare a child's performance with the average performance of children of the same age. The scale included

Exhibit 7-1
Tests Included in the 1905 Binet-Simon Scale

1. *Visual Coordination.* The child must follow a lighted match that is slowly passed before his or her eyes.
2. *Grasping Provoked Tactually.* The child must grasp a small wooden cube that is placed on the palm or back of her or his hand.
3. *Grasping Provoked Visually.* The child must grasp a small wooden cube that is placed within his or her reach.
4. *Awareness of Food.* The child must distinguish a small bit of chocolate from a piece of wood of similar dimensions.
5. *Seeking Food When a Slight Difficulty Is Interposed.* The child must unwrap a piece of chocolate.
6. *Execution of Simple Orders and the Imitation of Gestures.* The child is asked to carry out various commands given orally and also imitate several of the examiner's movements.
7. *Verbal Knowledge of Objects.* The child is asked to touch various parts of his or her body and also give the examiner an object when asked to do so.
8. *Verbal Knowledge of Pictures.* The child is asked to point to various objects or pictures.
9. *Naming Objects Designated in a Picture.* The child is asked to name pictured objects.
10. *Immediate Comparison of Two Lines of Unequal Lengths.* The child is asked to indicate which of two relatively short lines is longer.
11. *Repetition of Digits.* The child is asked to repeat three digits.
12. *Comparison of Two Weights.* The child is asked to say which of two boxes is heavier.
13. *Suggestibility.* The child is asked to point to four things: (a) an object that is not in the array of three objects, (b) an object in the array that is referred to by a nonsense word, (c) an object in a picture that is referred to by a nonsense word, and (d) the longer of two lines (when in fact both lines are of the same length).
14. *Verbal Definition of Known Objects.* The child is asked to define familiar objects, such as a house, a horse, a fork, and mamma.
15. *Repetition of Sentences of 15 Words.* The child is asked to repeat 15-word sentences.
16. *Comparison of Known Objects.* The child is asked to give differences between pairs of familiar objects, such as differences between paper and cardboard, a fly and a butterfly, and wood and glass.
17. *Memory for Pictures.* The child is shown pictures and is asked to recall the names of the pictured objects.
18. *Drawing a Design from Memory.* The child is shown two designs and is asked to draw them from memory.
19. *Repetition of Digits.* The child is asked to repeat increasingly longer series of digits (three, four, five, etc.).
20. *Resemblance of Several Known Objects.* The child is asked how two or more objects are alike, such as (a) a wild poppy and blood, (b) a fly, an ant, a butterfly, and a flea, and (c) a newspaper, a label, and a picture.
21. *Comparison of Lengths.* The child is asked to compare one standard line with a series of different lines presented in rapid sucession, and to indicate which line is longer in each case.
22. *Five Weights To Be Placed in Order.* The child is asked to arrange five weights in order—15, 12, 9, 6, and 3 grams.
23. *Gap in Weights.* The child is asked to identify the one weight missing from the series of weights used in Test 22. This test is given only when Test 22 is passed.
24. *Exercise in Rhymes.* The child is asked to rhyme words.
25. *Verbal Gaps To Be Filled.* The child is asked to give the last word that is missing in a sentence.
26. *Synthesis of Three Words in One Sentence.* The child is asked to make up a sentence using three words: *Paris, gutter, fortune.*
27. *Reply to an Abstract Question.* The child is asked what to do in 25 social situations. Examples: "What is the thing to do when you are sleepy?" "When one has need of good advice, what must one do?"
28. *Reversal of the Hands of a Clock.* The child is asked to look at a clock and state what the time would be if the large and the small hands of the clock were interchanged.
29. *Paper Cutting.* The child is asked to watch as a paper is folded into fourths and a piece is cut out of the edge that includes only one fold. Then the child must make a drawing of what the cut paper would look like if it were unfolded.
30. *Definitions of Abstract Terms.* The child is asked to explain the difference between two abstract terms, such as *esteem* and *affection* or *wariness* and *sadness.*

items that measured language, auditory processing, visual processing, learning and memory, judgment, and problem-solving.

Comments on Nineteenth-Century Theorists

Developments in the field of intelligence testing proceeded differently in England, Germany, the United States, and France. The English were concerned with statistical analyses; the Germans emphasized the study of psychopathology and more complex mental functions; the Americans focused on implementing Binet's ideas for developing an intelligence scale and on statistical methods for examining test data; and the French focused on clinical experimentation. The early test constructors also had varied reasons for developing tests. Galton and Pearson devised tests to aid in the study of heredity; James McKeen Cattell was interested in the study of individual differences in behavior; and Binet was interested in establishing levels of intellectual functioning.

Thus, the period from 1880 to 1905 was the "laboratory" period of psychology. Research focused on general psychology, individual differences, and mental measurement. The earliest approaches to developing a means of measuring intelligence focused on a study of sensation, attention, perception, association, and memory. The work of Binet, Ebbinghaus, and others built on that framework and had a unifying thread: the application of methods used in experimental psychological laboratories to solve practical problems. The interplay of these forces during this period gave birth to the field of applied psychology and ushered in a new era in psychometrics.

Figure 7-2. Alfred Binet.

LATER TWENTIETH-CENTURY DEVELOPMENTS

Goddard's Contribution

Henry H. Goddard (1866–1957), director of the Psychological Laboratory at the Vineland Training School in New Jersey, had a view of intelligence different from Binet's. Goddard believed that intelligence consisted of a single underlying function largely determined by heredity, whereas Binet believed that intelligence could be altered by environmental factors and was not based solely on genetics. Nevertheless, Goddard introduced the 1905 Binet-Simon Scale in the United States in 1908. In 1910, he published an updated version of the 1908 Binet-Simon Scale, making minor revisions and standardizing it on 2,000 American children. For many years, the 1908 Binet-Simon Scale was the scale most often used in the United States. The early use of the scale was primarily to evaluate individuals with mental retardation.

Terman's Contribution

Lewis M. Terman (1877–1956), at Stanford University, observed that the 1908 Binet-Simon Scale had great practical and theoretical value. He became interested in the intellectual assessment of school children and, after studying Goddard's work, collaborated with Hubert G. Childs (1871–?) in publishing a provisional revision of the Binet-Simon Scale in 1912. In 1916, he published a modified, extended, and standardized form of this revision called the Stanford Revision and Extension of the Binet-Simon Scale, or the Stanford-Binet.

Terman constructed the 1916 scale using relatively sophisticated psychometric procedures. The standardization group had about 1,000 children between the ages of 4 and 14 years, selected from California communities of average socioeconomic status. Terman adopted Louis William Stern's (1871–1938) concept of a mental quotient, renaming it the *intelligence quotient,* or IQ. (Stern defined *mental quotient* as mental age divided by chronological age, and to get rid of the decimal, he multiplied the ratio by 100. Stern originally introduced the concept at the German Congress of Psychology in Berlin in 1912 and described it in his 1914 book *The Psychological Methods of Testing Intelligence.*) The final items Terman selected and their placements in his test were based on the percentages of children who passed each item at successive age levels and on whether the items yielded a median IQ of 100 for groups of unselected children at each age level. Administration and scor-

Figure 7-3. Lewis M. Terman. Courtesy of Stanford University.

ing procedures were standardized, and he presented data with the percentages of children obtaining scores at different IQ levels. Finally, Terman provided a classification chart to qualitatively describe successive IQ ranges. Terman deserves credit for his thorough and accurate implementation of the method suggested by Binet and Simon. The 1916 scale would become a major contribution to the field of mental measurement and represented a milestone in the field.

Yerkes' Contribution

Soon after Goddard introduced the Binet-Simon Scale in the United States, discontent with the age-scale format surfaced. The leading researcher against the age-scale format was Robert M. Yerkes (1876–1956). He believed that intelligence tests should contain items that measured the same specific functions throughout. In addition, tests should assign points based on the correctness, the quality, and sometimes the speed of the child's responses. He referred to this arrangement as a *point-scale format.* In 1915, Yerkes, along with James W. Bridges (1885–?) and Rose S. Hardwick (1868–1939), published the *Yerkes-Bridges Point Scale.*

Yerkes also assembled a group of 40 psychologists, including Henry Goddard, Lewis Terman, and Walter Bingham, who developed the 1919 Army Alpha and Army Beta. The Army Alpha was a verbal test containing eight subtests; the Army Beta was a nonverbal test with seven subtests (see Table 7-1). By the end of World War I, the tests had been administered to approximately 2 million men. The correlation between the 1916 Stanford-Binet mental age and the Army Alpha total score was .81; the correlation between the Stanford-Binet mental age and the Army Beta total score was .73. Publication of the Army Alpha and the Army Beta was a pivotal moment in psychology, and these tests served to popularize intelligence testing in business and education.

Revisions of the Stanford-Binet

Lewis Terman and Maud Merrill (1888–1978) revised the 1916 Stanford-Binet in 1937 and again in 1960. In 1972, new norms were published using standard scores instead of ratio IQs. In 1986, Robert L. Thorndike (1910–1990), Elizabeth M. Hagen, and Jerome M. Sattler published a point-scale revision of the scale—the Stanford-Binet Intelligence Scale: Fourth Edition (Thorndike, Hagen, & Sattler, 1986a, 1986b). The Fifth Edition of the Stanford-Binet was published in 2003 by Gale H. Roid (see Chapter 16).

Wechsler's Search for Subtests

Like Yerkes, David Wechsler (1896–1981) was interested in using a point-scale format to develop an intelligence test. After studying numerous published tests, he chose 11 of them, which he modified and incorporated into his scale as subtests. His scale, called the Wechsler-Bellevue Intelligence Scale, Form I, was published in 1939. This scale was the forerunner of the Wechsler Adult Intelligence Scale–Third Edition (WAIS–III), the Wechsler Intelligence Scale for Children–Fourth Edition (WISC–IV), and the Wechsler Preschool and Primary Scale of Intelligence–Third Edition (WPPSI–III). (These tests are covered in Chapters 9 through 15.)

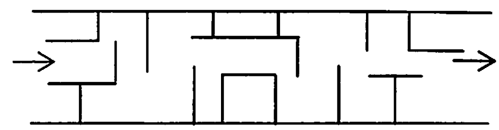
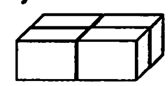
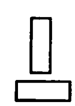
According to Boake (2002), nearly all of the Wechsler-Bellevue subtests were derived from the 1919 Army Alpha and Army Beta; the exception was the Block Design subtest, which was based on the 1923 Kohs Block Design Test. (The Picture Arrangement subtest was part of the preliminary version of the Army Beta but was dropped before the final version.) Although Wechsler designed some original material for all of the subtests, in some cases items differed only slightly from those in the 1919 Army Alpha and Army Beta.

Wechsler considered intelligence to be a part of the larger construct of personality and developed his scale by focusing on the global nature of intelligence. He hoped that his scale would measure the effective intelligence of an individual and aid in psychiatric diagnosis. Wechsler made no attempt to design subtests that would measure "primary abilities" (what others would call the basic units that make up general ability or intelligence—see the discussion of Thurstone's work later in this chapter) or to order the subtests into a hierarchy of relative importance. Rather, the overall IQ obtained from the Wechsler scale represented an index of general mental ability.

Comments on the Binet-Simon Scales

The 1905 Binet-Simon Scale stimulated the development of clinical psychology in the United States and elsewhere. Jenkins and Paterson (1961) noted that "probably no psychological innovation has had more impact on the societies of the Western world than the development of the Binet-Simon scales" (p. 81). Tuddenham (1962) expressed a similar opinion: "The success of the Stanford-Binet was a triumph of

Table 7-1
Items Similar to Those on the Army Alpha and the Army Beta

Army Alpha	*Army Beta*
Test 1. Following Oral Directions "When I say 'go,' make a cross in the first circle and also a figure 1 in the third circle." O O O O O O	**Test 1. Maze.** Trace the maze. 
Test 2. Arithmetical Problems If it takes 6 men 3 days to dig a 180-foot drain, how many men are needed to dig it in half a day?	**Test 2. Cube Analysis.** Count the cubes. 
Test 3. Practical Judgment If a man made a million dollars, he ought to [ ] Pay off the national debt [ ] Contribute to various worthy charities [ ] Give it all to some poor man	**Test 3. X – O Series.** Carry the series out to the end of the line. X O X O X O X O _ _ _ _
Test 4. Synonyms–Antonyms good – bad same – opposite little – small same – opposite	**Test 4. Digit Symbol.** Write the appropriate symbol under each number. 1 2 3 4 5 6 7 8 9 – ɥ ⊓ L ∩ O Δ X = 3 1 2 5 8 7 3 6 2 3 _ _ _ _ _ _ _ _ _ _
Test 5. Disarranged Sentence leg flies one have only true – false	**Test 5. Number Checking.** Circle the matching numbers. 699310 . . . . 699310 251004818 2551004418
Test 6. Number Series Completion 2 3 5 8 12 17 ___ ___	**Test 6. Picture Completion.** Identify missing parts. 
Test 7. Analogies gun – shoot: knife – run cut hat bird	**Test 7. Geometrical Construction.** Construct a square out of the two figures. 
Test 8. Information The Wyandotte is a kind of horse fowl cow granite	

pragmatism, but its importance must not be underestimated, for it demonstrated the feasibility of mental measurement and led to the development of other tests for many special purposes. Equally important, it led to a public acceptance of testing which had important consequences for education and industry, for the military, and for society generally" (p. 494).

