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Human Intelligence: The Model Is the Message

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Upon her deathbed, Gertrude Stein is reputed to have inquired, "What is the answer?" Getting no answer, she said, "In that case, what is the question?" (*1*). In the study of human intelligence, perhaps no response is more apt. Once a question about intelligence is proposed, one must go yet one step further back, and wonder, why that question? The root source of the question 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 look first at the models that have motivated the theory and research, and then at the questions that the models have generated and 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 models and metaphors, and the questions about intelligence they generate. If the debates have been unresolved, it is perhaps because their true nature has so often gone unrecognized.

Summary. Theories of intelligence, and some of the research testing them, are designed to answer three basic questions about intelligence: (i) What is the relation of intelligence to the internal world of the individual? (ii) What is the relation of intelligence to the external world of the individual? (iii) What is the relation of intelligence to experience? Various models of the mind underlying the theories have been proposed; the strengths and limitations of these models are assessed. A theory that addresses all three questions simultaneously is the triarchic theory.

The basic thesis I will describe, following Kuhn (*2*), 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 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 model underlying their research, and may even be unclear about the particular and limited set of questions that their model generates. They may thus see their partial theories, which address only the questions generated by a single model, as full theories of the phenomenon. Comparison of their theories with alternative ones derived from the same model (within-model comparisons) can be fruitful, but comparisons with alternative theories derived from different models (between-model comparisons) can be frustrating. The alternative partial theories are not really theories of the same thing, namely, that part of the phenomenon under investigation. By becoming more aware of the models underlying their theories and research, and of the specific questions that their models generate, scientists should become more aware of both the range and boundaries of their theories with respect to the phenomena they seek to investigate.

In this article, I will examine the three main questions that I believe researchers on intelligence have addressed. What is the relation of intelligence to the internal world of the individual? What is the relation of intelligence to the external world of the individual? What is the relation of intelligence to the experience of the individual? I will also examine the competing models and metaphors that have motivated these questions. A better appreciation of the questions and of the latent models generating theory and research on intelligence can help move the field forward and help us recognize properly the role of past contributions in shaping future ones.

The various models and theories to be considered (Table 1) address questions about human intelligence, but the theorists behind them may not define intelligence in the same way. Today (*3*) as in the past (*4*), 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 model and the theory used. My definition of intelligence is that intelligence consists of those mental functions purposively employed for purposes of adaptation to and shaping and selection of real-world environments.

Intelligence and the Internal World of the Individual

Most psychologists and others who study intelligence have attempted to "look inside the head" in order to understand the nature of intelligence. This view of intelligence as inside the head has led to a concomitant view of intelligence as something to be discovered. Although those who view intelligence as an internal property of the human organism have often agreed that intelligence is a psychological construct in search of a discoverer, they have not agreed as to the form this something inside the head takes. During the 20th century, two major models have competed with each other for the allegiance of the explorers in search of intelligence.

The geographic model: Intelligence as a map of the mind. The view of intelli-

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intelligence as a map of the mind extends back at least to Gall (5), perhaps the most famous of phrenologists. Gall implemented the model of a map in a literal way: He investigated the topography of the head, looking (and feeling) for the hills and valleys in each specific region of the head that would tell him a person's pattern of abilities. The measure of intelligence resides in the person's pattern of cranial bumps.

During the first half of the 20th century, the model of intelligence as something to be mapped dominated theory and research. However, the model of the map became more abstract, and less literal, than it had been for Gall. The psychologist studying intelligence was both an explorer and a cartographer, seeking to chart the innermost regions of the mind. Visual inspection and touching just would not do. The psychologist needed tools, and in the case of research on intelligence, the indispensable tool appeared to be a statistical method and model called factor analysis.

Factor analysis is a means for discovering latent structure in data. Most often, it is applied to a correlation matrix for all possible pairs of psychological tests. Human subjects receive a battery of tests measuring skills such as reasoning, vocabulary, spatial visualization, and the like, and then their scores on these tests are correlated. Factor analysis can be used to show sources of variation in the test correlations. It enables one to determine, among other things, the correlation of each test with each of the hypothetical factors underlying individual differences in test performance. In order for factor analysis to be useful in data reduction, it will almost always result in fewer factors than there were original tests. Each factor is purported to repre-

Table 1. Synopsis of major alternative models of intelligence.

