CHAPTER 2

What Is Intelligence? A Panoply of Views

As discussed in Chapter 1, a lot of accounts of intelligence, including in textbooks, assume that intelligence is basically whatever it is that intelligence tests and their proxies – SAT, ACT, GRE, etc. – measure.[1] Other accounts talk about intelligence without even defining it. So, let us start with how intelligence is defined and see if it is really that simple. It certainly might seem like a simple issue – IQ tests as we know them have been around for more than a century. But really, what is intelligence? Is it nothing more than what IQ tests test?

When you meet some people, your reaction may well be that they are truly intelligent. Other people you meet may seem to be very dull and perhaps, at best, flickering bulbs. What exactly is the difference between people in the first group and those in the second group?

2.1 Expert Definitions by Psychologists

Although the difference between intelligent and not so intelligent people might seem straightforward, scholars of intelligence have tried for many years, with less than complete success, to pin down the difference. They simply have not reached any complete or even almost complete consensus as to just what the difference is. Rather, scholars have differed in their definitions of intelligence, and thus of what makes a person more or less intelligent.

One modern definition of intelligence attracted fifty-two scholars,[2] only some of them experts on intelligence, to sign onto it:

> A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings – "catching on," "making sense" of things, or "figuring out" what to do.

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That would seem to be a lot of signatories and a lot of agreement. And indeed, there are a number of aspects of the definition with which I believe most modern-day theorists would agree. For example, most theorists would agree that intelligence involves reasoning, problem-solving, abstract thinking, comprehension of complex or otherwise difficult ideas, and the ability to learn from experience, quickly when necessary. However, the article in which the definition appeared was rather controversial.

The statement was sent to 131 scholars in all, meaning that fewer than half signed on. The failure of other scholars to sign it may have pertained to other statements beyond the definition of intelligence in the full *Wall Street Journal* article. For example, one further claim in the article was that genetics plays a larger role in intelligence than does environment; another was that intelligence tests are not culturally biased. Statements such as these may have turned off some potential signers (including the author of this book), although it is hard to know exactly why most scholars requested to sign on ultimately did not sign. Another issue was that not all the scholars who signed actually studied human intelligence: All were experts, but in a variety of fields. Sometimes, experts have firm opinions beyond their own field, but those opinions are not "expert opinions" when the experts go outside their own field.

There have been many other definitions of intelligence over time and place. Alfred Binet and Theodore Simon, turn of the twentieth century French scholars, emphasized judgment, or good sense.[3] They also included in their definition one's ability to criticize oneself and to learn from one's mistakes. David Wechsler emphasized the ability to act purposefully, to think rationally, and to adapt to the environment.[4] Howard Gardner has spoken of the need to find, solve, and create problems, and one's ability to create effective products as required.[5] Linda Gottfredson, who led the group of fifty-two scholars that proposed the definition of intelligence given above, highlighted the ability to deal with complexity.

Attempts by psychologists to define intelligence go back to the early years of the twentieth century. In 1921, the *Journal of Educational Psychology* published a symposium, "Intelligence and Its Measurement," in which the authors, experts on intelligence, grappled with the question of what intelligence is.[6] They came up with diverse definitions. One was that intelligence is the power of good responses from the point of view of truth or facts (Edward L. Thorndike). A second definition was that intelligence is the ability to carry out abstract thinking (Lewis M. Terman). A third definition was that intelligence is the ability to learn and adjust oneself to the environment (S. S. Colvin). There were many more definitions.

Sixty-five years later, Robert Sternberg and Douglas Detterman asked two dozen experts to define intelligence.[7] They came up with definitions rather similar to the earlier ones. But in the more recent symposium, there was more emphasis on what sometimes is called "metacognition." This is one's understanding and control of one's cognition (e.g., memory, reasoning, problem-solving, etc.).

One of the most famous definitions of intelligence is that of Edwin G. Boring.[8] Boring argued that intelligence is what intelligence tests test. Such a definition is sometimes referred to as an "operational definition," because intelligence is defined in terms of an operation. The advantage of such a definition is that one gets a rather clear-cut basis for defining intelligence. It is what is measured as intelligence. The downside of such a definition, obviously, is that it is circular.[9] Intelligence tests are created to measure this thing called "intelligence." Then intelligence is in turn defined in terms of the tests that were created to measure the thing the tests were created to measure. Figure that one out!

There are other potential downsides to the operational definition of intelligence. Consider three.

First, the definition enshrines the intelligence test as the ultimate arbiter of what intelligence is. But different intelligence tests available at a given time do not all measure precisely the same thing. So, they do not definitively define intelligence, even as an operational definition.

Second, the nature of items on at least some of the tests has changed over the years. For example, arithmetic computation used to appear on some tests based on the work of Louis Thurstone and Thelma Gwinn Thurstone.[10] But in the age of electronic calculators and computers, arithmetic computation seems less important to some test constructors than it once did. So, it is less likely to appear on current tests. Indeed, the nature of intelligence itself seems to change over time.[11] Patricia Greenfield has suggested that what people have meant by intelligence, and what people need to be intelligent, both have changed over the course of time. In earlier times, and today still, in some societies, intelligence has been viewed as involving social responsibility, wise thinking, and possibly some kind of spirituality or connection to the natural and sometimes supernatural world.[12] In such a society, people might view an intelligent person as understanding the social norms and conventions of his or her society and contributing to that society in a way that benefits the society as a whole.[13] In more economically developed societies, the emphasis instead is on advanced cognitive skills, often involving thinking about complex and abstract matters outside their natural contexts, as the definition of the fifty-two scholars suggested. On this view, an intelligent person is one who can solve complex mathematical problems or who knows the meanings of a lot of abstract and possibly abstruse words.

Third, if, as some theorists believe, intelligence needs to be measured in different ways in different cultures, then necessarily intelligence is defined as being, at least in part, culturally specific.[14] This issue is discussed further below but consider a simple example that is relevant to current times. Consider the ability to spot predatory animals that are naturally camouflaged, such as certain kinds of snakes. This ability is essential in some environmental settings but not others. The ability is related to others that Howard Gardner might call "naturalist" intelligence.[15] In natural environments, naturalist abilities (or "naturalist intelligence," as Gardner would call it) are very important, whether for predator evasion or for hunting and gathering. But for someone living in New York City, Hong Kong, or Tokyo, such abilities matter much less. These people may encounter little of natural environments. People in these environments have their own challenges with predators, of course, but the challenges generally are different. Some of the contemporary predators may be more likely to go after people's bank accounts than to go after the people physically. Modern predators are likely to take different forms from naturally camouflaged snakes lying in the brush; and if these people hunt, it likely will be on a recreational trip, not on a trip necessary for daily sustenance.

It might seem that a definition as old and potentially as empty and even as boring as Boring's would go out of date fast. Yet the operational definition remains popular, as noted at the beginning of this chapter. One author of a book on intelligence pretty much opens his book with a detailed description of the most recent edition (fourth) of the Wechsler Adult Intelligence Scale (WAIS-IV).[16] An issue with this opening is that it can be seen as defining intelligence in terms of a test, instead of specifying what a test should measure in terms of a definition. Ancient philosophers did precisely that – they were concerned with what intelligence is in the real world, not with a test score.

2.2 Ancient Philosophical Conceptions of Intelligence

Of course, attempts to define intelligence did not start in the twentieth century. Homer, in the *Odyssey*, distinguished between good looks, on the one hand, and good thinking, on the other. He noted that one person may make a poor physical impression because he is unattractive. Yet he or she may nevertheless speak in an articulate and persuasive way. Another person may be good-looking and well-groomed. But at the same time, that person may lack the ability to communicate well with others.

Plato also reflected on the nature of intelligence and associated mental abilities. In the Platonic dialogue *Theaetetus*, the Greek philosopher Socrates asks Theaetetus, an interlocutor, to imagine something about the mind. In particular, imagine that there exists in the mind of each person a block of wax. The block is of different sizes in different people. The block of wax also can differ in various properties. These properties include hardness, moistness, and purity. Socrates, citing Homer, suggests that one possibility is that the wax is pure, clear, and deep. In this case, the mind easily will learn and retain information. It will not be subject to confusion. It only will think things that are true. And because the impressions in the wax are clear, these impressions will be distributed (by means not really specified) quickly into their proper places on the block of wax. But suppose instead that the wax is muddy or impure or very soft or very hard. Then there will be defects of the intellect. People whose wax is soft will be good at learning. But they will be apt to forget things. Then there will be people whose balls of wax are shaggy and rugged or gritty, or whose wax has an admixture of earth or dung. These people's balls of wax will have only indistinct impressions. Those with hard wax will have the same problem because there will be no depth to their thoughts. But things are not much better if the wax is too soft. Then the impressions will be indistinct. That is because those impressions easily can be confused or remolded.

Aristotle also had some fairly well-formed views about the nature of intelligence. In the *Posterior Analytics Book 1*, he conceived of intelligence in terms of "quick wit." For example, suppose an intelligent person sees someone in conversation with a man of wealth. That intelligent person might conclude quickly that the "someone" is seeking to borrow money from the man of wealth. An interesting feature of this conception is that Aristotle is implicitly recognizing that intelligence is not just cognitive (or mental), but also social in nature.

2.3 Lay (Popular) Definitions

Of course, one does not have to ask experts what they believe intelligence to be. One also can ask laypeople. Why should one ask laypeople? After all, when all is said and done, they have no expertise at all in the field of intelligence. The answer is simple: The overwhelming majority of judgments about people's intelligence are not made by experts but rather by laypeople. These laypeople have never formally studied intelligence at all.

