PART I

THE NATURE OF INTELLIGENCE AND ITS MEASUREMENT

CHAPTER ONE

The Concept of Intelligence

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Looked at in one way, everyone knows what intelligence is; looked at in another way, no one does. Put another way, people all have conceptions – which also are called folk theories or implicit theories – of intelligence, but no one knows for certain what it actually is. This chapter addresses how people conceptualize intelligence, whatever it may actually be.

WHY CONCEPTIONS OF INTELLIGENCE MATTER

Why should we even care what people think intelligence is as opposed only to valuing whatever it actually is? There are at least four reasons people's conceptions of intelligence matter.

First, implicit theories of intelligence drive the way in which people perceive and evaluate their own intelligence and that of others. To better understand the judgments people make about their own and others' abilities, it is useful to learn about people's implicit theories. For example, parents' implicit theories of their children's language development will determine at what ages they will be willing to make various corrections in their children's speech. More generally, parents' implicit theories of intelligence will determine at what ages they believe their children are ready to perform various cognitive tasks. Job interviewers will make hiring decisions on the basis of their implicit theories of intelligence. People will decide who to date on the basis of such theories. In sum, knowledge about implicit theories of intelligence is important because this knowledge is so often used by people to make judgments in the course of their everyday lives.

Second, implicit theories of scientific investigators ultimately give rise to their explicit theories. It thus is useful to find out what these implicit theories are. Implicit theories provide a framework, or lay of the land, that is useful in defining the general scope of a phenomenon – especially a not-well-understood phenomenon. These implicit theories can suggest what aspects of the phenomenon have been more or less attended to in previous investigations.

Third, implicit theories can be useful when an investigator suspects that existing explicit theories are wrong or misleading. If an investigation of implicit theories reveals little correspondence between the extant implicit and explicit theories, the implicit theories may be wrong. But the possibility also needs to be taken into account that the explicit theories are wrong and in need of correction or supplementation. For example, some implicit theories of intelligence suggest the need for expansion of some of our explicit theories of the construct.

Finally, understanding implicit theories of intelligence can help elucidate developmental and cross-cultural differences. As mentioned earlier, people have expectations for intellectual performances that differ for children of different ages. How these expectations differ is in part a function of culture. For example, expectations for children who participate in Western-style schooling are almost certain to be different from those for children who do not participate in such schooling – or at least they should be (Greenfield, 1997).

This chapter is divided into four parts. First, I discuss lay conceptions of intelligence. This discussion is divided into two sections. The first section deals

with Western conceptions, and the second with conceptions from other parts of the world. The second part of the chapter deals with what might be called expert conceptions of intelligence. This discussion is divided into three sections. First, I discuss definitions of intelligence that have been proposed by experts. I then describe some conceptions of experts inferred by means other than direct definitions. Last I delineate some of the usually implicit metaphors that have driven explicit theories of intelligence proposed by experts. The third part of the chapter deals with implicit theories of how intelligence relates to society at large, and the fourth part consists of a brief summary and some conclusions.

LAY CONCEPTIONS OF INTELLIGENCE

Western Conceptions of Intelligence

Some of the studies of implicit theories of intelligence among mainland U.S. adults have been conducted by my collaborators and myself. We have been involved in three major sets of studies. The first was on implicit theories of intelligence, academic intelligence, and everyday intelligence in laypersons and experts (Sternberg, Conway, Ketron, & Bernstein, 1981). The second set was on implicit theories of intelligence as well as wisdom and creativity in laypersons and experts in various fields of endeavor (Sternberg, 1985c). A third set of studies was on implicit theories of intelligence across the adult life span (Berg & Sternberg, 1985).

In the first set of studies (Sternberg et al., 1981), three factors emerged from analyzing ratings of the ideally intelligent person as supplied by laypersons. The factors were labeled Practical Problem Solving, Verbal Ability, and Social Competence. The first factor included behaviors such as reasoning logically and well, identifying connections among ideas, and seeing all aspects of a problem. The second factor included behaviors such as speaking clearly and articulately, having verbal fluency, and conversing well. The third factor included behaviors such as accepting others for what they are, admitting mistakes, and displaying interest in the world at large. Sternberg (1985c) obtained fairly similar results in the second set of studies.

