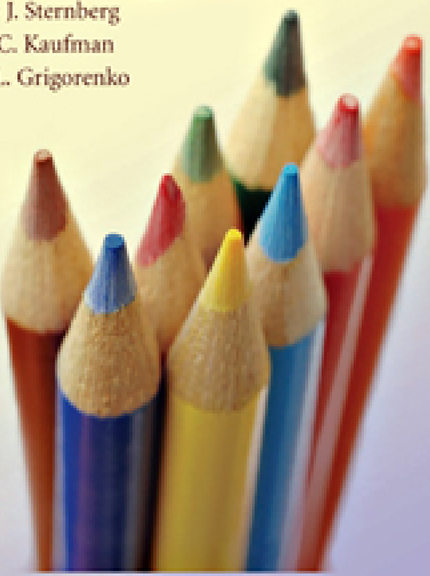
Applied Intelligence

Robert J. Sternberg
James C. Kaufman
Elena L. Grigorenko



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APPLIED INTELLIGENCE

Typical texts develop students' knowledge while only minimally developing the general skills they will need for success in school and in life. The goal of our text is to assist students in acquiring the most important skills for facing the diverse challenges life presents. The book contains an overview of theories of intelligence, but itself is based in large part on a theory according to which individuals need creative skills to generate new ideas and a vision for the future, analytical skills to make sure that the vision is a good one, and practical skills to execute the ideas and to persuade other people of their value. The book considers key skills in problem solving, logical reasoning, analysis of arguments, knowledge acquisition, creative and practical thinking, automatizing information processing, and avoiding life traps that derail even the most intelligent among us.

Robert J. Sternberg is Dean of the School of Arts and Sciences and Professor of Psychology at Tufts University. Before he went to Tufts, he was IBM Professor of Psychology and Education, Professor of Management in the School of Management, and Director of the Center for the Psychology of Abilities, Competencies, and Expertise at Yale University. This Sternberg was the 2003 President of the American Psychological Association and was the 2007–2008 President of the Eastern Psychological Association.

James C. Kaufman is an Associate Professor of Psychology at the California State University at San Bernardino, where he directs the Learning Research Institute. The author/editor of 14 books, he is the founding co-editor of *Psychology of Aesthetics, Creativity, and the Arts* and the associate editor of *Journal of Creative Behavior*.

Elena L. Grigorenko is Associate Professor of Child Studies and Psychology at Yale and Adjunct Professor of Psychology at Columbia University and Moscow State University (Russia). Dr. Grigorenko has published more than 200 peer-reviewed articles, book chapters, and books.

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ROBERT J. STERNBERG

Dean of the School of Arts and Sciences, Tufts University

JAMES C. KAUFMAN

California State University, San Bernardino

ELENA L. GRIGORENKO

Yale University

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To Seth and Sara

– RJS & ELG

For Allison,

For everything,

For always.

– JCK

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PREFACE

Can people make themselves smarter? Research in psychology suggests that they can – that the brain functions in much the way muscles do. The more you exercise it, the better it functions. Moreover, the better you understand it, the more you are in a position to make optimal use of it.

This book seeks simultaneously to accomplish two goals. It teaches students about the mind and how it functions, and at the same time, it helps them improve that functioning.

The book is written primarily for college students but can also be used by advanced high school students working at a college level. It is relevant in any course on thinking, reasoning, problem solving, decision making, critical thinking, creative thinking, or study skills that seeks simultaneously to help students understand better how they think and to improve their thinking skills. The book is appropriate either as a main text or a supplementary one.

A numer of features make this book unusual, if not unique, among programs for developing intellectual skills. First, the program is based on a contemporary psychological theory (the theory of successful intelligence) that has extensive data to support it (going back 35 years). Second, the book conceptualizes intelligence in a broad way; the range of cognitive skills addressed is much greater than in the typical program of this kind. Third, the book is written to motivate students as well as to teach them. Many practical examples are included, and the examples are drawn from many fields of endeavor. Fourth, the problems range from very abstract and test-like to very concrete and practical. This range is necessary to ensure that students transfer their learning from one task and situation to the next. For this transfer to occur, a program must teach for transfer – which the present program does. It is unlike many other programs that rely solely on test-like problems to enhance students' intellectual skills. Fifth, the book contains an entire chapter on emotional and motivational blocks to the use of intelligence. It does not matter how intelligent people are if they are unable to use their intelligence. This last chapter is intended to help students make full use of their developing intellectual skills.

The book comprises 14 chapters. The first two chapters are introductory. Chapter 1 presents alternative views of intelligence. Chapter 2 then presents the view that motivates this book, the theory of successful intelligence.

Chapter 3 presents metacognition and tools for improving one's metacognitive skills. Chapter 4 deals with advanced steps that can be taken to help one improve one's problem solving. Chapters 5–7 deal with the execution of problem solving. Chapter 5 concentrates on analogical and serial thinking, Chapter 6 on classificational and matrix-based thinking. Chapter 7 deals with logical thinking, and Chapter 8 with the kinds of inferential fallacies that can disrupt both formal and informal logical thinking.

Chapter 9 moves on to learning and knowledge acquisition. It discusses how we can improve our learning, particularly of new words and concepts. Chapter 10 teaches students how better to cope with novelty, and Chapter 11 deals with the umbrella set of skills and attitudes for coping with novelty, namely, creativity. Chapter 12 deals with how we can better automize thinking and other skills as they become routine. Chapter 13 deals with practical intelligence and common sense, and Chapter 14 with why people who are smart often fail despite their high intelligence. The book concludes with a complete set of references and an index.

The three of us have enjoyed working on this book, and we hope that it will be both fun and challenging to read. Many of the topics that we cover are areas that we also study. We would love to inspire you to think about these ideas – and, perhaps, to continue in the tradition of studying how people think, what intelligence is, and why people succeed.

Many people have contributed to making this book possible. The book is a successor to an earlier book, *Intelligence Applied*, written by the senior author and published in 1986. That book was supported by the Venezuelan Ministry for the Development of Intelligence. Luis Alberto Machado and Jose Dominguez Ortega were instrumental in making the earlier book happen, as were El Dividendo Voluntario para la Comunidad, Margarita Rodriguez-Lansberg, and Francisco Rivera. People who have contributed in various ways over the years to the development of the training materials here also include Barbara Conway, Janet Davidson, Louis Forster, Michael Gardner, Ann Kirkland, Robin Lampert, Diana Marr, Elizabeth Neuse, Susan Nolen-Hoeksema, Janet Powell, Craig Smith, Larry Soriano, Rebecca Treiman, and Richard Wagner.

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RJS
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September 2007

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Views of Intelligence

What is intelligence? There have been countless studies and books on this topic, but we're going to focus on a primary distinction between traditional conceptions and newer conceptions. One new conception of intelligence is the theory of successful intelligence, in which being intelligent is more than just being book-smart; it is knowing how to apply it – hence our title, *Applied Intelligence*. We view intelligence as encompassing many diverse concepts, including critical thinking, being able to know how much you know (metacognition), common sense, practical intelligence, creativity, and logic. We believe that an intelligent person is someone who can tell (or who knows how to check) if a forwarded e-mail is truth or an urban legend; someone who can recognize propaganda versus more convincing arguments; someone who usually has a good idea of how much he or she knows about something; someone who can adapt to new situations; and someone who can learn new things.

Before we discuss the theory of successful intelligence, we're going to attempt to briefly summarize more than one hundred years of research about intelligence and IQ testing. This chapter, therefore, will present a brief overview of the way psychologists and others have conceived of intelligence. For more details, see Sternberg (1990, 1994, 2000, 2004b; Sternberg, Lautrey, & Lubart, 2003; Cianciolo & Sternberg, 2004).

THE DEFINITIONAL APPROACH TO INTELLIGENCE

One way to seek to understand intelligence is simply to define it. We then use the definition as a basis for theorizing about intelligence, testing intelligence, and training intelligence. The nice feature of this approach is that it is simple: We need simply to find out what intelligence is, and then proceed from there. The obvious shortcoming of the approach is that it is not always persuasive. It is one thing to define intelligence; it is another thing to get people to accept the definition. Indeed, a ten-year-old child may create a terrific definition of "a fair allowance," but have more trouble convincing her father to accept it!

We might think that just as a rose is a rose, a definition is a definition. This proposition turns out to be not quite true. In fact, two principal kinds of definitions of intelligence have been proposed-the operational definition and the "real" definition.

Operational Definition

An *operational definition* attempts to define something in terms of the way it is measured. This type of definition is often counterintuitive. If we ask you to define "love," you might be more likely to look through poems than reference books. Indeed, one of the authors of this book frequently uses this as a classroom exercise. Even after explaining what an operational definition is, people resist – the immediate responses still tend to be "a feeling you have for someone else" or "how much you care about someone." But an operational definition is more specific and more exact. Eventually, someone in the class will say something like, "How many times a day you think about a person," or "How many sacrifices would you make for somebody." But it's still usually a sticking point for a small (but vocal) percentage of the class.

Thus, an operational definition might define intelligence as whatever it is that intelligence tests measure. We might think that no serious scientist would propose such a circular definition, or that if one did, no one would take it seriously. But precisely this definition of intelligence-as being whatever it is that intelligence tests measure-was proposed by a famous Harvard psychologist, E. G. Boring (1923). Moreover, Boring did not propose this definition as something merely suitable for scientific use. To the contrary, he suggested it in a popular magazine, the *New Republic*, as part of a public debate.

Many scientists and educators have proceeded in their research and testing as though Boring was right, and intelligence is nothing more and nothing less than what intelligence tests measure. Arthur Jensen (1969), a well-known advocate of the importance of heredity in intelligence, accepted this definition as a basis for his attempted demonstration in the *Harvard Educational Review* that group differences in intelligence can be understood as having a hereditary basis, and that as a result there is little hope for attempts to develop people's intelligence. One kind of group difference that Jensen and other scientists have particularly studied is intelligence differences across ethnicity. There are powerful implications for just how much we rely on a purely operational definition. Once the instruments we use are given the power to determine how we think about a construct, we get into dangerous territory.