Nevertheless, laypeople make judgments all the time. They do so when they hire people for jobs and later, perhaps, when they fire people from those same jobs. They also make judgments about intelligence when they go out on dates, or consider going out on dates, or perhaps getting married. In each of these instances, they may seek a partner who is as intelligent as they are. Or they may want to be more intelligent than their partner – or less intelligent! Parents make judgments about their children, just as the children make judgments about their parents. Adults make judgments about intelligence when they decide whom to hire to work on their house, their car, or their health. In short, most judgments in the world about intelligence are not the result of scores on standardized tests but rather the result of informal judgments laypeople make in their daily lives.

My colleagues and I studied people's conceptions of intelligence.[17] (These studies looked at particular groups of Westerners; conceptions of people in other cultures are considered later in this chapter.) The findings boiled down to three factors in people's conceptions of intelligence: practical problem-solving, verbal ability, and social competence. These lay conceptions, then, have more of a real-world, everyday slant than at least some of the expert definitions. Laypeople in the United States (and, as it turns out, in other cultures) place more emphasis than do experts on intelligence as it manifests itself in everyday use. How do experts see intelligence?

2.4 What Is the History of Ideas About What Intelligence Is?

Psychologists have a long history of trying to understand what intelligence is. Consider some of the more classical approaches.

2.4.1 A Psychophysical Approach

Psychological ideas about the nature of intelligence date back to the work of Sir Francis Galton (1822–1911), a British scientist. Galton believed that intelligence is a function of psychophysical abilities. These abilities include attributes such as strength, hand-eye coordination, pitch sensitivity, and the like. For several years, Galton maintained an at-the-time modern, well-equipped anthropometric laboratory (a laboratory that measures various aspects of the human body) at the Kensington Museum in London. At the lab, visitors could subject themselves to being measured for their level of skill on a variety of psychophysical tests. These tests allowed the visitors to assess themselves for a broad range of psychophysical skills and sensitivities. One example of a test was weight discrimination. This test measured the ability to notice small differences in the weights of various objects. Another example of a test was pitch sensitivity. This test measured the ability to hear small differences between musical notes. A third example of one of Galton's tests was an assessment of physical strength.[18]

An ardent follower of Galton was a professor at Columbia University, James McKeen Cattell. Cattell brought many of Galton's ideas over from England to the United States. Unfortunately for Cattell, a student of his, Clark Wissler, decided to test Cattell's tests. Wissler attempted to detect relations between the various psychophysical tests. He also looked at the relations of the psychophysical tests to academic performance at Columbia University.[19] He hoped that the discovery of such relations would show some kind of unity in the various dimensions of psychophysically based intelligence. But Wissler detected no unity. The various psychophysical tests were barely correlated with each other. Moreover, the psychophysical tests used by Cattell failed accurately to predict college grades. Thus, Galton's psychophysical approach to assessing intelligence soon faded almost into oblivion. From time to time, there have been attempts to bring back the approach, but with little success.

There is an irony in the work of Wissler: His results appear to have been correct. But his methodology was seriously flawed. First, correlations tend to be low when there is a restriction of range in a variable. For example, height is, in general, a good predictor of basketball skill. But it is not a good predictor among professional basketball players, who almost all are quite tall to begin with. There just is not that much variation in heights among professional basketball players, at least relative to the general population. Wissler tested only Columbia University students. Columbia students could be expected to be within a restricted range of intelligence, much like the pro basketball players who typically are within a restricted range of height. Second, the measures Wissler used were of doubtful reliability. That is, if you took the test on one day, your score might be quite different from what it would be on another day. So, it is not clear that the tests could have had high correlations with anything. Whatever the case may be, investigators in France had other ideas about the nature of intelligence.

2.4.2 A Judgment-Based Approach

Contemporary measurements of intelligence had their start with Albert Binet and his associate Theodore Simon in France, mentioned above. They believed that higher level, judgmental abilities, not lower level psychophysical ones, provide the keys to understanding intelligence. These abilities include thinking, reasoning, and problem-solving.[20] Thus, Binet and Simon started an intellectual tradition distinct from that of Galton and Cattell.[21] Binet and Simon emphasized complex rather than simple information processing as a basis for understanding intelligence.

The Ministry of Public Education in Paris, France, asked Binet to devise a procedure for distinguishing normal learners from slow learners. As a result, Binet and Simon set out to measure intelligence as a function of the ability to learn and think within an academic setting. They devised a test based on an individual's ability to learn, reason, and show good judgment. Thus, they measured skills like vocabulary, arithmetic problem-solving, and spatial visualization, among many others. Lewis Terman of Stanford University in the United States built on Binet and Simon's work in Europe. He constructed the earliest version of what is today known as the Stanford–Binet Intelligence Scale.[22]

Galton and Binet started with distinct conceptions of intelligence, either as psychophysically or judgmentally based, respectively. After them, many later researchers turned to a specific methodology to derive theories of intelligence – factor analysis. Instead of starting with a theory and contriving tests, therefore, they started with tests and then contrived theories. In some ways, their approach harked back to that of Boring in that, rather than starting with a conception of intelligence, many of them started with tests of intelligence.

2.5 Metaphors of Mind

There are different ways to conceive of intelligence. These different ways can, in a sense, be viewed as "metaphors of mind." What a scholar or anyone else "means by" intelligence depends in large part upon the metaphor of mind to which he or she adheres, perhaps without even thinking much about it.[23] These metaphors are briefly described here and will be elaborated upon throughout the book. The first of the metaphors to be considered is a geographic one.

2.5.1 The Geographic Metaphor: Intelligence as a Map of the Mind

The most widely known metaphor is what I have called a *geographic* one. This metaphor is also called a *psychometric* or *test-based* one.[24] The idea underlying this metaphor is that the mind can be viewed much as can be a map. It has different regions. Each region tends to understand and produce different kinds of things. One region might handle verbal tasks, another, mathematical tasks, and still another, spatial-orientation tasks. Of course, these regions may work together on many tasks, just as different regions of a country do. But the goal is to understand the geography and topography of the mind. Then one can use that information to determine how abilities are organized. One further can understand how people use abilities to greater or lesser effect. This is the metaphor that has been used by IQ testers ever since the beginning of the twentieth century.

2.5.1.1 The Theory of General Intelligence

Charles Spearman (1863–1945), an English psychologist, invented a statistical technique mentioned briefly above called *factor analysis*. This technique analyzes correlations (relations) among tests. It purports to identify the psychological sources of individual differences underlying the tests. Spearman discovered that a single general factor seemed to pervade performance on all tests of mental ability.[25] To Spearman, the general factor, which he labeled "*g*," provides the key to understanding intelligence. Spearman believed "g" to be a direct consequence of "mental energy," a belief that has been highly influential.[26] Spearman asserted that each psychometric test loaded on (was related to) the general factor. Each test also loaded on a factor specific to that test. He called each of the specific factors "*s*." Thus, his theory is sometimes referred to as a "two-factor theory," although in fact it refers not to two factors but rather to two types of factors.

2.5.1.2 The Theory of Bonds

Godfrey Thomson had a different idea about why all psychometric tests seem to intercorrelate positively with each other.[27] This generally positive relationship about which Thomson theorized is sometimes called a *positive manifold*. He proposed that, in fact, there is no psychological meaningful single general factor (one underlying ability) that encompasses all of the tests. The single factor that appeared in Spearman's work is essentially a chimera. Rather, according to Thomson, there are very large numbers of "bonds," or independent elements. Together, these elements are sampled by many of the psychometric tests. The bonds give the appearance of a single entity when in fact there are many diverse entities that just happen to be sampled at the same time. Edward Lee Thorndike had a similar idea.[28] He believed that shared associations that are formed in associative learning could explain much of intelligence. In this case, an example of associative learning would be to associate the word "cow" with "milk." So, Thomson, like Spearman, believed in the existence of a general statistical factor, but not of a general psychological ability *(g)*. In his view, the general statistical factor obscured the many independent elements that contributed to it.

2.5.1.3 *Primary Mental Abilities*

Louis Thurstone came to believe that intelligence comprises seven primary mental abilities.[29] A first ability is verbal comprehension, that is, understanding meanings of words and texts. A second, related ability is verbal fluency, or producing words as rapidly as needed, such as in speaking or writing. A third ability is number, or arithmetic computation and problem-solving. A fourth ability is spatial relations, involved, for example, in rotating figures in one's mind. A fifth ability is perceptual speed, as in discerning rapidly the letters or words before one. A sixth ability is memory, or remembering symbols, words, numbers, and so forth. And a seventh ability is inductive reasoning, or predicting the future from the past, as in a number-series problem. These abilities tend to be related to or correlated with each other. Thus, if one "factors the factors" – that is, does a factor analysis on the factors – one ends up with a general factor.

Spearman eventually convinced Thurstone of the existence of some kind of general factor. But Thurstone believed it to be secondary to understanding the nature of intelligence. There was no way, at least at the time, of truly saying whether Spearman's general factor or Thurstone's primary mental abilities truly were more "basic" in any meaningful sense.