In the third set of studies, Berg and Sternberg (1985) investigated the development of implicit theories of intelligence over the life span. Their participants ranged in age from 20 to 83 years and were divided into three groups averaging 30, 50, and 70 years of age. The main finding of interest was that older individuals tend to view everyday competence as more important in characterizing the difference between individuals of average and exceptional intelligence than do younger individuals. Moreover, middle-aged and older individuals tend to combine crystallized intelligence with problem-solving abilities for most age-specific prototypes. Thus, the distinction between fluid (abstract-reasoning) and crystallized (knowledge-based) abilities seems less important to the older individuals than to the younger ones.

Some of the most interesting work on implicit theories of intelligence has been done by investigators seeking an understanding of the nature of intelligence in children. Siegler and Richards (1982) asked college students what they thought intelligence is at different ages. In particular, participants were asked to describe the nature of intelligence in 6-month-olds, 2-year-olds, 10-year-olds, and adults. The authors reported the five traits (in order of the frequency of mention) that most often were mentioned as characterizing intelligence at different ages. At 6 months old, these traits were recognition of people and objects, motor coordination, alertness, awareness of the environment, and verbalization. At 2 years of age, they were verbal ability, learning ability, awareness of people and environment, motor coordination, and curiosity. At 10 years old, they were verbal ability, followed by learning ability, problem-solving ability, reasoning ability – all tied for second place in frequency of mention – and creativity. At the adult level, the traits were reasoning ability, verbal ability, problem-solving ability, learning ability, and creativity. Clearly, there is a trend toward conceiving of intelligence as less perceptual–motor and as more cognitive with increasing age.

One of the more interesting studies of implicit theories regarding children's intelligence was done with teachers rather than with college students. Fry (1984) asked teachers at the primary, secondary, and tertiary levels about their conceptions of intelligence. Elementary school teachers tended to emphasize social variables such as popularity, friendliness, respect for law and order, and interest in the

environment in their conceptions of intelligence. Secondary teachers, in contrast, were inclined to stress verbal variables, such as verbal fluency and energy, in their conceptions. The tertiary teachers tended to regard cognitive variables such as reasoning ability, broad knowledge, logical thinking, and the ability to deal maturely with problems as most important to intelligence. Thus, the teachers at the three levels in effect recapitulated the three factors obtained by Sternberg et al. (1981) in their study of implicit theories, but the emphasis was on the applicability of different factors at different ages. Problem-solving ability applied most to teachers' conceptions of college students' intelligence, verbal ability to their conceptions of secondary school students' intelligence, and social competence to their conceptions of elementary students' intelligence.

Yussen and Kane (1985) studied conceptions of intelligence, but they used as their participants children rather than adults. They interviewed students in the first, third, and sixth grades. Children were asked questions concerning such issues as visible signs of intelligence, qualities associated with intelligence, the constancy or malleability of intelligence, and the definition of intelligence. The authors found that older children's conceptions were more differentiated than were those of younger children and that with advancing age children increasingly characterized intelligence as an internalized quality. But older children were less likely than younger children to think that overt signs indicate intelligence. Older children also are less global in the qualities they associate with intelligence than are younger children. There is a tendency as well for younger children to think of intelligence largely in terms of social skills but for older children to think of intelligence largely in relation to academic skills.

Dweck (1999; Dweck & Elliott, 1983) has also investigated concepts of intelligence among children and has found that children generally have one of two kinds of concepts regarding the plasticity of intelligence. "Entity theorists" believe that intelligence is something you are born with and that its level remains constant across the life span. Because these children believe that there is not much they can do to increase their intelligence, they tend to be oriented toward showing intelligence through their performance. They are often afraid to make mistakes, particularly if they will be observed by others, and attempt to "look good" to others in their work. "Incremental theorists," on the other hand, believe that intelligence is something that increases throughout the life span and that the method of increase is through learning. They are inclined, therefore, to be learning rather than performance oriented and to seek new challenges that will help them improve their intelligence.