Other scientists have been less obvious and forthcoming in admitting their acceptance of the operational definition but have proceeded to use it nevertheless. For example, when new tests of intelligence are proposed, their validity (that is, the extent to which they measure what they are supposed to measure) is usually assessed by comparing scores on the new test to scores on older and more widely accepted tests. Thus, the older tests serve as the operational standard for the newer ones. To the extent that the new tests actually do measure anything new or different, they will then be less related to the old tests. As a result, any new tests that are truly new may be viewed as less valid than these older tests. Even experimental psychologists, who attempt to study intelligence in the laboratory and to go beyond existing IQ-based notions of intelligence, often validate their theories and new instruments against existing tests. Thus, they also become trapped into accepting the operational definition of intelligence. They may not be happy about doing so, but they do it nevertheless.

The operational definition of intelligence has two basic, interrelated problems. The first is that it represents circular reasoning. What is circular reasoning? It's when you assume your conclusion as a given fact. For example, Lauren might say that *Star Wars* is the greatest movie ever made. When someone asks her why, she says, "It just is." This response is an example of circular reasoning. If, by contrast, she says, "The special effects were revolutionary and the story is exciting," she has provided reasons for her conclusion. We will discuss circular reasoning in more detail later on in the book.

Intelligence tests were originally devised in order to measure intelligence, not to define it. The designers of the tests based them on their own conceptions of intelligence and hoped that eventually the definition of intelligence would become clearer. They never intended for these tests actually to define intelligence. On the contrary, some test developers believed that the tests could only make sense if they were based on some prior definition of intelligence. Those who argue that intelligence is simply what intelligence tests measure are going against the philosophies of most of the people who actually develop the tests.

The second problem with the operational definition of intelligence is that it seems to block further progress in understanding the nature of intelligence. If old, established tests are used as the primary or sole criterion against which new tests and conceptions of intelligence are to be assessed, then the new tests and conceptions will be viewed as valid only to the extent that they correspond to the old ones. There is no allowance for the possibility that the new tests or conceptions may actually be better than the older ones. The result is that we become locked into existing conceptions and measurements, regardless of whether they are any good or not. Existing tests of intelligence certainly may serve as one criterion against which to evaluate new tests and theories. It would be a pity, however, if they were to serve as the only criterion. Imagine if television programmers designed new shows based only on the shows that worked in the past. We would only have clones of successful programs (and, indeed, many people argue this is true!). Certainly, there is a reason why we use successful examples for constructing future products; the same ingredients that initially made *Law & Order* a success were later used to similar effect in shows like *CSI*, just as classic shows like *I Love Lucy* and *MASH* built on earlier shows. But when past work is too heavily relied on, you end up with shows that no one watches or remembers.

If past tests were the only consideration for developing future tests, we would lose the chance of ever learning more about the nature of human intelligence.

"Real" Definition

According to the philosopher Robinson (1950), a "*real*" *definition* is one that seeks to tell us the true nature of the thing being defined. Such a definition goes beyond measurement and seeks to understand the underlying nature of intelligence. Perhaps the most common way of trying to find out just what intelligence is has been to ask experts in the field of intelligence to define it.

The most well-known example of this approach was the result of a large meeting of experts published in 1921 in the *Journal of Educational Psychology*. Fourteen experts gave their views on the nature of intelligence, with definitions involving activities such as the ability to carry on abstract thinking, the ability to learn to adjust oneself to the environment, the ability to adapt oneself adequately to relatively new situations in life, the capacity for knowledge, the amount of knowledge possessed, and the capacity to learn or to profit from experience. From one point of view, an examination of the full set of definitions seems to lead to the conclusion that there were as many definitions of intelligence as there were experts asked to define it. From another point of view, however, at least two themes seem to run through several of the definitions: learning from experience and adapting to the environment. A view of intelligence accepted by many of these experts would seem to be one of intelligence as general adaptability to new problems and situations in life.

There have been more recent definitions of intelligence that have been accepted by at least some people in the field. For example, George Ferguson (1956) defined intelligence in terms of a person's ability to transfer his or her learning and accumulated experience from one situation to another (Barnett & Ceci, 2005). According to this definition, then, it is not just what we know that counts. It is also our ability to use this information in new kinds of situations that we confront in our lives. This concept, often called "transfer," is indeed a crucial component to success in the real world. If you learn something, can you apply it to many different areas? If you take information in this book and apply it to your daily life, you've successfully "transferred" the knowledge into another area. Let us imagine, for example, that you are having a debate about local politics with your roommate; she supports one local candidate for mayor, Roberto Diaz, over another, Rafaela Contini. You ask her why she supports Diaz, and your roommate says, "Diaz is simply better than Contini, and that is why I am going to vote for him." You have read this book, however, and you remember back a few pages to the example about circular reasoning. You tell your roommate, "You're giving me a circular reasoning argument that I read about in my book for class." Your roommate will then be thoroughly defeated and will do the dishes, while *you* have demonstrated an excellent instance of knowledge *transfer*. Because definitions can be so subjective, we might think that there is simply no basis for judging one definition as either better or worse than another definition. This is not the case, however. For example, we saw that the operational definition of intelligence is a particularly unproductive one. Sir Cyril Burt's definition of intelligence is also an unproductive one. Burt (1940) defined intelligence as innate general cognitive ability. Some psychologists, such as Jensen, seem to accept a view of intelligence that is quite close to this one, but the definition seems problematical for at least two reasons. First, it assumes that intelligence is innate, or, in others words, inherited and present from birth (i.e., passed through genes). Although intelligence probably is at least partly heritable, the degree of just how heritable is a complex and multilayered question. Assuming that intelligence is solely innate removes the role of the environment out of the definition. These are mighty important factors to disqualify automatically. Think about a class that you took that you enjoyed that was on a subject matter that didn't interest you. Maybe you enjoyed the professor, or maybe you had three good friends in the class with you. The context in which you studied the subject influenced your enthusiasm for the material. Burt seems to assume what really ought to be proved.

Second, the definition also assumes that intelligence is exclusively cognitive (in other words, only related to what people know or think). Although intelligence certainly draws on a wide array of cognitive abilities (such as what you know or how you think), it seems at least possible that it also may involve other kinds of abilities, such as motivation. Imagine all of the possible things that might impact our intelligence – such as our parents, our education, and so on. Once again, Burt seems to assume what really ought to be proved.

In sum, then, the "real" definition of intelligence can have some value if we look for common ideas among various experts' definitions. When we do this, the abilities to learn from experience and to adapt to the environment seem to be essential ingredients of intelligence. However, we must be careful in accepting these definitions without questioning them. First, we have seen that a definition may make too many assumptions without demonstrating issues scientifically. Second, experts obviously disagree among themselves as to the definition of intelligence, and there is no guarantee that any of their definitions are correct. Thus, "real" definitions of intelligence need to be interpreted with due caution.

THEORIES OF INTELLIGENCE

Just as there are different kinds of definitions, there are also different kinds of theories of intelligence. The theory that forms the basis of this book draws at least a little on each kind. Thus, it may be helpful to give a brief review of these theories.

Learning Theory

Although we would think that there must be a close relationship between learning and intelligence, psychologists studying learning have not been among the most active contributors to the field of intelligence. Usually, they have studied learning in its own right without touching on the topic of its relation to intelligence. Learning theorists are an exception to this generalization.

In the learning theorist's view, then, all behavior – no matter how complex or "intelligent" – is seen as of a single type and our "intelligence" is seen as simply a function of the number and strength of stimulus-response connections we have formed and, perhaps, the rate at which we can form new ones.

Learning theorists have tended to emphasize intelligence as being flexible and teachable. This emphasis contrasts to some of the more extreme supporters of intelligence tests, who have sometimes (although by no means always) been associated with points of view emphasizing the importance of heredity. Perhaps the most optimistic statement of what learning theory can do to mold a person's intellect and other skills was provided by John Watson (1930), who said, in one of the most well-known quotations of all psychology:

> Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select-doctor, lawyer, artist, merchant-chief

> and, yes, even beggar-man and thief-regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors.

The main contributions of the learning-theory approach to intelligence seem to have been, first, its focus on the importance of learning in intelligence, and second, its optimism regarding the possibility of human intelligence being modified and improved. Thus, whether or not learning theorists were literally correct in what they said regarding the nature of intelligence, they appear to have been correct in the spirit of what they had to say. We agree with them wholeheartedly that intelligence is a characteristic that can be increased and improved on, and that will be a main theme throughout this book.

Biological Models: Intelligence as a Physiological Phenomenon

Biological approaches seek to understand intelligence by directly studying the brain and its functioning, rather than by studying behavior (Jerison, 2000; Newman & Just, 2005; Vernon, Wickett, Bazana, & Stelmack, 2000). Early studies seeking to find a biological base of intelligence and other cognitive processes were a resounding failure, despite great efforts (Lashley, 1950). As tools for studying the brain have become more sophisticated, however, we are beginning to see the possibility of finding physiological indications of intelligence. Some researchers (e.g., Matarazzo, 1992) believe that we will have clinically useful psychophysiological measures of intelligence very soon, although tests that can be used in a wider variety of situations will be much longer in coming. In other words, it may be possible in the future to use psychophysiological measurements to assess individuals for characteristics such as mental retardation. For now, some of the current studies offer some appealing possibilities.

Electrophysiological Evidence

Research has found that complex patterns of electrical activity in the brain, which are prompted by specific stimuli, correlate with scores on IQ tests (Caryl, 1994; Jensen, 2005). Also, several studies suggest that the speed of conduction of neural impulses may correlate with intelligence as measured by IQ tests (e.g., Deary, 2000a; Deary, 2000b), although the evidence is mixed. Some investigators (e.g., Jensen, 1997; P. A. Vernon & Mori, 1992) suggest that this research supports a view that intelligence is based on neural efficiency.