2.5.1.4 *Structure of Intellect*

The field of intelligence learned an important lesson as a result of a so-called "structure of intellect" model proposed by J. P. Guilford.[30] Guilford suggested that there are 120 (later, 150, and still later, 180!) independent factors of intelligence. He argued that the factors array themselves in a cube, according to processes, contents, and products. For example, one ability would be cognition (process) of verbal (content) relations (product). John Horn and John Knapp later showed Guilford's factor-analytical methods to be artifactual. That is, they were statistically invalid.[31] Guilford, for most theorists, then went from being considered a major theorist of intelligence to becoming a scientifically misguided historical curiosity. Today, Guilford is more well-known for his impetus to research in the field of creativity than he is for his work on intelligence.[32]

2.5.1.5 Radex Model

Louis Guttman proposed quite a different model of intelligence, which he referred to as a "radex."[33] The radex model uses polar rather than Cartesian coordinates to understand intelligence. Imagine a circle. Nearer the center (focus) of the circle are those abilities that are more central to intelligence, such as general intelligence, which is right at the center. As one moves away from the center of the circle, one finds the abilities that are less central. Different conventional abilities, such as verbal, numerical, and spatial abilities, then are arrayed along the periphery of the radex (the circle). In terms of polar coordinates, the coordinate corresponding to closeness to general intelligence is the distance from the center of the circle, and the coordinate corresponding to the kind of ability is the angular coordinate.

2.5.1.6 Hierarchical Models

Today, psychologists who specialize in tests of intelligence believe there is more to intelligence than just *g*. These psychologists have created an economical and statistically defensible way of dealing with a number of factors of the mind. This way is through hierarchical models of intelligence.

One hierarchical model, proposed by Raymond Cattell, suggests that there are two particularly important abilities. They are *fluid ability* and *crystallized ability*.[34] Fluid ability is measured as a person's speed and accuracy of abstract reasoning, especially when dealing with novel problems. Crystallized ability is assessed by measuring accumulated knowledge and vocabulary. A similar model proposed by Philip E. Vernon argued instead for two different factors.[35] The first is what Vernon called verbal: educational ability, which roughly comprises the kinds of verbal, mathematical, and reasoning skills valued by schools. The second ability is kinesthetic: mechanical, roughly the kinds of skills used in mental rotation, mental visualization of three-dimensional structures, and so forth.

A more recent model proposed by John B. Carroll is a hierarchy comprising three strata.[36] Stratum I involves many narrow, specific abilities. These include, for example, spelling ability and speed of reasoning. Stratum II involves various broad abilities. They include, for example, fluid intelligence and crystallized intelligence. (Recall that fluid intelligence is a person's ability to cope with novel situations and to reason abstractly. Crystallized intelligence refers to a person's knowledge base, such as for vocabulary and general information.) And Stratum III comprises just a single general intelligence. This general intelligence is essentially Spearman's *g*. Of these strata, the most interesting is the middle stratum, which is neither too narrow nor too all-encompassing.

In addition to fluid intelligence and crystallized intelligence, Carroll included in the middle stratum several other abilities. They are:

g_f = fluid intelligence (ability to think flexibly and handle novel stimuli)
g_c = crystallized intelligence (knowledge base)
g_v = broad visual perception
g_a = broad auditory perception
g_y = general memory and learning
g_r = broad retrieval ability (recalling information from memory)
g_s = broad cognitive speediness
g_t = reaction time and decision speed (making rapid selections of simple information)

Carroll's model is rather widely accepted today. A more recent version, sometimes called CHC theory (an acronym for Cattell-Horn-Carroll), is perhaps even more widely accepted, and integrates Cattell's earlier theory with Carroll's later one.[37]

Not all psychometrically oriented theorists accept the Carroll model or the CHC model. Wendy Johnson and Thomas J. Bouchard proposed an alternative hierarchical model, the VPR model. They proposed that below general intelligence there are three factors in the second level of the hierarchy, verbal, perceptual, and image rotation (hence, VPR).[38]

There are four aspects of factor-analytic models worth considering. They show the kinds of assumptions inherent in factorially derived theories of intelligence.

First, as mentioned earlier, one starts with test data and then derives a theory based on the data, rather than vice versa. So, the theory starts not with some conception of the mind, in general, or of intelligence, in particular, but with test scores.

Second, the theory can be only as good as those test scores. The theory assumes that the test is measuring intelligence, and presumably, pretty much only intelligence and not a bunch of irrelevant factors. This book will question that assumption from multiple points of view and sources of evidence.

Third, factor analysis analyzes statistical regularities in data. Interesting as statistical regularities are, they do not automatically produce psychological interpretations. For example, there are many possible interpretations of the so-called general factor of intelligence – as mental energy, mental power, speed of neuronal conduction, accuracy, or neuronal conduction, and so on. One has to be very careful about reifying what is, at its base, a statistical phenomenon.

Fourth, identifying factors depends on the existence of individual differences. If there are no individual differences in an ability, or at least no discernible ones, then factor analysis will not identify the ability. If one had only a set of identical twins in the world, one would have great difficulty identifying their abilities by factor analysis, or if there was only one person left on a desert island, one would be totally unable to identify the abilities of the person on the island.[39]

Fifth, and finally, factor analysis of mental tests is, in a certain way, an extremely conservative procedure. It may be that it is time to rethink what intelligence is for the early twenty-first century as opposed to the early twentieth century. Today, some skills matter less than before. Arithmetic computation and spelling are obvious examples because of the advent of computers that can do very fast computations and can correct spelling errors. Other skills matter more, such as finding information in far-flung data bases and analyzing the validity of information that has not been vetted (such as by schools, libraries, newspaper or magazine editors). Someone might be quite good at twentieth-century skills and yet fail miserably at twenty-first-century ones. Indeed, arguably, many people are that way, good at understanding vetted information but unable to distinguish false and worthless information on the Internet from valid and useful information. They might thus perform well on an IQ test but not in their daily lives.

2.5.1.7 *What Is IQ?*

In practice, the psychometric approach of the geographic metaphor manifests itself through the use of IQ. IQ is an abbreviation for "intelligence quotient." IQ is referred to as a quotient because it originally was computed in that way – as:

IQ = (mental age/chronological age) × 100

Chronological age (also called "CA") is simply one's physical age, usually expressed in physical years and months, for example 6 years, 0 months (or "6–0"). Mental age (also called "MA") refers to level of mental functioning. If someone has a chronological age of 6 and a mental age of 6, that someone's IQ is 100. But suppose the individual's level of mental functioning is comparable to that of an eight-year-old. Then his or her IQ would be 133 (8/6 × 100).

Intelligence testing as we know it and the concept of mental age were introduced by Alfred Binet and Theodore Simon in 1905 but the concept of *intelligence quotient* was introduced later by German psychologist William Stern in 1912.

Why even have an intelligence quotient? Well, the idea was that Binet's concept of mental age was useful for telling educators or others at what mental level an individual was functioning. But it was not so useful for telling anyone how intelligent a child of a certain age was in comparison with other children of the same age. In the above example, the child of six was performing at the level of an average eight-year-old, which is clearly above average. But how much above average? The IQ of 133 suggests that the child is *a lot above average*. But again, by how much?

Tables were constructed to tell educators and others how to interpret IQs. For example, an IQ of 100 would represent the 50th percentile. The 50th percentile represents an average (or, to be precise, a median) score. It means that half the individuals who take the test score above an IQ of 100; half score below. A score of 133 is very high – between the 98th and 99th percentiles. This percentile range means that in a sample of 100 individuals, between 1 percent and 2 percent would achieve a score this high. At the other side of the distribution, a score of 67 (gotten by subtracting 33 points from an IQ of 100) would be very low. That level of IQ is achieved by fewer than 2 percent of people at the bottom of the IQ distribution. Table 2.1 shows a breakdown of how IQs sort themselves out. The table is based in

Table 2.1 *Verbal descriptions of IQ ranges*

145–160. Highly advanced or highly gifted. The individual is way above average in intellectual level and is capable of very highly advanced work.
130–144. Gifted or very advanced. The individual is well beyond the average in intellectual level and is capable of very advanced work.
120–129. Superior. The individual is substantially above average in intellectual level and is capable of advanced work.
110–119. High average. The individual is slightly above average in intellectual level and is capable of doing age-appropriate work at a slightly above-average level.
90–109. Average. The individual is roughly average in intellectual level and is capable of doing age-appropriate work at a typical level.
80–89. Low average. The individual is slightly below average in intellectual level and is capable of doing age-appropriate work at a slightly below-average level.
70–79. Borderline intellectually disabled. The individual is capable of functioning toward the bottom of the normal level and may need remedial work.
55–69. Mildly intellectually challenged. The individual is functioning below the normal level and likely will need remedial work, which nevertheless may not or may not bring her up to a normal level of functioning.
40–54. Moderately intellectually challenged. The individual is functioning well below the normal level and likely will need intensive remediation to reach a minimal standard of performance.
Below 40. Severely intellectually challenged. The individual is functioning at a level that will make intellectually normal performance nearly impossible. The individual probably will require assistance to do many intellectual tasks.

part according to the manual of the Stanford–Binet Intelligence Scales (5th ed.).[40]

The idea of a so-called "ratio IQ" (the ratio between mental age and chronological age multiplied by 100) once was very attractive because it was so simple. One could compare two children and directly infer how intelligent each is in comparison with the other. IQ scores, it was thought, could be used for many things. For example, educators believed they could be used for identification of an individual as gifted, or as having a general intellectual disability (formerly called "mental retardation"). Or suppose a specific achievement score was relatively much lower, such as in reading, than the IQ. Then a child might be diagnosed as having a specific learning disability.

As is so often the case in psychology and, really, in life, things that seem to be simple prove, in the end, to be more complex than they initially seemed to be. So it was with IQ.

