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Intelligence, Part I

5

Key Terms

bell curve
crystallized intelligence
fluid intelligence
g
intelligence quotient (IQ)
intelligence testing
hereditary genius
mental test
socioeconomic status (SES)

Chapter Outline

5.1 INTRODUCTION

In earlier chapters I examined individual differences in personality (chapters 2 and 3) and psychopathology (chapter 4). As noted in sections 1.4 and 4.1, personality encompasses individual differences in general, whilst psychopathology refers specifically to abnormal behavior and mental illness. Another major area of differential psychology is that concerned with the prediction of human performance (e.g., at school, work, and university). This area is commonly referred to as *intelligence* or *cognitive/intellectual ability*.

Given that performance is itself an aspect or type of behavior, intelligence, talent, or whichever construct is used to conceptualize individual differences in ability ought to be considered a part of personality, too. However, personality and intelligence developed independently as the two major areas in differential

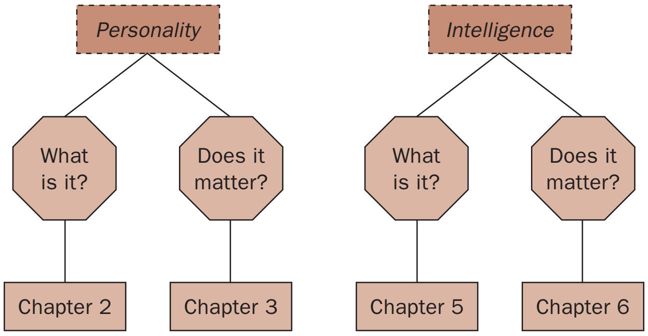

Figure 5.1 Personality and intelligence chapters in context.

psychology and, with the exception of Eysenck (see sections 2.4 and 2.6) and Cattell (see section 2.10), few researchers regarded intelligence as a component of personality. Thus textbooks and handbooks, whether edited or authored, have typically focused either on intelligence or on personality.

Whilst there are sufficient methodological and theoretical reasons to justify the relative independence of personality and intelligence, there has been a recent marked increase of interest in the relationship between both constructs (Chamorro-Premuzic & Furnham, 2004, 2005). This book provides the *wider* picture of differential psychology, including both major areas: personality *and* intelligence. In this chapter, I review the historical aspects underlying the conceptualization and development of intelligence and salient issues concerning the structure of human abilities. In simple terms, this chapter addresses the question of *what is intelligence*. As personality, intelligence is also manifested in a number of real-life outcomes and is thus consequential. The consequences of intelligence are discussed in chapter 6. In the same sense that chapter 5 is to intelligence what chapter 2 is to personality, then chapter 6 is to intelligence what chapter 3 is to personality (see Figure 5.1).

5.2 DEFINING INTELLIGENCE

To some extent, explaining the notion of intelligence may seem irrelevant since there is considerable overlap between lay and expert conceptions: both believe that certain mental or psychological processes account for differences in performance, and that these differences can be affected by biological as well as environmental factors. However, there is less agreement on how these differences can be measured, which abilities are more important, and whether people who score high on some ability may score low on others.

Despite these unresolved issues, the idea that some individuals are brighter than others has always been acknowledged in human society and is reflected in the number of language descriptors of ability. The *Oxford Thesaurus*, for instance, provides the following synonyms of intelligence: "clever, bright, sharp-witted, quick-witted, talented, gifted, smart, capable, able, competent, apt, knowledgeable, educated, sagacious, brainy, shrewd, astute, adroit, canny, cunning, ingenious, wily, inventive, skillful."

Contemporary uses of "intelligence" tend to be classified according to five different connotations, two of which are of psychological and three of military/organizational importance. The *Encarta Dictionary* provides the following definitions of intelligence:

1. **Ability to think and learn**: the ability to learn facts and skills and apply them, especially when this ability is highly developed.
2. **Secret information**: information about secret plans or activities, especially those of foreign governments, the armed forces, business enemies, or criminals.
3. **Gathering of secret information**: the collection of secret military or political information.
4. **People gathering secret information**: an organization that gathers information about the secret plans or activities of an adversary or potential adversary and the people involved in gathering such information.
5. **Intelligent spirit**: an entity capable of rational thought, especially one that does not have a physical form.

Only definitions 1 and 5 have a real psychological connotation, with definition 1 specifically reflecting the individual differences aspect of intelligence. Interestingly, though, definitions 2, 3, and 4 are associated with military strategies and the concept of information, two aspects that are related to the development and conceptualization of the notion of intellectual ability in differential psychology. Indeed, intelligence has been associated with military strategy since ancient times. For example, in one of the oldest surviving literary works of European history, the Greek poet Homer (ca. eighth century BC) described Odysseus, the hero of the Trojan war, as "clever," "quick-witted," and of "great intelligence." Since the late nineteenth century, ability tests have been widely developed and used in the military for selection and recruitment (notably in the United States), and information is a key component of intelligence as it is linked to knowledge and learned facts (see Cattell's concept of *gc* in section 5.4).

Table 5.1 provides several well-known definitions of intelligence by some of the most salient differential psychologists. Most of these definitions (1 to 11) appeared in a special issue of the *Journal of Educational Psychology* (1921) dedicated to "Intelligence and its measurement."

5.2.1 Conceptualizing intelligence

Although the idea that some people are brighter than others predates scientific psychology, it was psychologists who contributed to *measuring* these differences in a systematic, robust, and unbiased way. The scientific notion of intelligence derives largely from the use of psychometric instruments to predict future performance in school, which explains why the concept of intelligence is closely related to scholastic achievement or the ability to excel academically. For many decades, however, intelligence was defined operationally rather than conceptually or theoretically (i.e., in terms of underlying psychological processes). For instance, one of the best-known definitions of intelligence has simply described it as what intelligence tests measure (Boring,

Table 5.1 Some well-known definitions of intelligence

Definition of intelligence	*Author and year*
1. The ability to carry out abstract thinking	Terman (1921)
2. The capacity for knowledge, and knowledge possessed	Henmon (1921)
3. The capacity to learn or to profit by experience	Dearborn (1921)
4. The capacity to acquire capacity	Woodrow (1921)
5. The power of good responses from the point of view of truth or facts	Thorndike (1921)
6. Sensory capacity, capacity for perceptual recognition, quickness, range or flexibility of association, facility and imagination, span of attention, quickness or alertness in response	Freeman (1921)
7. Ability to learn or, having learned, to adjust oneself to the environment	Calvin (1921)
8. Ability to adapt oneself adequately to relatively new situations in life	Pentler (1921)
9. A biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behavior	Peterson (1921)
10. The capacity to inhibit an instinctive adjustment, the capacity to redefine the inhibited instinctive adjustment in light of imaginally experienced trial and error, and the capacity to realize the modified instinctive adjustment in overt behavior to the advantage of the individual as a social animal	Thurstone (1921)
11. Sensation, perception, association, memory, imagination, discrimination, judgment, and reasoning	Haggerty (1921)
12. Intelligence is what is measured by intelligence tests	Boring (1923)
13. A global concept that involves an individual's ability to act purposefully, think rationally, and deal effectively with the environment	Wechsler (1953)
14. The ability to use optimally limited resources – including time – to achieve goals	Kurzweil (1999)

1923). Despite the circularity of this definition, often chosen by critics to accuse intelligence researchers of dealing with a meaningless construct, Boring also provided a much more descriptive (and empirically based) definition of intelligence, conceptualizing it as a *general ability* or *form of mental power that develops in the first five years of life to remain relatively stable after that*.