Metabolic Evidence

Additional support for neural efficiency as a measure of intelligence can be found by using a different approach to studies of the brain: studies of how the brain metabolizes glucose, a simple sugar required for brain activity, during mental activities. (This process is revealed in PET – Positron Emission Tomography.) Richard Haier and his colleagues (Haier, Siegel, Tang, Abel, Buchsbaum, 1992) argued that higher intelligence correlates with reduced levels of glucose metabolism during problem-solving tasks – that is, "smarter" brains consume less sugar (meaning that they expend less effort) than do less smart brains doing the same task. Luckily, this process does not mean that people who eat less candy are smarter!

Furthermore, Haier and colleagues found that cerebral efficiency increases as a result of learning in a relatively complex task involving visuospatial manipulations (such as in the computer game Tetris, which is a marvelous argument to use if someone ever accuses you of spending too much time playing videogames). As a result of practice, smarter people show not only lower cerebral glucose metabolism overall but also more specifically localized metabolism of glucose. In most areas of their brains, smarter persons show less glucose metabolism, but in selected areas of their brains (thought to be important to the task at hand), they show higher levels of glucose metabolism. Thus, more intelligent people may have learned how to use their brains more efficiently.

Although Haier was one of the first scientists who looked for the "brain signatures" underlying intelligence using modern techniques of neuroimaging, many researchers also have done so within the last decade. In a summary of the recent work on the neurobiology of intelligence that reviewed both PET ("Positron Emission Tomography") and functional Magnetic-Resonance Imaging (fMRI, a form of magnetic resonance imaging of the brain that registers blood flow to functioning areas of the brain), Jeremy Gray and Paul Thompson (2004) stated that intelligent behaviors are supported by the lateral prefrontal cortex, and possibly other areas (e.g., such as the anterior cingulate cortex). Although there is little certainty in "where" in the brain intelligence is located, there is no doubt in the fact that differences in brain structure and brain activity correlate with performance on tests of intelligence. Thus, intelligence is biologically grounded in the brain, at least to some degree.

Psychometric Theory

Psychometric approaches to intelligence are those linked to the psychological measurement of intelligence. Like other approaches, the psychometric approach also looks at individual differences among people. Psychometric researchers use complex statistical techniques such as factor analysis to discover common patterns of individual differences across tests. These patterns are then hypothesized to derive from underlying sources of individual differences, namely, mental abilities.

As a simple example of such a factor analysis, consider five tests of mental abilities: vocabulary, mathematical computation, general information, reading comprehension, and mathematical problem solving. Factor analysis would compute the degree of relationship (*correlation*) between each possible pair of the five tests. These correlations are expressed on a scale from –1 to 1, where –1 means a perfect inverse relationship between scores on two tests, 0 means no relationship between scores on two tests, and 1 means a perfect positive relationship between scores on the two tests. For example, we would expect people's ability to do addition and subtraction problems to have a high positive relation. By contrast, we would expect people's ability to do addition and to run quickly to have very little correlation. What factor analysis does is to cluster together those tests that tend to be more highly correlated. For example, factor analysis would probably group the vocabulary, general information, and reading comprehension tests in one cluster, and the mathematical computation and mathematical problem-solving tests in another. Thus, observable performance on the five tests would be reduced to performance on two hypothesized underlying factors of mental ability, namely, verbal ability and quantitative ability (i.e., mathematical and analytical ability). The idea in factor analysis, then, is to simplify a pattern of scores on a set of tests.

Factor analysis can be used for anything. If you are a baseball fan, imagine entering data about a player's stolen bases, singles, doubles, triples, home runs, and grounding-into-double plays (GIDP). You might guess that stolen bases, singles, triples, and fewer GIDP might be grouped together in a "speed" factor, and doubles and home runs might be grouped together in a "power" factor. Or imagine listing all of your favorite movies. Preferences for the comedies might be grouped together into one factor, action movies into another factor, and horror movies into a third factor.

Psychometric theory and research seem to have evolved along three interrelated but distinguishable lines. These traditions, which convey rather different impressions of what intelligence is, can be traced back to Sir Francis Galton, Alfred Binet, and Charles Spearman. We will spend a little more time on this theory than on some of the other theories because of the influence the psychometric tradition has had on intelligence testing.

The Tradition of Sir Francis Galton

The publication of Charles Darwin's *Origin of Species* (1859) had a profound impact on many lines of scientific endeavor, among them the investigation of human intelligence. Darwin's book suggested that the capabilities of humans were in some sense continuous with those of lower animals and, hence, could be understood through scientific investigation of the kind that had been conducted on animals. There was also the intriguing possibility that in intelligence, as in physical characteristics, the development of intelligence in humans over the life span might in some way resemble the development of intelligence from lower to higher species.

Darwin's cousin, Sir Francis Galton, was probably the first to explore the implications of Darwin's book for the study of intelligence. Galton was an interesting person who dabbled in many different areas (Gillham, 2001). He explored Africa with Dr. Livingstone. He invented both fingerprinting and a whistle (to call for his dog during their walks). He was an ardent meteorologist who discovered the "anticyclone" and created an early weather map. He was obsessed with numbers and measuring things – he once counted how many pretty women he saw in each city he visited (London finished first, a suspicious finding as he was himself a Londoner). Galton took his passion for measuring things and applied it to the field of intelligence.

Galton (1883) proposed two general qualities that distinguished the more gifted from the less gifted. The first was energy or the capacity for labor. The second was sensitivity to physical stimuli:

> The discriminative facility of idiots is curiously low; they hardly distinguish between heat and cold, and their sense of pain is so obtuse that some of the more idiotic seem hardly to know what it is. In their dull lives, such pain as can be excited in them may literally be accepted with a welcome surprise.

For seven years, between 1884 and 1890, Galton maintained an "anthropometric" laboratory at the South Kensington Museum in London where, for a small fee, visitors could have themselves measured on a variety of psychophysical tests, such as weight discrimination and pitch sensitivity.

James McKeen Cattell brought many of Galton's ideas from England to the United States. As head of the psychology laboratory at Columbia University, Cattell was in a good position to publicize the psychophysical approach to the theory and measurement of intelligence. Cattell (1890) proposed a series of fifty psychophysical tests, such as dynamometer pressure (greatest possible squeeze of the hand), rate of arm movement over a distance of fifty centimeters, and the distance on the skin by which two points need to be separated for them to be felt separately. Underlying each was the assumption that physical tests measure mental ability. For example, Cattell claimed, "The greatest squeeze of the hand may be thought by many to be a purely physiological quantity. It is, however, impossible to separate bodily from mental energy."

The *coup de grace* for the Galtonian tradition – at least in its earliest forms – was administered by one of Cattell's own students. Clark Wissler (1901) investigated twenty-one psychophysical tests. His line of approach was correlational, the idea being to show that the various tests are fairly highly correlated and, thus, define some common entity (intelligence) that underlies all of them. Wissler's results were disappointing, however. He found the tests generally to be unrelated, and he concluded that his results "would lead us to doubt the existence of such a thing as general ability."

There is a great deal of irony in Galton's downfall. First and foremost, Galton himself pioneered the correlational statistics used by Wissler. Second, Wissler's study would have never been accepted today – he had very few participants, and they were all students at Columbia. All students would presumably have at least a certain level of intelligence, so the correlations would undoubtedly have been lowered because of this restriction of range.

However, even with Galton's work on intelligence less widely accepted today than at some times in the past, psychologists did not give up hope of finding a construct of general intelligence (Sternberg & Grigorenko, 2002). An alternative approach was already leading to greater success.

The Tradition of Alfred Binet

In 1904, the French Minister of Public Instruction formed a commission to study or create tests that would ensure that mentally defective children received an adequate education. The commission decided that no child suspected of retardation should be placed in a special class for the retarded without first being given an examination "from which it could be certified that because of the state of its intelligence, he was unable to profit, in an average measure, from the instruction given in ordinary schools." Alfred Binet, in collaboration with his colleague, Theodore Simon, devised tests to meet this placement need. Thus, whereas Galton's theory and research grew out of pure scientific concerns, Binet's grew out of practical educational concerns.

At the time, definitions for various degrees of subnormal intelligence lacked both precision and standardization, and personality and intellectual deficits were seen as being of the same type. Binet and Simon (1916/1973) noted a case of one institutionalized child who seemed to be a victim of this state of confusion: "One child, called imbecile in the first certificate, is marked idiot in the second, feebleminded in the third, and degenerate in the fourth." However much people may complain about being "labeled" by IQ tests today, they should be thankful they do not have to deal with these types of labels! Can you imagine being a psychologist and having to tell a worried parent, "I'm afraid your son is simply an idiot"?

Binet and Simon's conception of intelligence and of how to measure it differed substantially from that of Galton and Cattell, whose tests they considered a waste of time. To Binet and Simon, the core of intelligence was good judgment. Binet cited the example of Helen Keller as someone of known extraordinary intelligence whose scores on psychophysical tests would be notably inferior but who could be expected to perform at a very high level on tests of judgment.

According to Binet and Simon, intelligent thought is composed of three distinct elements: direction, adaptation, and criticism. *Direction* consists of knowing what has to be done and how to do it. When we need to add two numbers, for example, we give ourselves a series of instructions on how to proceed, and these instructions form the direction of thought. *Adaptation* refers to the selection and monitoring of our strategy during the course of performance. In solving a problem, we often have many paths to solutions, some of which will lead to better solutions and others to worse. Adaptive people tend to select better strategies, and they monitor their progress along the way to make sure that the strategy is leading where they want to be going. *Criticism* (or *control*) is our ability to criticize our own thoughts and actions – to know not only when we are doing well, but to be able to recognize when we are doing poorly, and to change our behavior in such a wav as to improve our performance.