The first difficulty the concept of mental-age-based IQ encountered is that, although mental ages increase in childhood, after a certain point (as mentioned earlier), the increase slows down and even stops. So, it became apparent rather quickly that the mental-age concept required for the computation of a ratio IQ was in some sense defective. It just did not work at higher ages. The exact age at which development slows down is not clear. Usually, intelligence tests placed them somewhere between fifteen years six months and eighteen years. That is, after about age sixteen, chronological ages were fixed at sixteen (or fifteen years six months or whatever).

The second difficulty with the concept of IQ is that mental ages not only decrease in their rate of increase, but usually start to decrease in older age. The exact age, again, is a matter of dispute – actually, great dispute. Some kinds of intelligence seem to start showing gradual declines in the thirties, others not until the sixties, seventies, or even eighties. Moreover, the point at which the decline starts differs for different people. As individuals grow older, the differences in their rates of decrease in mental functioning differ profoundly. And if one of the individuals stays intellectually active and mentally challenges him or herself on a regular basis, some abilities may continue to increase even into old age.

The third difficulty is that it is not clear that mental ages show a *continuous* increasing trend. The assumption of IQ measurement is that differences in mental age are continuous – that an increase of six months means the same thing at any age level. On this view, an increase of six months at age five means the same thing in terms of intellectual growth as an increase of six months at age ten. But stage theories call this view into question. Many such theories view intellectual growth as discontinuous, meaning that intellectual growth moves along in fits and starts. Hence, increases at different ages may mean quite different things in terms of intellectual growth. Although one can question Jean Piaget's theory of intellectual development or any other stage theory of intellectual development as well, there is at least some reason to believe that intellectual development is not fully continuous, and hence, that the idea of a smooth increase in mental age is flawed. For example, children do not show continuity in language development, but rather show bursts as they develop. For a few months they may seem to show little development and then, all of a sudden, they seem to spurt upward in their language skills.

The fourth difficulty with the mental-age concept is that the use of mental ages led some people to draw incorrect conclusions about the nature of the IQ scale. Age is expressed on what is called a "ratio scale." A physical age of zero actually means something tangible. One is counted as age zero the moment one comes into the world. Of course, one could start counting earlier, say, to the moment of conception. But there is still a moment at which conception occurs and at which age post-conception starts being meaningful. This is not the case with IQ, however. A zero IQ does not mean that a person has "no intelligence." Rather, if someone scores 0 on an IQ test, it probably means that the test did not adequately measure his or her intelligence.

IQ is, at best, on what is called an "interval scale." The additive differences between scores are probably meaningful (a difference of ten points is, in theory, twice as great as a difference of five points). But the multiplicative differences are *not* meaningful – an IQ of 120 is not meaningfully twice as high as an IQ of 60. This is because there is no meaningful zero reference point. It is not even clear what "twice as smart" means. In contrast, a person who is twice as old or twice as tall as another really is double the other in some meaningful way. For example, someone who is six feet tall is meaningfully double the height of someone three feet tall.

As a result of these challenges for the ratio IQ measure, test publishers long ago generally stopped using mental ages and ratio IQs. Rather, they started to use a so-called "normal distribution" to calculate IQs. The normal distribution is a distribution that occurs often in nature.

The large majority of IQs are near the center of the IQ distribution, and then IQs tail off as one goes higher or lower in the distribution. In a normal distribution, the average IQ is at the 50th percentile (half of the scores are

Table 2.2 *Percentile equivalents of some IQ scores*

IQ	Percentile
60	<01
65	01
70	02
75	05
80	09
85	16
90	25
95	37
100	50
105	63
110	75
115	84
120	91
125	95
130	98
135	99
140	>99

higher, half are lower), so that average IQ is set to 100. Table 2.2 shows some approximate percentile equivalents for various IQs.

But what exactly does IQ measure? Edwin Boring, as noted earlier in this chapter, believed that intelligence is whatever it is that IQ tests measure. Some contemporary theorists, however, consider IQ to be a limited measure of intelligence.

When I was a student in elementary school during the late 1950s, many schools did group IQ testing of all their students on a fairly regular basis. Today, such testing is gone. What happened?

First, the concept of IQ came to appear to some to be fairly rigid. Binet likely would not have been interested in a concept of IQ. Mental ages are flexible. Binet believed in the malleability of intelligence. So, he might have found the idea of IQ too limiting.[41]

Second, there were a number of legal challenges to the use of IQ testing, especially for children of under-represented minority status.[42] For example, it became unclear whether a given score meant the same thing for a child that lived in a household where parents were relatively uneducated versus a household where parents were highly educated.

Third, for some educators, the idea of an IQ became rather toxic. Schools sometimes had been using IQs as though they set some kind of absolute upper limit on what a child could accomplish. And such an upper limit could be discouraging to a school or a teacher seeking to bring out the best in each student.

Fourth, schools discovered that they could accomplish much the same thing that they had accomplished with IQ simply by using tests with other names. At the same time that reliance on IQ tests decreased, reliance on standardized tests increased. But the tests were called achievement tests, or mastery tests, or college-admissions tests, or whatever. It was possible to accomplish the same, often not so positive goals, with tests that had societally more acceptable labels. Essentially, these newer tests are proxies for IQ tests. In a sense, they launder IQ scores, giving roughly the same information but presenting it in a more socially acceptable way.

Eventually, many schools moved on and began using IQ tests, mostly individually administered, only for special purposes, such as for special-education placements. And that is where things are today. But as we shall see later, even some of those uses are questionable. They raise as many questions as they answer.

Not everyone has accepted the geographic metaphor. Indeed, Jean Piaget originally was trained by Alfred Binet but was disillusioned by Binet's focusing on right answers rather than wrong answers. Piaget felt that one learned much more about the development of intelligence from children's errors than from their correct responses.

2.5.2 The Developmental Metaphor: The Piagetian Approach

Jean Piaget believed that the function of cognitive development, in general, and of intelligence, in particular, is to aid in adaptation to the environment. Piaget thought in terms of a continuum of increasingly complex responses to the environment.[43] Piaget further proposed that both intelligence and its manifestations in behavior become increasingly differentiated with age.

Most theorists of intelligence were part of some kind of movement. Jean Piaget, in contrast, was pretty much a force unto himself. He called his approach *genetic epistemology*. The approach, which emphasized cognitive development, was based on a notion of equilibration.

Piaget believed that development occurs in stages that evolve through equilibration. Equilibration is a process of cognitive development in which children seek a balance (equilibrium) between what the environment offers in an encounter and what the child brings to the encounter.

In some situations, a given child's existing ways of thinking, or what Piaget called "schemas," are adequate for confronting and adapting to the challenges of the environment. The child is thereby in a state of equilibrium. At other times, however, information does not fit with the child's existing schemas. Rather, the information creates cognitive disequilibrium. This disequilibrium derives from shortcomings in thinking as the child encounters new challenges. Thus, disequilibrium is more likely to occur during transitions between stages of development.

According to Piaget, equilibration involves two processes: assimilation and accommodation. *Assimilation* is a process of regaining cognitive equilibrium by incorporating new information into existing schemas. For example, a very young child, seeing a cat for the first time, might call it a "doggie," thinking that all pets are "doggies." Piaget suggested that the child would modify existing schemas through *accommodation*. This is the process of responding to cognitive disequilibrium by modifying relevant schemas. The old schemas thus are adapted to fit the new information and reestablish equilibrium. An older child might recognize that the cat does not fit the schema for dogs. That child therefore might create a modified conceptual schema in which cats and dogs are viewed as distinct kinds of pets. Together, the processes of assimilation and accommodation produce a more sophisticated level of thought than was previously possible. In addition, these processes reestablish equilibrium. They offer the individual higher levels of adaptability. The cognitive perspective that follows was in part a reaction to the psychometric approach, which was viewed as too structural and without a clear elucidation of processes. But it was also in part a reaction to Piaget. Piaget was viewed as too oriented toward idealized competencies and not enough toward actual real-world performance.

Piaget also suggested that there are four major stages of intellectual development. The first, the sensorimotor stage, begins at birth and extends until roughly two years of age. During this stage, the child learns how to modify reflexes – inborn responses to stimuli – to make them more adaptive. The child also learns to coordinate actions, to retrieve objects that are hidden (including, deliberately), and, eventually, to begin representing information mentally. During the second, or preoperational stage, from about age two to age seven years, the child experiences development of language and also of mental imagery. The child further learns how to focus on a single perceptual dimension, such as shape or color. The third, concrete-operational stage lasts from about seven to twelve years of age. During this stage, a child develops so-called "conservation skills." That is, the child will recognize that amounts of substances stay the same, regardless of their form. If you reshape a ball of clay, the ball still has the same amount of clay, regardless of its shape. Finally, children emerge into the fourth, formal-operational stage, which begins at roughly age twelve and continues, in theory, throughout the individual's life. The formal-operational child learns to think and, especially, to reason with abstract concepts. For example, the child can understand analogies or what member of a group of numbers does not belong with the others.

There have been many challenges to Piaget's theory. I mention only a few of the major ones here.

One challenge to Piaget's theory is methodological. The data for the theory were largely clinical observations of Piaget's own children. For most scientists, observational data are a perfectly good starting point, but they need to be followed up by detailed experimentation or other controlled research. Piaget never did the research that would give people confidence that the results held up to tight experimentation. Successors, however, did engage in such research.