Nicholls (1990) has also studied children's conceptions of abilities. Like Dweck, he found that children differ in their conceptions of intelligence and its relationship to effort. Some children view effort and ability as largely differentiated, whereas others do not. Nicholls also found that children differ in their overall conceptions of intelligence. Some children view the development of intelligence as involving effortful learning or acquisition of information, whereas others do not. Also, as children become more sophisticated, they begin to differentiate the acquisition of information from problem solving with information.

Conceptions of Intelligence around the World

In some cases, Western notions about intelligence are not shared by other cultures (Berry, 1984; Sternberg & Kaufman, 1998). For example, the Western emphasis on speed of mental processing is not shared by many cultures (Sternberg et al., 1981). People in other cultures may even be suspicious of the quality of work done very quickly and may emphasize depth rather than speed of processing. They are not alone. Some prominent Western theorists have pointed out the importance of depth of processing for full learning and understanding of what one learns (e.g., Craik & Lockhart, 1972).

Yang and Sternberg (1997a) have reviewed Chinese philosophical conceptions of intelligence. The Confucian perspective emphasizes the characteristic of benevolence and of doing what is right. As in the Western notion, the intelligent person spends much effort in learning, enjoys learning, and persists in lifelong learning with enthusiasm. The Taoist tradition, in contrast, emphasizes the importance of humility, freedom from conventional standards of judgment, and full knowledge of oneself and of external conditions.

The difference between Eastern and Western conceptions of intelligence may persist even today.

Yang and Sternberg (1997b) studied contemporary Taiwanese conceptions of intelligence and found five factors underlying these conceptions: (a) a general cognitive factor, much like the general factor in conventional Western tests of intelligence; (b) interpersonal intelligence; (c) intrapersonal intelligence; (d) intellectual self-assertion; and (e) intellectual self-effacement. In a related study but with different results, Chen (1994) found three factors underlying Chinese conceptions of intelligence: nonverbal reasoning ability, verbal reasoning ability, and rote memory. The difference may be due to different subpopulations of Chinese, to differences in methodology, or to differences in when the studies were done.

Chen and Chen (1988) explicitly compared the concepts of intelligence of Chinese graduates from Chinese-language versus English-language schools in Hong Kong. They found that both groups considered nonverbal reasoning skills as the most relevant skills for measuring intelligence. Verbal reasoning skills and social skills were next and then numerical skills. Memory was seen as least important. The Chinese-language-schooled group, however, tended to rate verbal skills as less important than did the English-language-schooled group. Moreover, in an earlier study, Chen, Braithwaite, and Huang (1982) found that Chinese students viewed memory for facts as important for intelligence, whereas Australian students viewed such memory skill as of only trivial importance.

Das (1994), also reviewing Eastern notions of intelligence, has suggested that in Buddhist and Hindu philosophies, intelligence involves waking up, noticing, recognizing, understanding, and comprehending but also includes such things as determination, mental effort, and even feelings and opinions in addition to more intellectual elements.

Differences between cultures in conceptions of intelligence have been recognized for some time. Gill and Keats (1980) noted that Australian university students value academic skills, whereas Malay students value practical skills as well as speech and creativity. Dasen (1984) found that Malay students emphasize social and cognitive attributes in their conceptions of intelligence.

Western schooling also emphasizes other things (Srivastava & Misra, 1996) such as generalization or going beyond the information given (Connolly & Bruner, 1974; Goodnow, 1976), speed (Sternberg, 1985a), minimal moves to a solution (Newell & Simon, 1972), and creative thinking (Goodnow, 1976). Moreover, silence is interpreted as a lack of knowledge (Irvine, 1978). In contrast, the Wolof tribe in Africa views people of higher social class and distinction as speaking less (Irvine, 1978). This difference between the Wolof and Western notions suggests the usefulness of looking at African notions of intelligence and its manifestations in behavior as possible contrasts to Western notions.