Because of his emphasis on test development, Binet has often been accused of being atheoretical (in other words, not being driven by theories) in his approach to intelligence. This discussion of Binet's views should make it clear that nothing could be further from the case. To the contrary, he and Simon conceived of intelligence in ways that were theoretically sophisticated and that resembled in content much of the most recent thinking regarding cognitive processing (Hunt, 2005). Whatever the distinction between Galton's thinking and Binet's, it was not (as some would have it) that Galton was theoretically motivated and Binet was not. If anything, Binet had a better developed theory of the nature of intelligence. Instead, these scientists differed in the way they selected items for the tests with which they proposed to measure intelligence. Galton's test items were chosen to measure psychophysical abilities, but Galton did not attempt to validate his items. Binet's test items were more cognitive in nature, in that they measured the kinds of reasoning and judgmental abilities that Binet considered to constitute intelligence (see Lohman, 2005). He also chose his items, however, to differentiate between performance of children of different ages or mental capacities as well as to correlate at a reasonably high level.

Most of Binet's measures were verbal (for example, "Use the words *Paris, gutter*, and *fortune* in a sentence"), and this format was retained when Lewis Terman brought his tests to America. Terman was a professor at Stanford, and called his English version of the test the "Stanford-Binet." Intelligence tests stayed primarily verbal until World War I, when a group of psychologists developed several clever non-verbal tests of mental ability. The goal was to be able to measure the intelligence of people who were illiterate, poorly literate, or who spoke English as a foreign language. It may seem obvious now why you might want to not only use verbal abilities as a construct, but it was new and different then. The time that it might take to administer one nonverbal problem (such as a matrix problem, in which you had to form an analogy between two sets of pictures) could be used to administer twenty different vocabulary items. But there were new problems during World War I. Most pressingly, verbal tests could not accurately measure the mental ability of the growing number of immigrants who spoke little or no English.

A modern version of the Stanford-Binet is still used today. In its fifth edition, the *Stanford-Binet Intelligence Scales* (SB5, Roid, 2003) constitute an individually administered intelligence test used to assess the cognitive abilities of individuals from age two to adult. The latest edition is divided into Verbal and Nonverbal scales, and provides measurement of five separate aspects of intelligence such as Knowledge, Visual-Spatial Reasoning, and Working Memory. Typical tasks include pointing out absurd mistakes in a picture; remembering the last word from a series of questions; being able to create different designs from a form board; and a variation of the classic "shell game," in which a ball in placed under a cup, the cup is moved back-and-forth among other cups, and the person must then pick the cup holding the ball (Roid & Barram, 2004).

Although Binet was the first to invent an intelligence test that resembles modern tests, his test is not the most popular test. That distinction belongs to David Wechsler, one of the psychologists who helped out during World War I. Wechsler's (1997, 2003) intelligence tests for both children and adults are by far the most commonly used IQ tests (Flanagan & Kaufman, 2004). The Wechsler scales are based on Wechsler's notion of intelligence as "the overall capacity of an individual to understand and cope with the world around him" (Wechsler, 1958). Wechsler conceived of intelligence as a global entity in which no one particular ability is of crucial or overwhelming importance. First and foremost, however, Wechsler cared about the person, and believed that intelligence tests were most meaningful if they were interpreted in the context of the individual's personality. He developed his tests primarily to facilitate the clinical assessment of children, adolescents, and adults (Kaufman, 2000).

The Wechsler Intelligence Scales, starting with the Wechsler-Bellevue in 1939, have traditionally been divided into two sections, a Verbal Scale and a Performance (or nonverbal) Scale. They have typically yielded separate standard scores (known as Intelligence Quotients, or IQs) for each part, as well as a global score for the two parts combined.

The most recent version of the Wechsler scales – the Wechsler Intelligence Scale for Children: Fourth Edition (WISC-IV; Wechsler, 2003) – has retained the global IQ, but has abandoned the separate Verbal and Performance IQs in favor of scores in four separate aspects of mental ability: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. Like the Stanford-Binet, Wechsler's tests must be individually administered and consist only of those items appropriate to the age and ability of the subjects being tested. Examinees begin with items easier than those appropriate for their age and end with items difficult enough to result in repeated failure of solution. Also like the most recent edition of the Stanford-Binet (SB5), the WISC-IV has deemphasized global IQs in favor of an array of separate cognitive abilities.

The Verbal parts of the Wechsler tests, past and present, include subtests such as Information, which requires the demonstration of knowledge about the world; Similarities, which requires an indication of how two different objects are alike; and Comprehension, which requires the demonstration of common-sense understanding of social situations. Arithmetic, which requires the solution of arithmetic word problems, has traditionally been included on Wechsler's verbal scales. More recently, however, Arithmetic and tests of short-term memory are included on a separate Working Memory scale.

The Performance part of the test includes subtests such as Picture Completion, which requires recognition of a missing part in a picture of an object; Picture Arrangement, which requires rearrangement of a scrambled set of pictures into an order that tells a coherent story from beginning to end; and Block Design, which requires individuals to reproduce a picture of a design, constructed from a set of red, white, and half-red/half-white blocks, by actually building the design with physical blocks. Digit Symbol (called Coding on Wechsler's children's scales) requires the rapid copying of abstract symbols that are paired with numbers. Although this highly speeded subtest traditionally has been associated with Wechsler's Performance Scale in the past, it is included on the Processing Speed scale in more recent editions of Wechsler's tests.

In sum, the tradition of Alfred Binet involves testing higher-order cognitive skills in order to assess a person's intelligence. Binet and Wechsler were extremely broad in their conceptualizations of intelligence, and their notions are quite compatible with the conception of intelligence that motivates this book. Unfortunately, the tests are somewhat narrower than the conceptions of intelligence that generated them, so that the scores derived from the tests reflect not so much the originators' conceptions of intelligence as a set of higher-order cognitive skills that are used in a variety of academic, and to some extent, other tasks.

Whereas Binet and Wechsler were concerned with theories behind intelligent behavior, their tests were decidedly built on either practical (Binet) or clinical (Wechsler) considerations, and that practical-clinical framework guided test development for seventy-five years. However, new intelligence tests developed during the past twenty years (including the fifth edition of the Stanford-Binet) have been built from theories of intelligence. Even the newest Wechsler test, the WISC-IV, has clear-cut ties to theory (Flanagan & Kaufman, 2004). Indeed, it would be hard for a new or revised test *not* based even loosely on any theory to be competitive.

The Tradition of Charles Spearman

According to Charles Spearman (1927), originator of the factorial tradition, there are two kinds of factors in human intelligence: a general factor, which pervades all intellectual performances; and a set of specific factors, each of which is relevant to just one particular task. Spearman's belief that a single factor of intelligence was responsible for whatever was common in intellectual performance across tasks constituted what he believed to be a law of the "universal unity of the intellective function." This view is still widely held (Brand, 1996; Jensen, 1998, 2006).

What was the actual psychological mechanism that gave rise to such a unity of intellective function-to what Spearman referred to as the *g* (general) factor? Spearman considered a number of possible explanations, such as attention, will, plasticity of the nervous system, and the state of the blood, but he finally settled on an explanation in terms of mental energy. According to Spearman, the concept of mental energy originated with Aristotle, who defined energy as any actual manifestation of change. For Spearman, the energy was only a latent potential for such change. Thus, for Spearman but not for Aristotle, energy could be an entirely mental construct.

Subsequent Psychometric Theories

Louis Thurstone (1938) proposed a theory that tentatively identified seven primary mental abilities, which were identified through factor analysis. The mental abilities were verbal comprehension, quantitative ability, memory, perceptual speed, space, verbal fluency, and inductive reasoning. These primary mental abilities were later used as a basis for the formulation of the Primary Mental Abilities Tests. As it happened, scores on factors representing the primary mental abilities are almost always correlated with each other. If the scores on these factors are themselves factor analyzed (in much the same way that task or test scores would be), a higher-order general factor emerges from the analysis. Before his death, Thurstone found himself with little choice but to concede the existence of a general factor. Not surprisingly, he believed this general factor to be of little importance. Similarly, Spearman was eventually forced to concede the existence of group factors such as those identified by Thurstone. But Spearman believed that these group factors were of little importance.

J. P. Guilford proposed an extension of Thurstone's theory that incorporates Thurstone's factors while adding many others. He split the primary mental abilities and added new ones, so that the total number of factors is increased from 7 to 120. Guilford (1967) wrote that every mental task requires three elements: an operation, a content, and a product. Guilford pictured the relation among these three elements as that of a cube, with each of the elements-operations, contents, and products-representing a dimension of the cube. There are five kinds of operations: cognition, memory, divergent production, convergent production, and evaluation. There are six kinds of products: units, classes, relations, systems, transformations, and implications. Finally, there are four kinds of contents: figural, symbolic, semantic, and behavioral. Because the subcategories are independently defined, they can be multiplied, yielding 120 ($5 \times 6 \times 4$) different mental abilities. Each of these 120 abilities is represented by Guilford as a small cube embedded in the larger cube. Guilford and his associates devised tests measuring many of these abilities. Cognition of figural relations, for example, is measured by tests such as figural analogies. Memory for semantic relations is measured by presenting subjects with series of relations, such as "Gold is more valuable than iron," and then testing the subjects' retention of these relations using a multiple-choice test.

Theorists of intelligence such as Philip Vernon have proposed hierarchical models of mental ability. Vernon (1971) proposed a hierarchy with general intelligence at the top, verbal-educational and practical-mechanical abilities at the second level, and more specific abilities at lower levels. A more detailed hierarchical model, based on a reanalysis of many data sets from factor-analytic studies, has been proposed by John Carroll (1993). At the top of the hierarchy is general ability; in the middle of the hierarchy are various broad abilities (including learning and memory processes and the effortless production of many ideas). At the bottom of the hierarchy are many narrow, specific abilities such as spelling ability and reasoning speed.