A second challenge to Piaget is the set of results of such follow-up research. When investigators sought to confirm or disconfirm Piaget's theory, they discovered that it was at least somewhat problematical. In general, the consistent finding was that children were able to perform cognitive operations at ages earlier than Piaget indicated they should be able to.[44]

A third to challenge to Piaget is the whole idea of stages.[45] Does development really occur in discrete stages or is development more or less continuous? Although the development of some behavior seems stage-like – for example, conservation of volume – other kinds of behavioral development, such as of vocabulary or of arithmetic-processing skills, seem to be largely continuous. At best, Piaget seems to oversimplify the complexity of development, which may admit to both stage-like and continuous aspects in different domains.

A fourth challenge to Piaget, even among those who accept stages, is whether the stages Piaget had proposed are the correct ones. These objections have taken two forms. One is that the stages are a good start but not an accurate representation of cognitive development.[46] A second objection is that the stages end too early – that there are one or more stages of cognitive development beyond formal operations. For example, it has suggested that a fifth stage might be problem finding, that is, not just solving problems, but figuring out which problems are worth solving.[47] Another interpretation is that a fifth stage might involve seeing higher-order relations beyond the second, that is, third-order relations such as the relation between two analogies.[48]

A fifth challenge concerns the utility of the theory, given that it is a maturational theory. Piaget believed that development is a result of maturation, that is, of a genetic program unfolding over time. This view means, first, that environment matters little in development, and second and as a consequence, that one can do little to advance a child's development beyond what he or she is "ready for." Such a view has as an advantage the same thing that is a disadvantage. One is prone to realize that there are some cognitive tasks that children just are not ready for; but at the same time, one may fail adequately to challenge children, believing they just are not "ready for the challenge."

The sixth and final challenge, for our purposes, is a cultural one. The data have been mixed on whether Piaget's theory generalizes across cultures. But there are enough data suggesting failure of generalization that some researchers became skeptical, early on, regarding just how generalizable the theory is.[49]

It might sound, from this rather extensive critique, as though Piaget's theory was yet another flash-in-the-pan theory that was so flawed that one can hardly, in retrospect, figure out why the theory generated so much attention. But that would be reaching for too quick a conclusion. Although not entirely original,[50] Piaget's theory was one of the most influential psychological theories of the twentieth century, and with good reason. It introduced a new way of perceiving intellect and its development. Contemporary psychological theories are works in process – they are not final depictions of the psychological functioning of humans or other organisms. Anyone in science who believes he or she has final answers misunderstands the scientific method. The value of Piaget's theory is shown not so much in whether it was finally correct, but rather in its influence on the field. Piaget is one of the most highly cited authors in the field of psychology, exceeded perhaps only by Sigmund Freud (who was not a psychologist, but then, neither was Piaget!). Thus, the theory has been tremendously influential even if it has not proved to be anything close to a final word on how intelligence develops. No theory provides a final word. Piaget's theory, in many ways, served as a precursor for the computational theories that were to follow.

2.5.3 *The Computational Metaphor: Intelligence as Information Processing*

A third metaphor is a computational one.[51] The idea here is that intelligence can best be understood when the mind is viewed as a sophisticated computer. Intelligence, on this view, is largely computational. More

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intelligent people are either faster computers or have better algorithms and heuristics (convenient, but not necessarily foolproof, methods) for solving problems. The computer metaphor allows for both serial processing (one thing considered after another) and for parallel processing (many things considered at once).

The computational metaphor, at least in the field of intelligence, dates back to the work of Charles Spearman, a British psychologist.[52] Spearman proposed what he offered as three fundamental "qualitative" principles of cognition:

1 *Apprehension of experience*. This principle is essentially the same as what we would call perceptual processing today. It is seeing or hearing something and then encoding it in the mind in a way that makes it recognizable and understandable. For example, if you see a bear, you encode it as a large, probably brown, and possibly dangerous animal that is known to hibernate in the winter.
2 *Eduction of relations*. This is the process of inferring the relations between two things. For example, if you see the words "bear" and "animal," you might think of the relation that a bear is an animal. If you see "bear" and "hibernate," you might think that a bear hibernates in the winter.
3 *Eduction of correlates*. This is the process of applying a relation, perhaps one you just inferred, to a new situation. For example, if you think about a bear being an animal, you might think of groundhogs as also being animals that hibernate.

Spearman thought that the analogy offered the perfect model for understanding the processes of intelligence. An analogy takes the form, A is to B as C is to D, or as it is sometimes written, A : B :: C : D. Analogies have been used since the times of Spearman to measure intelligence, and they are often found on group tests of intelligence. An example of an analogy that might be found on such a test is MAPLE : DECIDUOUS :: PINE : (a) TREE, (b) NEEDLES, (c) EVERGREEN, (d) NORTHERN.

Spearman also proposed some "quantitative" principles of cognition. The most important, from the standpoint of the history of the field of intelligence, was *mental energy*. He believed mental energy to be the mind's "total simultaneous cognitive output constant in quantity, however varying in quality" (p. 131). Mental energy became the basis for his view that intelligence can be understood primarily in terms of a single general factor of intelligence (*g*), which he believed represented individual differences among people in mental energy.

Spearman argued that these processes best can be understood in terms of the solution of an analogy, such as FLY : INSECT :: FROG : AMPHIBIAN. In this instance, one apprehends experience when one encodes the meaning of each word in the analogy. One educes relations when one figures out how FLY is related to INSECT. One educes correlates when one applies the relation of FLY to INSECT (class membership) from FROG to AMPHIBIAN.

A well-known contemporary and rival of Spearman, Louis Thurstone, a professor at the University of Chicago mentioned earlier in this chapter, also suggested a computational basis for intelligence even before he proposed his notion of primary mental abilities.[53] His suggestion was that intelligence involves the ability to inhibit an instinctive response. This suggestion later formed the basis for an evolutionary theory of intelligence.[54] The idea was that all organisms have instincts that have evolved over eons of time. These instincts operate automatically. Most of the time they are adaptive but some of the time they get us in trouble (whether we are humans or other animals). For example, all of us have instinctively said or done things that, upon reflection, we view as incredibly stupid. "How could we have done such a stupid thing?," we wonder. On this view, the more intelligent individuals are able to inhibit these instinctive responses before they cause trouble.

What is important about the early work on the computational metaphor, as illustrated by the theorizing of Spearman and Thurstone, is that it might have formed the basis for much of the theory, research, and testing that was immediately to follow, but it did not. It more or less died on the vine, only to be rediscovered much later. Instead, work based on the geographic metaphor came to dominate much of theory and research on intelligence. One only can speculate on how the field of intelligence might have evolved had researchers and practitioners paid more attention to processing and less attention to the hypothetical mental geography of the mind.

In so-called "cognitive-correlates" research,[55] intelligence theorists have emphasized processes at relatively low levels of information processing.[56] In so-called "cognitive-components" research,[57] theorists emphasize components at relatively high levels of information processing.[58] Thus, Hunt (as a cognitive-correlates researcher) studied how quickly one could retrieve from long-term memory the names of letters. I (as a cognitive-components researcher) studied how quickly and accurately a subject could solve verbal or pictorial analogies. The nature of human information processing is highly interactive. Therefore, there is no single right or wrong level of analysis. Rather, all levels of information processing contribute to producing intelligent performance. The most useful level of analysis for intelligence depends on one's purpose in studying or measuring intelligence.

An alternative approach to intelligence emphasizes working memory. This kind of memory is often viewed as the activated part of long-term memory. It is what one is thinking about at a given time. Working memory is a critical and very useful component of intelligence.[59] In one experiment, participants read sets of brief passages. After they had read the passages, they were required to recall the last word of each passage.[60] Level of recall was highly correlated with psychometrically measured verbal ability. In another study, participants performed a variety of working-memory tasks. In one task, for example, the participants viewed a set of simple arithmetic problems. Following each arithmetic problem was a word or a digit. An example would be "Is $(3 \times 5) - 6 = 7$?"[61] The participants viewed sets of from two to six such problems. They were asked to solve each one. After solving the problems in the set, the participants tried to recall the words or digits that followed the problems. The number of words or digits recalled was highly correlated with psychometrically measured intelligence.

Working-memory measurements also predict quite well scores on tests of general ability.[62] Thus, an individual's ability to store and manipulate information in working memory is almost certainly an important aspect of human intelligence.

Recent thinking has suggested that working memory in itself might not be synonymous with intelligence but rather might be one of two forces that, in tandem, contribute to intelligence, or at least, fluid intelligence. In particular, one current view is that working memory actually consists of two distinct and oppositional processes: the *maintenance* of information in working memory in the face of distraction or decay of that information, and, at the same time, *disengagement* from old, potentially interfering information in memory in order to allow attention to be devoted to new and potentially relevant and useful information. That is, on the one hand, we need to hold on to some information for the tasks we need to complete; on the other hand, we have to let go of some information to make room for new and potentially more relevant information.[63] Thus, on this view, what matters for fluid intelligence is not working memory as a fleeting storage capacity for information while it is being processed, but rather the interplay between maintenance and disengagement.

The computational metaphor provides something important missing from other metaphors, namely, a detailed account of the processes involved in human intelligence. And yet it, like other metaphors, has limitations.

First, the computational approach can isolate mental processes but there is no real way of saying that the processes thus isolated are in any sense "basic." It is not even clear, at a computational level, what a basic process is. Any process, such as inference, might be further decomposable, into other subprocesses.