Practical demands and interest in the concept of IQ propelled the development of the testing movement, even though the movement had no support from any traditional branch of psychology. Binet and Simon were the first to have their scale recognized as a practical means of measuring mental ability. Success came to Binet and Simon when they measured intelligence in global terms, abandoning the attempt to break it into its component parts. The scale helped public schools identify students who were having difficulty learning and were in need of special services. With the introduction of

Figure 7-4. David Wechsler. Courtesy of The Psychological Corporation.

the Binet-Simon Scale, intelligence testing became a popular assessment technique throughout the United States. The Fifth Edition of the Stanford-Binet, published in 2003, is the latest step in the evolution of Binet's original idea. Testing has become a common practice in schools, clinics, industry, and the military, influencing public policy, business, and scientific psychology. The testing movement, although subject to criticism from some quarters, continues to thrive in the United States and in many other parts of the world.

DEFINITIONS OF INTELLIGENCE

Since the beginning of the testing movement, psychologists have offered definitions of intelligence. Two major attempts to survey psychologists' opinions about the definition of intelligence were a 13-member panel at a 1921 symposium (reported in the *Journal of Educational Psychology, 12,* 1921) and a 24-member panel at a 1986 symposium (Sternberg & Detterman, 1986). The definitions of intelligence at both symposiums emphasized attributes such as *adaptation to the environment, basic mental processes,* and *higher-order thinking* (e.g., reasoning, problem solving, and decision making). However, the psychologists at the 1986 symposium placed more emphasis on metacognition, executive processes (see the discussion of information-processing approaches later in the chapter), knowledge, the interaction between knowledge and mental processes, and context, particularly the value placed on intelligence by a given culture (see Table 7-2).

Let's now look at the definitions of intelligence offered by Binet, Terman, Wechsler, and other psychologists (see Table 7-3). Binet (Binet & Simon, 1905) regarded intelligence as a collection of faculties: judgment, practical sense, initiative, and the ability to adapt to circumstances. He selected his tests according to an empirical criterion—their ability to distinguish older from younger children at successive age levels. However, statistics were not used to arrange the test items.

Terman (1921), one of the psychologists at the 1921 symposium, defined intelligence as the ability to carry on "abstract thinking." He was well aware of the danger of placing

Table 7-2
Terms Used to Define Intelligence in Two Symposia

Terms	*1921 (percent of respondents)*	*1986 (percent of respondents)*
Higher-level components, which include abstract reasoning, representation, problem solving, and decision making	57	50
Adaptation needed to meet the demands of the environment effectively	29	13
Ability to learn	29	17
Physiological mechanisms	29	8
Elementary processes, such as perception, sensation, and attention	21	21
Overt behavioral manifestations represented by effective or successful responses	21	21
Speed of mental processing	14	13
g	14	17
Restricted to academic/cognitive abilities	14	8
Metacognition (knowledge about cognition)	7	17
Executive processes	7	25
Interaction of processes and knowledge	0	17
Knowledge	7	21
Discrete set of abilities, such as spatial, verbal, and auditory	7	17
That which is valued by culture	0	29

Source: Adapted from Sternberg and Berg (1986).

Table 7-3
Some Definitions of Intelligence

Author	Definition
Binet (in Terman, 1916)	"The tendency to take and maintain a definite direction; the capacity to make adaptations for the purpose of attaining a desired end; and the power of autocriticism" (p. 45).
Binet & Simon (1916)	". . . judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances. To judge well, to comprehend well, to reason well, these are the essential activities of intelligence" (pp. 42–43).
Spearman (1923)	". . . everything intellectual can be reduced to some special case of educing either relations or correlates" (p. 300).
Yerkes & Yerkes (1929)	". . . the term intelligence designates a complexly interrelated assemblage of functions, no one of which is completely or accurately known in man" (p. 524)
Stoddard (1943)	". . . the ability to undertake activities that are characterized by (1) difficulty, (2) complexity, (3) abstractness, (4) economy, (5) adaptiveness to a goal, (6) social value, and (7) the emergence of originals, and to maintain such activities under conditions that demand a concentration of energy and a resistance to emotional forces" (p. 4).
Freeman (1955)	". . . *adjustment or adaptation of the individual to his* [or her] *total environment,* or to limited aspects of it. . . . the capacity to reorganize one's behavior patterns so as to act more effectively and more appropriately in novel situations. . . . the *ability to learn*. . . . the extent to which [a person] is educable. . . . the *ability to carry on abstract thinking*. . . . the effective use of concepts and symbols in dealing with . . . a problem to be solved" (pp. 149, 150).
Wechsler (1958)	"The aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his [or her] environment" (p. 7).
Das (1973)	". . . the ability to plan and structure one's behavior with an end in view" (p. 27).
Humphreys (1979)	". . . the resultant of the processes of acquiring, storing in memory, retrieving, combining, comparing, and using in new contexts information and conceptual skills; it is an abstraction" (p. 115).
Gardner (1983)	". . . a human intellectual competence must entail a set of skills of problem solving—enabling the individual *to resolve genuine problems or difficulties* that he or she encounters, and, when appropriate, to create an effective product—and must also entail the potential *for finding or creating problems*—thereby laying the groundwork for the acquisition of new knowledge" (pp. 60–61).
Hunt (1985)	Intelligence is a collective term that refers to the possession of useful knowledge and special information-processing capabilities.
Anastasi (1986)	"Intelligence is not an entity within the organism but a quality of behavior. Intelligent behavior is essentially adaptive, insofar as it represents effective ways of meeting the demands of a changing environment. Such behavior varies with the species and with the context in which the individual lives" (pp. 19–20).
Detterman (1986)	"Intelligence can best be defined as a finite set of independent abilities operating as a complex system" (p. 57).
Estes (1986)	". . . intelligence . . . is a multifaceted aspect of the processes that enable animate or inanimate systems to accomplish tasks that involve information processing, problem solving, and creativity" (p. 66).
Pellegrino (1986)	"Intelligence is implicitly determined by the interaction of organisms' cognitive machinery and their sociocultural environment. . . . [There is] the need to consider cultural values and context in any understanding of intelligence" (p. 113).
Snow (1986)	Intelligence is part of the internal environment that shows through at the interface between person and external environment as a function of cognitive task demands.
Sternberg (1986)	". . . mental activity involved in purposive adaptation to, shaping of, and selection of real-world environments relevant to one's life" (p. 33).
Carroll (1997)	". . . IQ represents the degree to which, and the rate at which, people are able to learn, and retain in long-term memory, the knowledge and skills that can be learned from the environment (that is, what is taught in the home and in school, as well as things learned from everyday experience)" (p. 44).
Sattler (2001)	"Intelligent behavior reflects the survival skills of the species, beyond those associated with basic physiological processes" (p. 136).

too much emphasis on the results of one particular test: "We must guard against defining intelligence solely in terms of ability to pass the tests of a given intelligence scale. It should go without saying that no existing scale is capable of adequately measuring the ability to deal with all possible kinds of material on all intelligence levels" (p. 131). Terman's comments are still valid and appropriate today.

For Wechsler (1958), intelligence is composed of qualitatively different abilities. He argued, however, that intelligence is not the mere sum of abilities, because intelligent behavior is also affected by the way the abilities are combined and by each individual's motivation. Wechsler took a pragmatic view of intelligence, stating that intelligence can be recognized by what it enables us to do. From Wechsler's perspective, it is possible to measure various aspects of intellectual ability; however, intelligence test scores do not fully capture intelligence. Although his theory was partially empirically based, he did not supply empirical referents for terms—such as *aggregate, global, purposefully,* and *rationally*—that he used in his definition of intelligence (see Table 7-3).

Several of the definitions of intelligence in Table 7-3 have in common an emphasis on the ability to adjust or adapt to the environment, the ability to learn, or the ability to perform abstract thinking (e.g., to use symbols and concepts). Some definitions also emphasize the information-processing aspects of intelligence, the sociocultural and environmental aspects of intelligence, and the survival aspects of intelligence.

In 1987, 1,020 experts in the fields of psychology, education, sociology, and genetics were asked to rate 13 behavioral descriptions of important elements of intelligence; their ratings showed strong consensus about what constitutes intelligence (Snyderman & Rothman, 1987). All of the experts believed that intelligence tests adequately measure most of the important elements of intelligence. Here are the 13 behavioral descriptions and the percentage of respondents who rated them as important:

1. Abstract thinking or reasoning (99.3%)
2. Problem-solving ability (97.7%)
3. Capacity to acquire knowledge (96.0%)
4. Memory (80.5%)
5. Adaptation to one's environment (77.2%)
6. Mental speed (71.7%)
7. Linguistic competence (71.0%)
8. Mathematical competence (67.9%)
9. General knowledge (62.4%)
10. Creativity (59.6%)
11. Sensory acuity (24.4%)
12. Goal-directedness (24.0%)
13. Achievement motivation (18.9%)

Not all cultures have the same view of intelligence. Western cultures emphasize the problem-solving, logical, and conceptual aspects of intelligence. Eastern cultures, in contrast, emphasize the holistic, social nature of intelligence, placing a premium on the ability to identify complexity and contradictions (Nisbett, 2003). Nonetheless, a study on the WISC–III standardization samples of 12 countries in Europe, Asia, and North America (a data set that contained 15,999 children) showed that the average scores across countries and factor structures were remarkably similar (Georgas, Van de Vijver, Weiss, & Saklofske, 2003). The results provide evidence of similar cognitive processes across many cultures, at least as measured by the WISC–III.

"After 20 years of schooling, your aptitude test shows that you're skilled at just one thing—taking tests."

Courtesy of H. L. Schwadron.

INTRODUCTION TO FACTOR ANALYTIC THEORIES OF INTELLIGENCE

Factor analysts played a powerful role in shaping 20th-century developments in the field of assessment. Historically, the factor analytic theorists fell into two camps. One camp favored a *multifactor theory of intelligence,* maintaining that intelligence is a composite of a number of independent abilities, such as mathematical, mechanical, and verbal faculties. Among those in this camp were Thorndike, Thurstone, Guilford, Cattell, and Horn. The other camp favored a *general and specific factor (g, s) theory of intelligence.* This camp included Spearman, Vernon, and Carroll. The testing of these rival theories became possible in 1927 when Spearman introduced statistical techniques such as factor analysis. However, part of the difficulty with factor analysis is that the outcomes depend on the nature and quality of the data, the type of statistical procedure used, and the proclivities of the investigator who chooses the labels to designate the factors. *Factor labels are merely descriptive categories and do not necessarily reflect underlying entities.*

MULTIFACTOR THEORY CAMP

Thorndike's Multifactor Theory of Intelligence

Edward L. Thorndike's (1874–1949) multifactor theory of intelligence postulates that intelligence is the product of many interconnected but distinct intellectual abilities. Certain mental activities have elements in common and combine to form clusters. Three such clusters are social intelligence (dealing with people), concrete intelligence (dealing with things), and abstract intelligence (dealing with verbal and mathematical symbols); Thorndike's (1927) conceptions were based on his theory and not on statistical methods.

Thurstone's Multidimensional Theory of Intelligence

Louis L. Thurstone's (1887–1955) view of human intelligence was initially the most divergent from Spearman's (see below). Thurstone (1938) maintained that human intelligence possesses a certain systematic organization and cannot be regarded as a unitary trait. Further, the structure of intelligence can be inferred from a statistical analysis of the patterns of intercorrelations found in a group of tests. Using the centroid method of factor analysis, which is suitable for analyzing factors simultaneously, Thurstone identified seven primary (specific) ability factors, each with equal weight: verbal comprehension, word fluency, number skills, memory, perceptual speed, inductive reasoning, and spatial visualization. His work led to the development of the Primary Mental Abilities Test. Although Thurstone's multidimensional theory at first eliminated Spearman's general factor (*g*) as a significant component of mental functioning, subsequent research showed that the primary factors correlated moderately among themselves, leading Thurstone to postulate the existence of second-order factors that may be related to *g*.

Guilford's Structure of Intellect Theory

J. P. Guilford (1967) developed the three-dimensional *Structure of Intellect model* as a means of organizing intellectual factors. One dimension represents the *operations* involved in processing information, the second dimension represents *content*, and the third dimension represents *products*. Intellectual activities must be understood in terms of the mental operation performed, the content on which the mental operation is performed, and the resulting product. The model posits 120 possible factors: five different operations (cognition, memory, divergent production, convergent production, and evaluation), four types of content (figural, symbolic, semantic, and behavioral), and six products (units, classes, relations, systems, transformations, and implications; see Figure 7-5). A combination of one element from each of the three dimensions yields a factor. An example of a factor is Cognition of Semantic Units, which involves knowing what a word means and being able to explain it. Cognition refers to the operations dimension, semantic refers to the content dimension, and units refers to the product dimension.

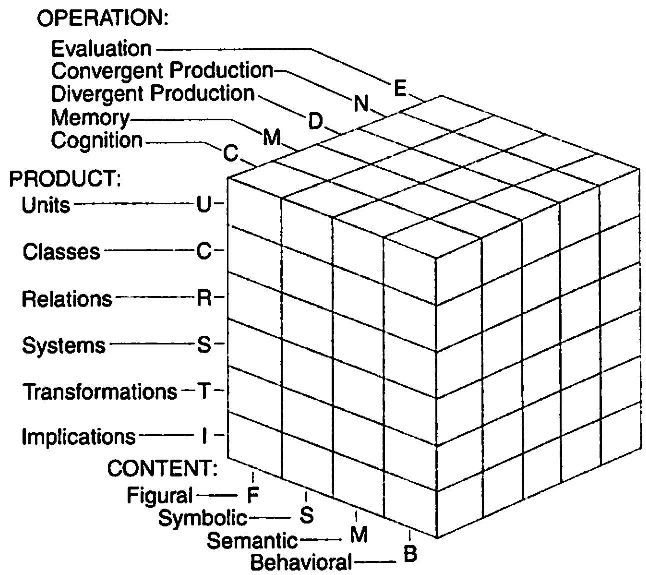


Figure 7-5. Guilford's Structure of Intellect model.