Although intelligence is only an *inferred* notion, that is, a *latent construct*, it does refer to observable behavior. The extent to which intelligence is or is not a meaningful concept will therefore depend on empirical data or observable behavior. Typically, this behavior is measured in terms of individual differences in standardized performance on tests correlated with real-life outcomes, such as academic exam grades or job performance. Thus, the key issue is not whether we measure "intelligence" but whether we have found something worth measuring (Miles, 1957).

As shown in Figure 5.2, the notion of intelligence is directly inferred from the relationship between test scores (e.g., IQ points) and other criteria, such as performance in school or at work. If these are significantly correlated, we can assume that intelligence has similarly affected both test performance and school/job performance.

Any definition of intelligence will also have to conceptualize the underlying or latent processes that *cause* individual differences in test and school/job performance. Definitions of intelligence will be examined more closely throughout this chapter, but for an overview and preliminary understanding of the concept it should suffice to define it as a "general ability to reason, plan, solve problems, think abstractly, learn quickly, and learn from experience" (Gottfredson, 2000, p. 81). Intelligence, then, does not refer to specific abilities but to an "indivisible quality of mind that influences the execution of all consciously directed activities" (Robinson, 1999, p. 720).

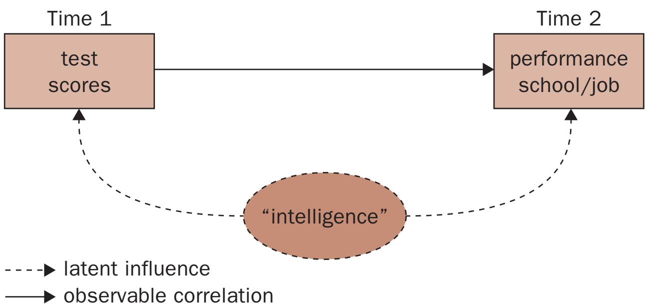

Figure 5.2 Graphical depiction of the latent concept of intelligence in relation to both test scores and real-world performance.

5.3 HISTORY OF INTELLIGENCE TESTING

A history of intelligence is largely a history of **intelligence testing**, that is, an account of psychology's attempt to quantify and measure individual differences underlying performance in an objective, scientific manner.

intelligence testing the attempt to quantify and measure individual differences in cognitive ability by means of standardized tests that use words, numbers, or figures and are usually administered in written (paper or computer) or oral form

In the words of René Descartes (1596–1650), a French philosopher and one of the most influential figures of modernity, "If something exists, it exists in some amount. If it exists in some amount, then it is capable of being measured." Accordingly, differential psychologists have dedicated themselves, in particular during the first half of the twentieth century, to designing psychometric instruments to compare individuals on what they believed were the most important aspects of human intellect: intelligence.

5.3.1 Galton's hereditary genius

The first scientific attempt to conceptualize individual differences in cognitive ability is attributed to Francis Galton (1822–1911), who argued that **genius** was **hereditary** and normally distributed in the population. Both these ideas are still shared by most experts in the field. Galton's beliefs about talent and performance were heavily influenced by the work of his cousin Charles Darwin (1809–82), though autobiographical events played an equally important role (see Box 5.1). Through the application of some of the statistical techniques developed by Quételet (1796–1874), Galton deduced that genetic forces determined different levels of intelligence, which in turn played a major role in selection and competition for survival. In some cases these assumptions led Galton to uphold some absurd conclusions, such as the belief that military leaders were usually short because taller men were more vulnerable shooting targets. With the same absurdity, Galton also believed in the intellectual superiority of some groups over others: he considered the ancient Greeks to be superior to his English counterparts, who were in turn superior to Africans and African Americans.

hereditary genius the idea that different levels of intelligence are determined by hereditary or genetic factors

Galton also believed that the high correlation between the achievements of eminent judges and those of their ancestors signified the genetic source of genius, thus undermining the role of status and influence in determining those achievements. This

Box 5.1
The Life of Francis Galton

Much has been said about the life of Francis Galton, often with admiration, but as often with dislike and disapproval. Regardless of any judgment, two things are probably beyond debate: (1) the fact that Galton can be counted amongst only a handful of highly influential figures in differential psychology (and, in light of the recent progress of behavioral genetics and the eloquent evidence for the causal nature of general intelligence, several experts would assess the impact of Galton's work as unmatchable in the field), and (2) the fact that Galton's theory of eminent talent was closely related to (and probably partly derived from) aspects of his personal life. It is this second fact which is most interesting as interpretations differ as to how far and in which direction episodes in Galton's life led him to develop his theory of hereditary genius.

To some, the fact that Galton was born to a well-to-do aristocratic family (his ancestors included the founders of the Quaker religion and Barclay's bank, as well as Erasmus Darwin) inspired his ideas of inborn superiority and group differences in ability. However, Galton's emphasis on *nature* rather than *nurture* (the phrase is his) was not all determined by personal accomplishments. Although he was a prodigious child with an IQ once estimated at 200 points and compared only to the likes of Goethe, Leibniz, and John Stuart Mill (Boring, 1950; Terman, 1917), Galton's achievements were often below expectations, particularly in his adult academic career. Educated by his older sister Adele, he could read and write at the age of 2, read the clock and multiply by 2, 3, 4, 5, 6, 7, 8, and 10 at the age of 4, and was reportedly disappointed when, at the age of 5, he started school only to learn that none of his classmates had read the *Iliad* (which, by the way, he could partly quote by heart).

These signs of intelligence were, however, unmatched in subsequent years, most notably when he failed to excel in mathematics at Cambridge's Trinity College. This failure would have a profound impact on Galton's career, leading him to abandon the study of mathematics and explore other disciplines, notably geography (Galton is credited with the design of the first modern weather map, which appeared in *The Times* in 1875). By the time Darwin's *Origin of Species* was first published in 1859, Galton was already bitterly disappointed by his failure to become a leading mathematician, despite his enormous determination and hard work. In that sense, Darwin's ideas about evolution may have helped Galton to explain his own limitations rather than his extraordinary talent. Galton never denied the importance of effort and preparation, neither in theory nor in practice.

However, what attracted Galton's attention was the fact that, even after extensive training and preparation, differences in performance – and talent – still remained between individuals. "The eager boy [he said], when he first goes to school and confronts intellectual difficulties, is astonished at his progress. He glories in his newly developed mental grip, and (may believe) it to be within his reach to become one of the heroes who have left a mark upon the history of the world. The years go by, he competes in the examinations of school and college, over and over again with his fellows, and soon finds his place among them. He knows he can beat such and such of his competitors; that there are some with whom he runs on equal terms, and others whose intellectual feats he cannot even approach" (Galton, 1972/1869, p. 57).

was also true for his belief in women's intellectual inferiority: "As a rule men have more delicate powers of discrimination than women, and the business experience of life seems to confirm this view. The tuners of pianofortes are men, and so I understand are the tasters of tea, and wine, the sorters of wool, and the like" (Galton, 1973/1883, p. 20).