Second, computational research has revealed fairly strong content effects. That is, a person's ability to make inferences in the verbal domain might be rather different from the person's ability to make inferences in the mathematical or figural domain.[64] Thus, there are sources of individual differences that remain untapped simply by specifying processes devoid of content.

Third, it has not always been clear at what level to define cognitive theories. For example, in early work, some major theorists suggested that when there is a computer program that simulates human behavior, the program is the theory.[65] Others have suggested higher levels of analysis.[66]

Fourth, computational theories, like the psychometric and developmental theories considered earlier, have relatively little to say about the effects of culture on cognition, even though we know that cognition is very much affected by its cultural context.[67] People in different cultures understand and perform the same tasks in different ways, for example, in their relative emphases on abstract thinking.[68] Thus, simply identifying components of thought tells us relatively little about how those components function in one cultural context versus another.

Finally, the theories have a tendency to oversimplify things. For example, a number of theories have identified intelligence with speed of information processing.[69] Carroll's psychometric model, described earlier, also describes speed factors. Yet, sometimes more intelligent people are actually slower to respond to stimuli.[70] That is, they make an effort, as needed, to think things through carefully. They seem to adjust their speed to the circumstances. At the very least, one does not want to rush to the conclusion that intelligence and mental speed go hand in hand.

Today, computational theories still excite a lot of interest among psychologists studying intelligence. But biologically-based theories seem even more to have come to the fore.

2.5.4 The Biological Metaphor

A fourth metaphor is a biological one – that the seat of intelligence is in the brain.[71] On this view, understanding intelligence means understanding the brain and its interconnections. Some of these interconnections are internal within the brain. Others are internal to other parts of the central nervous system. Scientists who adhere to this metaphor often try to figure out what part, or parts, of the brain are responsible for which particular behavior. Or they might measure the volume of the brain itself, for example, looking at brain size and its correlation with intelligence. Scientists studying the brain and its interactions with the central nervous system use diverse methods of analysis. Some scientists utilize brain scans of various types, including positron emission tomography (PET scans) and functional magnetic resonance imaging (fMRI scans). Other scientists compare and contrast the intellectual performance of normal people whose brains are intact with the performance of individuals suffering from brain damage.

Over time, there have been a number of biologically based theories of intelligence. Ward Halstead proposed that there are four biologically based abilities: (a) an integrative field factor, (b) an abstraction factor, (c) a power factor, and (d) a directional factor.[72] Halstead viewed all four of these abilities as emanating from the functioning of the cortex of the frontal lobes.

More influential in the field of intelligence than Halstead has been Donald Hebb, one of the most distinguished and influential psychologists in the history of the field. Hebb suggested a distinction between two types of intelligence, which he called *Intelligence A* and *Intelligence B*.[73] Intelligence A refers to biological intellectual potential; Intelligence B refers instead to the functioning of the brain as a result of the actual cognitive development that has occurred within the individual. Hebb further suggested an Intelligence C, or intelligence as measured by conventional psychometric tests of intelligence. Note, then, that Hebb distinguished the IQ of intelligence tests from intelligence as it is either in the brain or in action as developed over time. Hebb further proposed that learning, which is key to intelligence, is built up through what he called cell assemblies. These are successively more and more complex interconnections among neurons that are built up as learning actually takes place.

A third biological based theory is that of Alexander Luria, another giant in the field of psychology.[74] This theory has had a serious impact on at least some proposed earlier tests of intelligence.[75] Luria suggested that the brain comprises three main units with respect to intelligence: (a) a unit of arousal in the brain stem and midbrain structures; (b) a senior sensory input unit in the temporal, parietal, and occipital lobes; and (c) an organization and planning unit in the frontal cortex.

The more modern form of Luria's theory is called PASS theory, which is an acronym for planning, attention-arousal, simultaneous processing, successive processing.[76] Simultaneous and successive processing – which are similar to parallel and serial processing of information – are related to the sensory-input abilities referred to by Luria. One processes simultaneously when one handles a lot of input at once, as in viewing a picture. One processes successively when one handles pieces of input, one after another, as in solving a problem requiring you to specify the next number in a series, such as 2, 4, 6, 8, . . .?

A next phase of biological theorizing sought to account for more specifically targeted aspects of brain or neuronal functioning. One theory was based on alleged speed of neuronal conduction in the brain. For example, it was proposed that individual differences in nerve-conduction velocity might be a major source of individual differences in intelligence.[77] How, exactly, does one measure speed of neuronal conduction? Two procedures, both of them scientifically speculative, were used to measure neuronal-conduction velocity, whether in the central nervous system (in the brain) or in the peripheral nervous system (e.g., in the arm).

One procedure tested brain-nerve-conduction velocities via two medium-latency potentials, N70 and P100 (the N and the P stand for "positive" and "negative," respectively; the numbers following the letters refer to the number of milliseconds at which the potential was evoked after presentation of a stimulus). In particular, participants viewed a checkerboard pattern presented in black-and-white. The black squares would change to white and the white squares, to black. Over the course of a large number of trials, participants' responses to these changes in shading between black and white were detected by electrodes that were attached in four places to the respondent's scalp.

Correlations of derived latency (reaction time) measures with IQ were rather small (generally in the 0.1 to 0.2 range of absolute value). In some cases, the correlations were statistically significant, suggesting at least a modest relationship between IQ and the latency measures. The problem is that, in this field, correlations in the range of 0.1 to 0.2 are a dime a dozen. Even if they are statistically significant, it is not clear what, if any, practical significance they have. The correlations do not make a compelling case for individual differences in speed of neuronal conduction being in any way causal of differences in IQ.

Two studies, using different methodology, looked at the relation between nerve-conduction IQ and velocity in the arm.[78] In these studies, nerve-conduction velocity was measured in the median nerve of the arm by the investigators' attaching electrodes to the arm. In one of the two studies, the investigators measured nerve-conduction velocity for conduction extending from the wrist to the tip of the finger. The resulting correlations with IQ were in the 0.4 (moderate) range. There also were somewhat smaller correlations with reaction-time latencies (around 0.2). These results suggested a relationship between IQ and speed of information transmission in the peripheral nerves. But the results did not replicate in a later study.[79]

Other research has explored a measure called P300 (positive latency at 300 msec) as a measure of intelligence. Higher amplitudes of P300 waves are sometimes viewed as suggestive of higher levels of extraction of information from stimuli.[80] Higher P300 amplitudes also have been taken to suggest greater attention in adjustment to novelty.

Using PET, Richard Haier found that people with higher IQs typically show lesser activation in relevant parts of the brain than do those people with lower IQs.[81] These results suggest that the higher-IQ people find the tasks to be easier. As a result, they put in less effort than do the poorer performers and hence the brain signals are weaker. P-FIT (parietal-frontal integration) theory, which was proposed by Rex Jung and Richard Haier, argues that general intelligence stems, at least in part, from the efficiency of the communication between particular regions of the brain, in particular, parts of the parietal, frontal, temporal, and cingulate cortices.[82] Today, much of the research on human intelligence based on a biological approach uses fMRI in order to pinpoint intelligent processing in the brain.

None of this research takes into account the cultural factors that affect what people mean by intelligence and that affect what constitutes adaptive behavior in a given cultural milieu.

2.5.5 A Cultural Metaphor

A fifth metaphor is a cultural or anthropological one. This metaphor is based on the view that intelligence is a cultural invention.[83] Scientists who adhere to this metaphor view intelligence as a cultural construct. It is a construct cultures invent to explain why some people do certainly culturally valued tasks better than do others. But the tasks that cultures value differ across cultures. So, what intelligence "is" will be perceived as different from one culture to another. It is for this reason that at least some people were likely unwilling to sign the so-called (by the authors) "Mainstream Science" definition of intelligence described earlier. They did not believe that merely administering intelligence tests measuring skills valued in parts of the West provided a fair measure of the intelligence of people from culturally diverse environments. They may have believed that people in parts of the West might, in many cases, do poorly on tests measuring skills valued in other cultures, such as hunting big game, gathering, ice fishing, building appropriate homes, self-treating parasitic illnesses, and so forth.

Let us consider some of the cultural views on intelligence and how radically they differ from more conventional views. Intelligence may be conceived and thought about in different ways in different cultural settings[84] (see reviews in Berry, 1991; and Sternberg & Kaufman, 1998). For example, the Confucian perspective on intelligence emphasizes benevolence and doing what is viewed as right and proper.[85] As in certain Western notions of intelligence, the intelligent person puts a great deal of effort into learning. He or she enjoys learning and persists with enthusiasm in lifelong learning. Learning, in this view, never stops. In the Taoist tradition, the emphasis is different. In this tradition, the emphasis is on the importance of humility and of freedom from adherence to conventional norms and societal standards of judgment. Also of importance is comprehensive knowledge of oneself as well as of the circumstances in the world in which one lives.

The difference between certain Eastern and Western conceptions of intelligence has persisted over many years.[86] Contemporary Taiwanese Chinese conceptions of intelligence involve five factors. The first is a general cognitive factor. This factor appears to be much like the general (or *g*) factor emerging from factor analysis of scores on conventional Western intelligence tests. The second factor was what might be called "interpersonal intelligence." It included social competence, such as is used in understanding other people and then acting upon that understanding. The third factor was intrapersonal intelligence, or understanding oneself. Interpersonal and intrapersonal intelligence are much as in Gardner's theory of multiple intelligences. The fourth factor was intellectual self-assertion, which is essentially one's willingness and ability to communicate one's views clearly and, if necessary, forcefully to others. And the fourth factor was intellectual self-effacement. This factor involves understanding both of what one knows and also, and perhaps more importantly, of what one does not know.