Major motivating (presupposed) question	Major motivating (derivative) question	Typical theories	Typical theorists
	Geographic model		
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 Multiple intelligences	Spearman Thurstone Guilford Cattell, Vernon Gardner
	Computational model		
What is the relation of intelligence to the internal world of the individual?	What are the information processing routines (programs) underlying intelligent thought?	Mental speed Verbal efficiency Componential	Jensen Hunt Sternberg
	Anthropological model		
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
	Biological model		
What is the relation of intelligence to the experience of the individual?	How does intelligence evolve as a system both phylogenetically and especially, ontogenetically?	Genetic Epistemological	Piaget
	Sociological model		
What is the relation of intelligence to the experience of the individual?	How are social processes in development internalized?	Zone of proximal development Mediated learning experience	Vygotsky Feuerstein
	Governmental model		
What is the relation of intelligence to the internal and external worlds of the individual and to experience?	How do individuals govern themselves?	Triarchic	Sternberg

sent a latent source of individual differences in observed test scores. To the extent that the factorial model fits the data, scores of subjects on the various factors will sum to reproduce observed scores on the tests of mental abilities.

During the first half of this century, the major debate among theorists of intelligence was over the "true" factorial structure, or map, of intelligence. The major competing theories were those of Spearman (*6*), Thurstone (*7*), Guilford (*8*), Cattell (*9*), and Vernon (*10*).

Spearman (*6*), who is usually credited with having invented factor analysis, suggested that intelligence could be understood in terms of a single latent factor that pervaded performance on tests of mental ability and a set of specific factors, each of which was involved in performance on only a single mental ability test. The specific factors were of only casual interest, but the general factor provided the key to understanding intelligence. Spearman labeled the general factor "g," and concluded that it derived from individual differences in mental energy.

Thurstone (*7*), in contrast, proposed that the core of intelligence resided not in one single factor, but in seven such factors, which he referred to as primary mental abilities. According to Thurstone, the primary mental abilities are verbal comprehension (measured by tests such as vocabulary), verbal fluency (measured by tests that require an individual to think of as many words as possible beginning with a given letter in a limited amount of time), inductive reasoning (measured by tests such as analogies and number series), spatial visualization (measured by tests requiring mental rotation of pictures of objects), number (measured by computation and

Table 1 (continued).

Typical unit of analysis	Typical methodology	Major strengths	Major weaknesses
		Geographic model	
Factor	Factor analysis	Clear specification of proposed mental structures Direct operationalization through mental tests Availability of sophisticated quantitative machinery for implementation	Insufficient emphasis on mental processing Nonfalsifiability Overdependence on individual differences Rotational indeterminacy: same map can be viewed through different coordinate systems Questionable generalizability to everyday intelligence
		Computational model	
Elementary information process	Reaction-time analysis; computer simulation	Detailed specification of mental processes and strategies Real-time analysis of task performance Availability of sophisticated quantitative and computer machinery for implementation	Insufficient emphasis on mental structures as sources of individual differences Questionability of whether the mind is in fact like a computer program Questionable generalization to everyday intelligence
		Anthropologicals model	
Cultural context	Cross-cultural comparison of notions of intelligence Cross-cultural comparison of performance on culturally "equated" tasks	Recognition of cultural-societal role in determining what constitutes intelligent behavior Greater cross-cultural applicability of theorizing	Imprecise or no specification of details of cognitive functioning Potential lack of parsimony in extreme relativist positions Lack of detailed specification of theories
		Biological model	
Schemata (equilibration of)	Clinical observation	Recognition of importance of development Specifications of mechanisms of intellectual development Breadth of theory within the realm of logical-scientific thinking	Overestimation of minimum ages for attainment of cognitive competencies Applicability to scientific but not nonscientific forms of thinking Questionability of concept of developmental stage Subjectivity of clinical analysis
		Sociological model	
Mediated learning experience	Cognitive training studies	Recognition of importance of internalization of experiences initially encountered with others Recognition of role of mediator (mother) in internalization Recognition of difference between latent capacity and manifest developed ability	Lack of detailed specification as to how internalization takes place Questionability of validity of measurement of operations for zone of proximal development Questionability of what can be concluded from training studies
		Governmental model	
Internal components of information processing External functions of components Facets of experience	Componential analysis Prototype analysis Real-world simulation	Consideration of all three motivating questions Breadth of theory Specification of cognitive processing Ties to real-world functioning	Insufficient unification and integration of subtheories Lack of detailed elaboration of nature and role of content in intelligence Lack of evidence supporting contextual subtheory

simple mathematical problem-solving tests), memory (measured by picture and word recall tests), and perceptual speed (measured by tests that require an individual to recognize small differences in pictures or to cross out the "A's" in strings of letters).