Cattell and Horn's Fluid and Crystallized Theory of Intelligence

Raymond B. Cattell and John Horn (Cattell, 1963; Horn, 1967, 1968, 1978a, 1978b, 1985, 1998; Horn & Cattell, 1967) proposed two types of intelligence—fluid and crystallized. *Fluid intelligence* refers to essentially nonverbal, relatively culture-free mental efficiency. It involves adaptive and new learning capabilities and is related to mental operations and processes. Examples of tasks that measure fluid intelligence are figure classifications, figural analyses, number and letter series, matrices, and paired associates. Fluid intelligence is more dependent on the physiological structures (e.g., cortical and lower cortical regions) that support intellectual behavior than is crystallized intelligence. Fluid intelligence increases until some time during adolescence, when it plateaus; it then begins to decline because of the gradual degeneration of physiological structures. Fluid intelligence is more sensitive to the effects of brain injury than is crystallized intelligence. Fast processing speed and a large working memory appear to be related to fluid intelligence.

Crystallized intelligence refers to acquired skills and knowledge that are developmentally dependent on exposure to the culture. It involves overlearned and well-established cognitive functions and is related to mental products and achievements. Examples of tasks that measure crystallized intelligence are vocabulary, general information, abstract

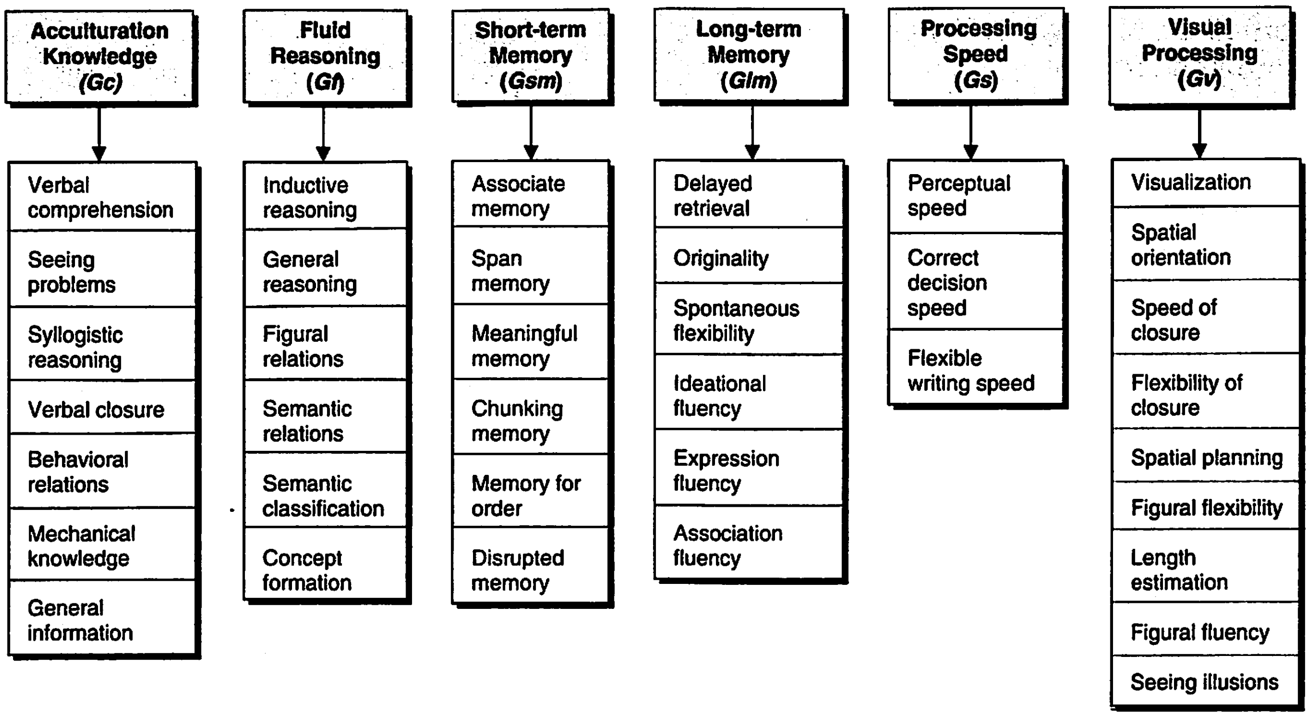


Figure 7-6. Horn's model of intelligence. Note that short-term memory (Gsm) is also referred to as short-term apprehension and retrieval (SAR) and working memory. Long-term memory (Glr) is also referred to as fluency of retrieval from long-term storage (TSR). Adapted from Horn and Blankson (2005).

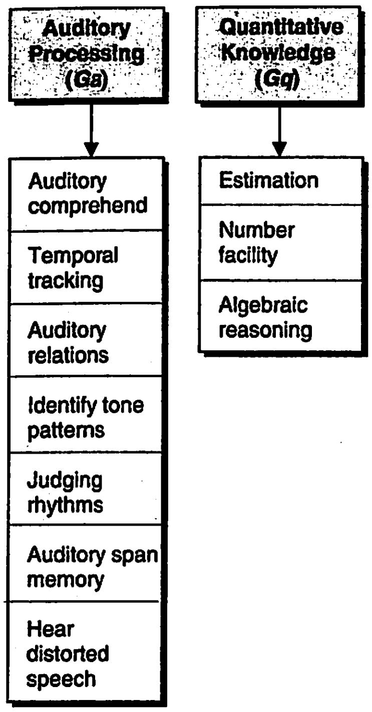
word analogies, and mechanics of language. Crystallized intelligence is highly influenced by formal and informal education throughout the life span. It is also less sensitive to brain injury and so is used to estimate premorbid intelligence when that is not known. Fluid intelligence is the basis for the development of crystallized intelligence.

Some tasks, like arithmetic reasoning, inductive verbal reasoning, and syllogistic reasoning, measure both fluid and crystallized intelligence equally. Tasks that measure fluid intelligence may require more concentration and problem solving than tasks that measure crystallized intelligence, which tap retrieval and application of general knowledge abilities. Intelligence tests differ in the proportion of tasks that measure fluid intelligence (*Gf*), crystallized intelligence (*Gc*), and other types of intelligence.

Horn (1985) argued against the concept of general intelligence, maintaining that research does not support a unitary theory. Instead, he asserted that intellectual ability is composed of several distinct functions that probably have genetic underpinnings and that take different courses of development over the life span. For example, fluid ability and visual thinking decline with age, whereas crystallized ability and long-term acquisition and retrieval show no such decline.

Horn and Blankson (2005) proposed 87 primary mental abilities, which have been replicated in factor analytic studies, and 8 second-order abilities. Figure 7-6 shows 47 of the 87 primary abilities that are associated with the second-order abilities. Definitions of the second-order abilities follow (Horn, 1987, p. 220; 1998, p. 62; Horn & Blankson, 2005, p. 43; with changes in notation):

1. *Acculturation knowledge (Gc):* a broad pattern of achievements and knowledge based on cultural experiences (also referred to as *crystallized ability*)
2. *Fluid reasoning (Gf):* a broad pattern of reasoning, seriation, sorting, and classifying
3. *Short-term memory (Gsm):* a broad pattern of immediate awareness, alertness, and retrieval of material recently acquired (also referred to as *short-term apprehension and retrieval* [*SAR*] and *working memory*)
4. *Long-term memory (Glm):* a facility in retrieving information stored in long-term memory (also referred to as *fluency of retrieval from long-term storage* [*TSR*])
5. *Processing speed (Gs):* an ability to scan and react to simple tasks rapidly
6. *Visual processing (Gv):* a facility for visualizing and mentally manipulating figures and responding appropriately to spatial forms
7. *Auditory processing (Ga):* a pattern of skills involved in listening and responding appropriately to auditory information
8. *Quantitative knowledge (Gq):* an ability to understand and apply mathematical concepts



GENERAL AND SPECIFIC FACTOR CAMP

Spearman's Two-Factor Theory of Intelligence

Charles E. Spearman (1863–1945) was an early proponent of a factor analytic approach to intelligence. Disagreeing with Thorndike's multifactor theory of intelligence, Spearman proposed a two-factor theory of intelligence to account for the patterns of correlations observed among group tests of intelligence (Spearman, 1927). Spearman's theory stated that a general factor (*g*) plus one or more specific factors per test account for performance on intelligence tests (see Figure 7-7). Spearman thought of the *g factor* as general mental energy and proposed that complicated mental activities require the greatest amount of *g*. For example, the *g* factor is involved in deductive operations linked with intellectual skill, speed, intensity, and output. Key aspects of *g* are the ability to determine the relationship between two or more ideas and to find a second idea associated with a previous one. Spearman considered the *g* factor as an index of general mental ability (or intelligence), representing the "inventive," as opposed to the "reproductive," aspect of mental ability (Jensen, 1979).

Tests with high *g* loadings require conscious and complex mental effort, such as that involved in reasoning, comprehension, and hypothesis testing. Examples are tests of matrix reasoning, generalizations, verbal analogies, arithmetic problems, paragraph comprehension, and perceptual analogies. Tests with low *g* loadings are less complex and emphasize recognition, recall, speed, visual-motor abilities, and motor abilities. Examples are maze speed, crossing out numbers, counting groups of dots, simple addition, and tapping speed.

Although evidence strongly supports the idea that *g* is important in human ability and is an excellent predictor of occupational success in many different fields, this does not mean that *g* is an entity. We can accept the evidence for Spearman's *g* without accepting Spearman's explanation of *g* as "mental energy, or any other explanation that suggests a unitary something underlying the behavioral phenomena" (Humphreys, Parsons, & Park, 1979, p. 75). For more information about *g*, see Jensen (1998).

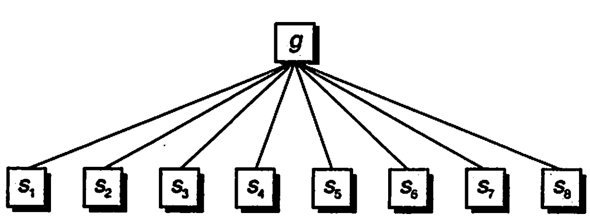


Figure 7-7. Spearman's two-factor theory of intelligence; *g* refers to the general factor, or general ability, and *s* to specific factors.

Vernon's Hierarchical Theory of Intelligence

Philip E. Vernon (1950) proposed a hierarchical theory of intelligence (see Figure 7-8). At the highest level is *g*, or general ability. At the next level are two major group factors—*verbal-educational* and *spatial-mechanical.* At the next lower level are subdivisions (or minor group factors) of the two major group factors. The subdivisions of the verbal-educational factor are creative abilities, verbal fluency, and numerical factors; the subdivisions of the spatial-mechanical factor are spatial, psychomotor, and mechanical information factors. The lowest level contains specialized factors unique to certain tests. Factors low in the hierarchy refer to narrow ranges of behavior, while those high in the hierarchy refer to a wider range of behavior. Vernon (1965) believed that we must consider a general group factor (*g*) in any attempt to understand or measure intelligence. His belief has substantial support across numerous studies, as indicated by positive intercorrelations among cognitive tests administered to representative populations.

Carroll's Three-Stratum Factor Analytic Theory of Cognitive Abilities

John B. Carroll (1993, 1997) proposed a *three-stratum factor analytic theory of cognitive abilities* based on a review of 465 research studies (see Figure 7-9). The theory postulates that

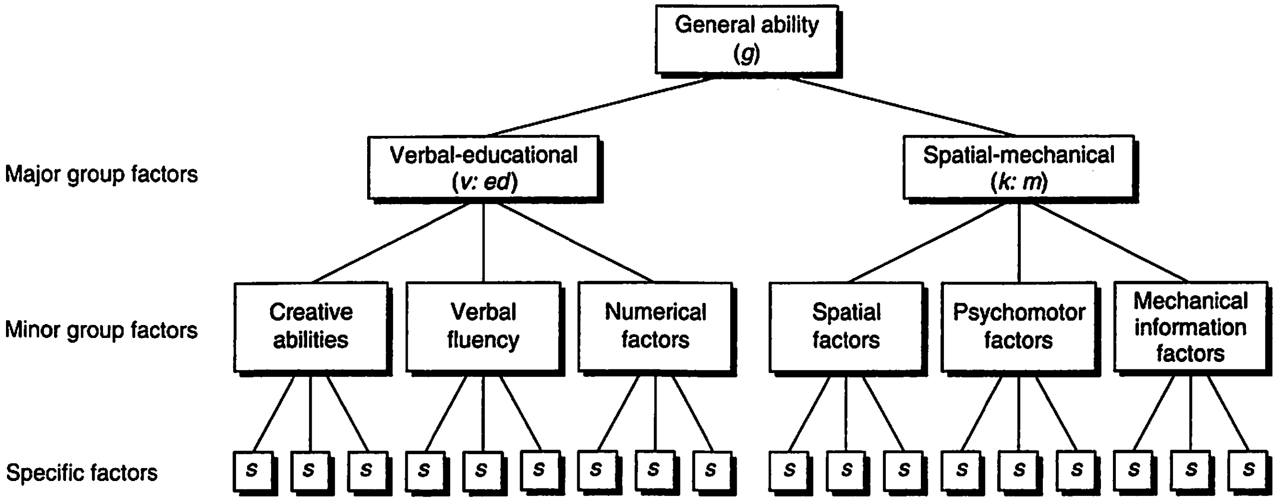


Figure 7-8. Vernon's hierarchical model of intelligence.

there are many distinct individual differences in cognitive ability and that the relationships among these individual differences can be classified into three strata, or levels. "All of the abilities covered by the theory are assumed to be 'cognitive' in the sense that cognitive processes are critical to the successful understanding and performance of tasks requiring these abilities, most particularly in the *processing of mental information.* In many cases, they go far beyond the kinds of intelligences measured in typical batteries of intelligence tests" (Carroll, 1997, p. 126). The 65 narrow abilities listed in Figure 7-9 represent different types of factors. The *level factors* (lightface type) indicate an individual's level of mastery along a difficulty scale. The *speed factors* (bold type) indicate an individual's speed in performing tasks or in learning material. The *speed and level factors* (italic type) indicate an individual's speed in performing tasks or in learning material combined with an individual's level of mastery along a difficulty scale. The *rate factors* (bold italic type) indicate the amount of material an individual learns in a given amount of time.