A different study yielded somewhat different results. It yielded three factors underlying Chinese folk theories of intelligence. The first was nonverbal reasoning ability, or the ability to, reason with abstract symbols such as geometric shapes or numbers. The second factor was verbal reasoning ability, as would be used, for example, in verbal analogies. The third factor was rote memory. This involves remembering precisely what one has read or has been told orally.[87]

The conceptions of intelligence revealed in Taiwan differ quite a bit from those identified in people's conceptions of intelligence in the United States – (a) practical problem-solving, (b) verbal ability, and (c) social competence.[88] But both in Taiwan and in the United States, people's conceptions, or "implicit theories," of intelligence go quite far beyond the kinds of skills that conventional intelligence tests measure. One might be inclined quickly to dismiss the conceptions of the laypeople – after all, what do laypersons know compared with experts? But from a different point of view, experts are entrenched – as a result of their training and general professional socialization, they are used to thinking in a certain way. They often are the last to change their views in response to what is going on in the world.[89]

In Africa, conceptions of intelligence center especially on skills that help to facilitate, maintain, and further develop harmonious and stable relations among members of a group.[90] For example, Chewa adults in Zambia place emphasis on social responsibilities, cooperation, and obedience to authorities as important to intelligence; in particular, intelligent children are expected to be respectful of and obedient to adults.[91] Parents of children in Kenya also emphasize the importance of responsible and socially appropriate participation in family and larger-group social life as important aspects of children's intelligence.[92] In Zimbabwe, the word for intelligence, *ngware*, signifies a trait of someone who is both prudent and cautious, particularly in interpersonal relationships. Among the Baoulé tribe, service to the family and surrounding community as well as politeness toward, and respect for elders, are seen as crucial aspects of intelligence.[93]

The emphasis on the social, interpersonal aspects of intelligence is not limited to African cultural groups. Views of intelligence in many Asian cultures also emphasize the social and other-oriented aspects of intelligence more than does the conventional and highly individualistic Western, or IQ-based, notion of intelligence.[94]

Neither African nor Asian cultural groups emphasize exclusively social aspects of intelligence. They simply emphasize social skills more than do conventional US conceptions of intelligence. But as we saw, people in the United States also view "social competence" as part of intelligence. At the same time, African and Asian cultures recognize the importance of cognitive skills as part of intelligence. In rural Kenya, investigators found that there are four distinct terms constituting conceptions of intelligence – *rieko* (consisting of knowledge and skills), *luoro* (which roughly translates to "respect"), *winjo* (which involves comprehension of how to handle real-life problems), and *paro* (initiative or drive)[95] – with only *rieko* clearly referring to knowledge-based cognitive skills (including but not limited to academic skills).

It is important to realize that, in a given country, there is no one single conception of intelligence that pervades all cultures or subcultures. For example, different ethnic groups in San Jose, California, have rather different conceptions of what it means for children to be intelligent. Latino-American parents of schoolchildren tend to highlight the importance of social-competence, interpersonal skills in their conceptions of intelligence. In contrast, Asian-American parents tend to emphasize the importance of more conventional cognitive skills. Anglo-American parents, like the Asian-American parents, also emphasize more the importance of cognitive skills. Teachers, representing the dominant culture of the country's educational establishment, also emphasize more cognitive- than social-competence skills. The rank order of performance of children in the various ethnic groups (including subgroups within the Latino-American and Asian-American groups) could be predicted perfectly by the extent to which their parents shared the teachers' conventional conception of intelligence.[96] In other words, teachers had a tendency to reward those children who were socialized into a folk theory of intelligence that happened to correspond to the teachers' own folk theory.

Cultural views of intelligence are part of what even broader theories, systems theories, try to take into account in understanding intelligence.

2.5.6 A Systems Metaphor

A further metaphor is a systems metaphor.[97] The idea of a systems metaphor is that intelligence can be understood only in terms of a complex system that integrates mental representations, processes, and other systems of thought. The systems metaphor, in a sense, incorporates many of the other metaphors.

In the intelligence business, the systems metaphor is new, at least, relatively speaking. It inevitably expands our view of intelligence because it views intelligence as involving much more of thinking and acting than just a narrow set of cognitive structures of processes.

The first modern theorist to introduce a systems theory was probably Howard Gardner.

Although intelligence is usually thought of as unitary, Howard Gardner proposed a theory of multiple intelligences.[98] According to this theory, intelligence, broadly speaking, comprises multiple independent constructs. It is not just a single, unitary construct. However, instead of speaking of multiple abilities that together constitute intelligence, as did Thurstone in his theory of primary mental abilities (described earlier in this chapter), this theory distinguishes eight distinct intelligences. The intelligences are alleged to be relatively independent of each other. Each is a separate system of functioning. However, these systems can interact to produce what we see as intelligent performance.

Linguistic Intelligence. This intelligence is used in reading a book, writing a poem, speaking to someone, or understanding a lecture. It is heavily involved in verbal sections of traditional tests of intelligence and of scholastic achievement. Most intelligence tests directly measure linguistic intelligence.

Logical-Mathematical Intelligence. This intelligence is used in solving a mathematics problem, such as a time-rate-distance problem, or adding numbers, or proving a logical theorem. Pretty much all intelligence tests measure logical-mathematical intelligence in some degree. Scholastic achievement tests all measure logical-mathematical intelligence.

Visual-Spatial Intelligence. This intelligence is used to do mental rotations of objects (i.e., imagining objects rotating in space). It also is used to figure out how many suitcases can fit in the trunk of a car, to determine how sharply to steer to make a turn in a car, and in other related tasks. Visual-spatial intelligence is measured by many, but not all, tests of intelligence. It is not measured, for example, by tests that are wholly verbal.

Naturalist Intelligence. This intelligence is used in observing patterns in nature, such as in the classification of trees, flowers, clouds, stars, or other natural patterns. This intelligence is important for people who work in fields such as botany, horticulture, astronomy, and physics. It also is important for people in the arts who draw or write about nature. This purported intelligence is not measured by conventional tests of intelligence.

Bodily-Kinesthetic Intelligence. This intelligence is indispensable to athletic pursuits, such as tennis, basketball, or soccer. But it is also important for everyday activities that require coordination and various motor skills. This purported intelligence also is not measured by conventional tests of intelligence.

Musical Intelligence. This intelligence is used to sing, dance, write music, play music, and listen intelligently to music. The intelligence is important to all musical activity, including even clapping one's hands to rhythm. This purported intelligence, like naturalist and bodily-kinesthetic intelligence, is not measured by conventional tests of intelligence.

Interpersonal Intelligence. This intelligence is used to relate to other people, as in relations with one's significant other, with one's children, or with friends or colleagues at work. It is very similar to what is sometimes called "social intelligence." This intelligence is also not measured by typical psychometric intelligence tests.

Intrapersonal Intelligence. This intelligence is used to understand and have insights into oneself. For example, it would be used to recognize when one needs to make changes in one's life. This intelligence, like most of those in Gardner's theory, is not measured by intelligence tests.

In some respects, Gardner's theory is similar to test-based, factorial theories, such as those of Thurstone or Vernon. It specifies several abilities that are construed to reflect intelligence of some sort. However, Gardner views each ability as a separate and distinct intelligence. He does not see the various abilities as parts of a single whole and unified intelligence. Moreover, there is a crucial difference between Gardner's theory and factorial theories. Factorial theories are based on factor analysis of ability tests. Gardner, in contrast, used converging operations, gathering evidence from multiple sources and types of data.

In particular, the theory uses eight "signs" as criteria for detecting the existence of a discrete kind of intelligence (taken from Gardner, 1983, pp. 63–7):

1 *Potential isolation of a particular intelligence by brain damage*. The destruction or the sparing of a distinct, discrete area of the brain may destroy or else it may spare a particular kind of intelligent behavior. For example, particular areas of the brain can be linked to verbal aphasia—impairment of language functioning.
2 *The existence of exceptional and highly distinctive individuals*. Examples of exceptional individuals would be mathematical or musical prodigies. These individuals demonstrate an extraordinary ability in a particular kind of intelligent behavior. Otherwise, they may have notable deficits in their intelligent behavior.
3 *An identifiable core operation or set of core operations*. An example would be the detection of relationships among a set of musical tones. The core operation or operations are essential to the performance of a particular kind of intelligent behavior, such as behaviors emanating from musical intelligence.

4 *A distinctive developmental history leading an individual from the level of novice to the level of master*. This history is accompanied by varied levels of expert performance. That is, there are many levels of expertise in the expression of the intelligence.
5 *A distinctive evolutionary history of the intelligence*. Each intelligence somehow serves a different adaptive function in the evolutionary history of the organism.
6 *Supportive evidence from cognitive-experimental investigations*. An example of such evidence would be task-specific performance differences across different intelligences. For example, cognitive-experimental research might reveal that visuospatial tasks involve different mental processes from those involved in verbal tasks. These differences would need to be complemented by cross-task performance similarities within particular intelligences. For example, mental rotation of visuospatial imagery and recall memory of visuospatial images should show overlapping cognitive processes as they emanate from the same intelligence.
7 *Supportive evidence from psychometric tests pointing to differentiable and discrete intelligences*. For example, one would expect to find performances on tests of visuospatial abilities loading on different psychometric factors from performances on tests of linguistic abilities.
8 *Susceptibility to encoding of information in a symbol system*. For example, language, mathematics, and music all have their own distinctive symbol systems and notations.