Another similar theory is the Cattell-Horn theory of intelligence (Horn & Cattell, 1966), often referred to as Gf-Gc theory. The Cattell-Horn theory initially proposed two types of intelligence, crystallized (Gc) and fluid (Gf). Gc is what a person knows and has learned, while Gf is how a person handles a new and different situation (i.e., problem solving). Horn expanded the theory to include more dimensions (known as Broad Abilities), such as visualization (Gv), short-term memory (Gsm), long-term retrieval (Glr), and processing speed (Gs) (Horn, 1985; Horn & Hofer, 1992; Horn & Noll, 1997). In recent years, Carroll's hierarchical theory and the Horn-Cattell Gf-Gc theory have been merged into the Cattell-Horn-Carroll or CHC theory (Flanagan, McGrew, & Ortiz, 2000; Flanagan & Ortiz, 2002). The CHC theory has been particularly influential in the development of recent IQ tests, most notably the fifth edition of the Stanford-Binet (Roid, 2003), the Kaufman Assessment Battery for Children – Second Edition (KABC-II; Kaufman & Kaufman, 2004), and the Woodcock-Johnson – Third Edition (WJ-III; Woodcock, McGrew, & Mather, 2001).

The CHC model incorporates both the concept of a general intelligence (all of the different aspects of intelligence are considered to be related to a common "*g*," although this aspect is not often emphasized; see Flanagan & Ortiz, 2002) and the concept of many different aspects of intelligence. Largely because of the influence of CHC theory, all current IQ tests (including the SB5 and WISC-IV) have shifted the historical focus from a small number of part scores to a contemporary emphasis on anywhere from four to seven cognitive abilities. The debate about which is "better," one intelligence versus many aspects of intelligence, still goes on (for a review, see Sternberg & Grigorenko, 2002).

What seems to be missing from most factorial theories of intelligence is any clear notion of the processes involved in intelligence. Jean Piaget's theory sought to specify such processes, as did cognitive theories of intelligence, which will be considered in a later section.

Piaget's Theory

Jean Piaget, a Swiss psychologist, first entered the field of intellectual development when, working in Binet's laboratory, he became intrigued with children's wrong answers to Binet's intelligence test items. To understand intelligence, Piaget reasoned, the investigation must be twofold. First, as was done by Binet, we must look at a person's performance. But also, and here is where Piaget began to part company with Binet, we must consider why the person performs as he or she does, taking account of the cognitive structure underlying the individual's actions. Through his repeated observation of children's performance and particularly of their errors in reasoning, Piaget concluded that there are coherent logical structures underlying children's thought but that these structures are different from those underlying adult thought. In the six decades that followed, Piaget focused his research on defining these cognitive structures at different stages of development and how these structures might evolve from one stage to the next.

Piaget believed that there were two interrelated aspects of intelligence: its function and its structure. A biologist by training, he saw the function of intelligence to be the same as other biological activities – adaptation. According to Piaget (1972), adaptation includes assimilating the environment to one's own structures (whether physiological or cognitive) and accommodating one's mental structures (again either physiological or cognitive) to include new aspects of the environment. According to Piaget, "A certain continuity exists . . . between intelligence and the purely biological process of morphogenesis and adaptation to the environment."

In Piaget's theory, the function of intelligence-adaptation provides continuity with lower biological acts: Piaget believed intelligence to be a system of operations for translating thinking into action.

Piaget rejected the sharp separation proposed by some between intelligent acts, on the one hand, and habits or reflexes, on the other. Instead, he preferred to speak of a continuum in which "behavior becomes more intelligent as the pathways between the subject and the object on which it acts cease to be simple and become progressively more complex."

Piaget further proposed that the internal organizational structure of intelligence and the way intelligence is manifested differ with age. It is obvious that an adult does not deal with the world in the same way as an infant. Indeed, most infants would have skipped this paragraph already: They could not have read it!

The infant typically acts on its environment via sensorimotor structures and as a result is limited to the apparent physical world. The adult, by contrast, is capable of abstract thinking and is thus free to explore the world of possibility. Guided by his interest in the philosophy of knowledge and his observation of children's behavior, Piaget divided the intellectual development of the individual into distinct stages. As the child progresses from one stage to the next, the cognitive structures of the preceding stage are reorganized and extended, through the child's own adaptive actions, to form the underlying structures of the next stage.

Piaget's description of the child's intellectual development depends on three core assumptions about the nature of this developmental process. First, four factors interact to bring about the development of the child. Three of these factors are the ones usually proposed: maturation, experience of the physical environment, and the influence of the social environment. To these three factors, however, Piaget added a fourth, which coordinates and guides the other three: equilibration, that is, the child's own self-regulatory processes. Thus, Piaget's theory centers on the idea that children are active participants in the construction of their own intelligence.

Piaget's second assumption is that this intellectual development results in the appearance of developmental stages that follow an invariable sequential order. Each succeeding stage includes and extends the accomplishments of the preceding stage. Third, although the rate of development may vary across children, Piaget considered the stages themselves and their sequence to be universal.

In sum, Piaget's theory argued for is a single path of intellectual development that all people follow, regardless of how quickly they develop. Notice that Piaget, unlike psychometric theorists, did not rely on individual differences in forming his theory.

Cognitive-Processing Theories

Cognitive-processing conceptions of intelligence seek to understand the ways in which people mentally represent and process information (Pretz & Sternberg, 2005). Cognitive-processing researchers use computer simulations and mathematical models to find patterns of data that suggest strategies of cognitive processing (Sternberg & Pretz, 2005).

Cognitive research has often used the computer program as a metaphor for understanding how humans process information. The major distinguishing feature of the approach, however, is not its reliance on computer concepts, but, rather, its concern with how information is processed during the performance of various kinds of tasks.

Perhaps surprisingly, one psychologist interested in information processing was Charles Spearman, who (as we mentioned) was one of the founders of psychometrics. Spearman might also have been one of the most influential figures in popularizing the cognitive tradition, had the time been right. The time apparently was not right, however. Whereas Spearman's 1904 psychometric theory and methodology were eagerly adopted by workers in the laboratory and in the field, Spearman's later cognitive theories were not. One reason why they were not well accepted may have been that there was not adequate equipment; people in the 1920s could not surf the Internet or run computer programs. Spearman (1923) proposed three principles of cognition (which he might as easily have called *processes* of cognition) that he described using an example of someone solving an analogy. The first principle, apprehension of experience, states that "any lived experience tends to evoke immediately a knowing of its characters and experiencer." In an analogy, such as LAWYER is to CLIENT as DOCTOR is to ____, apprehension of experience would correspond to the encoding of each analogy term, in which the problem solver perceives each word and understands its meaning.

The second principle, eduction of relations, states "the mentally presenting of two or more characters (simple or complex) tends to evoke immediately a knowing relation between them." In the sample analogy, eduction of relations would correspond to understanding the relation between LAWYER and CLIENT (a lawyer provides professional services to a client). The third principle, eduction of correlates, states “the presenting of any character together with any relation tends to evoke immediately a knowing of the correlative character.” In the sample analogy, eduction of correlates would correspond to the application of the rule previously inferred to generate an acceptable completion to the analogy: PATIENT.

Almost forty years later, two works appeared that revived the cognitive approach. One was by Newell, Shaw, and Simon (1958), the other by Miller, Galanter, and Pribram (1960). The goal of both programs of research was, as Miller and his colleagues put it, “to discover whether the cybernetic [computer-based] ideas have any relevance to psychology.” Both groups concluded that they did have relevance and, moreover, that the computer could be a highly useful tool in developing psychological theories. Miller and his collaborators sought to understand human behavior in terms of “plans,” that is, “any hierarchical process in the argument that can control the order in which a sequence of operations is to be performed.” Critical for the cognitive approach was the authors’ view that “a plan is, for an organism, essentially the same as a program for a computer.” The authors acknowledged that this relationship was not proven, however:

The reduction of plans to nothing but programs is still a scientific hypothesis and is still in need of further validation. For the present, therefore, it should be less confusing if we regard a computer program that simulates certain features of an organism’s behavior as a theory about the organismic plan that generated the behavior.

The computer simulation method allowed cognitive psychologists to test theories of human information processing by comparing predictions generated by computer simulation to actual data collected from human subjects. In computer simulations, the researcher attempts to get the computer to mimic the cognitive processes that would be used by humans, if they were solving the problem at hand. If you have ever played any video game in which you play (or battle) against the computer, then you have experienced these types of simulations. The computer’s artificial intelligence tries to create an opponent that is talented enough to challenge you. Playing a game like Rise of Nations or Warcraft simply would not be fun if the opposing soldiers did not try to fight you back! Indeed, many computer games may look good and have interesting concepts – but if they are too easy or too hard, they will not be a success.

Whereas many psychometric theorists of intelligence have agreed that the factor is the fundamental unit of intellectual behavior, many cognitive theorists have agreed that the information-processing component, as it is sometimes called, is the fundamental unit. Cognitive theorists assume that all behavior of the human information-processing system is the result of combinations of elementary processes, although they have disagreed as to exactly which processes are most important to understanding intelligence. Consider just a few of the theories that have been proposed about how information processing is related to intelligence, and also consider how they have been tested.

A primary difference among cognitive theorists is in the level of cognitive functioning they emphasize in attempting to understand intelligence. At one extreme are those who have proposed to understand intelligence in terms of sheer speed of information processing, and who have used very simple tasks to measure pure speed uncontaminated by other variables. At the other extreme are those who have studied very complex forms of problem solving and are less interested in speediness.

Pure Speed

People who believe that individual differences in intelligence can be traced back to sheer speed of information processing have tended to use simple reaction time and related tasks (Neubauer & Fink, 2005). In a simple *reaction-time* paradigm, the individual is required simply to make a single response as quickly as possible following the presentation of a stimulus. For example, we might tell you to press the space bar on your keyboard whenever a picture of a frog showed up. Then we might show you a penguin, a fish, a frog, a giraffe, a frog, and an aardvark. Your reaction time would be measured by how quickly you hit the space bar after the frog was shown each time.

This paradigm has been widely used since the days of Galton as a measure of intelligence. Despite such early support, the levels of correlation obtained between measures of simple reaction time and various standard measures of intelligence have been weak. There seems to be much more to intelligence than pure speed.