The three levels of Carroll's theory are as follows:

1. *Narrow (stratum I).* This level consists of 65 narrow abilities comprising levels of mastery in various cognitive areas such as general sequential reasoning, reading comprehension, memory span, visualization, speech sound discrimination, originality/creativity, numerical facility, and simple reaction time.
2. *Broad (stratum II).* This level consists of eight broad factors: fluid intelligence, crystallized intelligence, general memory and learning, broad visual perception, broad auditory perception, broad retrieval ability, broad cognitive speediness, and processing speed (decision speed).
3. *General (stratum III).* This top level consists of only a general factor, or *g.*

Definitions of the eight broad factors follow (Carroll, 1993, pp. 618, 624, 625, with changes in notation):

1. *Fluid intelligence:* a type of intelligence concerned with basic processes of reasoning and other mental activities that depend only minimally on learning and acculturation
2. *Crystallized intelligence:* a type of intelligence concerned with mental processes that reflect not only the operation of fluid intelligence, but also the effects of experience, learning, and acculturation
3. *General memory and learning:* an ability involved in tasks that call for learning and memory of new content or responses
4. *Broad visual perception:* an ability involved in tasks or performances that require the perception or discrimination of visual forms as such; involved only minimally, if at all, in the perception of printed language forms
5. *Broad auditory perception:* an ability involved in tasks or performances that require the perception or discrimination of auditory patterns of sound or speech, particularly when such patterns present difficulties because of fine discriminations, auditory distortion, or complex musical structure
6. *Broad retrieval ability:* an ability involved in tasks or performances that require the ready retrieval of concepts or items from long-term memory
7. *Broad cognitive speediness:* an ability involved in tasks or performances that require rapid cognitive processing of information
8. *Processing speed:* an ability involved in tasks or performances that require reaction time and/or decision speed

Carroll's theory expands and supplements previous theories of the structure of cognitive abilities, such as Thurstone's theory of primary mental abilities, Guilford's structure-of-intellect theory, Cattell and Horn's *Gf-Gc* theory, and Wechsler's

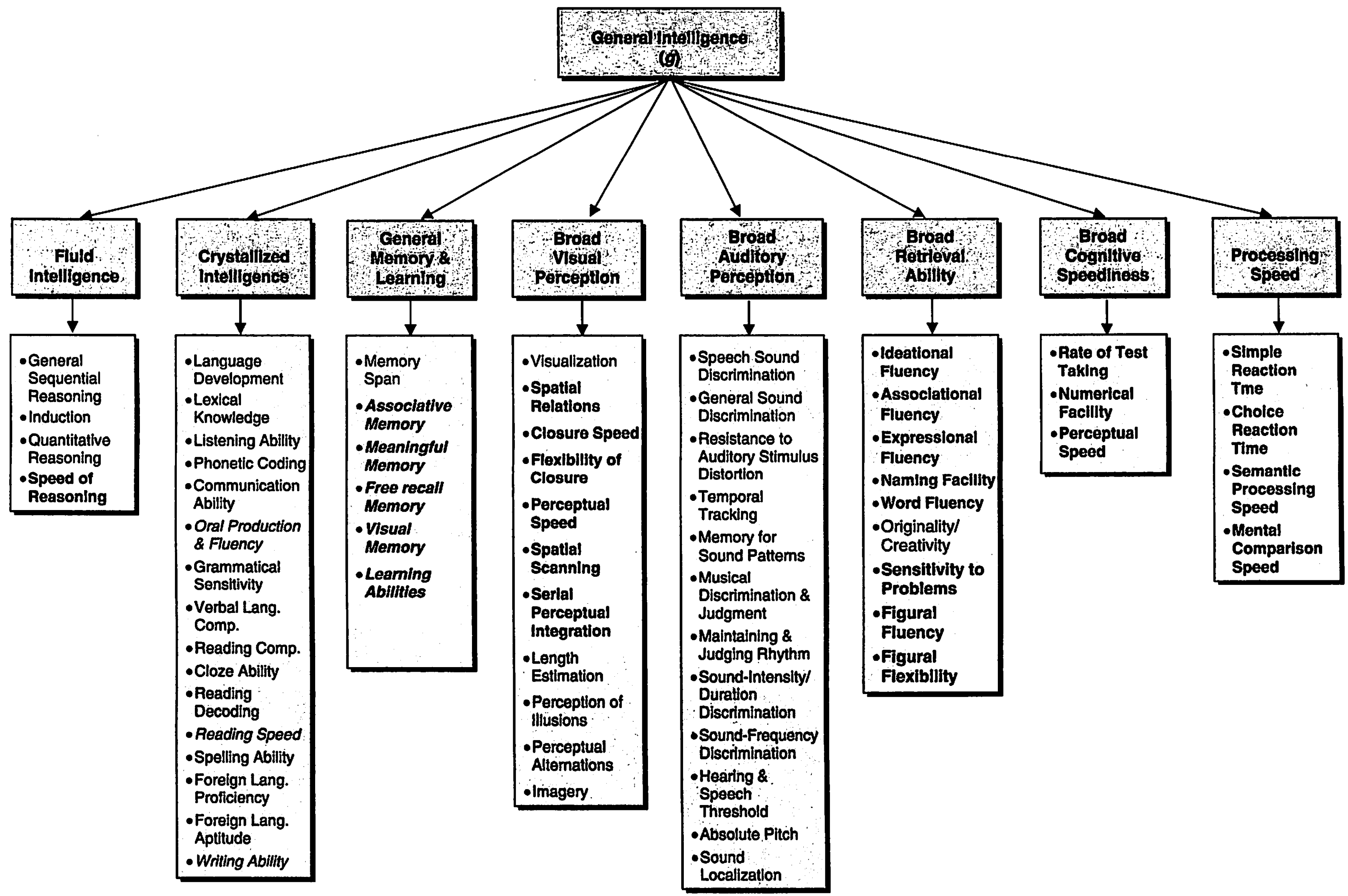


Figure 7-9. The Carroll structure of mental abilities. The three-stratum structure of cognitive abilities (lightface type = level, bold type = speed, italic type = speed and level, and bold italic type = rate factors). Adapted from Carroll (1993, 2005).

Intelligence testing in the 21st century.

Courtesy of Hugh Mahon and Jerome M. Sattler.

theory of verbal and performance components of intelligence (see Chapter 9). Hierarchical confirmatory factor analyses of tests such as the Wechsler Intelligence Scale for Children–IV and the Woodcock-Johnson (Revised and III) support the three-stratum theory (Bickley, Keith, & Wolfe, 1995; Carroll, 1993, 1997; Phelps, McGrew, Knopik, & Ford, 2005).

OTHER THEORIES OF INTELLIGENCE

Other psychologists have proposed theories of intelligence that provide both narrower and broader conceptions of intelligence than those proposed by factor analytic theorists. Some of these conceptions emphasize real-world applications of intelligence and stress the importance of considering both genetic and environmental determinants. Although all of the following theoretical views have merit, as do those of the factor analysts, none fully account for the rich diversity of intelligent behavior.

Campione, Brown, and Borkowski's Information-Processing Theory of Intelligence

Joseph Campione and Ann Brown (1978) used an information-processing model to develop a general theory of intelligence, which was expanded by John Borkowski (1985). Information-processing models of intelligence focus on the ways individuals mentally represent and process information. Human cognition is conceived of as occurring in a series of discrete stages. At each stage information is processed and passed on to the next stage for further processing. Mental processes, then, are composed of specific covert cognitive behaviors that transform and manipulate information from the time it registers in the individual to the time the individual makes a response.

Campione and Brown's theory postulates that intelligence has two basic components (see Figure 7-10). One is the architectural system, which represents a structural component, and the other is an executive system, which represents a control component. The *architectural system* has three subcompo-

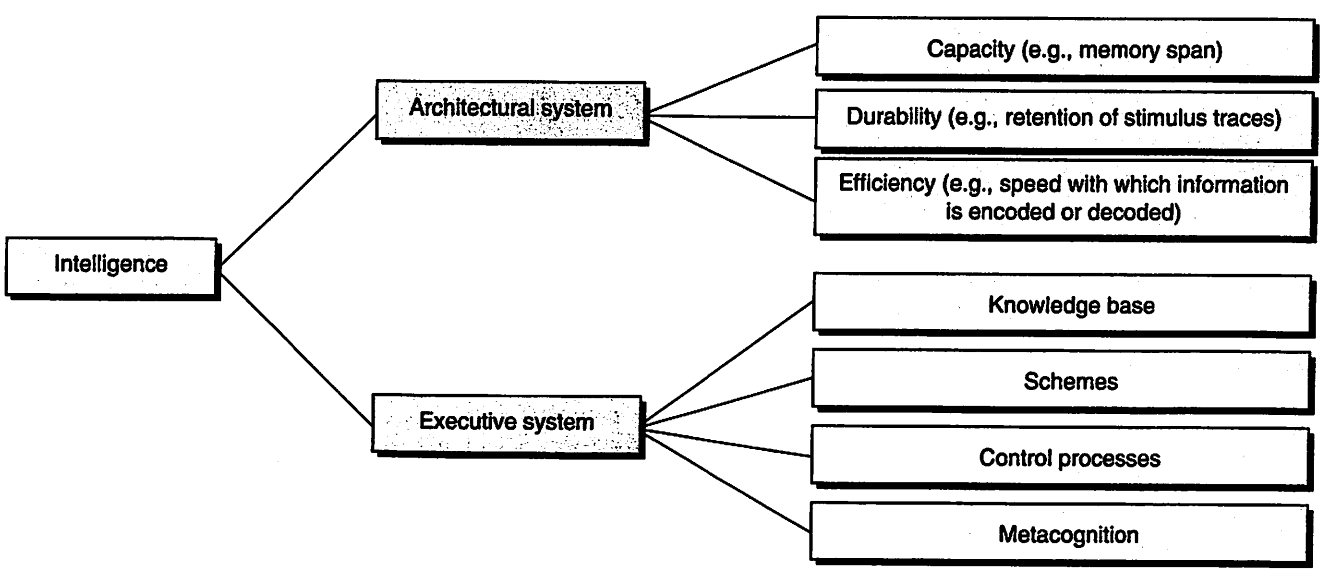


Figure 7-10. Campione, Brown, and Borkowski's model of intelligence.

Exhibit 7-2
Campione, Brown, and Borkowski's Information-Processing Theory of Intelligence

THE ARCHITECTURAL SYSTEM

The *architectural system* refers to the biologically and genetically based properties necessary for processing information, such as memory span, ability to retain stimulus traces, and ability to encode and decode information efficiently. These properties are closely linked to a person's perceptual skills and reflect sensory activity and nervous system integrity. They are relatively impervious to improvement by environmental forces and are essential to basic cognitive operations, such as perception and short-term memory. Thus, the architectural system corresponds to the major stores (i.e., brain structures), or the system's hardware.

The three subcomponents in the architectural system, required to register and respond to sensory input, are the following:

- *Capacity:* the amount of space available in brain modules (e.g., number of slots in short-term memory and amount of filing space in long-term memory)
- *Durability:* the rate at which information is lost
- *Efficiency of operation:* the temporal characteristics associated with selection and storage of information (e.g., speed of encoding, rate of memory search, rapidity with which attention is altered, and duration of alertness)

THE EXECUTIVE SYSTEM

The *executive system* refers to environmentally learned components that guide problem solving: (a) a *knowledge base* (knowledge that can be retrieved from long-term memory), (b) *schemes* (such as those found in Piagetian theory), (c) *control processes* (e.g., rehearsal strategies), and (d) *metacognition* (introspective knowledge). The four components are complementary, overlapping, hypothetical constructs. Although they are assumed to be independent, future research may find that they are actually interdependent.

The components in the executive system are skills that emerge from experience and from instruction in complex problem-solving tasks. The skills associated with the executive system enable an individual to engage in creative, adaptive learning by initiating and regulating retrieval of knowledge from long-term memory, modifying the knowledge base, and mediating problem solving; they allow the individual to rise above rote, nonstrategic learning. These skills appear to be products of enriched learning experiences and hence are highly modifiable. A developmental study of executive-function processes might include (a) self-control and search tasks for toddlers, (b) problem-solving tasks that require simple planning and rule-like behavior for preschoolers and young children, and (c) tasks that require complex planning, self-monitoring, and maintenance of multiple pieces of information in working memory for older school-aged children and adults (Welsh & Pennington, 1988).

Knowledge Base

Knowledge plays a central role in intelligent behavior, because "knowledge informs perceptions, provides a home for new memories amidst the storage of old ones, and informs cognitive routines and strategies in the face of complex problems" (Borkowski, 1985, p. 112).