Ruzgis and Grigorenko (1994) have argued that, in Africa, conceptions of intelligence revolve largely around skills that help to facilitate and maintain harmonious and stable intergroup relations; intragroup relations are probably equally important and at times more important. Serpell (1974, 1977, 1982) found that Chewa adults in Zambia emphasize social responsibilities, cooperativeness, and obedience as important to intelligence; intelligent children also are expected to be respectful toward adults. Kenyan parents also emphasize reasonable participation in family and social life as important aspects of intelligence (Super & Harkness, 1986). In Zimbabwe, the word for intelligence, *ngware*, actually means to be prudent and cautious, particularly in social relationships. Among the Baoule, service to the family and community and politeness toward, and respect for, elders are seen as key to intelligence (Dasen, 1984).

Wober (1974) investigated concepts of intelligence among members of different tribes in Uganda as well as within different subgroups of the tribes. Wober found differences in concepts of intelligence within and between tribes. The Bagandans, for example, tended to associate intelligence with mental order, whereas the Batoro tribespeople were inclined to associate it with some degree of mental turmoil. On semantic–differential scales, Bagandan tribespeople thought of intelligence as persistent, hard, and obdurate, whereas the Batoro thought of it as soft, obedient, and yielding.

Harkness and Super (1983) analyzed concepts of intelligence among the Kokwet of western Kenya. He found that intelligence in children seemed to be conceived differently from intelligence in adults. The word *ngom* was applied to children and seemed to note responsibility, highly verbal cognitive quickness, the ability to comprehend complex matters quickly, and good management of interpersonal relations. The word *utat* was applied to adults and

suggested inventiveness, cleverness, and sometimes wisdom and unselfishness. A separate word, *keelat*, was used to signify smartness or sharpness.

Similar emphasis on social aspects of intelligence has been found as well among two other African groups – the Songhay of Mali and the Samia of Kenya (Putnam & Kilbride, 1980). The Yoruba, another African tribe, emphasize the importance of depth of listening rather than just referring to intelligence and of being able to see all aspects of an issue and to place the issue in its proper overall context (Durojaiye, 1993).

The emphasis on the social aspects of intelligence is not limited to African cultures. Notions of intelligence in many Asian cultures also emphasize the importance of the social aspects of intelligence more than do the conventional Western or IQ-based notions (Azuma & Kashiwagi, 1987; Lutz, 1985; Poole, 1985; White, 1985).

It should be noted that neither African nor Asian notions emphasize exclusively social notions of intelligence. In a collaborative study with several investigators, Sternberg and Grigorenko (1997; Sternberg et al., in press) have studied conceptions of intelligence in rural Kenya. In one such rural village, well over 90% of the children are infected with parasitic infections. Consequently, they experience stomachaches quite frequently. Traditional medicine suggests the usefulness of a large variety of natural herbal medicines that can be used to treat such infections. It appears that at least some of these – although perhaps a small percentage – actually work. More important for our purposes, however, is that children who learn how to self-medicate with these natural herbal medicines are viewed as being at an adaptive advantage over those children who do not have this kind of informal knowledge. Clearly, the kind of adaptive advantage that is relevant in this culture would be viewed as irrelevant in the West, and vice versa.

Although these conceptions of intelligence emphasize social skills much more than do conventional Western conceptions of intelligence, they simultaneously recognize the importance of cognitive aspects of intelligence. Note, however, that there is no one overall Western or even U.S. conception of intelligence. Okagaki and Sternberg (1993) found that different ethnic groups in San Jose, California, had rather different conceptions of what it means to be intelligent. For example, Latino parents of schoolchildren tended to emphasize the importance of social competence skills in their conceptions of intelligence, whereas Asian parents tended rather heavily to emphasize the importance of cognitive skills. Anglo parents also placed greater emphasis on cognitive skills. Teachers, representing the dominant culture, emphasized cognitive rather than social competence skills more. The rank order of children of various groups' performance (including subgroups within the Latino and Asian groups) could be predicted perfectly by the extent to which their parents shared the teachers' conceptions of intelligence. That is, teachers tended to reward those children who were socialized into a view of intelligence that happened to correspond to the teachers' own. Yet, social aspects of intelligence, broadly defined, may be as important as, or even more important than, cognitive aspects of intelligence in later life. For example, a team that needs to complete a cognitive task may not be able to do so if members are unable to work together. Heath (1983) also found differences in conceptions of intelligence between White and Black groups characterized by the Black groups' emphasizing nonverbal communication skills more and the White groups' placing more emphasis on verbal communication skills.