Inspection Time

Ian Deary and Laura Stough (1996; for review, see also Deary, 2000a) have proposed that a very low-level psychophysical measure, inspection time, may provide us with insights into the fundamental nature of intelligence (see also Deary, 2000b). The basic idea is that individual differences in intelligence may come from differences in how we process very simple stimulus information. In the inspection-time task, a person looks at two vertical lines of different lengths, and simply has to say which line is longer. Inspection time is the amount of time someone needs, on average, in order to correctly discriminate which of two lines is longer (such as 0.4 seconds). Investigators have found that more intelligent individuals can take less time to pick the longer line. The actual measurement of inspection time is not by reaction time, but by presenting the pair of lines for different amounts of time, with the score taken from the time it takes for someone to earn a certain percentage score of correct comparisons.

Choice Speed

A slight complication of the above view is that intelligence derives not from simple speed of processing, but rather from speed in making choices or decisions to simple stimuli. In a typical *choice reaction-time* paradigm, the individual is presented with one of two or more possible stimuli, each requiring a different response. The individual has to choose the correct response as rapidly as possible following stimulus presentation. Correlations with psychometric measures of intelligence have been higher than those obtained for simple reaction time, but they are still relatively weak.

An interesting finding in the research of Jensen (2006) and others is that the correlation between choice reaction time and IQ tends to increase with the number of stimulus-response choices involved in the task. In other words, the more choices a person has to make (and, therefore, the more complex the task), the more the test scores correlate with measured intelligence.

Speed of Access

Individual differences in intelligence are believed to be related to neural efficiency and speed of information processing (Grabner, Neubauer, & Stern, 2006; Neubauer & Fink, 2005). In 1978, Earl Hunt proposed that individual differences in verbal intelligence may be understandable largely in terms of differences in *speed of access* to verbal information stored in long-term memory. According to Hunt, the more quickly people can access information, the better they can use their time with presented information, hence, the better they can perform on a variety of verbal tasks. Hunt, Lunneborg and Lewis (1975) initiated a paradigm for testing this theory that makes use of a letter-comparison task previously used by two psychologists, Posner and Mitchell (1967), in some of their research.

In this paradigm, subjects are presented with pairs of letters – such as AA, Aa, or Ab – that may be the same or different either physically or in name. For example, AA are the same both physically and in name; Aa are the same in name only; and Ab are the same neither in name nor in physical appearance. No pair of letters, of course, could be the same physically but not the same in name. The task is to indicate as rapidly as possible whether the two pairs are a match.

In one condition, people respond to whether the pairs are a *physical* match; in another, the same subjects respond to whether the letters are a *name* match. What is measured is each person's average name-match time minus physical-match time. This measure is considered to be an index of the time it takes a person to access verbal information in long-term memory. The physical-match time represents a person's sheer speed of responding; it takes little mental effort to see if two things look alike. Subtracting this time from the name-match time creates a relatively pure measure of access time. For example, someone may consistently take 0.1 second to respond to whether two pairs are a physical match, and 0.9 seconds to respond to whether the two pairs are a name match. We could then calculate that the person spent 0.8 seconds on accessing the information. In contrast to those who study simple reaction time and focus on sheer speed of responding, Hunt and his colleagues do what they can to subtract out this element.

The letter-comparison task is consistently correlated with verbal IQ at weak to moderate levels. So although it does appear to be related at some level to intellectual performance at some level, it is at best only one part of what standard psychometric intelligence tests measure.

Working Memory

Recent work suggests that a critical component of intelligence may be working memory. Indeed, some investigators have argued that intelligence may be little more than working memory (Kyllonen, 2002; Kyllonen & Christal, 1990). In one study, participants read sets of passages and, after they had read the passages, try to remember the last word of each passage (Daneman & Carpenter, 1983). Recall was highly correlated with verbal ability. In another study, participants perform a variety of working-memory tasks. In one task, for example, the participants saw a set of simple arithmetic problems, each of which was followed by a word or a digit (Engle, 1994; Engle, Carullo, & Collins, 1992; Hambrick & Engle, 2005). The participants saw sets of two to six such problems and solved each one. After solving the problems in the set, they tried to recall the words that followed the problems. The number of words recalled was highly correlated with measured intelligence. Thus, it appears that the ability to store and manipulate information in working memory may be an important aspect of intelligence. It is probably not all there is to intelligence, however.

Components of Reasoning and Problem Solving

A number of investigators have emphasized the kinds of higher-order processing involved in reasoning and problem solving in their attempts to understand intelligence, among them Robert Glaser, James Pellegrino, Herbert Simon, and Robert Sternberg (see Cianciolo & Sternberg, 2004; Lohman, 2000). Following in the tradition of Spearman's three principles of cognition, these investigators have sought to understand individual differences in intelligence in terms of information processing in tasks such as analogies, series completions, and syllogisms. Some investigators seek to understand intelligence in terms of information processes, or *components*, by discovering the processes people use in problem solving from the moment they first see a problem to the time they respond. Consider, for example, the widely studied analogy item, such as CHICKEN is to EGG as DOG is to ____. In a typical theory of analogical reasoning, completing this item is broken down into component processes such as *inferring* the relation between the first two terms of the analogy (a CHICKEN produces an EGG) and *applying* this inferred relation to the second half of the analogy (a DOG produces . . . a PUPPY). The basic idea is that someone's skill in solving these problems derives from the ability to execute these processes. Moreover, the processes involved in analogy solution have been shown to be quite general across many different kinds of problems. The components of information processing are of interest because they are not task-specific. If these components only worked in solving analogies, they would be of much less interest.

Investigators seeking to understand intelligence in terms of executive processes study the ways in which people plan, monitor, and evaluate their performance in reasoning and problem solving. The idea in this approach is not just to look at what individuals do in solving problems but also to look also at why and how they decide to do what they actually do.

Investigators using reasoning and problem-solving items have generally obtained higher correlations between scores on their tasks and psychometrically measured IQ scores than investigators who use some of the other approaches discussed above. Typically, correlations have been moderate to high.

Cultural and Contextual Models

We have seen how psychometric, computational, and biological psychologists view intelligence as something basically residing inside the head. In contrast, contextualist theorists talk about a psychological phenomenon (e.g., intelligence) largely in terms of the context in which someone is observed and suggest that the phenomenon cannot be understood – let alone measured – outside the real-world context of the individual (Serpell, 2000; Sternberg, 2004a, 2004b, 2007a; Sternberg & Grigorenko, 2004; Suzuki & Valencia, 1997). These theorists study how intelligence relates to the external world. In fact, they view intelligence as so inextricably linked to culture that they believe intelligence to be something that a culture creates (Sternberg, 2004a). The purpose of this creation is to define the nature of adaptive performance and to account for why some people perform better than others on the tasks that the culture happens to value (see Suzuki & Valencia, 1997).

Multiple Intelligences

Howard Gardner (1983, 1993, 1999, 2006) does not view intelligence as just a single, unitary construct. However, instead of speaking of the many different abilities that together make up intelligence, as have some other theorists, Gardner has proposed a theory of multiple intelligences, in which eight distinct intelligences function somewhat independently of one another, but may interact to produce intelligent behavior: linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal (dealing with other people), intrapersonal (dealing with oneself), and naturalist. Gardner (1999, 2006) has also speculated on the possible existence of existential and spiritual intelligences. Each intelligence is a separate system of functioning, although these systems can interact to produce what we see as intelligent performance.

For example, a playwright might rely heavily on linguistic intelligence but might use logical-mathematical intelligence in plotting story lines or checking through their stories for inconsistencies. Indeed, one of the authors of this book once wrote a play in which a character says that he hates the fact that the college class he is attending at the moment takes place at night; two pages later, another character comments at how beautiful the sun in the sky is. It was quite embarrassing when someone (who likely had higher logical-mathematical intelligence) pointed out the inconsistency! Measuring these intelligences separately might give schools and individuals a profile of a range of skills that is broader than would be obtained, say, from just measuring verbal and mathematical abilities. This profile could then be used to facilitate educational and career decisions.

In order to identify these particular intelligences, Gardner has used converging operations, gathering evidence from multiple sources and types of data. The base of evidence used by Gardner includes (but is not limited to) the distinctive effects of localized brain damage on specific kinds of intelligences, distinctive patterns of development in each kind of intelligence across the life span, evidence from exceptional individuals (from both ends of the spectrum), and evolutionary history.

Gardner's view of the mind is modular. Modularity theorists believe that different abilities – such as Gardner's intelligences – can be isolated as coming from distinct parts of the brain. Thus, a major task of existing and future research on intelligence would be to isolate the portions of the brain responsible for each of the intelligences. Gardner has speculated as to at least some of these relevant portions, but hard evidence for the existence of the separate intelligences (or any measures that could be used in any type of practical way) has yet to be produced.

Instrumental Enrichment

Another approach to intelligence is to focus on whether and how it can be trained and improved. Instrumental Enrichment (IE), Reuven Feuerstein's well-known training program (1980), was originally designed for children with mental retardation, but it has since been recognized by Feuerstein and others as valuable for a wide variety of students. Based on Feuerstein's theory of intelligence, the IE program is intended to improve the cognitive functioning related to the input, elaboration, and output of information. The idea is that mediation of experience by parents and other caregivers can enhance intellectual functioning (Mintzker, Feuerstein, & Feuerstein, 2006). Feuerstein has compiled a long list of cognitive deficiencies he believes his program can help to correct. Among them are (a) unplanned, impulsive, and unsystematic exploratory behavior; (b) lacking the ability to consider two sources of information at once, so that the child deals with data in a scattered way rather than grouping and organizing facts; and (c) not being able to experience the existence of an actual problem and subsequently define it. Feuerstein's IE program is designed to correct these deficiencies and, at the same time, to increase the student's motivation and feelings of self-worth.

