Part I

Introduction

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Metaphors as the foundations for theories of intelligence

Upon her death bed, Gertrude Stein has been said to have inquired, "What is the answer?" Getting no answer, she said, "In that case, what is the question?" (Toklas, 1963)

Metaphors as a way of viewing the mind

In the study of human intelligence, perhaps no response is more apt. Once a question about intelligence is posed, one must go yet one step further back, and wonder, why that question? The root source of many of the questions asked about intelligence appears to be the model, or metaphor, that drives the theory and research. In order to understand the evolution and current state of theory and research on intelligence, one must first look at the metaphors that have motivated the theory and research and then at the questions that the metaphors have generated in the theories addressed. The study of human intelligence has been marked by noisy and often passionate debates, but debates that have seemingly been over answers have, as often as not, truly been debates over metaphors and the questions about intelligence they generate. If the debates have been unresolved, and usually they have been, it is perhaps because their true nature has so often gone unrecognized. People have as often talked past each other as to each other, without even recognizing that they are doing so.

The basic thesis of this book, following Kuhn (1970), is that research in the field of human intelligence, as in other scientific fields of endeavor, is guided by a somewhat motley collection of models or metaphors. Each metaphor generates a series of questions about intelligence, which the theories and research seek to address. Scientists are sometimes unaware of the exact nature of the metaphor underlying the research, and may even be unclear about the particular and limited set of questions that their metaphor generates. They may thus see their partial theories, which address only the questions generated by a single

Table 1.1. *Synopsis of major alternative metaphors of intelligence*

Metaphor	Major motivating (presupposed) question	Major motivating (derivative) question	Typical theories	Typical Theorists
Geographic	What is the relation of intelligence to the internal world of the individual?	What form does a map of the mind take?	Two-factor Primary mental abilities Structure-of-intellect Hierarchical	Spearman Thurstone Guilford Cattell–Vernon
Computational	What is the relation of intelligence to the internal world of the individual?	What are the information-processing routines (programs) underlying intelligent thought?	Verbal efficiency Componential	Hunt Sternberg
Biological	What is the relation of intelligence to the internal world of the individual?	How do the anatomy and physiology of the brain and the central nervous system account for intelligent thought?	Hemispheric localization Speed of neural transmission Accuracy of neural transmission	Levy Jensen Eysenck
Epistemological	What is the relation of intelligence to the internal world of the individual?	What are the structures of the mind through which knowledge and mental processes are organized?	Genetic epistemological	Piaget
Anthropological	What is the relation of intelligence to the external world of the individual?	What forms does intelligence take as a cultural invention?	Radical cultural relativism Conditional comparativism Ethological	Berry Cole Charlesworth
Sociological	What is the relation of intelligence to the external world of the individual?	How are social processes in development internalized?	Zone of proximal development Mediated learning experience	Vygotsky Feuerstein
Systems	What is the relation of intelligence to the internal and external worlds of the individual?	How can we understand the mind as a system in a way that crosscuts metaphors?	Multiple intelligences Triarchic	Gardner Sternberg

metaphor, as full theories of a phenomenon. Comparison of their theories with alternative ones derived from the same metaphor (within-metaphor comparison) can be fruitful, but comparisons with alternative theories derived from different metaphors (between-metaphor comparison) can be frustrating. The alternative partial theories are not really theories of the same thing, namely, that part of the phenomenon under investigation. Moreover, even the within-metaphor comparison may be less meaningful than the scientists believe, because experimental operations that they view as choosing the "correct" theory of intelligence may merely be serving to distinguish among alternative instantiations of a given metaphor. The theory may indeed be correct in some respects, but that correctness is predicated on the usefulness of the metaphor underlying it.

By becoming more aware of the metaphors underlying their theories and research, and of the specific questions that their metaphors generate, scientists should become more aware of both the range and boundaries of their theories with respect to the phenomenon they seek to investigate. In particular, scientists may have a better idea both of the questions that their theories can address and of those that they cannot address because of the limitations of the metaphors upon which they are predicated.