EXPERT CONCEPTIONS OF INTELLIGENCE

Expert Definitions of Intelligence

Perhaps the most famous or infamous definition of intelligence, depending upon one's point of view, was proposed by Boring (1923) in an article in *The New Republic*. Boring proposed that intelligence is what tests of intelligence test. Boring was not so foolish as to believe that this operational definition was the end of the line for understanding intelligence. On the contrary, he saw it as a "narrow definition, but a point of departure for a rigorous discussion ... until further scientific discussion allows us to extend [it]" (p. 35).

To the extent that some view the definition as infamous, it is probably because they see this definition as seriously flawed. First, it seems to define away intelligence rather than defining it. To this day, it is not totally clear what intelligence tests measure, and thus it cannot be clear on the basis of this definition what intelligence is. Second, tests of intelligence do

not intercorrelate perfectly, and therefore they do not produce a singular entity of the kind the definition implies. Or if they do, it is a subset of what they measure rather than the whole thing (Spearman, 1927). Third, the definition is extremely conservative in that it never will enable us to understand intelligence in a way that goes beyond the traditional tests. Finally, many view the definition as circular.

Probably the most famous study of experts' definitions of intelligence was done by the editors of the *Journal of Educational Psychology* ("Intelligence and its measurement," 1921). Contributors to this issue provided several different definitions as follows:

1. The power of good responses from the point of view of truth or facts (E. L. Thorndike);
2. The ability to carry on abstract thinking (L. M. Terman);
3. Sensory capacity, capacity for perceptual recognition, quickness, range or flexibility of association, facility and imagination, span of attention, quickness or alertness in response (F. N. Freeman);
4. Ability to learn or having learned to adjust oneself to the environment (S. S. Colvin);
5. Ability to adapt oneself adequately to relatively new situations in life (R. Pintner);
6. The capacity for knowledge and knowledge possessed (B. A. C. Henmon);
7. A biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behavior (J. Peterson);
8. The capacity to inhibit an instinctive adjustment, the capacity to redefine the inhibited instinctive adjustment in the light of imaginally experienced trial and error, and the capacity to realize the modified instinctive adjustment in overt behavior to the advantage of the individual as a social animal (L. L. Thurstone);
9. The capacity to acquire capacity (H. Woodrow);
10. The capacity to learn or to profit by experience (W. F. Dearborn); and
11. Sensation, perception, association, memory, imagination, discrimination, judgment, and reasoning (N. E. Haggerty).

To the extent that there are common themes in these definitions, they would appear to be with respect to the ability to adapt to the environment and the ability to learn. Other contributors to this symposium did not provide clear definitions of intelligence but concentrated instead on how to test it.

Of course, there have been many definitions of intelligence since those represented in the journal symposium, and an essay has been written on the nature of definitions of intelligence (Miles, 1957). But a subsequent symposium was designed to update the earlier one.

Two dozen experts (including one team of two) in the field of intelligence were asked to define intelligence 65 years later (Sternberg & Detterman, 1986). The panelists were Anne Anastasi, Paul Baltes, Jonathan Baron, John Berry, Ann Brown and Joseph Campione, Earl Butterfield, John B. Carroll, J. P. Das, Douglas Detterman, William Estes, Hans Eysenck, Howard Gardner, Robert Glaser, Jacqueline Goodnow, John Horn, Lloyd Humphreys, Earl Hunt, Arthur Jensen, James Pellegrino, Sandra Scarr, Roger Schank, Richard Snow, Robert Sternberg, and Edward Zigler. Rather than try to review each definition here, I will summarize the main similarities and differences between the two symposia (see Sternberg & Berg, 1986).