Nonetheless, several of Galton's ideas and research methods are of major importance for modern differential psychology. His decision to look at indicators of academic performance and the distribution of university grades was undoubtedly groundbreaking, as was his idea to test the genetic basis of intelligence by comparing not only adopted and biological children with their parents but also MZ against DZ twins. In 1882, Galton set up an Anthropometric Laboratory in London's Science Museum, aimed at measuring individual differences in basic cognitive functions, which he considered proxy measures of human intellectual capacity. (Anthropometric literally means "measurement of man.") Both Galton and his student Karl Pearson were responsible for the invention of several important statistical methods and tests (notably correlations and regressions) that are still largely employed by psychologists and social scientists today (see sections 3.2.1 and 3.2.2).

5.3.2 J. M. Cattell's mental test

Galton's statistical and methodological approach was emulated in the US by James McKeen Cattell (1860–1944), who studied in Germany under Wilhelm Wundt (1832–1920), one of the founders of experimental psychology. According to J. M. Cattell (not to be confused with R. B. Cattell, discussed in sections 2.10 and 5.4), intelligence could be conceptualized in terms of ten basic psychological functions, such as tactile discrimination, hearing, weight discrimination, and so on. Furthermore, J. M. Cattell devised a psychometric instrument to measure individual differences in these basic processes, which for the first time received the name of **mental test**.

mental test a series of psychometric tests originally devised by J. M. Cattell to measure individual differences in basic psychological functions such as tactile discrimination, hearing, and weight discrimination

Rather than merely attempting to measure individual differences in cognitive ability, J. M. Cattell was concerned with the development of a scientific psychological discipline, one based on experimental and quantitative methods. Thus, most of the variables he measured were more "elemental" than "mental," and referred to very basic cognitive processes that are now known to be *related* to intelligence, although they certainly fail to define the concept in broad terms. Furthermore, although J. M. Cattell's (1890) mental tests represented reliable measures of individual differences in performance, later studies showed that these measures were neither intercorrelated nor related to academic performance indicators such as grades (Wissler, 1901).

Nonetheless, J. M. Cattell's contribution in providing the foundations of psychometric differential research (especially in the US) cannot be understated, as illustrated by the following quote:

> We do not at present wish to draw any definite conclusions from the results of the tests so far made. It is of some scientific interest to know that students entering college have heads on the average 19.3cm long . . . that they have an average reaction-time of 0.174 sec., that they can remember seven numbers heard once, and so on with other records and measurements. These are mere facts, but they are quantitative facts and the basis of science. Our own future work and that of others must proceed in two directions . . . (a) to what extent are the several traits of body, of the senses and of the mind interdependent? . . . what can we learn from the tests of elementary traits regarding the higher intellectual and emotional life? (b) on the other hand we must use our own measurements to study the development of the individual and of the race, to disentangle the complex factors of heredity and environment. (Cattell & Farrand, 1896, p. 648)

The first goal outlined refers to the purer methodological and psychometric aspects of intelligence, which will be covered throughout this chapter and the beginning of the next. The second goal attainable once individual differences in intelligence are conceptualized and measured refers to the relationship between cognitive and other known variables, such as the causes and consequences of differences in ability (see chapter 6).

5.3.3 Binet and the origins of IQ testing

By creating a more pragmatic measure of intelligence, accounting for basic cognitive processes and also for the more concrete abilities to perform mental operations and solve real-life problems, Alfred Binet (1857–1911) set the foundations of modern intelligence testing.

In 1904, the French Ministry of Public Instruction commissioned Binet to develop a method of identifying children with learning difficulties. Rather than relying on teachers' assessments, which were often biased against children with discipline problems, the French government wanted a method that effectively discerned capable pupils from less capable pupils. This implicit distinction between behavioral problems (such as absenteeism and disruptive behavior) and learning difficulties (such as lack of understanding of subjects) illustrates the differences between the realms of personality and intelligence. Binet (Binet & Simon 1905/1961a) believed that whilst personality describes and predicts individuals' behavior in and outside the classroom, intelligence would explain school performance based on the requirements to learn, understand, and relate concepts, theories, and methods acquired in the classroom.

Addressing the request of the French Ministry, and inspired by the readings of Galton (see section 5.3.1), Binet and his student Theodore Simon (1873–1961) began to work on the creation of a standardized test to measure reasoning ability and the use of judgment. Up to 50 children representative of the average pupil of each year group were initially recruited to pilot tests. Individually, they responded to a total of 30 items in order of increasing difficulty, with every six items corresponding to a level relating to a year group. Level 3, corresponding to a 3-year-old, set the task of shaking hands with the examiner, following the movement of a lit match, and pointing to their eyes or nose; level

7, expected of a 7-year-old, set the task of describing a picture, repeating a series of digits, and completing a series of sentences. The most difficult tasks designed for older but also brighter children included rhymes and the repetition of up to seven random digits. The last level of difficulty answered correctly determined the level of reasoning and learning ability. This score was then computed in terms of years and months, so that answering correctly all questions of level 7 plus three in level 8 would indicate that the child's ability or mental age was that of someone aged 7.5 or $7^1/_2$ years.

Binet's advances in psychological testing were undoubtedly a consequence of his pragmatic approach to individual differences in intelligence and school achievement. To Binet, intelligence was all about practical sense and adaptation to the real world. Instead of starting from a theoretical or experimental perspective accounting for intrapsychic processes and sensorial operations, like Galton and J. M. Cattell, Binet adopted a commonsense applied approach whose goal was specifically the design of an effective, robust tool to predict differences in school performance. Rather than observing people's reactions to meaningless stimuli, Binet gave his subjects real tasks such as reading the time or completing a sentence. More importantly, Binet's predictive tool allowed educators to compare learning potential at a very early age (i.e., 4 years), irrespective of previous instruction.

Binet was nonetheless very cautious about the usefulness of his measure and the meaning of what it assessed, as illustrated in his comprehensive definition of intelligence which has stood the test of time:

> It seems to us that in intelligence there is a fundamental faculty, the alteration or the lack of which, is of the utmost importance for practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances. A person may be a moron or an imbecile if he is lacking in judgment; but with good judgment he can never be either. Indeed the rest of the intellectual faculties seem of little importance in comparison with judgment. (Binet & Simon, 1916/1973, pp. 42–3)

Aware of the limitations of his scale, Binet called for qualitative research on the developmental aspects of intelligence, a call later addressed by one of his students, Jean Piaget (see section 5.6). In addition, Binet thought his scale could only provide a *sample* of all intelligent behaviors, and that its use was limited to a few samples that shared a certain cultural background. Indeed, a shared cultural background was certainly necessary to provide individuals with the knowledge to solve most of Binet–Simon's tests.

As it was, then, such doubts discouraged Binet from claiming to have found a measure of any fundamental capacity: "I have not sought in the above lines to sketch a method of measuring, in the physical sense of the word, but only a method of classification of individuals. The procedures which I have indicated will, if perfected, come to classify a person before or after such another person, or such another series of persons; but I do not believe that one may measure one of the intellectual aptitudes in the sense that one measures a length or a capacity" (Binet, quoted in Varon, 1936, p. 41).

While Binet's test is commonly recognized as the first psychometric intelligence test (and considered a milestone in the history of intelligence theory and research), it was the American adaptation of this test, introduced at Stanford by Terman (1916), that would have a greater impact on the psychometrics of intelligence (its revised versions still represent a state-of-the-art intelligence scale today). Henry Goddard (1866–1957), who studied with Binet and translated the scale into English, imported the test to the US, where it was quickly subject to larger and more robust validation studies. The popularity of the instrument in America was largely due to political and socioeconomic reasons. In a time of intense search (and hope) for a meritocratic society, Binet's scale seemed to provide a fair criterion for selection. The test went beyond being considered a mere predictor of children's performance in school to being hailed as an effective tool for "curtailing the reproduction of feeblemindedness and (eliminating) an enormous amount of crime, pauperism, and industrial inefficiency" (White, 2000, p. 7).