Guilford (*8*) proposed a model with as many as 120 factors. In his structure-of-intellect model, intelligence could be understood in terms of a cube that represented the crossing of various operations, contents, and products. For example, one such factor would be cognition (operation) of figural (content) relations (product), which would be involved in perceiving figural terms in an analogies test. Another factor would be divergent production (operation) of verbal (content) units (product), which would be involved in producing as many words as possible beginning with a certain letter in a fixed amount of time. In his most recent version of the theory, Guilford (*11*) has proposed as many as 150 factors.

Some thought that the number of factors in the structure-of-intellect model resulted in a loss of needed parsimony (*12*), and questions were raised about aspects of the methodology used to extract the various factors (*13*). A more parsimonious way of handling even a moderate number of factors of the mind appeared to be through a hierarchical model. Cattell (*9*) proposed one such model, whereby general intelligence could be understood as comprising two major subfactors, fluid and crystallized abilities. Fluid ability requires understanding of abstract and often novel relations, as is required in inductive reasoning tests (for example, analogies and series completions). Crystallized ability represents the accumulation of declarative knowledge (facts and ideas) and procedural knowledge (strategies) and is measured by tests such as vocabulary and general information. Nested under these factors are factors of increasing degrees of specificity. A similar view was proposed by Vernon (*10*), who used labels of practical-mechanical and verbal-educational abilities to refer to constructs similar to Cattell's fluid and crystallized abilities. Recently, Gustafsson (*14*) proposed a hierarchical model that is based on the most modern methods of confirmatory factor analysis and that integrates much of the earlier work.

The model of mental maps and the factor-analytic methods used to create the maps became increasingly less popular in some circles in the second half of the 20th century. There were three main reasons for the increasing skepticism.

First, the model of maps and the factor-analytic methods used to instantiate it had little, if anything, to say about mental processes. Yet, two individuals could receive the same score on a mental-ability test through very different processes, and indeed, by getting completely different items correct (*13*, *15*). By the 1960's, psychologists in all aspects of cognitive study were becoming especially concerned with information processing, and research on intelligence, like so much other research in the field, got caught up in this new wave of interest.

Second, it proved to be extremely difficult to test factor-analytic models against each other, or even to falsify them at all (*15*). This difficulty stemmed in large part from the problem of rotation of factorial axes. Although the points obtained from typical factor analyses are fixed in an n-dimensional Euclidean space, the orientation of the axes used to interpret the points is not fixed. Indeed, any of an infinite number of either orthogonal or oblique orientations may be used to characterize the locations of the points in space (just as lines of longitude and latitude, or polar coordinates, represent only two of an infinite number of possible descriptions for locations on the globe): The mathematical fit of the model to the data does not change as a function of orientation of axes, and each orientation is equally acceptable. But different factorial theories proved to differ as much in terms of the orientations of factorial axes for a given solution as in terms of anything else, so that model-fitting did not prove to be useful in distinguishing among theories (*15*). Psychometricians (psychologists specializing in measurement) resorted to arguing about the psychological plausibility of the various rotations, but such arguments proved to be inconclusive, because theorists in each camp thought their rotations to be the most psychologically plausible. Modern, confirmatory methods of factor analysis do not yield solutions with arbitrary axes (*16*), and such methods are now gaining widespread use among those still wedded to a psychometric approach to intelligence and other psychological constructs (*17*).

Third, the whole notion of trying to understand intelligence primarily on the basis of individual-differences data came under attack. McNemar (*18*) queried whether two identical twins, stranded on a desert island and growing up together, would ever generate the notion of intelligence if they did not encounter differences in their mental abilities. Psychologists were coming to answer this question affirmatively and to consider that they should not be dependent on the existence of substantial individual differences for isolating abilities. Yet, factor analysis, as it was typically used, critically depended on such differences.

Psychologists either had to find a new model, find a new method, or both. Most psychologists opted for both and, during the 1970's, most research on intelligence followed neither the map model nor the method of factor analysis, with a major exception.