Schemes

In the Piagetian perspective, *schemes* refer to abstract cognitive structures by which individuals assimilate or accommodate new information. Schemes (or rules of thinking) are the active and constructive aspects of human intelligence. In Piagetian theory, the major stages of cognitive development—sensorimotor, preoperational, concrete operational, and formal operational (see Table 7-4 later in the chapter)—represent groups of schemes. A child passes from one stage to another when there is a major change in the scheme.

Control Processes

Control processes refer to the rules and strategies that aid in memorizing, understanding, problem solving, and other cognitive activities. Strategic behaviors, such as self-checking, rehearsal, and other self-instructional procedures, can be taught to promote greater strategy generalization. Children who possess sophisticated cognitive strategies and skilled routines are likely to become efficient, effective problem solvers who can create strategies to meet new cognitive challenges.

Metacognition

Metacognition refers to thoughts about thoughts, or awareness of one's own thought processes and strategies of thought. Two aspects of metacognition are declarative knowledge ("knowing that") and procedural knowledge ("knowing how"). *Declarative knowledge* refers to knowledge and awareness of factors that impede or facilitate cognition. *Procedural knowledge* refers to knowledge of the procedures that one employs to regulate cognitive activities.

Metacognition helps inform and regulate cognitive routines and strategies. The integration of metacognitive knowledge with strategic behaviors results in more effective problem solving. The metacognitive components of intelligence include (a) recognizing the existence of a problem, (b) defining the nature of the problem, (c) choosing steps to solve the problem, (d) representing information about the problem, (e) allocating resources, (f) monitoring solutions, and (g) evaluating solutions. Metacognition aids in planning, self-monitoring, and ingenuity and may lead to strategy selection, self-reflection, and even the generation of new strategies.

Puzzlement is an experiential aspect of metacognition and may be "both a source of new metacognitive knowledge and a cue for utilizing stored knowledge about appropriate strategies to confront the problem at hand" (Borkowski, 1985, p. 135). Examples of metacognition include the following:

- Knowing that a strategy that worked for one task might need to be slightly modified for a new task
- Knowing that some strategies will work for several tasks
- Knowing how to retrieve information from memory
- Knowing whether there is sufficient information to accomplish a goal
- Knowing whether a problem solution appears to be correct
- Knowing how to deal with uncertainty when one encounters a logical dilemma

Source: Adapted from Borkowski (1985).

nents: capacity, durability, and efficiency of operation. The *executive system* has four subcomponents: knowledge base, schemes, control processes, and metacognition. Exhibit 7-2 presents the theory in more detail.

Sternberg's Triarchic Theory of Successful Intelligence

Robert J. Sternberg's (1986, 2005) triarchic theory of successful intelligence postulates that intelligence has three basic dimensions: componential, experiential, and contextual (see Figure 7-11). These dimensions explain mental activity in real-world environments. Individuals may have excellent skills in any one or more of the three dimensions.

The *componential dimension* relates intelligence to the internal information-processing components of the individual. A component is "a mental process that may translate a sensory input into a mental representation, transform one mental representation into another, or translate a mental representation into a motor output" (Sternberg, 1986, p. 24). There are three types of components: metacomponents, performance components, and knowledge acquisition components.

- *Metacomponents* are executive processes used in planning, monitoring, and evaluating cognitive activities. Metacomponents are higher-order processes that allow individuals to analyze problems and provide solutions to them. Metacomponents also tell other components what to do and when to do it.
- *Performance components* are processes useful in carrying out the plans formulated by the metacomponents. The performance components allow individuals to do varied tasks, such as retrieving information from long-term memory and mentally comparing different stimuli.
- *Knowledge acquisition components* are processes used in obtaining new information. Knowledge acquisition components allow individuals to distinguish relevant from irrelevant information, combine meaningful pieces of information, and compare new information with previously obtained information.

The *experiential dimension* relates intelligence to how well individuals connect their internal world to external reality. This ability involves insights, synthesis, dealing with novelty, and automatization of mental processes. As experience with a task or situation increases, the need to deal with novelty decreases and automatic processes or routines take over. Establishing automatic processes allows individuals to attend to other tasks. The ability to deal effectively with novelty is a good measure of intelligence. However, being skilled in dealing with novel

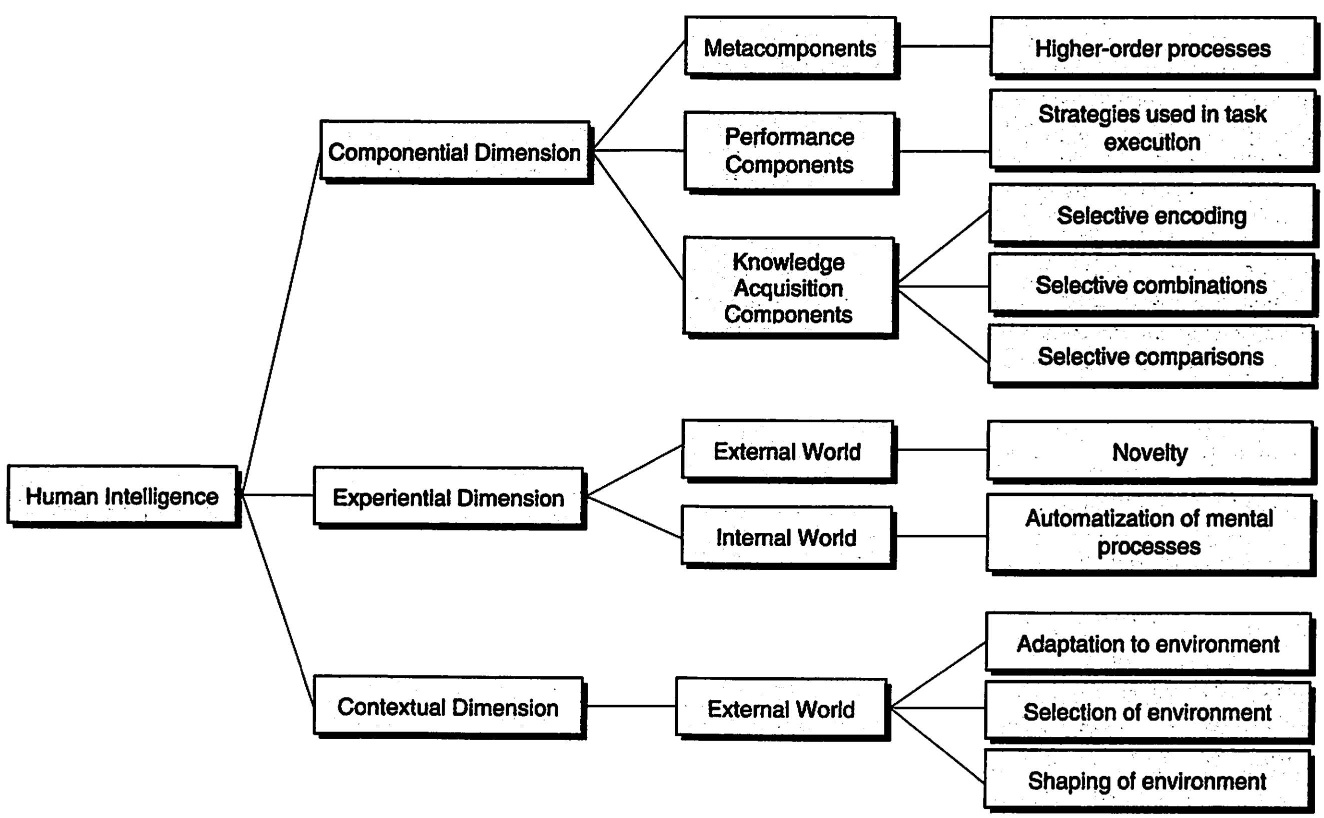


Figure 7-11. Sternberg's triarchic theory of successful intelligence.

Frank and Ernest

tasks does not ensure that an individual is skilled in the automization of mental processes, and vice versa.

The *contextual dimension* relates intelligence to how well individuals adapt to, select, and shape their environments. This type of intelligence is often referred to as "street smarts." Adaptation occurs when individuals make changes within themselves in order to cope better with their surroundings. Shaping occurs when individuals change their environments to better suit their needs. And selection occurs when new environments are found to replace previous ones that were less satisfying than the new one.

The *successful intelligence* part of the theory focuses on "the ability to adapt to, shape, and select environments to accomplish one's goals and those of one's society and culture" (Sternberg & Kaufman, 1998, p. 494). Individuals with successful intelligence are able to discern their strengths and weaknesses and then determine how to use their strengths and minimize their weaknesses. Three broad ability areas are associated with successful intelligence:

- *Analytical abilities* are useful in analyzing and evaluating one's life options. They include "identifying the existence of a problem, defining the nature of the problem, setting up a strategy for solving the problem, and monitoring one's solution" (Sternberg & Kaufman, 1998, p. 494).
- *Creative abilities* help to generate problem-solving options, to promote one's ideas that may not be popular, and to convince others of the value of the ideas.
- *Practical abilities* are those applied to real-world problems in order "to implement options and to make them work. . . . A key aspect of practical intelligence is the acquisition and use of tacit knowledge, which is knowledge of what one needs to know to succeed in a given environment, knowledge that is not explicitly taught and that usually is not verbalized" (Sternberg & Kaufman, 1998, p. 494, with changes in notation).

Underlying the triarchic theory of successful intelligence is the premise that schools—by focusing too narrowly on analytical and memory abilities and failing to promote creative and practical abilities—do not use children's multiple abilities. The theory emphasizes the importance of aspects of intelligence that are not typically measured well by standardized intelligence tests.

Das, Naglieri, and Kirby's Planning-Attention-Simultaneous-Successive Processing (PASS) Model of Intelligence

J. P. Das, Jack Naglieri, and John R. Kirby (1994) describe cognitive ability as a function of planning, attention, simultaneous processing, and successive processing (see Figure 7-12). *Planning* involves cognitive control, knowledge, intentionality, and self-regulation. *Attention* involves focused cognitive activity. *Simultaneous processing* involves perception of stimuli as a whole, including the ability to integrate words into a meaningful idea. *Successive processing* involves making a decision based on stimuli arranged in a sequence. The four types of processing operate together when individuals work on intellectual tasks, although some processes play a stronger role than others, depending on the task. The Cognitive Assessment System (CAS) was designed according to the PASS theory (Naglieri & Das, 1997b; see Chapter 18).

Gardner's Multiple Intelligence Theory

Howard Gardner (1998; Gardner, Kornhaber, & Wake, 1996) postulates that intelligence is composed of several relatively autonomous competencies, or multiple intelligences (see Table 7-3 for Gardner's definition of intelligence). He has identified eight competencies and two tentative competencies,

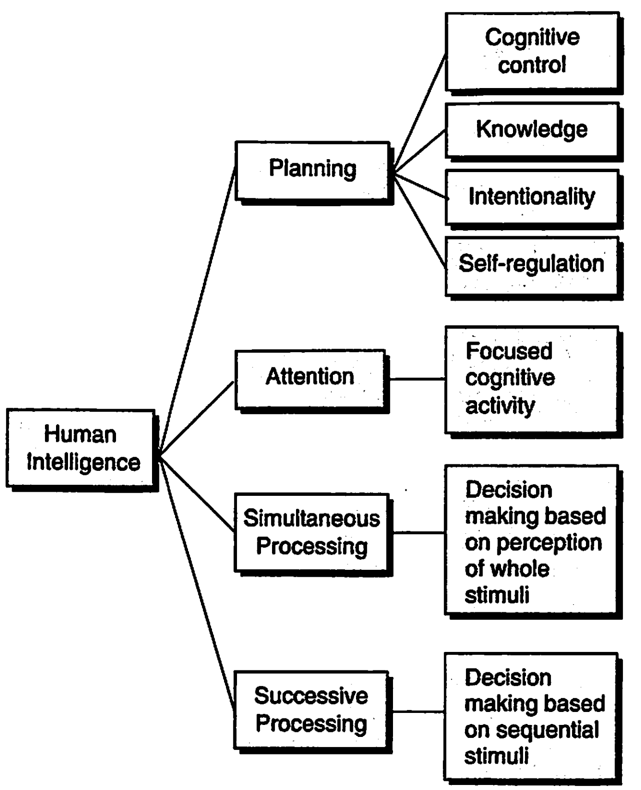


Figure 7-12. Das, Naglieri, and Kirby's planning-attention-simultaneous-successive processing (PASS) model of intelligence.

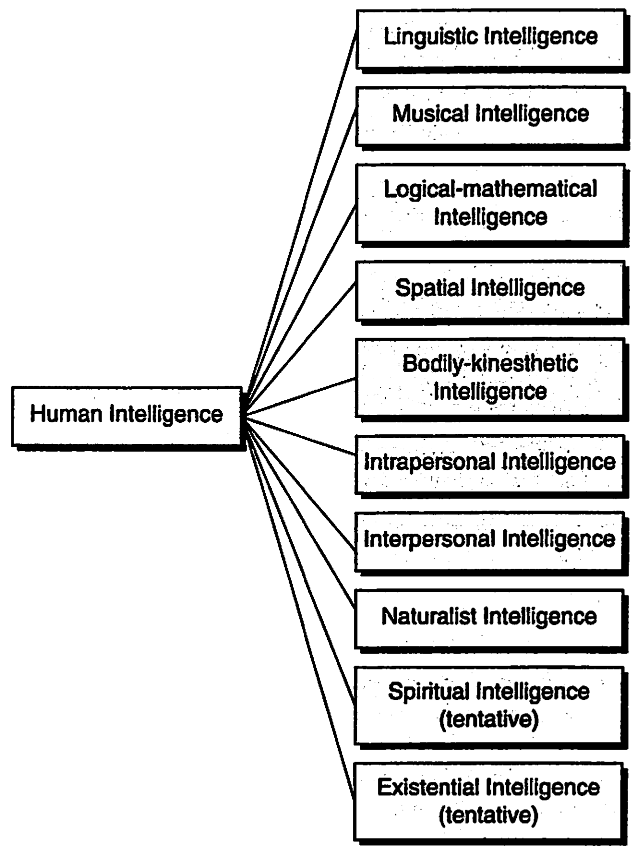


Figure 7-13. Gardner's multiple intelligence theory.

but he believes that more might be discovered (see Figure 7-13). The competencies, with examples, follow.