In this book, I will examine some of the principal metaphors that have underlain theories of intelligence and the particular theories that have been guided by these metaphors. In examining these metaphors and theories, I will be particularly concerned with how they address either or both of two questions:

1. What is the relation of intelligence to the internal world of the individual?
2. What is the relation of intelligence to the external world of the individual?

A better appreciation of the questions and their answers, and of the latent metaphors guiding theory and research on intelligence, can help move the field forward and assist us in recognizing properly the role of past contributions in shaping future ones. I believe it is difficult to understand the history of theoretical work on intelligence and how the different approaches to intelligence interrelate unless one understands past and present theories in terms of their underlying metaphors.

Table 1.1 lists the various metaphors that have underlain intelligence research and some theories guided by these metaphors, as well as the principal question about human intelligence that each of the theories has addressed. Today, as in the past, there seem to be as many definitions of intelligence as there are investigators of it, with each definition depending, to some extent, on both the metaphor and the theory used. Two chapters – Chapters 2 and 3 – will be devoted to definitions of intelligence. But in order to make clear my biases up front, I should say that I define intelligence as consisting of those mental functions purposively employed for purposes of adaptation to, and shaping and selection of, real-world environments.

Table 1.1 provides a synopsis of the various metaphors considered in Parts III, IV, and V of this book. Part II deals with implicit theories, including definitions, and hence does not fall under the metaphorical rubric. Six metaphors are considered.

The geographic metaphor

The geographic metaphor is based on the notion that a theory of intelligence should provide a map of the mind. The use of the map as a metaphor almost automatically generates certain questions, but not others. Geographic theories will specialize in answering questions such as the following:

1. What are the latent sources of individual differences, or factors, along which people differ that generate observed individual differences in psychometric test scores?
2. How do people differ with respect to their scores on each of these factors?
3. How does the map of the mind evolve as an individual grows older? For example, do the factors of intelligence become more differentiated with age?
4. How predictive is each of the factors of intelligence of performance criteria, such as grades in school?

Various factorial theories compete to answer these questions. The competition often seems no more sensible than would a competition between a map using Cartesian coordinates and a map using polar coordinates, or between a geographical map and a topographical map. A given geographical entity or set of entities can be mapped in many different ways, and often the alternative theories correspond to different ways of mapping the same regions. In fact, there are an infinite number of possible maps that could be correct for a given geographical region, and which map is best turns out to be a question of usefulness rather than of veridicality. Each map may be useful, but for its own particular purposes. The major difference among the geographic theories is in the way in which they orient axes within a factorial space, and mathematically, any orientation of axes is correct. The argument among theorists often therefore becomes one of what the correct psychological orientation of axes is, but of course, there is no one correct orientation. If one wishes simply to predict overall performance, a theory that emphasizes a general factor may be most useful. If one wishes differential prediction, a theory that emphasizes various group factors may be more useful.

Because geographic theories are structural, they tend to address questions about structure but not about other aspects of intelligence. For example, most of the geographically based theories have little or nothing to say about process, although there are exceptions to this generalization (e.g., Guilford, 1967). Moreover, they have nothing to say about how the geographic regions that are isolated map into the brain. Although geographic theorists can deal with development by showing maps of the mind at different points in a child's developmental course, geographic theories do not tend to deal with the transition mechanisms that lead individuals from one map to another. Because the theories are static, they simply do not deal with dynamic development, the way, say, a biological or sociological theory can. Geographically based theories also tend to be derived on the basis of individual-difference data, so that their depiction of intelligence is in terms of sources of individual differences. To the extent that intellectual abilities exist that are common in both the nature and level of ability across people, geographical theories tend not to represent them.