First, at least some general agreement exists across the two symposia regarding the nature of intelligence. The correlation between frequencies of listed behaviors was .50, indicating moderate overlap in present and past conceptions. Attributes such as adaptation to the environment, basic mental processes, and higher order thinking (e.g., reasoning, problem solving, decision making) were prominent in both listings.

Second, certain themes were prominent in both symposia. The issue of the one versus the many – Is intelligence one thing or is it manifold? – continued to be of concern, although no consensus existed in either symposium. The issue of breadth of definition also continued to be of concern. As in the earlier symposium, some panelists in the 1986 symposium defined intelligence quite narrowly in terms of biological or cognitive elements, whereas others included a broader array of elements, including motivation and personality. The issue of breadth, like that of the one versus the many, remains unresolved.

Third, despite similarities in views over the 65 years, some salient differences in the two listings could also be found. Metacognition – conceived of

as both knowledge about and control of cognition – played a prominent role in the 1986 symposium but virtually no role at all in the 1921 symposium. The salience of metacognition and executive processes can be attributed to the rise of the computational metaphor in the current study of intelligence. In the later symposium, a greater emphasis also was placed on the role of knowledge and the interaction between knowledge and mental processes. The change in emphasis was not entirely with respect to functions that occur within the organism. The later panelists showed considerable emphasis on the role of context, and particularly of culture, in defining intelligence, whereas such emphasis was absent in the earlier symposium.

Definitions of intelligence tend to be based on classical views of concepts (Katz, 1972) whereby an attempt is made to specify the defining attributes of intelligence, that is, what attributes are individually necessary and jointly sufficient for a person to be considered intelligent. Neisser (1979) pointed out that intelligence may instead be prototypically organized, meaning that there are no clear defining attributes but rather only characteristic attributes that tend to be typical of intelligent persons. In this view, an intelligent person would be someone displaying certain attributes, but there would be no particular attributes that could be identified as necessary and sufficient for describing a person as intelligent.

Another possibility is that there is no prototype. On views of intelligence involving not just a single ability but many, one could argue that there are so many different ways to be intelligent that no one prototype or even small number of prototypes would suffice to characterize a person as intelligent. Rather, it may be that we have stored in our minds multiple exemplars of intelligent people, and we assess a person's intelligence in relation to these exemplars. For example, there might be someone we know who is test-smart, someone who is high in common sense, and so on. Such a model would be based on multiple-exemplar theories of concept meanings (see, e.g., Ross & Spalding, 1994).

Inferences about Expert Conceptions of Intelligence

HISTORICAL VIEWS. Historically, some scholars who have explored intelligence would be considered experts, but not in the field of intelligence. These are writers, philosophers, theologians, and others who, in the course of their writings, speculated on but did not attempt precisely to define the nature of intelligence. Some of these speculations are summarized here. (For a more nearly complete analysis, see Sternberg, 1990.)

Homer, in the *Odyssey*, distinguished between good looks and good thinking. He noted that one man may make a poor physical impression but speak in an articulate and persuasive way. Another man may be handsome but lack the ability to communicate well with others.

Plato had much to say regarding the nature of intelligence. Perhaps his most well-known comments are in the dialogue *Theaetetus*. Socrates asks Theaetetus to imagine that there exists in the mind of man a block of wax that is of different sizes in different men. The block of wax also can differ in hardness, moistness, and purity. Socrates, citing Homer, suggests that when the wax is pure and clear and sufficiently deep, the mind easily will learn and retain information and 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 quickly into their proper places on the block of wax. But when the wax is muddy or impure or very soft or very hard, there will be defects of the intellect. People whose wax is soft will be good at learning but be apt to forget. People whose wax is hard will be slow to learn but will retain what they learn. People whose wax is shaggy or rugged or gritty, or whose wax has an admixture of earth or dung, will have only indistinct impressions. Those with hard wax will have the same because there will be no depth to their thoughts. If the wax is too soft, the impressions will be indistinct because they easily can be confused or remolded.