Terman's large-scale studies allowed him to test and improve the reliability of the scale and thus extend it to subtests and to a large age group from 3 to 14 years. Another modification from the Stanford/Binet version was the way in which the scores were calculated. A child's score would now be expressed as **intelligence quotient** or **IQ** (a term introduced by Stern, 1912), i.e., the mental age divided by the chronological or real age, multiplied by 100. Thus, someone aged 10 who reached level 10 would have an IQ of 100 (average); someone aged 10 who reached level 8 would have an IQ of 80 (below average); and someone aged 10 who reached level 12 would have an IQ of 120 (above average).

> **intelligence quotient (IQ)** a score derived from standardized tests of intelligence, usually combining several subtests of different cognitive ability tests (e.g., verbal, mathematical, spatial)

In the 1960s these normative differences were standardized through a measure called *standard deviation* (SD) (a comparative indicator of a person's score against the general population). The SD eventually replaced Terman's formula and is still used as a tool to compare individuals on intelligence (not just according to age but also according to specific population groups such as gender, ethnicity, and nationality). Today, the concept of IQ is almost synonymous with intelligence, used widely by both laypeople and academics and graphically represented by a normal distribution or **bell curve** of scores, with a mean of 100 and an SD of 15 (see Figure 5.3). On average, 50 percent of the population has an IQ of 90 to 100 points, 2.5 percent have an IQ of 130 or above, another 2.5 percent score 70 or below, and only 0.5 percent, that is, 1 person in 200, score 140 or above.

> **bell curve** also known as normal distribution, referring to the graph that represents the frequency of scores or values of any variable. In psychology many variables, notably IQ scores, are normally distributed in the population

One fundamental advantage of IQ tests is that they measure *stable* individual differences in intellectual ability. Accordingly, an individual's score on an IQ

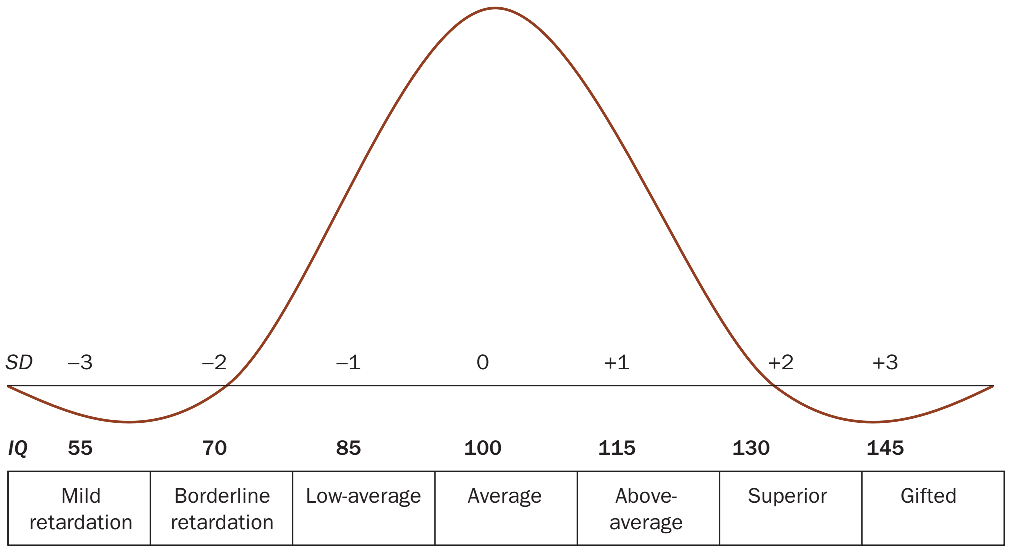

Figure 5.3 Graphical depiction of the bell curve or normal distribution of IQ.
The "bell curve" figure above shows the normal distribution of IQ scores, which have a mean of 100 and a standard deviation (SD) of 15. Thus, if your IQ = 100 you have "average" intelligence, whereas an IQ of 130 shows superior intelligence, and an IQ of 70 signals borderline retardation.

measure will not vary from day to day, month to month, or year to year. In fact, after the age of 6, individuals' IQ scores remain pretty much the same, though the development of adult intelligence takes place until the age of 15 (see section 5.6).

Despite their usefulness in the prediction of school grades, early IQ tests were mainly an applied tool and did not refer to any theory or attempt to explain the mental processes underlying test performance. Even after Terman's (1916) American adaptation of Binet's scale into a reliable measure for the prediction of scholastic achievement, one that was used for many decades and subsequently, though not substantially, revised in 1937, 1960, 1972, and 1986, there were few efforts to define intelligence or elaborate a theory for understanding individual differences in intellectual ability.

5.3.4 Spearman's *g* factor of general intellectual ability

Meanwhile, in Britain, Charles Spearman (1863–1945), another student of Wundt, applied factor analysis and data reduction procedures (see section 2.7) to show that different ability tests were significantly intercorrelated, and that the common variance could be statistically represented in terms of a single, general factor or ***g*** (see Figure 5.4). Like Galton and J. M. Cattell, Spearman (1904) started by examining individual differences in basic information processing, looking at elementary cognitive processes such as olfactory and visual-sensory discrimination. Like Binet, he compared these scores to academic performance indicators, creating a criterion to examine the validity of his measure in order to observe whether test scores could accurately distinguish between high and low levels of learning. Spearman therefore combined both strengths of differential psychology and intelligence research. In the early German school he found the experimental methods to quantify cognitive processes, and in the early French tradition he found the criterion to validate his tests. The theory behind Spearman's research was also instrumental in continuing and consolidating the English paradigm (initiated by Galton) of intelligence as an inherited ability.

> ***g*** used to refer to the "general intelligence factor" underlying performance which can be extracted statistically from scores on a range of ability tests

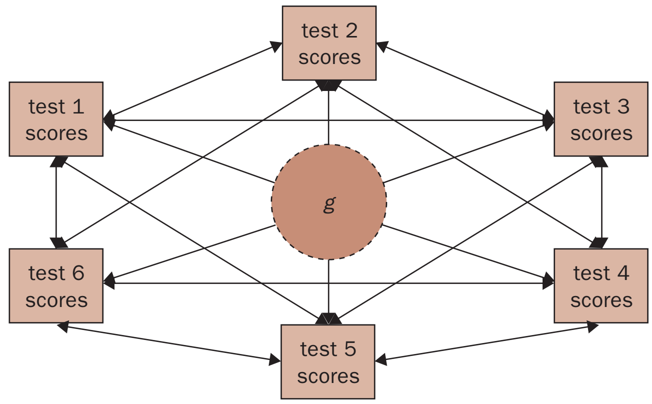

Figure 5.4 Illustration of the concept of *g* (general intelligence) as underlying common variance to different cognitive tests.

The main advantage of focusing on elementary processes to define individual differences in intellectual ability was the possibility of designing robust experiments in laboratory conditions. This opportunity led to a revival of cognitive research on intelligence in the 1970s and early 1980s, causing a paradigmatic revival of the early conceptualizations of Galton, J. M. Cattell, and Spearman. Rather than measuring intelligence through a series of abstract and unobservable mental operations (that are merely "assumed" to take place while participants complete an ability test), researchers defined intelligence in terms of *reaction time* (Jensen, 1982) or *inspection time* (Deary, 1986), more easily quantified and measured (see chapter 6). Basic cognitive processes such as inspection time have been reported to account for up to 20 percent of the variance in IQ test scores (see Davidson & Downing, 2000).