1. *Linguistic intelligence*—capacities involved in the use of language for communication
2. *Musical intelligence*—rhythmic and pitch abilities involved in composing, singing, and playing music
3. *Logical-mathematical intelligence*—logical thinking and numerical ability
4. *Spatial intelligence*—perceiving the visual world, transposing and modifying one's initial perceptions, and re-creating aspects of one's visual experience
5. *Bodily-kinesthetic intelligence*—capacities involved in dancing, acting, and athletics
6. *Intrapersonal intelligence*—knowledge of self, including the ability to identify one's feelings, intentions, and motivations
7. *Interpersonal intelligence*—ability to discern other individuals' feelings, beliefs, and intentions
8. *Naturalist intelligence*—ability to discern patterns in nature
9. *Spiritual intelligence* (tentative)—concern with cosmic or existential issues and recognition of the spiritual as an ultimate state of being
10. *Existential intelligence* (tentative)—concern with ultimate issues

The competencies are building blocks out of which thought and action develop. They constitute the basis of human symbol-using capacities, and they interact to produce a diverse mixture of human talents that individuals can employ to achieve societal ends. Clearly, combinations of several intelligences are usually involved in behavior.

Gardner proposes to use multiple intelligence theory to assess children; the resulting multiple intelligence profile might be useful for guidance and education. Gardner believes that we can assess children's intellectual competencies through planned observations. For example, we can teach infants patterns and then test the infants to see whether they remember the patterns. We can give preschool children blocks, puzzles, games, and other tasks and observe their performance. Their block constructions may provide information about spatial and kinesthetic intelligence, their ability to relate a set of stories may reveal information about linguistic capacities, and their ability to operate a simple machine may give information about kinesthetic and logical-mathematical skills. "The future musician may be marked by perfect pitch; the child gifted in personal matters, by his [or her] intuitions about the motives of others; the budding scientist, by his [or her] ability to pose provocative questions and then follow them up with appropriate ones" (Gardner, 1983, p. 386).

Gardner suggests that different assessment strategies are required for evaluating children of different ages. Testing for spatial ability, for example, might include hiding an object from a 1-year-old, giving a jigsaw puzzle to a 6-year-old, and giving a Rubik's cube to a preadolescent. Developing a reasonably accurate picture of a child's abilities may require 5 to 10 hours of observation of regular classroom activities over the course of a month. Table G-7 in Appendix G in the Resource Guide is a checklist for evaluating children's multiple intelligences. Gardner has not developed a nationally standardized test to measure these different types of intelligence. Shearer (1996), however, has developed the MIDAS (Multiple Intelligence Developmental Assessment Scales), with forms for four age groups. The MIDAS is an objective questionnaire designed to measure Gardner's multiple intelligences; it can be completed either by the examinee or by a knowledgeable informant.

Ceci's Bio-Ecological Theory of Intelligence

Stephen J. Ceci's bio-ecological theory of intelligence is based on the idea that the following four propositions must be considered in understanding intelligence (Ceci, Rosenblum, de Bruyn, & Lee, 1997). First, intelligence is composed of multiple cognitive abilities rather than made up of one pervasive general factor. Second, the interplay of genetic and environmental interactions at various points in development produces changes in intelligence, although genes set the upper and lower limits of development. Third, cognitive processes depend on the context in which cognition takes place, including the motivational properties of different environments and how individuals mentally represent tasks. Fourth, noncognitive intrinsic traits and abilities, including temperament (e.g., restless, impulsive), physical traits (e.g., skin color, facial features), and motivation (e.g., seeking rewards, lack of interest in rewards), are important in the development of intelligence, because they affect people's life experiences.

Piaget's Developmental Theory of Intelligence

Jean Piaget (1896–1980) perceived intelligence as a form of biological adaptation to one's environment. According to Piaget, an individual is constantly interacting with the environment, trying to maintain a balance between personal needs and environmental demands. Cognition extends the scope of biological adaptation by allowing the individual to move from the level of immediate action to a symbolic level through internalization processes.

Piaget (1950, 1953) proposed that cognitive processes emerge through a developmental progression that is neither a direct function of biological development nor a direct function of learning; rather, the emergence represents a reorganization of psychological structures resulting from the individual's interactions with the environment. His theory thus disregards the dichotomy between maturation and learning and between cognitive and social-emotional components of development.

For Piaget, two inherent tendencies govern interactions with the environment—namely, organization and adaptation.

- *Organization* is the tendency to combine two or more separate schemes into one higher-order, integrated scheme. *Schemes* are individual structures that produce changes in cognitive development; they are "mini-systems" of related ideas that form a framework to accommodate incoming sensory data. Schemes are initially action based (sensorimotor); later in development, schemes move to a mental level.
- *Adaptation* consists of two complementary processes: assimilation and accommodation. *Assimilation* is a process of taking in information and experiences and fitting them into already established schemes or concepts. *Accommodation,* in turn, is a process whereby existing cognitive structures and behaviors are modified to adapt to new information and experiences. Both assimilation and accommodation occur simultaneously whenever a person adapts to environmental events, but the particular balance between the two probably varies across situations.

Assimilation occurs, for example, in the initial phase of make-believe play with an object, when a child ignores special features of the object and responds to it as if it were something else. A child displays accommodation when he or she learns a new scheme by imitating someone else's behavior. For example, if you give a young child a hair brush and he or she shakes it, the child is assimilating. If you demonstrate how to brush your hair with the hair brush and the child does what you do, the child is accommodating. Assimilative processes permit intelligence to go beyond a passive coping with reality, while accommodative processes prevent intelligence from constructing representations of reality that have no correspondence with the real world. Intelligence represents the rational processes—the processes that show the greatest independence from internal and environmental regulation.

Piaget's model of intelligence is hierarchical in that cognitive development is divided into four major periods: the sensorimotor, preoperational, concrete operational, and formal operational periods. Some of these have various stages (see Table 7-4). Each stage represents a form of cognitive organization that is more complex than the preceding one. Each stage is invariant and universal. The stages represent a form of biological adaptation and emerge from the individual's interaction with the environment.

As development proceeds, different types of organization and adaptation occur. At first, children's perceptions dominate their thoughts. By about 2 years, the child has begun to develop language and memory, although the child's thinking is still egocentric. By about 7 years, the child's thought

Table 7-4
Outline of Piaget's Periods of Cognitive Development

Period/Stage	*Approximate ages*	*Characteristic behaviors*
I. Sensorimotor period	Birth to 2 years	Child passes through six stages, beginning with the exercise of simple reflexes and ending with the first signs of internal, or symbolic, representations of actions.
1. Exercising reflexes	Birth to 1 month	Simple reflex activity is exhibited; sensorimotor schemes are exercised.
2. Primary circular reactions	1 to 4 months	Activities involve only the infant's own body and are endlessly repeated. First adaptations are acquired, such as integration and coordination of activities (e.g., finger sucking or watching one's hands).
3. Secondary circular reactions	4 to 8 months	Procedures are developed to make interesting sights persist; reactions also involve events or objects in the external world (e.g., shaking a rattle to hear the noise).
4. Coordination of secondary schemes	8 to 12 months	Two or more previously acquired schemes are combined to obtain a goal; acts become clearly intentional (e.g., reaching behind a cushion for a ball).
5. Tertiary circular reactions	12 to 18 months	Trial-and-error behavior and goal-seeking activity are designed to produce novel results; movements are purposely varied and the results observed (e.g., pulling a pillow nearer in order to get a toy resting on it).
6. Invention of new means through mental combination	18 to 24 months	Mental combinations appear; representational thought begins (e.g., using a stick to reach a desired object).
II. Preoperational period	2 to 7 years	Child acquires language and symbolic functions (e.g., ability to search for hidden objects, perform delayed imitation, engage in symbolic play, and use language).
III. Concrete operational period	7 to 11 years	Child develops conservation skills; mental operations are applied to real (concrete) objects or events.
IV. Formal operational period	11 years and upward	Child can think abstractly, formulate hypotheses, use deductive reasoning, and check solutions.

processes have become more systematic, and concrete problem-solving skills have begun to develop. By 11 to 12 years, the child can think abstractly, construct theories, and make logical deductions without the need for direct experience. Piaget's developmental model assumes that mental organization operates as an integrated whole, includes rules of transformation, is self-regulating, changes with development to give rise to new higher levels of organization, and differs at each level in the complexity of the rules of transformation and self-regulation (Elkind, 1981).

Although the Piagetian and psychometric approaches to intelligence differ in perspective, they complement each other in several ways (see Table 7-5). For example, the psychometric evaluation of intelligence documents the degree of delay of children with disabilities, predicts school success, and assesses brain injury and psychopathology, whereas the Piagetian approach diagnoses learning difficulties and helps with the design of educational interventions.

There is presently no comprehensive battery of Piagetian tests of intelligence, although some success has been achieved with the development of sensorimotor scales. Studies have found positive correlations between Piagetian measures and psychometric scales of intelligence in infant, preschool, and school-aged populations (Bat-Haee, Mehyrar, & Sabharwal, 1972; Dodwell, 1961; Dudek et al., 1969; Elkind, 1961; Goldschmid, 1967; Gottfried & Brody, 1975; Humphreys & Parsons, 1979; Kaufman, 1972; Keasey & Charles, 1967; Keating, 1975; Lester, Muir, & Dudek, 1970; Orpet, Yoshida, & Meyers, 1976; Pasnak, Willson-Quayle, & Whitten, 1998; Rogers, 1977; Wasik & Wasik, 1976). In particular, Piagetian tasks—such as those focusing on the ability to use formal operations, to understand the principle of conservation, and to use sensorimotor operations—relate to psychometric measures of intelligence. Piagetian tasks also have unique elements not present in psychometric measures of intelligence. The significant correlations between Piagetian tests and psychometric tests indicate that children who achieve high scores on psychometric tests of intelligence are not merely "good test-takers"; they have advanced levels of cognitive development in several areas.

Table 7-5
Comparison of Piagetian and Psychometric Approaches to Intelligence

	Differences	
Similarities	*Piagetian*	*Psychometric*
1. Both accept genetic determinants of intelligence.	1. Assumes that there are factors that give development a definite nonrandom direction	1. Assumes that tested intelligence is randomly distributed in a given population, with the distribution following the normal curve
2. Both accept maturational determination of intelligence.	2. Is concerned with intraindividual changes occurring in the course of development	2. Is concerned with interindividual differences
3. Both use nonexperimental methodology.	3. Views mental growth as the formation of new mental structures and the emergence of new mental abilities; assumes that mental growth is qualitative, not quantitative, and presupposes significant differences in the thinking of younger versus older children	3. Views the course of mental growth as a curve, from which the amount of intelligence at some criterion age can be predicted on the basis of intelligence at any preceding age; views intellectual growth largely as a statistical concept derived from correlations of test scores obtained at different ages for the same individuals
4. Both attempt to measure intellectual functions that the child is expected to have developed by a certain age.	4. Assumes that genetic and environmental factors interact in a functional and dynamic manner with respect to their regulatory control over mental activity; assumes that genetic and environmental factors cannot be easily separated out	4. Assumes that genetic and environmental contributions to intelligence can be measured
5. Both conceive of intelligence as being essentially rational.		
6. Both assume that maturation of intellectual process is complete during late adolescence.		
7. Both are capable of predicting intellectual behavior outside the test situation.		

Note. Similarity items 5, 6, and 7 obtained from Dudek, Lester, Goldberg, and Dyer (1969); the remainder of the table adapted from Elkind (1974).

COMMENT ON MODERN VIEWS OF INTELLIGENCE

Current hierarchical theories of intelligence lie somewhere between Spearman's and Thurstone's views. They stress a general factor (*g*) at the top of the hierarchy, several broad classes of abilities in the middle, and primary factors at the bottom. They view intelligence as multifaceted, with a general factor entering into many cognitive tasks and narrower group factors and specialized abilities forming the core of abilities. The *g* factor may be best understood as a summary measure, or index, of the positive correlations among ability measures rather than as being associated with an underlying cognitive factor (e.g., speed or efficiency of information processing, working memory, or the capacity to handle cognitive complexity) or a biologically related factor (e.g., brain size, neural efficiency or pruning, or neural plasticity; van der Maas, Dolan, Grasman, Wicherts, Huizenga, & Raijmakers, 2006). The hierarchical model, although it may not fit the complexities of human ability perfectly, is a useful approximation.

The IQ, which often is seen as a measure of *g*, should be viewed as a somewhat arbitrary summary index of many abilities. Because different intelligence tests sample different combinations of abilities, an individual's IQ is likely to vary from one test to another, depending on what the tests measure and on the individual's background. Furthermore, measures of intelligence sample only a limited spectrum of intellectual ability, and the responses provided by individuals on intelligence tests are related to their unique learning histories.