What are some of the characteristics of the Feuerstein program? Instrumental Enrichment does not attempt to teach either specific items of information or abstract thinking through a well-defined, structured knowledge base. To the contrary, it is as content-free as possible. Its materials or "instruments" each emphasize a particular cognitive function and its relationships to various cognitive deficiencies. Feuerstein sees the student's performance on the materials as a means to an end, rather than as an end in itself. Emphasis in analyzing IE performance is on processes rather than on products, so that the student's errors are viewed as a means of insight into how the student solves problems.

The IE program consists of thirteen different types of exercises, which are repeated in cycles throughout the program. Although the problems are abstract and "unworldly," instructors are required to bridge the gap between them and the real world as much as possible. The following samples of the kinds of materials in the program convey a sense of the types of activities in which students engage:

1. *Orientation of dots*. The student is presented with a variety of two-dimensional arrays of dots and is asked to identify and outline, within each array, a set of geometric figures, such as squares, triangles, diamonds, and stars.
2. *Numerical progressions*. In one kind of numerical progression problem, the student is given the first number in a sequence and a rule by which the sequence can be continued, for example, +3, –1. The student then has to generate the continuation of the sequence.

We not only can but we should teach intelligence. Programs are now available that do an excellent, if incomplete, job of improving intellectual skills, but the vast majority of students are not now being exposed to these programs. Indeed, the heavy content of traditional curricula barely allows room for such training. For this reason many scholars believe the time has come to supplement standard curricula with training in intellectual skills. Intelligence should still be tested, but we believe there also should be an emphasis on developing and nurturing intelligence.

Summing Up

To sum up, the various theoretical approaches seem, on the surface, to be quite different. Biological approaches seek to understand intelligence by linking it to specific brain regions or patterns of their activation. Psychometric researchers seek to understand the structure of the mental abilities that constitute intelligence. Piaget sought to understand the stages in the development of intelligence. Cognitive researchers seek to understand the processes of intelligence. Multiple intelligences theory proposes eight distinct intelligences. Instrumental Enrichment seeks to nurture and improve intellectual abilities.

When we look at them in this way, we see that the approaches are not wholly mutually incompatible – they do not so much give different answers to the same questions as they give different answers to different questions. For example, the psychometric researchers emphasize structural models, whereas the cognitive researchers emphasize process models. In fact, the two kinds of models are complementary to each other. The factors of intelligence can be understood in terms of processes that enter into them. So, for example, if one has a factor of verbal ability, it is legitimate to ask what processes are responsible for individual differences in verbal ability. Or we might ask if certain processes tend to go together in intelligent performance in human beings. Factor analysis addresses this question. It conveniently organizes the processes of human intelligence into constellations of higher-order mental abilities. We need to understand intelligence from all these points of view. Which approach an investigator decides to take will be a function of the investigator's theoretical and methodological predispositions, as well as of the particular questions about intelligence that are of the most interest.

The theory presented in this book draws on all these approaches, and others, as well, although it is probably most heavily influenced by the cognitive approach. However, it is not enough just to look at cognitive processing. To understand intelligence fully, we also need to understand how these cognitive processes operate in everyday life. In many respects, the theory of intelligence in this book is more comprehensive than most of the theories discussed in this chapter. As you learn about the theory, you will see how it operates as you solve intellectual games and puzzles that illustrate various aspects of the theory and that may help you to sharpen your thinking skills.

2

The Theory of Successful Human Intelligence

The theory of successful human intelligence presented in this book provides a broader basis for understanding intelligence than do many (and perhaps most) of the theories considered in Chapter 1 . The theory consists of three parts (and, therefore, is also called the "triarchic theory"). The first part considers intelligence as what goes on inside of someone – an internal world, so to speak. These "internal" abilities (or "mental mechanisms") can lead to more intelligent or less intelligent behavior (Sternberg, 1997; Sternberg, 1999b; Sternberg, 2003; Sternberg, 2006). There are three kinds of mental processes that are important in planning what things to do, learning how to do the things, and actually doing them.

The second part of the theory examines a person's experience in handling a task or dealing with a situation. There are certain points in the performance of a task in which a person's intelligence has a critical role. In particular, this part of the theory emphasizes dealing with novelty and how mental processing in intelligence sometimes can be made automatic.

The third part of the theory relates intelligence to the external world of the individual, and specifies three kinds of acts – environmental adaptation, environmental selection, and environmental shaping – that characterize intelligent behavior in the everyday world. This part of the theory emphasizes the role of the environment in determining what constitutes intelligent behavior in a given setting.

The first part of the theory, which specifies the mental mechanisms of intelligent behavior, is universal. Individuals may differ in what mental mechanisms they apply to a given task or situation. However, the potential set of mental mechanisms underlying intelligence is claimed to be the same across all individuals, social classes, and cultural groups. For example, people in every culture have to first identify what problems they need to solve (defining problems), and then develop strategies to solve these problems. The fact that some cultures may be defining problems related to farming and others may be defining problems related to selling merchandise online does not matter (Sternberg, 2004a; Sternberg, 2004b).

The portion of the theory dealing with relative novelty (how new something is to you) and automatization of information processing (how quickly you can begin to do something without thinking about it, such as brushing your teeth). Part of being intelligent is figuring out how to cope with relatively new tasks and situations. An example is learning to drive a stick-shift car when you already know how to drive an automatic, or the first time you went to a party where you did not know anyone there. Similarly, people in all cultures have to learn to automatize some of their behavior. For example, what first is relatively novel – driving a stick shift – may soon become automatic as one drives the stick shift without even consciously thinking about it. In other words, driving something other than an automatic may *become* automatic!

This part of the theory is universal in the relationship between relative novelty and how quickly these new-to-you activities can be automatized. It is also relative, however, in that the things that are new and different will change across cultures, groups, and societies. In other words, a task that is quite familiar to urban Americans might be quite unfamiliar to rural Africans, or vice versa (Sternberg, 2004a; Sternberg, 2004b). An average urban American might be able to find a beanie baby on eBay, make a bid, and then pay for the toy with PayPal – and consider this task ordinary and everyday. At the same time, a rural African might know how effectively and effortlessly to hunt various kinds of game that an urban American would have no clue about how to catch.

The third part of the theory is concerned with adaptation to existing environments (changing yourself to fit into the environment), shaping of existing environments into new environments (changing the environment to fit yourself), and selection of new environments (finding a new environment after an old one is a bad fit to your needs, desires, and skills). For example, let's say that you have decided to major in psychology. But you then discover that your psychology department is different then you expected and not as interesting to you as you hoped. You would need to adjust to this new reality – that is, get used to the fact that the department emphasizes things that you find boring. You could then adapt to this existing environment. Next, you might try to shape the environment – maybe you might try to see if you could take courses in related departments (such as Sociology) to fulfill courses for your major. Finally, you could select a new environment – change your major or switch universities.

This part of the theory, like the second part, is also both universal and particular. It is universal with respect to the importance of environmental adaptation, selection, and shaping to survival. It is relative with respect to which behaviors constitute environmental adaptation, selection, and shaping. For example, what is adaptive in one country might not be particularly adaptive in another – and might be grossly maladaptive in a third. Talking about one's political opinions freely, for example, might lead to rewards in one country and to death in another. The definitions of appropriate behavior can very widely from one environment to another.

In short, then, parts of the theory of successful intelligence are culturally universal, and parts are culturally relative. When people ask whether intelligence is the same thing from one culture to another or even from one individual to another, they are asking too simplistic a question. The most complex but appropriate question is, "What aspects of intelligence are universal and what aspects of intelligence are relative with respect to individuals and groups?" This theory addresses and attempts to answer this question.

COMPONENTS OF INTELLIGENCE

The first part of the theory of successful intelligence specifies the internal mental mechanisms that are responsible for intelligent behavior. These mental mechanisms are referred to as information-processing components. *A component* is a mental process. It may translate a sensory input (i.e., something you see or hear) into a mental representation (an image or thought in your mind). It also may transform one mental representation into another, such as when you go from one thought to another. Finally, a component may translate a mental representation into a motor output. For example, you may have the thought that you want to go and eat a mango. Then you can take that thought and physically stand up and walk to the refrigerator (where, most likely, you will be disappointed and not find a mango) (Sternberg, 1977).

Components perform three basic kinds of functions: *Metacomponents* are higher-order processes used in planning, monitoring, and evaluating performance of a task. *Performance components* are processes used in actually doing the task. *Knowledge-acquisition components* are processes used in learning new things (Sternberg, 1985). For example, metacomponents might be used to decide on a topic for a term paper. Performance components might be used to do the actual writing. And knowledge-acquisition components might be used to learn the information about which one will write. It is essential to understand the nature of these components, because they form the mental bases for the other parts of the theory. As mentioned earlier, these are components for dealing with novel kinds of tasks and situations, automatizing performance, and adapting to, shaping, and selecting environments.

Metacomponents

The *metacomponents* are "executive" processes, in that they essentially tell the other kinds of components what to do. They also receive feedback from the other kinds of components as to how things are going in problem solving or task performance. They are responsible for figuring out how to do a particular task or set of tasks, and then for making sure that the task or tasks are done correctly.

The theory of successful intelligence strongly emphasizes the role of metacomponents in intelligence. Consider an example of why these components are so important.

The assumption that "smart is fast" permeates North American society. Interestingly, this assumption is by no means universal. For example, it is not prevalent in most parts of South America. When North Americans call someone as "quick," it's a compliment – they are describing someone as having an attribute that they consider to be associated with an intelligent person. The pervasiveness of this assumption can be seen in a recent study of people's conceptions of intelligence, in which Americans were asked to list behaviors characteristic of intelligent persons (Sternberg et al., 1981). Answers such as "learns rapidly" "acts quickly," "talks quickly," and "makes judgments quickly," were common. It is not only the average person who believes that speed is so important to intelligence: As we discussed in the first chapter, several prominent scholars base their theories of intelligence in part on individual differences in the speed with which people process information.