Gardner (*19*), in his recent theory of multiple intelligences, has revived the map as a model of the mind. According to Gardner, humans have seven, and possibly more, distinct intelligences: linguistic, musical, logical-mathematical, spatial, bodily kinesthetic, interpersonal, and intrapersonal. Gardner's theory differs in two major respects from conventional factor theories. First, the identities of the intelligences were derived not through factor analysis but through a series of converging operations: Gardner used multiple criteria, such as potential isolation by brain damage, evidence from exceptional individuals (both at the lower and higher ends of the spectrum), evolutionary history, and the like to identify his intelligences. Second, the range of talents labeled as "intelligences" is considerably broader than that in conventional factorial theories.

The theory of multiple intelligences has several problems. First, factorial evidence has shown that the various abilities are not independent, as Gardner suggests. For example, logical-mathematical and spatial abilities are difficult to test for separately because of their high degree of statistical correlation. Second, it is not clear exactly what each intelligence consists of, especially because this theory, like other map-based theories, does not specify processes. Finally, the multiple intelligences might better be referred to as multiple talents. For example, some might argue that the tone-deaf person who is low in one important aspect of "musical intelligence" is not mentally retarded in the same way as an adult individual who has never acquired verbal skills might be. Rather, the tone-deaf individual is lacking an aspect of musical talent.

The computational model: Intelligence as a computer program. During the last decade, the predominant model of intelligence has been that of the computer program. Researchers have sought to understand intelligence in terms of the information processing that people do when they think intelligently. Information-processing investigators have varied primarily in terms of the complexity of the processes that they have sought to study (*20–23*).

Jensen (*20*) has suggested that intelligence can be understood in terms of speed of neural conduction and proposed choice reaction time as an appropriate means for indirectly measuring this speed. In his procedure, one of a set of lights flashes on a board, and the subject must extinguish the light by pressing a button as rapidly as possible.

Hunt (*21*) has suggested that intelligence, and especially verbal intelligence, be understood not in terms of mental speed in general but a particular kind of mental speed, namely, speed of access to lexical information, such as letter names, that are stored in long-term memory. In order to measure this, Hunt used a task proposed earlier by Posner and Mitchell (*24*) in which subjects must indicate for pairs of letters, such as "A A," "A a," and "A b," whether they constitute a match in name. In a simpler experimental condition, subjects must indicate only whether the letters match physically. Hunt has taken as the measure of speed of lexical access the difference between name match and physical match time. Thus, in his equation, Hunt subtracts out the elementary reaction time that is important to Jensen's theory. More recently, Hunt (*25*) has been studying the relation between intelligence and people's ability to divide their attention.

Sternberg (*22*) sought to understand information processing in more complex tasks, such as analogies, series problems, and syllogisms. The idea was to take the kinds of tasks used on conventional intelligence tests and to isolate the mental processes and strategies used in performing these tasks. Through "componential analysis," he has decomposed reaction times and error rates on such tasks into underlying processes such as inferring relations between stimuli, mapping higher order relations between relations, and applying previously inferred relations to new situations.

Simon (*23*), in his early information-processing work, studied the information processing of subjects involved in solving complex problems such as chess problems and logical derivations. In his work with Newell and others (*26*), computer simulations were created that could solve these complex problems. Most recently, Simon and others such as Chi, Glaser, Larkin, and Lesgold have been studying intelligent performance on tasks requiring substantial amounts of expert knowledge, such as medical diagnosis and the solution of physics problems (*27*).

The computational model and the information-processing methods used to elaborate and test it have not been without their own problems (*19, 22, 28*). Consider three of the main ones.

First, it is not clear just how similar a computer program and human intelligence are. There are those who would argue that we should be seeking to understand the programmers, not the programs, in our quest to understand intelligence. Of course people differ from computer programs in a number of ways, not the least of which is their considerably greater complexity and range of mental functioning. In using the computational model, these differences may tend to receive rather short shrift.

Second, and in common with most map-based theories, it is not clear whether the kinds of laboratory and test-like tests that have dominated the study of intelligence truly measure psychological constructs that are interesting in and generalizable to the outside world. Everyone knows people who perform well on tests but who seem to perform rather poorly in their everyday lives, and neither the computational nor the map model seems to account for just what, if anything, is wrong or missing when these people apply their intelligence to their everyday lives.