Gardner does not entirely dismiss the use of psychometric tests for measuring intelligence. But the base of evidence used by Gardner goes well beyond the factor analysis of various psychometric tests. Moreover, Gardner believes the psychometric tests are extremely limited in the range of intelligences they test. Primarily, they measure linguistic and logical-mathematical intelligences. Sometimes they also measure visual-spatial intelligence. They are not targeted at measuring the other intelligences.

Gardner views the mind as modular, a view first introduced in a different context by Jerry Fodor.[99] Theorists who believe in the modularity of mind believe that different skills – such as, but not limited to, Gardner's multiple intelligences – can be isolated in performance as deriving from distinct, identifiable, and separate modules, or areas of the brain. On this view, a major task of research on intelligence is to isolate the portions of the brain responsible for each of the multiple intelligences. Gardner has speculated as to where at least some of these locales may be. But hard scientific evidence for the existence of such independent intelligences is still lacking. Furthermore, it is not even clear just how modular the mind is.

Consider, for example, performance of autistic savants. Savants are individuals with severe cognitive and social deficits but nevertheless with corresponding high levels of ability in a relatively narrow domain. Is the existence of such savants really evidence for modular intelligences? Perhaps and perhaps not. The narrow long-term memory skills and highly specific aptitudes of savants may not really be intelligent in the sense that the word "intelligent" usually is used. Contemporary evidence may suggest the opposite of Gardner's claim. It appears that rather than being modular, intelligent functioning, even of a given kind, is widely distributed throughout the brain.

Gardner's theory has several notable strengths. First, it expands the way we think about intelligence. It encourages us all to think of skills as intelligences that previously would have been conceived of merely as talents. Second, it suggests ways in which teachers can teach to children with multiple patterns of abilities. Third, it draws upon diverse sources of information for the delineation of the intelligences.

Gardner's theory also has notable weaknesses. The first is that thirty-five years after the theory was first proposed, there is a lack of hard empirical evidence validating the theory. One attempt failed.[100] Of course, theories are sometimes proposed before predictive empirical data are collected. But one nevertheless would hope that after three and a half decades, there would be adequate hard empirical evidence supporting the predictive power of the theory.

Second, and following from the first point, it is not clear that one can identify eight entirely independent skill sets, or intelligences. There have been literally thousands of studies of the factorial structure of intelligence and abilities such as linguistic, logical-mathematical, and visual-spatial. These studies generally have shown the various abilities to be correlated – that is, people who are better at one tend to be better at the others.[101] It also seems dubious that interpersonal and intrapersonal skills would be entirely independent. They might be, but then one would need predictive empirical evidence to show that to be the case.

Third, some of the intelligences may not be unitary. For example, some people are good readers but not particularly good writers (linguistic intelligence). Others are very good at algebra but could not adequately formulate a complex logical proof. A good singer is not necessarily a good composer. And a good composer may or may not be virtuoso on an instrument. It simply is not clear that the intelligences represent single sources of brain power or variation among people.

Fourth, it is not clear what is to be gained by calling some of the skills sets "intelligences." Perhaps it serves a desirable social function to do so. (For example, one can now say that a star athlete is intelligent in his or her own way.) But social functions are different from scientific ones. Moreover, the different intelligences, at least in today's world, do not have equal or nearly equal adaptive value. People who have a "tin ear" to music generally can get along quite well in their lives. People with severely deficient linguistic or logical skills often find their lives present severe challenges. One could imagine a society in which musical skills were the key to success. They certainly are key to success among musicians. But musicians are a small percentage of the population. There are small percentages of the population where other skills, such as fire-eating, also may be essential for success.

It may sound like I am putting too much emphasis on the predictive value of a theory. But there is a reason for doing so. When scholars review past literature, as Gardner has in his books, they can be selective as to what they choose to review, potentially placing more emphasis on results that suit their theories. All scholars are susceptible to confirmation bias. The problem is that other scholars can review similar literatures, for example, the literature on intelligence, and come to exactly the opposite conclusion. In their reviews (cited earlier in this chapter), for example, John Carroll and Arthur Jensen came to opposite conclusions from Gardner's. Predictive studies enable one to discover which theories can hold up not only to potentially selective reviews of literature, but also to predicting what should happen in the future. What empirical results can we predict in advance that will test the validity of a given theory?

On the one hand, Gardner's theory scientifically has not (at least to date) proved to be entirely viable. But it has served the useful scientific function of broadening our thinking about intelligence. And it has served a very useful societal function of pointing out that schools and society as a whole should not be locked into narrow conceptions of what makes a person capable. Whether the multiple intelligences are truly distinct systems of individual intelligences or perhaps better described as a range of talents, they provide diverse paths for life success. And in today's world, people need to be aware that there are multiple paths to succeeding in life besides having a high IQ. There is more to adaptation than IQ, and Gardner was among the first to point this out in an elegant and educationally compelling way.

A second systems theory is my own, the augmented theory of successful intelligence. Because I will describe it in detail in the rest of this book I will not describe it in detail here as well. Basically, the theory states that intelligence inheres in one's finding a personally and socially meaningful set of goals in life, figuring out how to reach those goals, and then doing one's best to achieve them, given the limitations imposed by one's sociocultural context. Intelligence, in this view, is not a "thing" that can be fully measured by a single intelligence test because it is not even quite the same thing for one person versus another. A musician who wants to become a composer or a performer needs to find a life path and, particularly, a career path that is different from that of a lawyer or a surgeon. Each individual needs a different set of skills and attitudes, and even within a given profession, there are different ways of achieving success. Intelligence in this view is largely "idiographic" – differing from one person to the next. We all have to find, construct, and continually evaluate our own path.

2.5.7 Beyond Metaphors

Although the theory of adaptive intelligence presented in this book draws upon a systems theory – the theory of successful intelligence – it is, in a sense, beyond metaphors. On this theory, it really does not matter what metaphor one uses – all of them can be useful. One can study adaptation biologically – indeed, adaptation is a biological imperative. One can study adaptation psychometrically by measuring it. One can study the systems underlying adaptation. Regardless of the metaphor under which intelligence is understood, intelligence must serve an adaptive purpose. It must serve to create a fit not only for one individual, but also for individuals collectively, with the world they inhabit. Stephen Ceci recognized the importance of such adaptation in his bioecological view of intelligence.[102] If there is a misfit between individuals or groups and the environment, problems inevitably result. If the individuals who fail to achieve fit become sufficiently powerful and at the same time destructive, the metaphor of mind does not matter. That is, it does not matter whether one views intelligence geographically, biologically, culturally, or in some other way. The powerful individuals collectively may well end up destroying their own habitat and the world as they know it. Those who believe themselves to be "masters of the universe" misunderstand their ultimate role in the universe. They ultimately become victims of the universe they thought they had mastered.

The world is at a crossroads. If, because of global climate change, air pollution, water pollution, poisoned food, or whatever, people eventually kill themselves off, their scores on the clever little tests will be a testament to their own ultimate stupidity. Perhaps no one recognized this better than poet Percy Shelley in Ozymandias, presented in Chapter 1.[103]

Shelley's poem, of course, was about hubris. And hubris is what is taking down humanity and many other species with it. It also has taken down intelligence research, and the views of those who believe they have found definitive answers about intelligence and that everyone who disagrees with them is wrong. Hubris did not work well for the Greek mythological characters like Ajax; it also does not work well for behavioral scientists who believe that only they and their followers have found the ultimate "truth." Their hubris locks them into a single paradigm and prevents them from seeing outside the small, cramped mental black box they have created for themselves. For them, those who disagree with them are believers in myths. But they are the mythmakers. Even physicists have not found ultimate truths; why would behavioral scientists then have had such fantastic success?

Someday some other species will look back and, if it is able, will wonder what happened. What were the forces that destroyed humanity? The dinosaurs, were their descendants still around today, could blame their demise on a heavenly body that, to their bad fortune, landed on Earth. We will have only ourselves to blame. Ozymandias thought he was pretty smart, too. He ended up where we and our descendants will if we do not change course.

2.6 Conclusion

All of the different views on intelligence may suggest that researchers on intelligence have little or no common basis for understanding or studying the phenomenon. But in the end, they actually do have quite a bit of common basis. Most researchers agree that intelligence involves, at minimum, the ability to learn, the ability to reason abstractly, the ability to adapt to the environment and solve the problems life presents, and the ability to understand, and at some level control, one's cognitive processing. The concept of *adaptation to the environment* is key in any definition of intelligence – intelligence is an evolved trait. To the extent that more intelligent rather than less intelligent humans (or any other organisms) have survived, it must be in part because they adapted more effectively to their environments and flexibly when those environments changed. So, despite the differences, you cannot go too far wrong, if in trying to understand intelligence, you focus on learning, reasoning, problem-solving, and most of all, adaptation. Those are keys to understanding what intelligence is, almost without regard to the differences one might find among scholarly definitions. But no one today, including me, has any final answers in this field. We only seek closer and closer approximations to some as yet unknown and possibly unknowable truth.

Intelligence, then, is one of the most important traits that have allowed humans and other organisms to succeed in their environments. But there is one thing always to keep in mind. As the ability to adapt to the environment increases, so can the ability to change the environment. And the changes humans have wrought have not all been positive. They have included global climate change, air pollution, and wars. So, intelligence is an important ability, but like any ability, it can be used toward better or worse ends. One of our responsibilities as citizens of our country and of the world is to use intelligence for ends that will create a better world, not that will destroy the world.

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