Spearman, a skillful statistician, developed a series of tests that provided the empirical basis for his theory of intellectual ability as well as the foundation for future far-reaching research on individual differences. Indeed, even today, intelligence research is inspired by the application of similar statistical methods to the ones used by Spearman.

Spearman's first important finding was that different mental tests are significantly interrelated, so that performance on one type of test or exam is similar to that in others. Furthermore, because each test score reflects not merely the ability of the testee but also a certain level of error in measurement (rather than a "pure" measure of ability, tests can be "polluted" by several factors such as distractibility, stress, attention impairment, or fatigue), Spearman developed a formula to *attenuate* for these measurement errors and provide an estimate of the *true* relationship between two variables. This formula [r(true) = r(observed) × √(reliability of v1)(reliability of v2)] is still widely used. Taking into account the *reliability* (another concept introduced by Spearman) of a variable or measure, an accurate estimate of the true common or shared variance between two variables (v1 and v2 in the formula) is achieved, rather than the spurious correlation that may result from errors of measurement.

Another crucial statistical technique developed by Spearman and directly related to his concept of intelligence was *factor analysis* (see section 2.7). This technique requires the researcher to obtain a series of measurements, which are then plotted into a correlation matrix to show the relationships between each pair of variables. Factor analysis can then be used to identify underlying patterns in the data and co-variations between a group of variables are attributed to a latent factor. Thus, if individuals' scores on different tests are similar, one can assume that tests are measuring the same thing. This finding enabled Spearman (1927) to discover that, although there may be different aspects of cognitive performance, intelligence could be represented as a general underlying capability. Regrettably, much of the psychometric research after Spearman has focused on the statistical properties of standardized performance tests rather than on the nature of the processes underlying individual differences in intelligence.

5.3.5 Thurstone's "primary" mental abilities

Louis Thurstone (1887–1955) questioned Spearman's general intelligence (*g*) factor and devised a competing statistical technique called *multiple factor analysis*. In direct contradiction to Spearman's procedure of data analysis, Thurstone's method was based on decomposition of the variance identification of multiple factor loadings and identification of an independent group of factors.

Table 5.2 Thurstone's primary abilities

1 *Verbal comprehension*	Vocabulary (knowledge of words), reading and comprehension skills, verbal analogies (capacity for conceptual association)
2 *Word fluency*	Ability to express ideas, generate large number of words, and use concepts (e.g., anagrams, rhymes, metaphors)
3 *Number facility*	Ability to carry out mental calculations with speed and accuracy
4 *Spatial visualization*	Ability to mentally rotate figures and orientate oneself in space
5 *Associative memory*	Rote memory
6 *Perceptual speed*	Ability to rapidly spot visual stimuli (similarities, differences, patterns)
7 *Reasoning*	Inductive, deductive, inferential, logical processes of thought

Thurstone regarded intelligence as an adaptational process by which individuals attained everyday life goals by planning ahead, imagining a specific goal/outcome, and inhibiting instinctive responses to prioritize rational, goal-oriented processes. While Thurstone accepted the hypothesis of a general underlying intelligence factor, he concluded that intelligence should also be conceptualized and measured at the "primary" level. To this end, he conceptualized seven "primary" abilities, namely, *verbal comprehension*, *word fluency*, *number facility*, *spatial visualization*, *associative memory*, *perceptual speed*, and *reasoning* (see Table 5.2).

Thurstone's seven primary abilities provide a more precise picture or profile of an individual's intellectual capability. However, Thurstone's claim that primary abilities are a more useful tool than the *g* factor to predict academic performance has obtained little empirical support. Despite their relatively low incremental validity (predicting performance over and above *g*), primary abilities do contribute to our understanding of individual differences in intelligence and may explain specific differences between individuals and different cognitive tasks.

Spearman's and Thurstone's rival theories and methods have since been successfully combined to establish a *hierarchical* model of abilities acknowledging both general and specific factors. This hierarchical structure is also consistent with Binet's scale and that of David Wechsler (1896–1981), a student of Spearman who would later come to design one of the most important intelligence measures to date. That intelligence can be conceptualized in terms of different hierarchical levels was largely supported by the intercorrelations between tests of different contents, such as understanding paragraphs, recalling words, interpreting pictures, and solving arithmetic problems. Spearman himself tested this idea on a small sample of 24 schoolchildren and found empirical support for his theory: although there are many specific abilities required to perform on different types of tests, there is a single underlying general intelligence factor that emerges when the (true) intercorrelations between specific abilities and tests are examined. The structure of human abilities can thus be conceptualized in terms of a two-tier hierarchical model comprising specific abilities (*gs*) on one hand, and general intelligence (*g*) on the other.

Because *g* is a measure of general intellectual ability, it is less context and problem dependent than any specific ability test. Spearman argued that the common and essential element of abilities coincides with that of elementary functions. Thus *g* cannot be improved through practice but is, as Galton believed, largely biological.

5.4 CATTELL'S THEORY OF FLUID AND CRYSTALLIZED INTELLIGENCE

Spearman's (1904, 1927) findings had a crucial impact on one of his PhD students, Raymond Cattell (1905–98) (not related to J. M. Cattell), who went on to develop the well-known theory of crystallized and fluid intelligence. Cattell was actively involved in Spearman's development of factor analysis and, like Spearman, he was convinced of the advantages of applying multivariate statistical methods to behavioral research. Cattell's background in natural sciences led him to believe that with the help of statistical and mathematical techniques, psychology would soon be able to rival the objectivity of the hard sciences. Cattell's application of statistics was not limited to the study of intelligence but provided the empirical basis of his personality theory (see section 2.10). Though his wider impact was in the major areas of personality and intelligence, throughout his 70-year academic career Cattell elaborated and tested a great number of theories and methods on virtually every salient aspect of differential psychology, publishing over 35 books and 500 chapters and papers.

Based on factor analyses of the structure of and relationship between different types of ability tests, Cattell distinguished between **fluid intelligence** (*gf*) – the ability to perform well on nonverbal tasks, which do not require previous knowledge but instead measure a rather pure, culture-free element of cognitive performance – and **crystallized intelligence** (*gc*) – the ability to do well on verbal tasks, which are substantially influenced by previous knowledge and acculturative learning.

fluid intelligence (*gf*) the ability to learn new things and solve novel problems, irrespective of previous knowledge, education, or experience

crystallized intelligence (*gc*) the knowledge, information, and skills that can be used to solve problems related to what one has already learned

Broadly speaking, *gf* represents information processing and reasoning ability, that is, inductive, conjunctive, and disjunctive reasoning capability used to understand relations and abstract propositions (Stankov, 2000). Conversely, *gc* is used to acquire, retain, organize, and conceptualize information. Whereas *gf* is dependent on the efficient functioning of the central nervous system, *gc* is dependent on experience and education within a culture. *Gf* is therefore biological and declines over the adult lifespan as the mind's efficiency diminishes, whilst *gc* may increase with cultural exposure and as experience makes individuals wiser and more knowledgeable. A useful metaphor to understand the relationship between *gf* and *gc* is that of a computer: *gf* represents the processor, memory, and other characteristics of the hardware, whilst *gc* represents the software as well as information and data stored. Hence *gf*, like the processor of a PC, refers to *processes* rather than content. Conversely, *gc*, like the data files and software saved onto a PC, refers to *content* (or information) rather than processes. Measuring both *gf* and *gc* is beneficial for estimating both a person's learning potential and acquired knowledge (Stankov, Boyle, & Cattell, 1995).