Third, the computational model may not take sufficient account of or specify the differences in what people mean by intelligence in various parts of the world. An assumption of the computational model has been that we need to discover programs of operation that are intelligent for a given set of tasks. But tasks of life differ from one place and time to another, and so, some would argue, does the nature of intelligence. These arguments lead us to the next important question underlying theory and research on intelligence.

Intelligence and the External World of the Individual

Not all psychologists have looked at human intelligence exclusively as an internal property of the organism. Some have looked to the external world, particularly to culture and subculture, to understand what intelligence is. Such psychologists have even viewed intelligence as a cultural invention. In order to understand the invention, one must first understand the culture and why it would invent intelligence in a particular way.

Many psychologists subscribing to this point of view have specialized in cross-cultural studies of the nature of intelligence. Others have sought to understand intelligence as a prototype or cultural ideal of what it is that constitutes an intelligent person. For example, Neisser (*29*) suggested that the concept of intelligence is much like the concept of chair: just as there are chairs that conform in varying degrees to our ideal for a chair, so are there people who conform in varying degrees to our ideal for an "intelligent person." Sternberg, Conway, Ketron, and Bernstein (*30*) and Sternberg (*31*) assessed these prototypes statistically and showed that people have them and use them in judging both their own intelligence and that of others. Berry (*32*) compared such prototypes cross-culturally, showing that they differ by culture. According to such views, then, to understand intelligence, one should look not inside the head, metaphorically, but to the culture in which a person resides.

The anthropological model: Intelligence as a cultural invention. Psychologists subscribing to the notion that the nature of intelligence is wholly or partly determined by the nature of the environment in which one lives are often called contextualists. At least four positions of varying degrees of extremity can be separated.

1) A radical cultural relativist view. Berry (*33*) has argued that indigenous notions of cognitive competence should be considered to be the sole basis for valid descriptions and assessments of intelligence. In this scheme, the Western concept of intelligence has no universal merit at all. Intelligence must be defined in a way that is appropriate to the people of each culture.

2) A conditional comparative view. Cole and his colleagues in the Laboratory of Comparative Human Cognition (*34*) have accepted the view of Berry (*33*), Boas (*35*), and others that there is no single notion of intelligence that is appropriate for all members of all cultures. However, these investigators assert that the radical cultural relativist position does not take into acount the fact that cultures interact. In their view, it is possible to do a kind of "conditional comparison" in which the investigator sees how different cultures have organized experience to deal with a single domain of activity. This comparison is possible, however, only if the investigator is in a position to assert that performance of the task or tasks under investigation is a universal kind of achievement and if he or she has a developmental theory of performance in the task domain.

3) Intellectual dualism. Still less radical is the position of Charlesworth (*36*),

whose "ethological" approach to studying intelligence has focused on what he refers to as the "other part" of intelligence—that is, intelligent behavior as it occurs in everyday, rather than in test, situations—and how these situations may be related to changes in development. Thus, Charlesworth is content to leave the conventionally tested part of intelligence to psychometricians and cognitive psychologists and to concentrate on the other, contextually determined part of intelligence.

4) Integrated viewpoints. Least radical is the position taken by contextualists such as Keating (*37*), Jenkins (*38*), and Baltes, Dittman-Kohli, and Dixon (*39*), who have combined contextual positions with more or less standard kinds of psychological research and experimentation. For example, Baltes has conducted fairly standard psychometric research, but has viewed his research contextually. He and his colleagues have put forth some propositions regarding the nature of intelligence over the life-span that take into account the contexts in which intelligence occurs at different points in life. For instance, they note that with aging, the individual's life goals and cognitive tasks change and are less oriented toward cognitive efficiency as measured by traditional intelligence tests. These goals and tasks are oriented toward typical (as opposed to maximal) performance. Moreover, there is an increasing specialization and thus individualization in the nature of cognitive functioning, and hence of intelligence.

Contextualist positions have the appeal of taking into account the fact that not all cultures view intelligence in the same way, or consider the same behaviors to be intelligent. At the same time, they have certain limitations from a scientific point of view. First, they often tend to ignore cognitive functioning, so that even if one accepted the contextual point of view, one would have little or no idea of the cognitive processes underlying intelligence even within particular cultures. Second, they can strain parsimony to the extreme: if intelligence differs across cultures, and even subcultures, one might plausibly keep dissecting levels of subcultures until one reaches the level of the individual. Each individual does, in fact, live in at least a slightly different subculture or intermeshing of subcultures. At the point that intelligence is completely particularistic with respect to the individual, it is not clear that scientific reduction is possible any longer. Third, contextual views often tend to be somewhat vague, making it difficult to say just what the theory of intelligence is to which they give rise. In contrast to such vagueness is the theory of Piaget (*40*), which is probably the most fully specified theory of intelligence ever proposed, and which is considered below.