Aristotle also had some well-formed views on the nature of intelligence. In the *Posterior Analytics Book 1* he conceived of intelligence in terms of "quick wit." For example, an intelligent person seeing someone in conversation with a man of wealth might conclude quickly that the person is seeking to borrow money from the man of wealth.

CONTEMPORARY VIEWS. In the studies mentioned earlier, Sternberg (1985c; Sternberg et al., 1981) looked at expert as well as lay views. Experts were all in the field of psychology. In the

Sternberg et al. (1981) study, comparable factor analyses were carried out for experts as for laypersons. Three interpretable factors emerged for the experts. They were verbal intelligence, problem-solving ability, and practical intelligence. These factors were similar to those of laypersons but had a somewhat more academic slant in terms of the behaviors that loaded highly on them.

Sternberg (1985c) looked at expert conceptions, but in this study, the experts were professors in the fields of art, business, philosophy, and physics. The experts had somewhat different conceptions of intelligence that seemed to reflect the requirements of scholarship in their fields. Whereas professors of art emphasized knowledge and the ability to use that knowledge in weighing alternative possibilities and in seeing analogies, business professors emphasized the ability to think logically, to focus on essential aspects of a problem, and to follow others' arguments easily and to see where these arguments lead. The emphasis on assessment of argumentation in business professors' implicit theories is far weaker in art professors' implicit theories. Philosophy professors emphasize critical and logical abilities very heavily – especially the ability to follow complex arguments, to find subtle mistakes in these arguments, and to generate counterexamples to invalid arguments. The philosophers' view very clearly emphasizes those aspects of logic and rationality that are essential in analyzing and creating philosophical arguments. Physicists, in contrast, place more emphasis on precise mathematical thinking, on the ability to relate physical phenomena to the concepts of physics, and on the ability to grasp the laws of nature quickly. Thus, experts tended, sometimes subtly, to emphasize the skills important in their profession when queried as to their implicit theories of intelligence.

Metaphors Underlying Experts' Conceptions of Intelligence

I have argued that several identifiable metaphors underlie experts' conceptions of intelligence (Sternberg, 1985b, 1990).

GEOGRAPHIC METAPHOR. A first metaphor, a geographic metaphor, views intelligence as a map of the mind. Examples of theorists holding this view include Spearman (1927), Thurstone (1938), Guilford (1967), Cattell (1971), Vernon (1971), and Carroll (1993). The basic unit of analysis in this metaphor is the factor that typically is alleged to be a source of individual differences among people. This metaphor has as some of its advantages its (a) clear specification of proposed mental structures; (b) direct operationalization through mental tests; and (c) availability of sophisticated quantitative machinery for implementation. Possible disadvantages are (a) insufficient emphasis on mental processing, (b) difficulties in falsification of theories based on exploratory factor analysis, (c) very strong dependence on individual differences, (d) rotational indeterminacy in exploratory factor analysis, and (e) questionable generalizability to everyday intelligence.

COMPUTATIONAL METAPHOR. A second metaphor is a computational one. Examples of theorists who have adopted this metaphor are Simon (1976), Hunt (1978), and Sternberg (1977). The basic unit of analysis is the elementary information process (or component). Exponents of this metaphor typically use reaction-time analysis, protocol analysis, and computer simulation in their research. Some advantages of this metaphor are (a) its detailed specification of mental processes and strategies, (b) real-time analysis of task performance, and (c) the availability of sophisticated quantitative and computer machinery for implementation. Some possible disadvantages are (a) insufficient emphasis on mental structures as sources of individual differences, (b) our uncertainty as to whether the mind really is well modeled by a computer, and (c) the questionable generalization of these theories to everyday life.