In addition, Cattell (1987) added a third dimension of intelligence, *gsar*, to conceptualize performance on short-term memory and retrieval tasks, that is, tests that require manipulation and information retrieval in short-term memory. *Gsar* includes memory, visualization, and speed factors. Figure 5.5 depicts Cattell's three-component theory of intelligence, represented by *gf*, *gc*, and *gsar*.

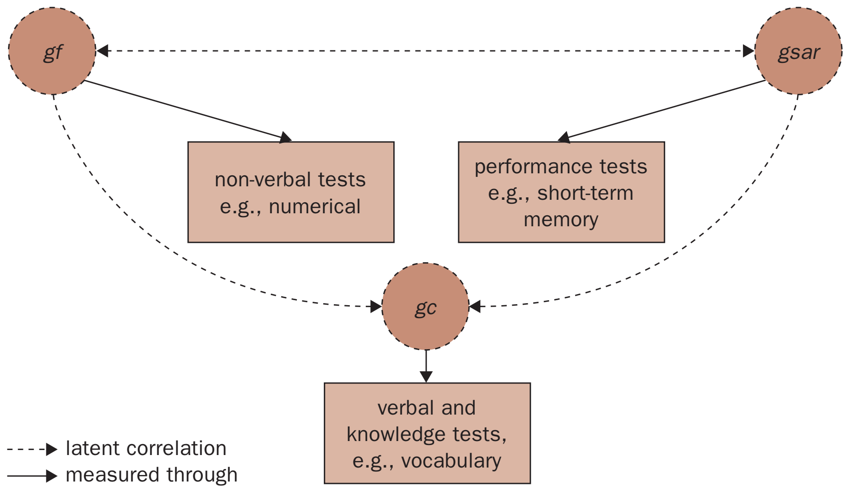

Figure 5.5 Cattell's (1987) three components of intelligence.

Although there has been a longstanding tendency to employ tests of *gf* or nonverbal abilities rather than *gc* or verbal abilities, the last 15 years have been dominated by a vindication of measures of *gc* (see Ackerman, 1999; Ackerman & Heggestad, 1997). Studies have shown that intelligent individuals tend to do better on verbal rather than nonverbal measures, whereas the opposite is true for lower-IQ scorers (see Matarazzo, 1972). Measures of *gc* would therefore represent a better tool to distinguish between high and low intelligence. Moreover, one cannot fully understand adult human intelligence without reference to any conceptual knowledge (that is, individual differences in comprehension, use, and knowledge of concepts). Thus, verbal ability measures such as verbal comprehension, general knowledge, and vocabulary tests constitute an optimal route to the measurement of general intellectual ability.

5.5 GENETIC VS. ENVIRONMENTAL CAUSES OF INTELLIGENCE

The idea that intelligence may be inherited has powerful social implications and has therefore often escaped objective scientific scrutiny. Both Binet and Spearman, pioneers in the psychological study of intelligence, believed that there was a strong hereditary basis for individual differences in intellectual ability. Before them, Galton argued that not only talent but also character (now referred to as personality traits) were largely inherited. However, to a greater (Binet, Cattell) or lesser (Galton, Spearman) extent, these pioneers also acknowledged the influence of social and cultural (i.e., environmental) factors on the development of specific skills. Thus, while two individuals with similar educational backgrounds may differ in ability because of different genetic dispositions, two individuals with the same genetic history could also experience different intellectual developments if exposed to unequal training or environments.

Environments and opportunities are often a function of social class or **socioeconomic status** (**SES**), long identified as a significant correlate of intelligence. However, as with most correlational studies, the causal direction underlying this relationship is difficult to identify. Further obstacles for empirical research have been caused by the lack of objectivity (and theoretical soundness) in the conceptualization and measurement of SES indicators. As there are several possible causal paths for interpreting the relationship between social class, education, and intelligence (see Figure 5.6), there has been a longstanding ideological debate as to whether SES determines intelligence or vice versa.

socioeconomic status (SES) a measure of an individual's position within a social group based on various factors, including occupation, education, income, location of residence, membership in civic or social organizations, and certain amenities in the home (e.g., telephone, TV, books)

Few differential psychologists have developed such consistent and convincing arguments (and evidence) for understanding the relationship between SES and *g* as Linda Gottfredson (1997, 1998, 2004). Against the traditional sociological interpretation of SES as the key causal factor of social inequalities (e.g., in health, education, and income), Gottfredson shows how general intelligence may be identified as the fundamental cause not only of these inequalities but also of SES itself. This would explain disparities in educational level, health, and income among members of the same SES, leading to the conclusion that measures of *g* are better predictors of these outcomes than parental (or family) SES. Thus children with higher IQs than their parents will typically achieve higher SES. Similarly, *g* can explain frequently large disparities in life opportunities among siblings who grow up in the same environment or home.

Because *g* remains stable from a very early age, influences of SES on an individual's intelligence seem unlikely. Even in closed and highly regulated political systems, such as hardcore socialism or communism, *g* is normally distributed in the population, with neither social nor economic regulation able to reduce individual differences in cognitive ability (Firkowska, Ostrowska, Sokolowska, Stein, Susser, & Wald, 1978; Jensen, 1998).

Of course, no one would argue that a simple measure of intelligence can map out an individual's future in all domains of life, or that key decisions determining life-changing events are the mere product of one's cognitive ability. However, "*g*'s effects are

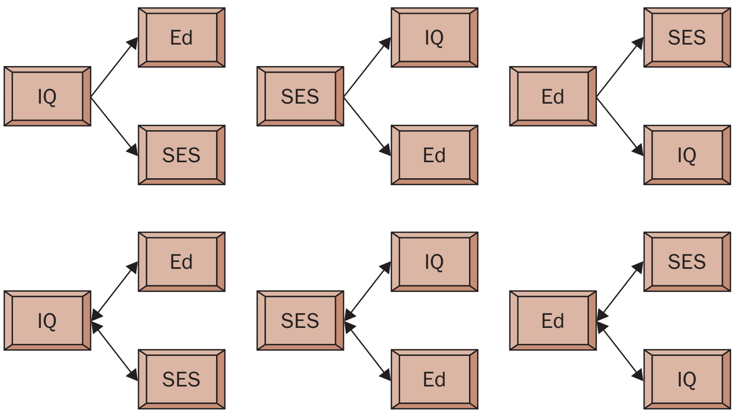

Figure 5.6 Some possible combinations for the causal relationships underlying the significant correlations between intelligence, education, and socioeconomic status.
IQ = intelligence, Ed = education, SES = socioeconomic status. Only unidirectional causations are presented.

pervasive and consistent" (Gottfredson, 2004, p. 180) and the aggregate performance of an individual in domains as diverse as school, work, health, and relationships is, to a substantial degree, affected by his/her level of intelligence. The consequences of intelligence in everyday life are examined in chapter 6. Correlates of *g* range from physical fitness to alcoholism (negatively), and that IQ measures at the age of 11 can predict a series of mental and physical illnesses at the age of 70 (Brand, 1987; Deary, 2000; Deary, Whiteman, Starr, Whalley, & Fox, 2004).