The assumption that more intelligent people think and act more quickly also underlies the overwhelming majority of intelligence tests. It is rare to find a group test of intelligence that is not timed, or a timed test that virtually everyone can finish at a comfortable rate of problem solving. This assumption is a gross overgeneralization, however: It is true for some people and for some mental operations, but not for all people or all mental operations. What is critical is not speed per se, but speed selection – knowing when to perform at what rate, and being able to think and act rapidly or slowly depending on the task or situational demands.

Let's say, for example, that you and your spouse are writing thank you notes after a wedding. Some thank you notes may be to people whom neither of you know very well (such as your parents' friends). Other notes may be to people you are very close to and who may have given you generous and heartfelt gifts. Someone who just acts quickly would speed through all of the thank you notes. Someone who acts slowly may write long and detailed thank yous on every card. Someone who excels at speed selection, however, will able to spend the appropriate amount of time – longer and more thoughtful messages for those whom you are close to (or who gave you a really expensive gift!) Thus, it is resource allocation, a metacomponential function, which is central to general intelligence (Sternberg, 1984; Sternberg, 1985).

Converging kinds of evidence support this view – that resource allocation rather than simply speed is critical to intelligence. Some of this evidence comes from our everyday experiences in the world. We all know people who take their time in doing things, but do them extremely well. And it is common knowledge that snap judgments are sometimes poor judgments. Indeed, in the Sternberg et al. (1981) study on people's conceptions of intelligence, "does not make snap judgments" was listed as an important attribute of intelligent performance. Moreover, there are theoretical reasons for believing that to be quick is not always to he smart. In a classic but little-known book on the nature of intelligence, Louis Thurstone (1924) proposed that a critical element of intelligent performance is the ability to withhold rapid, instinctive responses, and to substitute for them more rationa1, well-thought-out responses. According to this view, the instinctive responses a person makes to problems are often not the best ones for solving those problems. Indeed, anyone who has ever had a boss or professor who was unpleasant or incompetent can attest to this phenomenon. If you relied on your instinctive response (such as, "Wow, you're an incredibly big jerk, aren't you? I wonder how you've avoided getting fired!"), you would not last long. The ability to inhibit acting upon these responses and to consider better responses is critical for high-quality task performance.

A number of findings from psychological research by many investigators undermine the validity of the view that to be smart is always to be fast. First, it is well known that, in general, a *reflective* rather than an *impulsive* cognitive style in problem solving is associated with more intelligent problem-solving performance. Jumping into problems without adequate reflection is likely to lead to false starts and erroneous conclusions. Indeed, more intelligent people tend to spend relatively more time than less intelligent people on global (higher-order) planning and relatively less time on local (lower-order) planning (Sternberg, 1981). In contrast, less intelligent people emphasize local rather than global planning. In other words, the more intelligent people spent more time before beginning a task, deciding what to do. They were then less likely to pursue dead ends or get lost in their problem solving. The less intelligent people started tasks without fully thinking them through, and thus had to keep planning and replanning as they made their way through the tasks. They kept turning down blind alleys. If you play either computer- or card-based games of skill or strategy, you have probably already learned this concept. As inherently appealing as it may be to rush in and start playing, better gamers know to read the manual and develop a plan of attack.

The point is that what matters for effectiveness in intelligent task performance often is not total time spent, but rather, how the time is distributed across the various kinds of planning. Although for the problems we used (complex forms of analogies), quicker problem solving was associated, on average, with higher intelligence, looking simply at total time masked the inverse relation in the amounts of time spent on the two kinds of planning.

Yet timed tests (such as the SATs or the GREs) often force a person to solve problems impulsively. The emphasis on speediness is sometimes argued to play a role in gender differences on the SATs and GREs. In mathematics, males tend to use an impulsive style and females tend to use a reflective style. As a result, males are rewarded by the timed format and outscore females, despite females typically performing better in math classes (see Gallagher & Kaufman, 2005, for a review of this literature). It is often claimed that the strict timing of such tests merely mirrors the requirements of highly pressured and productive societies. But most of us seem to encounter few significant problems in work or personal life that demand only the five to fifty seconds allowed on a typical problem on a standardized test. Of course, some people, such as air traffic controllers, must make consequential split-second decisions as an integral part of their everyday lives. But such people seem to be the exception rather than the rule.

In addition, although greater intelligence is associated with more rapid execution of most performance components, problem encoding – understanding exactly what a problem says – is a notable exception to this trend (Sternberg & Rifkin, 1979). The more intelligent person tends to spend relatively more time encoding the terms of a problem, presumably in order to facilitate subsequent operations on these encodings. For example, it is typical of a good medical doctor to spend much time talking to the patient and asking him or her to go through various tests and evaluations. Only when a lot of information on the patient is available, that is, the doctor has encoded as full a picture of the patient's condition as possible, will the doctor engage other mental operations while performing his cycle of decision making and establishing a diagnosis.

Encoding happens not only in professional, but also everyday life. When one of us arrived in his first job, he arranged the books on his shelf in what was pretty much a random order. Whenever anyone wanted to borrow a book or when the author needed one, he had to look through many of the titles before he finally happened on the one he was looking for. Finally, he got fed up with this disorganization and decided to alphabetize the books by title. In effect, he was devoting additional time to encoding the titles of the books in a way that would make them more easily retrievable when he or other people needed them. Then, when he needs a book, he could find it much more rapidly because of the additional time he spent in encoding the book titles. Of course, lending libraries operate on a similar principle.

Obviously, it would be foolish to argue that speed is never important. For example, in driving a car, slow reflexes or thinking can result in an accident that otherwise might have been averted. Indeed, speed is essential in many situations. But most of the important tasks people face in their lives don't require problem solving or decision making at split-second speed. Instead, they require intelligent allocations of time. Ideally, intelligence and achievement tests would stress allocation of time rather than sheer speed in solving various kinds of problems. We believe that the metacomponent of resource allocation is a critical one in intelligence.

Other kinds of metacomponents can matter too. One such metacomponent is the monitoring of one's behavior. In teaching, we tell students that the single easiest and least time-consuming step they can take to improve their grades on papers is to proofread their papers after they write them. Proofreading can catch not only typographical errors but also errors of logic or even of fact. This simple step can make the difference between a student's receiving a pleasing grade and an unsatisfactory grade.

This metacomponent comes in handy during exams and tests. At least one of us regularly finds that most students lose anywhere from five to thirty points on each exam by not reading the directions and thereby carefully monitoring their own test performance. Not answering all of the questions asked, only giving two instead of the requested three examples, and other basic mistakes could be caught by a careful read-through of the exam.

It was only in the 1990s that intelligence tests first started to measure planning abilities. Newer tests such as the Das-Naglieri Cognitive Assessment System (Naglieri & Das, 1997; see also Das, Naglieri, & Kirby, 1994) and the Kaufman Assessment Battery for Children – Second Edition (Kaufman & Kaufman, 2004) include planning in their intelligence assessments.

Performance Components

Performance components are used in the execution of various strategies for solving problems. Whereas metacomponents decide what to do, performance components actually do it. The performance components are probably the ones that are best measured by existing tests of intelligence and academic skills.

The number of performance components that people might use in dealing with anything that might ever face them is without doubt extremely large. If our goal were to identify them all, we could probably fill the rest of this book doing exactly that (thankfully, we won't). Fortunately, certain performance components are more important than others. For example, studies of mental test and academic performance have shown that one set of components – those of inductive reasoning, such as inferring and applying relations – are quite general across many of the items typically found in intelligence tests.

Inferring relations is involved when you try to figure out how two words or concepts are related to each other, such as the concepts of *intelligence* and *achievement*. It is not altogether different from playing "Six Degrees of Kevin Bacon" – the game in which one tries to link someone in film or television to the popular actor Kevin Bacon. Applying relations is involved when you figure out the best way to use knowledge you have inferred for other purposes. For example, you may get a poor grade on a test or assignment in a class. But if your performance on other tests and assignments is good or excellent, a professor will be able to look at the pattern of your performance and, perhaps, decide that your poor grade does not mean that you are bad at psychology. If your pattern of performance is strong overall, then this particular failed assignment might not make much difference in your grade.

A handful of performance components accounts for performance on many of the tasks found on intelligence tests and in many forms of academic achievement. Thus, if you wish to improve your score on IQ or achievement tests, you don't have to identify and improve large numbers of components. You can concentrate on just a few of them, as we will discuss later in this book.

It is important to realize that people can use different performance components to solve a given problem. Let's say that someone who always gets lost asks you for very good directions to your house. When you approach this task, you may use your visual-spatial abilities to draw a detailed map. You may use your verbal abilities to write out clear and concise directions. Maybe you use both sets of abilities and give directions and draw a map (as in the Internet search engine MapQuest). The point is that you might succeed at this task using different combinations of performance components. If one only evaluates the outcome (e.g., were the directions satisfactory?), virtually nothing is revealed about the kinds of mental processes you used to solve the problem.

Separation of the performance components used in solving problems is critically important for diagnosis and remediation of problem-solving performance. Consider a specific example: suppose that people are given a test requiring reasoning by analogy. A typical problem on such a test might be VENEZUELA: SPANISH:: BRAZIL: (a. ENGLISH, b. PORTUGUESE, c. FRENCH, d. GERMAN). In a typical testing situation, people would solve many analogies such as this one, and the measure of their reasoning ability would be their total number correct on the test. There is a problem with the logic of scoring the analogies test in this way, however. Consider a person (let's call her Maria) who is a very competent reasoner but who has a reading disability. In other words, Maria has no trouble reasoning about relations, but has considerable trouble in encoding the terms of the problem on which she must reason. People with a reading disability such as Maria may have great difficulty in obtaining a high score on an analogies test, especially if it is timed, merely because they read the terms slowly and with great difficulty. But the low score does not reflect difficulties in reasoning but, rather, difficulties in encoding the terms of the analogical reasoning problem. Other people might get problems wrong simply because they lack knowledge, such as of