A difficult issue for all of the geographic theorists is how fine a mapping one wishes of the mind. A major source of disagreement among geographic theorists has been in terms of how many factors of intelligence there are, but if one appreciates the metaphor underlying these theories, one realizes that this debate is a fruitless one. Just as different kinds of mappings are possible, so are different degrees of differentiation within regions. For example, a map of a state or province will go into much greater detail with regard to cities and communities within the state or province than will a map of an entire country. Just as it is possible to split geographic subdivisions essentially endlessly, so is it possible to split factors of the mind by including within the battery of tests narrower and narrower portions of the spectrum of human abilities.

The point to be realized here is that when one views geographic theories in terms of the metaphor that underlies them, one better appreciates both the strengths and the weaknesses of the theories. Questions that have been paramount in the minds of the theorists and have been major sources of debate seem to be fruitless in terms of yielding a unique answer. There is no correct orientation of axes or number of factors in a factorial theory, any more than there is any one correct orientation of axes or degree of localization in a map of a geographic region. Moreover, just as maps can answer some questions about a region but not others, so can geographically based theories answer some questions about intelligence but not others. Appreciating the metaphor leads one to a better sense of what questions can and cannot be answered by any theory that subscribes to a given metaphor.

The computational metaphor

The computational metaphor envisions the mind as a computing device and analogizes the processes of the mind to the operations (software) of a computer. The metaphor has proven enormously productive of both theory and research. Perhaps because the computational metaphor was generated largely in response to the geographic one, its strengths and weaknesses tend to be complementary. For example, whereas the geographic metaphor, because of its static nature, tends to be weak in addressing questions of process, the computational metaphor tends to be very strong in addressing questions of process. But in the computational metaphor, inferences about structure are much more indirect than they are in the geographic metaphor, in which the results of a factor analysis directly provide a structural model. Moreover, whereas data from experiments generated by geographically based theories primarily make use of individual-differences data, data from experiments generated by computationally based theories tend to focus on commonalities across people and processing. Normally, the main source of variation observed is across stimulus conditions rather than across subjects, with the result that the computational metaphor tends to be strong in pointing out commonalities in processing rather than individual differences. Indeed, many information-processing studies do not consider individual differences at all, whereas psychometric studies virtually always do.

The computational metaphor seemed, when it was first used, to be an answer to the ever proliferating number of factors being posited by geographic theorists. But in fact, it provides no answer, because just as factors can be subdivided endlessly, so can processes be endlessly subdivided. For example, one can speak of "encoding" stimuli, but certainly there are many subprocesses involved in figuring out what a stimulus is. Again, there is no one correct level of analysis: It depends upon what one wishes to do with the theory. But it is important to realize that arguments over how finely processes should be split will tend to be fruitless, because there is no one right answer. For example, in a computer program, one would wish to pay more attention to the details of how stimuli are perceived in a program that is designed to simulate visual perception than in a program that uses visual perception only in the service of, say, inductive reasoning.

Because of the insensitivity of many computational theorists to individual differences, these theorists have not always been quick to realize that often there is no one correct information-processing model, either of performance on a given task or of performance on classes of tasks. Rather, there may well be individual differences in the processes and strategies different people use to solve a given problem or class of problems. Indeed, the particular processes or strategies that an individual chooses may depend in part on the structure of his or her abilities as revealed by a geographically based theory. In early work (e.g., Sternberg, 1977), there was a tendency to view elementary information processes as underlying factors. In other words, the idea was that by isolating the processes of intelligence, we could identify for each geographic factor what the underlying computational mechanisms were. But it has become clear that there is no real way of knowing whether it is the processes that underlie the factors or the factors that underlie the processes. It could just as well be that certain structural entities in the brain generate the various processes isolated by information-processing analyses. Hence, arguments over which level of analysis is more basic, say, geographic or computational, are likely to go nowhere. In general, it will be shown throughout the book that questions as to what metaphor is "most basic" are fruitless: Metaphors are not right or wrong; they are more or less useful for various purposes.