Carroll's three-stratum theory has much empirical support. Still, Sternberg (2000, 2004) pointed out that the *g* factor found in research studies may be an artifact of how current individual intelligence tests are constructed and how factor analytic methods analyze data. In addition, Horn and Blankson (2005) noted that the theory of *g* cannot account for either the structure of intelligence (i.e., the patterns found among tests of intelligence) or the development of intelligence (i.e., how cognitive abilities develop with age). They maintain that human intelligence cannot be organized "in accordance with one common principle or influence. The evidence from several sources points in the direction of several distinct kinds of factors" (p. 53). Some writers have integrated the Cattell-Horn and Carroll models, recognizing that there are important differences between the models, and refer to the integrated model as the Cattell-Horn-Caroll *Gf-Gc* model or the C-H-C theory (Flanagan, McGrew, & Ortiz, 2000).

Campione, Brown, and Borkowski's formulation is an exciting theory of intelligence for those engaged in intellectual assessment. The theory includes various cognitive assessment tasks in a broad-based model. It emphasizes that (a) intelligent behavior represents a dynamic interaction of structural and control components, (b) child-rearing practices and quality of education are important determinants of functional components (i.e., executive system abilities), (c) environmental enrichments are important for all children who have the requisite ability structure (i.e., in the architectural system), and (d) intelligent behavior is dependent on biologically and genetically based components, as well as on culturally based educational and environmental enrichments. The Campione-Brown-Borkowski theory, along with other information-processing approaches, provides valuable guidelines for developing psychometric tests, intervention strategies, and remediation programs.

Guilford's model has several difficulties. First, it fails to reproduce the essentially hierarchical nature of intelligence test data, with minor factors, major factors, and a general factor. An overwhelming body of evidence suggests a central factor in intellectual activity, which his model does not incorporate. Second, although many of the three-way combinations in the model suggest logical ways to construct tests, they do not represent distinct human abilities. Third, factor analytic studies do not support Guilford's model.

Sternberg's triarchic theory of successful intelligence combines internal aspects of intelligence (such as problem solving and reasoning) with external aspects of intelligence (such as experience and practice). However, more information is needed about how the componential, experiential, and contextual dimensions relate to one another. Additionally, the mixing of personality characteristics (confidence, sociability) with intelligence clouds Sternberg's theory of intelligence (Eysenck, 1994). Furthermore, the theory is limited because "components are positively correlated and do not, in general, exhibit sufficient generality to provide a basis for understanding individual differences in intelligence" (Brody, 1992, p. 125). The theory suggests that there are many real-life intelligent decisions that are not adequately measured by current standardized tests. Thus, we need to consider intelligent behavior in a wider context than that assessed by current standardized intelligence tests. Unfortunately, a reliable and valid measure of successful real-life intelligence does not yet exist.

Das, Naglieri, and Kirby's PASS model is not supported by research. Several investigators have reported that the CAS yields general and specific factors instead of four distinct factors (Kranzler & Keith, 1999; Kranzler, Keith, & Flanagan, 2000, 2001; Kranzler & Weng, 1995). In addition, the planning and attention factors of the CAS are highly correlated. Perhaps the PASS model is best described as measuring processing speed, fluid intelligence/visual processing, and memory span, rather than measuring planning, attention, simultaneous processing, and successive processing (Kranzler et al., 2000).

Gardner's multiple intelligence theory has several difficulties (Bouchard, 1984; Carroll, 1997; Eysenck, 1994; Sternberg, 1985, 1991). First, although provocative, it is by no means novel. His linguistic intelligence corresponds closely to crystallized intelligence, and his logic-mathematical ability is similar to fluid intelligence. Additionally, previous literature has recognized a spatial or visualization factor and an auditory organization factor (which subsumes musical ability). Second, bodily-kinesthetic skill, musical ability, and personal intelligence are better regarded as talents, skills, or aspects of personality than as intelligence. Third, the eight to ten competencies (or intelligences) are not independent; that is, there is a modest correlation among most cognitive abilities. Fourth, the components of each type of intelligence are not clear. Fifth, a more appropriate term for "multiple intelligences" is "multiple talents" or "multiple abilities." Finally, the current instruments used to assess multiple intelligence do not have acceptable psychometric properties. "It is very difficult, if not impossible, to quantify performance on them; assessments take place over extremely long periods of time, and it is questionable whether anything approaching objective scoring is even possible. . . . Those who are advocating this type of approach need to demonstrate the psychometric soundness of their instruments" (Sternberg, 1991, p. 266).

Ceci's bio-ecological model of intelligence nicely integrates biological and environmental influences on intelligence, but the model is very general. Although the basic tenets of the model are supported by research, the theory lacks testable hypotheses, and there are no standardized measures to assess the model.

Piaget's theory remains an influence on contemporary views of intelligence. The theory describes infant and childhood cognition as progressing sequentially from rudimentary perceptual and cognitive elements to more complex hierarchical cognitive processes. Modern information-processing approaches to cognitive development are in part based on Piaget's theory. However, Piaget's stage-based theory is limited "because intelligence is fluid in its development and does not exhibit strict, stage-like properties" (Cianciolo & Sternberg, 2004, p. 18). Finally, although Piaget's theory has influenced teaching practices, empirical research on its effectiveness has been limited (Green & Gredler, 2002).

Contemporary views of intelligence emphasize both biological and developmental influences. Genetically determined cognitive ability is always seen as being modified by experience. Contemporary views suggest that intelligence is a more global concept than was previously imagined. For ideas of what form intelligence tests may take in the future, see Exhibit 7-3.

THINKING THROUGH THE ISSUES

1. Review the 1905 Binet-Simon Scale in Exhibit 7-1 to gain an appreciation of the variety of items it contained. What items in this scale are the forerunners of assessment procedures currently in use?

Exhibit 7-3

Intelligence Tests in the Future: What Form Will They Take and What Purposes Will They Serve?

John Horn

Realistic appraisal, based on historical analysis, suggests that the tests used to measure intellectual abilities in applied settings in the future will be very similar to the tests used in the latter part of the 20th century. However, if the technology of measurement for applied purposes follows advancements in scientific understanding of human intelligence, then we can expect that intelligence tests of the future will

1. Be structured to provide for measurements of many separate abilities, ranging from elementary processes to broad but distinct dimensions of intelligence.
2. Involve, perhaps, abilities to comprehend and assimilate information that comes to one via the continuous flow of TV-like presentations.
3. Contain subtests designed to indicate features of temporal integration of information, auditory organization, and elementary cognitive processing of information.
4. Derive more from the study of adulthood development than from the study of childhood development.

The mainstreams of cognitive psychology will be diverted more and more into the study of intelligence and thus will influence the shape of practical tests. Tests will be used less and less to measure global intelligence just for the sake of measuring it or to make objectionable distinctions; more testing will be done to help identify particular ability strengths and weaknesses. Theories about intelligence will improve, and more test construction will be based on sound theory.

Lauren B. Resnick

What is the likelihood that IQ tests as we currently know them will still be in use in the schools in the near future? What new kinds of tests of aptitude and intelligence can we reasonably look for? IQ tests or some similar kinds of assessment instruments are likely to be functionally necessary in the schools as long as the present form of special education for children with disabilities remains with us—or until we are prepared to spend substantially more public resources on education for all children than we are now doing. Further, I have suggested that there is a very real possibility of a revival of interest in IQ tests in the educational mainstream as a protective response by school people threatened with legal responsibility for ensuring that all children, even the very hard to teach, learn. I believe these two areas—special education and the school's legal responsibility—are the things to watch in the future for new developments in global IQ measurement.

What new kinds of tests can we expect? I have suggested the possibility of a serious shift in the science, and therefore the technology, of intelligence testing. Aptitude tests useful for monitoring instruction and adapting it to individual differences are essentially nonexistent today. Current work on the cognitive analysis of intelligence and aptitude tests may be able to provide the basis for much more systematic and refined matching of instructional treatments to aptitudes. We can particularly look forward to this development as work on the cognitive components of intelligence shifts attention from performance on the tests themselves to the learning processes that underlie both skillful test performance and skillful performance in school subject matters.

Ann L. Brown and Lucia A. French

We would like to see an extension of the predictive power of intelligence tests so that we are able to (a) predict school failure prior to its occurrence and (b) predict potential adult competence by a consideration of performance on tests of everyday reasoning. To achieve these ends we will need to invest considerable energy in ethnographic surveys and experimental testing programs directed at improving our scanty knowledge in two main areas. First we need sensitive indices of early cognitive incompetence that are related to subsequent academic intelligence. Secondly we need theories and measures of functional literacy, minimal competence, and mundane cognition, so that we can begin to predict life adaptation as well as academic success. We would also like to see an increased emphasis on the diagnosis and remediation of cognitive deficits, of both the academic and the everyday variety.

William W. Turnbull

My view is that we are likely to see evolutionary rather than quantum changes in intelligence tests, at least as they are used in academic settings. We are likely to see tests that provide separate scores on a variety of abilities. They are likely to be standard scores. The ratio defining the IQ may by then have been abandoned everywhere and the term IQ may have disappeared into psychological and educational history.

Norman Frederiksen

Realistic simulations of real-life problem situations might be used to supplement the usual psychological tests and thus to contribute to the database needed to develop a broader conception of intelligence. It is possible to develop scoring systems that describe intelligent behavior in ways that go far beyond the "number right" score, that make possible the measurement of qualitative variables, such as problem-solving strategies and styles, and that may even provide information about some of the information-processing components of intelligent behavior. Many of the scores based on simulations are reliable, their interrelationships are consistent across different groups of subjects, and some of them predict real-life criteria that are not well predicted by conventional tests. Our glimpse of a broader picture of human intelligence suggests that the structure of intellect of the future will include a much broader spectrum of intelligent behaviors. Furthermore, it will not be a static model but will be one that recognizes the interactions involving test formats, subject characteristics, and the settings in which the problems are encountered. The structure of intelligence is not necessarily a fixed structure but one that may vary as the subjects learn and as the circumstances are altered.

(*Continued*)

Exhibit 7-3 (*Continued*)

Earl Hunt and James Pellegrino
Microcomputers can serve as automated testing stations for use in psychometric assessment. There are economic advantages in conducting aptitude and intelligence testing with such stations. Is it possible to improve the quality of cognitive assessment by extending the range of cognitive abilities to be assessed? Two types of extension are considered: modifying and expanding testing procedures for psychological functions that are components of conventional tests, and the extension of testing to psychological functions not generally assessed by conventional intelligence or aptitude tests. Computerized presentations will make relatively little difference in our ways of testing verbal comprehension. Computer-controlled testing could well extend the ways in which we evaluate spatial-visual reasoning and memory. The impact of testing on the evaluation of reasoning is unclear. Computer-controlled item presentation makes it possible to conceive of tests of learning and attention, neither of which is evaluated in most psychometric programs today.

Robert J. Sternberg
New tests of intelligence, in comparison to previous ones, will (a) be more heavily based on psychological theories (e.g., basing items on theories of information processing), (b) have more breadth (i.e., measuring a broader set of abilities), (c) measure the processes underlying intelligence (e.g., distinguishing between reasoning and perceptual processing), (d) measure the practical side of intelligence (i.e., measuring what happens in everyday life), (e) measure the ability to cope with novelty (i.e., coping with the unfamiliar and strange), (f) measure synthetic and insightful thinking (i.e., creating new products that show examinees' ability to think synthetically and even creatively), (g) merge testing and learning functions (e.g., merging measuring what has been learned with a program of instruction for teaching intellectual skills), (h) measure learning styles (e.g., finding out how individuals solve problems, such as by verbal or spatial means), (i) measure learning potential (e.g., measuring the child's ability to profit from instruction), (j) use computerized adaptive testing (e.g., having the computer present items at an appropriate level of difficulty given the examinee's past performance), and (k) use dynamic computerized testing (e.g., having the computer respond differently as a function of the answer given by the examinee). Also, in the future, the longevity of tests will be reduced more frequently and replaced with better measures of intelligence.

Richard E. Snow
We need to study and measure mental playfulness and idiosyncracy. We also need to study and measure conative [refers to volition or striving] and affective aspects of cognitive performance, because there is growing reason to expect subtle intersections between individual differences in motivation, volition, anxiety, and so forth, and individual differences in intellectual performance.

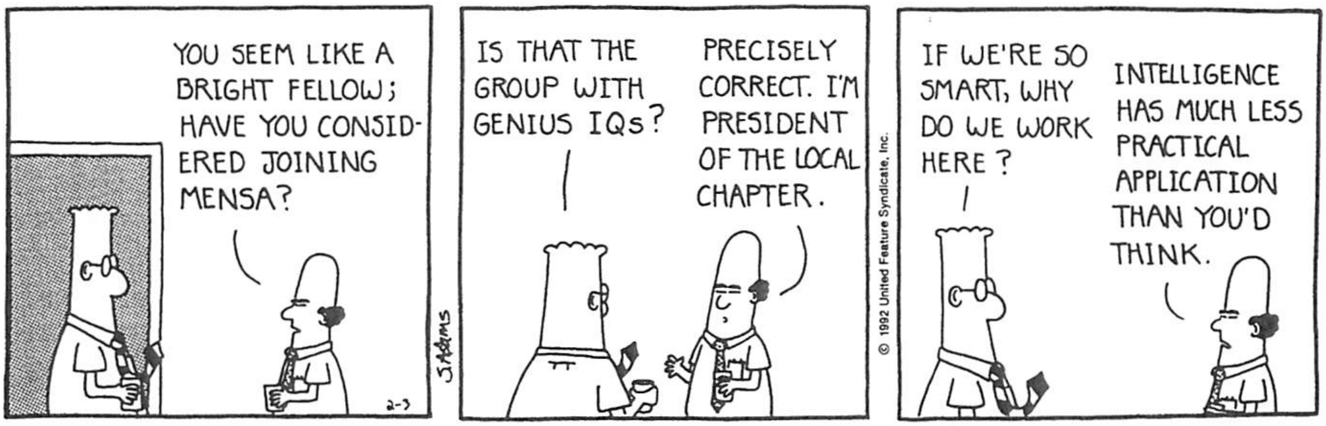
Source: Adapted from Brown and French (1979, p. 270); adapted from Frederiksen (1986, p. 451); adapted from Horn (1979, p. 239); Hunt and Pellegrino (1985, p. 207); adapted from Resnick (1979, p. 252); adapted from Snow (1986, pp. 137–138); Sternberg (1986); adapted from Turnbull (1979, p. 281).

