1 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.

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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

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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.

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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

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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