Computational theorists have argued among themselves as to exactly what constitutes an information-processing theory. Some theorists, such as Newell and Simon (1972), have viewed their computer programs as the theories themselves. Other investigators, such as Schank (1972), view computer programs as operationalizations, and imperfect ones at that, of theories. My own thinking tends to be in accord with

Schank, but again, I doubt that there is a right or wrong answer regarding what, exactly, is the underlying theory.

Perhaps the biggest danger with computational metaphors is that they will fail to distinguish the forest from the trees. Because they tend to deal with information processing at a nitty-gritty level, it is easy for computational theorists to get wrapped up in the details of information processing and at times to lose sight of why they are studying a particular task or even of where performance on that task fits into the grander scheme of things. Certainly, not all information-processing theorists are guilty of tunnel vision, or of losing the forest, but there are many information-processing theories in studies of task performance that, while elegant, at the same time seem to tell us relatively little about fundamental and generalizable principles of intelligence.

The biological metaphor

Biologically based theories seek to understand intelligence in terms of the functioning of the brain. Because our understanding of the brain is still quite rudimentary, biological theories often have a highly speculative tinge associated with them. Data that have been collected, for the most part, are of three kinds.

The first kind results from studies that seek to localize specific abilities in the brain. Most commonly, subjects are patients who have had damage of one kind or another that has resulted in the destruction of a portion of the brain. This portion of the brain is considered no longer to be functional, and neuropsychologists study the effects of the lesion on information processing. In other words, they seek to find out what functions are lost as a result of the damage to the brain. Most of the neuropsychologists who do this kind of work are not interested just in intelligence, but in cognitive functioning more generally. However, their findings often have important implications for intelligence research. The biggest problem in interpreting this research is that the data from different laboratories often seem to be contradictory. These contradictions could well result from differences in the patients studied or in the exact methods used to study the patients. But the picture that emerges from this research is not always crystal clear. Nevertheless, this kind of research has been very informative with regard to localization of certain intellectual functions.

My worry in interpreting these studies is that data from patients with severe lesions may not generalize to or be representative of the population at large. In other words, the patients used in these studies are obviously highly nonrepresentative of a typical population that would be studied by other psychologists, and it is possible that because of this nonrepresentativeness, false generalizations could be made. However, it is obviously not possible to create lesions in humans just for the purpose of studying intelligence, so the data we get are about as good as can possibly be hoped for. Of course, lesions are sometimes purposely created in animals, but we still end up with a generalization problem, in this case, the generalization from other species to the human one.

A second kind of data is electrophysiological. Electrodes are generally taped to a person's skull, and evoked potentials or EEGs are measured either while subjects are at rest or while they are performing some task. The idea here is usually to look at patterns in the electrophysiological data or to combine the data into one or more scores and then relate the patterns or scores to measures that are believed to assess intelligence, such as the Wechsler Adult Intelligence Scale. The data obtained from users of electrophysiological paradigms have been highly variable, but so have been the locations at which recordings have been made as well as the measures used to summarize the electrophysiological data. In a number of instances, moderate or even fairly high correlations have been obtained between scores on electrophysiological indices and scores on conventional intelligence tests. Enough positive data have been obtained to suggest that there is some relationship, although the exact nature of the relationship is not yet clear.

As I read the data, there are two major problems in the electrophysiological approach as it pertains to intelligence. These problems need to be taken into account in interpreting electrophysiological data.

First, the astonishingly large number of recording sites available as well as ways of scoring and summarizing the data from electrophysiological studies leaves a fairly wide margin for capitalization on chance. We need to be at least somewhat concerned with the replicability of results, in particular, replicability outside the laboratory in which a certain data set was initially collected, and even replicability outside the sphere of influence of the researchers who collected those data. This concern seems especially important, as in at least one instance, the reported correlation between an electrophysiological index and measured IQ was roughly at the level of the reliabilities of the measures, a result that is likely to arouse suspicion in at least some readers of the original report.