2. Psychologists are continually developing and modifying theories of intelligence. How can a study of historical developments in the field of intelligence aid you as a clinician?
3. Do you think the concept of IQ will survive in the 21st century? If so, in what form?
4. How do you think lay people conceptualize intelligence? How do their conceptualizations differ from those of professionals in the field?
5. Which model or models of intelligence do you believe are most valid, and why?
6. How could the many definitions of intelligence be unified into a single theory? Would this be useful? Why or why not?
7. Which theoretical perspective do you believe most adequately explains your cognitive processing? Least adequately? Explain.
8. Gardner and others believe that observations of children's behavior can provide more useful indices of children's cognitive ability than the current standardized tests of intellectual ability. Do you agree or disagree with this position? Explain.
9. Observe a child for 15 minutes. On the basis of your observation, without any tests, to what extent can you evaluate the child's level of vocabulary, reasoning, social comprehension, short- and long-term memory, spatial ability, and other forms of problem-solving ability? How reliable and valid do you believe your observations are? What are some difficulties in conducting observations designed to obtain information about cognitive ability? What can you do to reduce such difficulties?

SUMMARY

Nineteenth-Century and Early Twentieth-Century Developments

1. Jean Esquirol (1772–1840) was one of the first modern-day scientists to make a clear distinction between mental incapacity and mental illness. Mental incapacity was defined by Esquirol as a characteristic of "idiots," who never developed their intellectual capacities, whereas mental illness was considered to be a characteristic of "mentally deranged persons," who lost or were unable to use abilities they had once possessed.
2. It was not until the latter half of the 19th century that psychology emerged as a separate scientific discipline. The psychophysical methods developed by Ernst H. Weber (1795–1878) and Gustav T. Fechner (1801–1887) and the statistical studies of mental processes initiated by Sir Francis Galton (1822–1911) formed the background for much of the progress that would take place in the 20th century.
3. Sir Francis Galton is regarded as the father of the psychometrically based testing movement. He was the first to use objective



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techniques, and he developed the statistical concepts of regression to the mean and correlation.

4. Karl Pearson (1857–1936) developed numerous statistical procedures, including the product-moment correlation formula for linear correlation, the multiple correlation coefficient, the partial correlation coefficient, the phi coefficient, and the chi-square test, the latter for determining how well a set of empirical observations conforms to an expected distribution (thus measuring "goodness of fit").
5. In Germany, five individuals made major contributions to the field of assessment: Wilhelm Wundt (1832–1920), Emil Kraepelin (1855–1926), Herman Ebbinghaus (1850–1909), Carl Wernicke (1848–1905), and Theodore Ziehen (1862–1950).
6. J. M. Cattell established a psychological laboratory at the University of Pennsylvania. In 1890, he published an article in the journal *Mind* in which he first used the term "mental test."
7. Psychological tests made their public debut in the United States at the 1893 Chicago World's Fair, where Hugo Münsterberg (1863–1916) and Joseph Jastrow (1863–1944) collaborated on a demonstration testing laboratory.
8. In the early 1890s, Franz Boas (1858–1942), at Clark University, and J. Gilbert, at Yale University, studied how children responded to various tests.
9. Clark Wissler (1870–1947) investigated the validity of several tests of simple sensory functions that he thought were related to cognitive processes.
10. In 1899, Stella Sharp reported that tests similar to those used by Binet and Henri in France were unreliable and thus were of little practical use.
11. Even though the studies by Wissler and Sharp had serious methodological shortcomings, they temporarily dampened interest in the field of mental measurement.
12. In France at the end of the 19th century, Alfred Binet (1857–1911), Victor Henri (1872–1940), and Theodore Simon (1873–1961) used tests of higher mental processes, instead of tests of simple sensory functions, to measure intelligence.
13. The period from 1880 to 1905 was the "laboratory" period of psychology.
14. The work of Binet, Ebbinghaus, and others had a unifying thread: the application of methods used in experimental psychological laboratories to solve practical problems. The interplay of these forces during this period gave birth to the field of applied psychology and ushered in a new era in psychometrics.

Later Twentieth-Century Developments

15. Henry H. Goddard (1866–1957), director of the Psychological Laboratory at the Vineland Training School, introduced the 1905 Binet-Simon Scale in the United States in 1908.
16. In 1916, Lewis M. Terman (1877–1956) published a modified, extended, and standardized form of the Binet-Simon Scale called the Stanford Revision and Extension of the Binet-Simon Scale, or the Stanford-Binet.
17. For the 1916 Stanford-Binet, Terman adopted Louis William Stern's (1871–1938) concept of a mental quotient, renaming it the intelligence quotient, or IQ.
18. Stern had defined mental quotient as mental age divided by chronological age, and to get rid of the decimal, he multiplied the ratio by 100.
19. Robert M. Yerkes (1876–1956) proposed that a point-scale format be used to construct tests.
20. Lewis Terman and Maud Merrill (1888–1978) revised the 1916 Stanford-Binet in 1937 and again in 1960.
21. David Wechsler (1896–1981) chose 11 published tests, which he modified and incorporated into his scale (the Wechsler-Bellevue Intelligence Scale, Form I) as subtests.
22. The 1905 Binet-Simon Scale stimulated the development of clinical psychology in the United States and elsewhere.
23. Practical demands and interest in the concept of IQ propelled the development of the testing movement, even though the movement had no support from any traditional branch of psychology.

Definitions of Intelligence

24. Prominent in definitions of intelligence are attributes such as adaptation to the environment, basic mental processes, and higher-order thinking (e.g., reasoning, problem solving, and decision making).
25. Experts in the fields of psychology, education, sociology, and genetics generally agree that the following are important elements of intelligence: abstract thinking or reasoning, problem solving

ability, capacity to acquire knowledge, memory, adaptation to one's environment, mental speed, and linguistic competence.

26. Not all cultures have the same view of intelligence. Western cultures emphasize the problem-solving, logical, and conceptual aspects of intelligence. Eastern cultures, in contrast, emphasize the holistic, social nature of intelligence, placing a premium on the ability to identify complexity and contradictions.

Introduction to Factor Analytic Theories of Intelligence

27. Factor analysts played a powerful role in shaping 20th-century developments in the field of assessment.
28. Historically, the factor analytic theorists fell into two camps. One camp favored a multifactor theory of intelligence, maintaining that intelligence is a composite of several independent abilities, such as mathematical, mechanical, and verbal faculties. Among those in this camp were Thorndike, Thurstone, Guilford, Cattell, and Horn. The other camp favored a general and specific factor (*g, s*) theory of intelligence. This camp included Spearman, Vernon, and Carroll.
29. Part of the difficulty with factor analysis is that the outcomes depend on the nature and quality of the data, the type of statistical procedure used, and the proclivities of the investigator who chooses the labels to designate the factors.
30. Factor labels are merely descriptive categories and do not necessarily reflect underlying entities.

Multifactor Theory Camp

31. Edward L. Thorndike's (1874–1949) multifactor theory of intelligence postulates that intelligence is the product of many interconnected but distinct intellectual abilities.
32. Louis L. Thurstone (1887–1955) maintained that human intelligence possesses a certain systematic organization and cannot be regarded as a unitary trait.
33. J. P. Guilford (1967) developed the three-dimensional Structure of Intellect model as a means of organizing intellectual factors. One dimension represents the operations involved in processing information, the second dimension represents content, and the third dimension represents products.
34. Raymond B. Cattell and John Horn proposed two types of intelligence—fluid and crystallized.
35. Fluid intelligence refers to essentially nonverbal, relatively culture-free mental efficiency. It involves adaptive and new learning capabilities and is related to mental operations and processes.
36. Crystallized intelligence refers to acquired skills and knowledge that are developmentally dependent on exposure to the culture. It involves overlearned and well-established cognitive functions and is related to mental products and achievements.
37. Horn argued against the concept of general intelligence, maintaining that research does not support a unitary theory. Instead, he asserted that intellectual ability is composed of several distinct functions that probably have genetic underpinnings and that take different courses of development over the life span.

General and Specific Factor Camp

38. Charles E. Spearman (1863–1945) proposed a two-factor theory of intelligence to account for the patterns of correlations observed among group tests of intelligence. The theory stated that a general factor (*g*) plus one or more specific factors per test account for performance on intelligence tests.
39. Philip E. Vernon proposed a hierarchical theory of intelligence. At the highest level is *g*, or general ability. At the next level are two major group factors—verbal-educational and spatial-mechanical. At the next lower level are subdivisions (or minor group factors) of the two major group factors.
40. John B. Carroll proposed a three-stratum factor analytic theory of cognitive abilities. The first level consists of 65 narrow abilities comprising levels of mastery in various cognitive areas. The second level is composed of eight broad factors: fluid intelligence, crystallized intelligence, general memory and learning, broad visual perception, broad auditory perception, broad retrieval ability, broad cognitive speediness, and processing speed. The third level is composed of a general factor, or *g*.

Other Theories of Intelligence

41. Joseph Campione, Ann Brown, and John Borkowski's information-processing theory of intelligence has two major components. One is the architectural system (the structural component), which has three subcomponents: capacity, durability, and efficiency of operation. The other is the executive system (control component), which has four subcomponents: knowledge base, schemes, control processes, and metacognition. This model stresses the dynamic interplay of structural and control components.
42. Robert J. Sternberg's triarchic theory of successful intelligence consists of the componential dimension, which relates intelligence to the internal information-processing components of the individual; the experiential dimension, which relates intelligence to how well individuals connect their internal world to external reality; and the contextual dimension, which relates intelligence to how well individuals adapt to, select, and shape their environments. The broad abilities associated with successful intelligence are analytic, creative, and practical abilities.
43. J. P. Das, Jack Naglieri, and John R. Kirby describe cognitive ability as a function of planning, attention, simultaneous processing, and successive processing.
44. Howard Gardner posits the existence of at least eight relatively autonomous intellectual competencies: linguistic intelligence, musical intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence, interpersonal intelligence, and naturalist intelligence.
45. Stephen J. Ceci's theory of intelligence is based on the following four propositions: (a) intelligence is composed of multiple cognitive abilities, (b) the interplay of genetic and environmental interactions at various points in development produces changes in intelligence, (c) cognitive processes depend on the context in which cognition takes place, and (d) noncognitive intrinsic traits and abilities are important in the development of intelligence, because they affect people's life experiences.
46. Jean Piaget's model of intelligence is a hierarchical one, in which cognitive development is divided into four major periods: sensorimotor, preoperational, concrete operations, and formal operations.
47. Piagetian and psychometric approaches to intelligence complement each other. Both approaches accept genetic and maturational determinants and emphasize the rational nature of intelligence. The Piagetian approach emphasizes developmental changes and the emergence of new mental structures, whereas the psychometric approach emphasizes the normal distribution of intelligence and interindividual differences.

Comment on Modern Views of Intelligence

48. Current hierarchical theories of intelligence lie somewhere between Spearman's and Thurstone's views. They stress a general factor (g) at the top of the hierarchy, several broad classes of abilities in the middle, and primary factors at the bottom. They view intelligence as multifaceted, with a general factor entering into many cognitive tasks and narrower group factors and specialized abilities forming the core of abilities.
49. The IQ, which often is seen as a measure of g, should be viewed as a somewhat arbitrary summary index of many abilities.
50. Contemporary views of intelligence emphasize both biological and developmental influences. Genetically determined cognitive ability is always seen as being modified by experience.

KEY TERMS, CONCEPTS, AND NAMES

Esquirol (p. 216)
Weber (p. 216)
Fechner (p. 216)
Galton (p. 216)
Pearson (p. 216)
Wundt (p. 217)
Kraepelin (p. 217)
Ebbinghaus (p. 217)
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Ziehen (p. 217)
J. M. Cattell (p. 217)
Münsterberg (p. 217)
Jastrow (p. 217)
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Sharp (p. 217)
Binet (p. 218)
Henri (p. 218)
Simon (p. 218)
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Childs (p. 219)
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Point-scale format (p. 220)
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STUDY QUESTIONS

1. Compare and contrast work on intellectual assessment in England, Germany, the United States, and France during the 19th century and the early years of the 20th century.
2. Discuss Terman's contribution to the field of intelligence testing.
3. Discuss the contributions of Yerkes and Wechsler to the testing movement.
4. What effect did the Binet-Simon Scales have in the United States during the early 20th century?
5. Consider the definitions of intelligence discussed in the chapter. What are the commonalities and differences among the definitions?
6. Compare and contrast the work of the following factor analytic theorists: Spearman, Thorndike, Thurstone, Guilford, Vernon, Cattell and Horn, and Carroll.
7. Discuss information-processing approaches to intelligence.
8. Discuss Sternberg's triarchic theory of successful intelligence.
9. Discuss Das, Naglieri, and Kirby's PASS theory of intelligence.
10. Discuss Gardner's multiple intelligence theory.
11. Discuss Ceci's bio-ecological theory of intelligence.
12. Discuss Piaget's developmental theory of intelligence.
13. What are some similarities and differences between Piagetian and psychometric approaches to intelligence?
14. In your view, what form will intelligence tests take in the future?