BIOLOGICAL METAPHOR. A third metaphor is a biological one. Some of the main theorists here are Luria (1973, 1980), Hebb (1949), Halstead (1951), and, more recently, Vernon (Vernon & Mori, 1992; Wickett & Vernon, 1994). The main unit of analysis varies across theories. For Hebb, it was the cell assembly; for Vernon, speed of neuronal conduction. Others, like Luria and Halstead, have proposed structural theories linking parts of the brain to various intellectual functions. A number of different methods of analysis have been used, including measurement of evoked potentials, measurement of speed of neuronal conduction, assessment of hemispheric

specialization, and use of radioactive tracers to trace via positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) scanning parts of the brain that are involved in different kinds of mental tasks. Some advantages of this metaphor are that it (a) links intelligence to its sources in the brain, (b) often employs fairly precise experimental and measurement techniques, and (c) carries the intriguing possibility, not yet realized, of culture-reduced or even culture-fair measurement. Some disadvantages are that (a) the results of the approach are largely a promissory note not yet usable in any practical application; (b) a tendency exists to ignore the contexts in which intelligence manifests itself; and (c) the claims for the approach, especially with regard to causality, go beyond the data. This last point is worth a bit of elaboration. Suppose, as has been claimed, that some measurement of a resting electroencephalography (EEG) proves to be related to scores on a test of intelligence (Hendrickson, 1982; see chapters in Eysenck, 1982). It is not clear from this correlation that the underlying biological process is somehow causative of intelligence. For example, cognitive processing may be responsible for the correlation: Brighter individuals may use the time to think, whereas less bright individuals do not. Or biological and cognitive processing may both be dependent on something else. For example, electroencephalography is only an index of certain kinds of brain activity, the nature of which is unclear. Other measures, such as evoked potentials, really suffer from the same limitation.

GENETIC–EPISTEMOLOGICAL METAPHOR. A fourth metaphor is a genetic–epistemological one. The main theorist is Piaget (1972). The fundamental unit of analysis is the schema. Typical methodology is close observation via case studies and experimentation. Some advantages of this metaphor are its (a) comprehensiveness as a theory of intelligence and intellectual development, (b) the incredible range of research that has been done under the metaphor on children of all ages all around the world, and (c) the detail with which many structures and processes have been described. Some disadvantages are (a) the concentration of the theory on the logical and scientific aspects of intelligence as opposed to other aspects of intelligence, (b) the placement of the commencement of the last stage of intellectual development at roughly 11 or 12 years old, almost certainly before individuals have reached intellectual maturity, and (c) the overestimation of ages at which children are capable of showing various intellectual performances.

ANTHROPOLOGICAL METAPHOR. A fifth metaphor is an anthropological one. The question here is that of what forms intelligence takes as a cultural invention. The basic unit of analysis is the individual in interaction with his or her cultural context. Examples of anthropologically oriented theorists are Berry (1984), Cole (1996), and Greenfield (1997). Advantages of this metaphor are its (a) recognition of cultural roles in determining what constitutes intelligent behavior and possibly even the nature of intelligence, (b) greater potential cross-cultural applicability of theorizing, and (c) the recognition of the need to gear testing of intelligence to the cultural context. Some disadvantages are that (a) cognitive functioning is specified imprecisely or not at all, (b) specification of theories tends to lack crucial details, and (c) extreme relativist positions – that intelligence differs in nature in each culture – lack parsimony.

SOCIOLOGICAL METAPHOR. This metaphor emphasizes the importance of socialization in intelligence. Well-known theorists include Vygotsky (1978) and Feuerstein (1980). For Vygotsky, a particularly important construct is internalization, whereby the child watches behavior in social interactions and then internalizes – takes into him or herself – relevant aspects of the situation and makes them his or her own. For Feuerstein, a key construct is mediated learning, which is knowledge acquisition that occurs when a mediator, usually a parent or teacher, explains the environment to the child. Advantages of this metaphor are its (a) recognition of the importance of internalization of experiences initially encountered with others, (b) recognition of the role of the mediator in internalization, and (c) recognition of the difference between latent capacity and manifest developed ability. Some disadvantages are (a) lack of detailed specification as to how internalization takes place, (b) questionable validity of the actual measurement operations for Vygotsky's zone of proximal development – the difference between performance before and after