Adoption and twin studies (see chapter 7) have provided evidence in support of both genetic and environmental influences on intelligence, showing that individual differences in ability are determined by genes as well as the environment (though mostly by the former). Early evidence on the genetic basis of intelligence was reported by Newman, Freeman, and Holzinger (1937), who found that identical twins had a greater similarity in intelligence than non-identical twins, even when the former were raised apart. Studies on adopted children confirmed these findings because they reported larger correlations in intelligence between natural parents and their children than between adoptive parents and children, even where children had virtually no contact with their natural parents. Most data showed that less than 20 percent of the variance in IQ could be accounted for by environmental (non-genetic) factors. However, several studies by Cyril Burt were found to report fake twin data that exaggerated the genetic basis of intelligence. In recent years twin studies have come to show that, although intelligence is largely inheritable, there are some environmental influences that cause siblings raised in the same family to have different levels of intelligence (Plomin & Petrill, 1997). Adoption studies, however, have yielded ambiguous results, with correlations ranging from $r = .22$ up to $r = .77$ (see Grigorenko, 2000; Sternberg & Grigorenko, 1997). The complexities of behavioral-genetic studies will be examined in more detail throughout chapter 7.

5.6 PIAGET AND THE DEVELOPMENTAL THEORY OF COGNITIVE ABILITY

Although most of this chapter focuses on the *psychometric* approach to the concept of intelligence, the contribution of Jean Piaget (1896–1980), a famous developmental psychologist, deserves to be mentioned. Piaget was a student of Simon at Binet's research center in Paris. However, he soon abandoned psychometrics to investigate the qualitative aspects of intelligence. While working on the French standardization of Burt's intelligence scale, he noted that the crucial question to enable an understanding of intellectual ability was not how many correct or incorrect responses children could give, but why children of the same age tended to make exactly the same type of mistakes. This would come to be clarified not through standardized multiple-choice tests but through individual clinical interviews.

Piaget was therefore concerned with how individuals develop adult intellectual capacities, and identified various developmental stages in the evolution of adult intellect. His theory of intellectual development is based on four universal stages, namely the *sensorimotor*, *preoperational*, *concrete operational*, and *formal operational* stages, which follow a baby's intellectual transition from a nonverbal, preconceptual, elementary stage in the early four years of life to the complex stages of language acquisition and conceptual reasoning in young adolescence (see Table 5.3).

Table 5.3 Stages of intellectual development according to Piaget

Development stage	*Approximate age*	*Characteristics*
Sensorimotor	0–2	No mental representations of objects outside child's immediate view; intelligence develops through motor interactions with environment
Preoperational	3–7	"Thought" emerges; child is able to make mental representations of unseen objects, but cannot use deductive reasoning yet
Concrete operations	8–12	Deductive reasoning, conservation of number, and distinction between own and others' perspectives
Formal operations	13–15	Ability to think abstractly

Like Spearman, Piaget believed in a single, general intelligence factor but focused on the evolutionary or developmental aspects of intelligence, which he considered to be the result of a series of ubiquitous qualitative stages. More importantly, and unlike most early intelligence researchers, Piaget was more interested in elaborating a theoretical framework for understanding the development of the processes underlying adult intelligence than in individual differences in psychometric test performance. His theory was therefore more concerned with similarities than differences between individuals.

The essence of Piaget's (1952) theory is the universal interaction between biological and environmental variables. Biological (genetic) factors provide the raw materials required for the progressive construction, through active experiences and interactions with the environment, of adult intelligence. Each stage of development is therefore genetically prescribed and inherent in human organisms, meaning children cannot be "taught" the passage from one stage to another. At each evolutionary stage (i.e., sensorimotor, preoperational, concrete operational, and formal operational), there are certain cognitive operations an individual is able to perform and others she is not. Piaget's theory therefore explains the passage from basic sensorial and motor skills (at the age of 2 years) to very abstract (formal/logical) mental operations by processes of adaptation (assimilation and accommodation) and organization (linking mental structures and applying them to real-life problems), resulting in the progressive development of schemes, i.e., groups of interrelated ideas or concepts.

Piaget is also responsible for some of the most comprehensive and detailed definitions of the concept of intelligence. Whereas such definitions do not necessarily emphasize aspects of individual differences, they have been accepted widely in all areas of psychology, including individual differences. Some of Piaget's definitions are presented below:

- "Intelligence is an adaptation . . . To say that intelligence is a particular instance of biological adaptation is thus to suppose that it is essentially an organization and that its function is to structure the universe just as the organism structures its immediate environment" (Piaget, 1963, pp. 3–4).
- "Intelligence is assimilation to the extent that it incorporates all the given data of experience within its framework . . . There can be no doubt either, that mental life is also accommodation to the environment. Assimilation can never be pure because by incorporating new elements into its earlier schemata the intelligence constantly modifies the latter in order to adjust them to new elements" (Piaget, 1963, pp. 6–7).
- "Intelligence does not by any means appear at once derived from mental development, like a higher mechanism, and radically distinct from those which have preceded it. Intelligence presents, on the contrary, a remarkable continuity with the acquired or even inborn processes on which it depends and at the same time makes use of" (Piaget, 1963, p. 21).

However, Piaget's theory remained virtually untouched by differential approaches to intelligence, with few attempts at applying it to individual differences taxonomies (for an exception see Kirk, 1977). This is predominantly because it applies to children and adolescents (with final stages of intellectual development at approximately age 15) rather than to adults. Despite its fundamental contribution to developmental psychology, then, the applied implications of Piaget's theory to individual differences in intellectual ability remain of secondary importance. However, since Piaget's theory provides a robust explanation of the development of the processes underlying universal cognitive functions that are ubiquitous to adult mental operations, it can be used to understand structural aspects of human intelligence. Once these are present, individual differences in intelligence can address why some are more intelligent than others.

5.7 THE GREAT DEBATE: *G* VS. MULTIPLE ABILITIES

Although the predictive validity of established IQ measures is well documented (see chapter 6), critics have argued that the traditional conception of intelligence is not sufficiently comprehensive as it refers mainly to academic abilities or being "book smart" (Gardner, 1983; Goleman, 1995; Sternberg, 1985, 1997). Instead, they propose that individual differences in intellectual ability should be defined in terms of *multiple intelligences* (see chapter 8), as individuals may be good at some ability tests but bad at others.

The idea that human intellectual ability can be "broken down" into several unrelated components was most emphatically defended by Guilford (1959, 1967, 1977), who came to develop the most comprehensive catalogue of human abilities that extended to 150 different types based on a preliminary distinction between the three dimensions of *operations*, *products*, and *contents*. Accordingly, Guilford (1977) distinguished five types of operations (cognition, memory, divergent production, convergent production, and evaluation), five types of contents (auditory, visual, symbolic, semantic, behavioral), and six types of products (units, classes, relations, systems, transformations, implications) (see Figure 5.7). Guilford's (1981) revision of this model finally

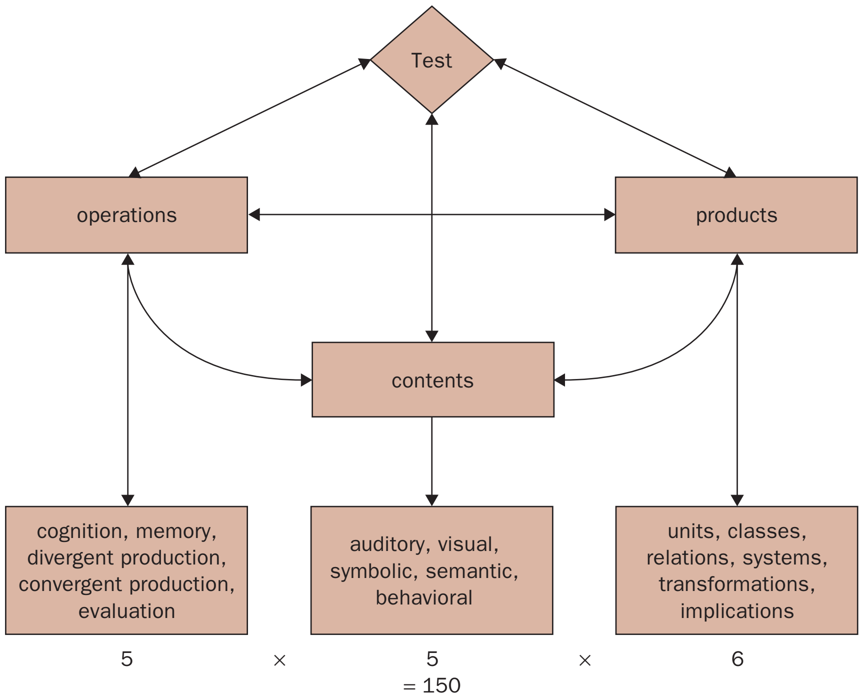

Figure 5.7 A graphical depiction of Guilford's (1977) model of intelligence.

acknowledged the existence of a hierarchy comprising 85 second-order and 16 third-order factors. Evidence for this model is yet to be provided (Brody, 2000).

Although various theories have proposed an understanding of intelligence in terms of several unrelated abilities, the scientific study of intelligence has provided conclusive evidence for the existence of a general intelligence factor and its accurate predictive power with regard to academic outcomes. Thus, empirical evidence mainly refutes theories of multiple intelligence (Gottfredson, 2003; see also chapter 8).

In a large US psychometric study involving nearly 2,500 participants, all correlations between the 13 subtests of the Wechsler Adult Intelligence Scale (WAIS-III) (see section 6.2) were significant and positive (ranging from about $r = .30$ to $r = .80$) (Wechsler, 1997). The pattern of correlations also supported Cattell's idea that some types of tests are more interrelated than others. However, the underlying general intelligence factor hypothesized to be the source of variations between individuals' cognitive performance was clearly identified in this large and representative dataset. Thus mental abilities, as tested by different ability tests, tend to be closely associated so that they cluster together in one common factor (see again Figure 5.4). This factor, which accounts for approximately 50 percent of the variance in IQ test performance, is the best existing measure of individual differences in human intelligence and a powerful predictor of a wide range of real-life outcomes.

The most compelling source of evidence for the existence of a general intelligence factor derives from Carroll's (1993) book on human intelligence, a great meta-analytic review of the salient twentieth-century studies on intellectual abilities. After reanalyzing over 400 sets of data, results revealed that a single, general intelligence factor can account for a considerable amount of variance in ability test performance. This factor was identified at the highest hierarchical level of the pyramid and is the major determinant of different components of cognitive performance, namely fluid intelligence, crystallized intelligence, general memory and learning, processing speed, broad cognitive speediness, broad retrieval ability, broad auditory perception, and broad visual perception (see Figure 5.8).

Although the eight types of abilities at the second level of the hierarchy refer to different aspects of human performance, all these aspects tend to be significantly intercorrelated so that, in any large and representative sample, those individuals who do well in *some* tests will also show a tendency to do well on the *other* tests, and vice versa. The debate as to whether there is one intelligence or many intelligences supposes incorrectly that these two hypotheses are incompatible, whereas both are in fact correct. Indeed, while there are many identifiable and distinctive types of abilities, from the second level of abilities summarized above to narrower, third-order abilities that can be mapped onto the second level, there is also a general intelligence factor accounting for most of the variance in different ability test performance.

Accordingly, while data clearly show that the general intelligence factor does exist, there is no justification for arguments against it (Carroll, 1993; Deary, 2001; Wechsler, 1997). The real issue is whether the general intelligence factor can be useful by effectively predicting real-life outcomes, particularly beyond academic performance or school success. This issue is further discussed in chapters 6 and 12.

5.8 SUMMARY AND CONCLUSIONS

In this chapter I have examined the concept of intelligence, which has a longstanding history in differential psychology and is closely linked to the development of psychometric tests. As seen:

1. Intelligence is measured through standardized performance tests, which require participants to identify the correct solution to cognitive problems (e.g., mathematical, verbal, spatial). These tests were originally designed to predict school and military performance but have shown to be valid predictors of a wide range of real-life outcomes as well. Indeed, the reliability and validity of well-established IQ tests is matched by few other psychological measures.
2. There is some debate about the structure of intelligence, with some viewing it as a general factor and others seeing it as a set of largely independent, more specific abilities. Hierarchical models, on the other hand, recognize the existence of both general and specific factors, making better sense of the data. At the same time, there is wide consensus that there are two major aspects of intelligence, namely fluid

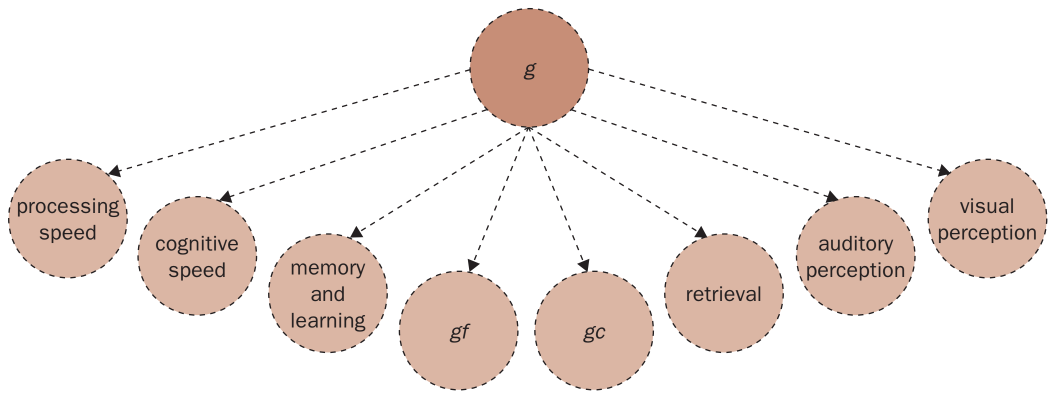

Figure 5.8 Conceptual representation of Carroll's (1993) hierarchical structure of intelligence.

intelligence (*gf*), or the ability to learn new things and solve novel problems (irrespective of previous experience, knowledge, or education), and crystallized intelligence (*gc*), or the knowledge/information that can be used to solve problems related to what one has already learned.

3. In 1996, leading intelligence researchers compiled a comprehensive dossier on the topic to clarify the known and unknowns about intelligence. This dossier shows that, contrary to popular belief, there is great consensus amongst experts on the nature of intellectual ability. Thus 52 eminent researchers in the field agreed that "Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings – 'catching on,' 'making sense' of things, or 'figuring out' what to do" (Gottfredson, 1997, p. 13).

Now that I have introduced the concept and measurement of intelligence, it is time to understand the causes and consequences of intellectual ability; in other words, why some people are more intelligent than others, and what advantages this brings. This is the topic of chapter 6.

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