Intelligence and the Experience of the Individual

By experience, I refer to the interface through life between the internal and external worlds of the individuals. Because experience mediates the relation between the internal and external worlds of the individual, it makes sense, from a certain point of view, to emphasize in one's theorizing the interaction between experience and intelligence. Experiential theories tend to be developmental in character, focusing on how the nature of intelligence changes over part or all of the life of the individual. The two most influential experiential theories have been those of Piaget (*40*) and Vygotsky (*41*).

A biological model: Intelligence as an evolving system. Piaget's (*40*) theory of intelligence is so rich and variegated that it is impossible to do justice to it in a brief summary. The theory is heavily grounded in the biological notion that survival depends on adaptation to the environment, and hence, that intelligent survival requires intelligent adaptation. There are perhaps three particularly crucial aspects to Piaget's theory. The first is the notion of the schema, which is an organized sequence of mental structures and steps for accomplishing a given set of tasks. The second is the notion of equilibration—that the organism acquires cognitive capacity through a delicate balance of two cognitive mechanisms, namely, assimilation and accommodation. In assimilation, the organism fits new environmental inputs into its existing cognitive schemata. In accommodation, the organism transforms its cognitive schemata so as to accept the environmental inputs. Thus, accommodation, but not assimilation, requires restructuring of one's cognitive system.

The third critical aspect of Piaget's theory is his concept of incremental periods of intellectual development that build upon one another. In the sensorimotor period (lasting from birth to approximately 2 years of age), the infant interacts with the environment through relatively simple, overt sensory and motor schemata. In the preoperational period (lasting roughly from age 2 to age 7), the child acquires the ability to let one object represent another that is not present; in other words, the infant uses advanced symbolic capacity. In the concrete-operational period (lasting roughly from age 7 to age 12), the child can apply mental operations to concrete objects—for example, the child may realize that if one pours water from a tall thin vessel to a short fat one, the amount of water is conserved and hence remains the same. In the formal-operational period (lasting roughly from age 12 on), the child can apply mental operations to abstract or formal objects, realizing, for example, not only relations between objects but also higher order relations between relations (as in thinking by analogy). Thus, the intellectual development of the child is characterized by the maturation over time of increasingly broad and complex cognitive functions.

A sociological model: Intelligence as the internalization of social processes. In one respect, the developmental theory of Vygotsky (*41*) is in direct opposition to that of Piaget. Whereas Piaget argues that intelligence moves from the inside, outward, Vygotsky argues that it moves from the outside, inward. According to Vygotsky, intelligence has its origins in social processes—in one's interactions with other persons—and is internalized only after it is manifested socially. Thus, whereas Piaget emphasizes the role of internal maturation, Vygotsky emphasizes the role of external interactions with one's peers and, especially, with one's parents. The child becomes able to do later what he or she is initially able to do only with the guidance of an adult mentor, such as a mother.

An important concept in Vygotsky's theory is the zone of proximal development, or the distance between one's realized potential and one's latent potential. According to Vygotsky, this zone can best be measured by examining a child's response to guided instruction. By watching the child learn under the guidance of an adult mentor (such as a parent or tester), one can infer the extent to which that child's realized potential departs from his or her latent potential: a low performer, for example, who profits well from instruction may actually have a great deal of potential locked away awaiting realization through social processes.

The experiential theories of Piaget, Vygotsky, and others have had a profound influence on the field of intelligence and have forced theorists to consider the roles of maturation and experience in intelligence and development.

Today, there exist many critiques of these theories, and especially of Piaget's (*42*). First, Piaget overestimated the age at which children can accomplish many intellectual tasks, apparently because the tasks were presented in ways such that the children did not well understand what was required of them. Second, Piaget's conception of intelligence was probably overly formalistic and logically based: neither children nor adults appear to resemble logicians to the extent that would be required by Piaget's theory. Finally, the whole notion of a period or stage has come into serious question (*43*), and many developmental psychologists have abandoned the notion altogether, believing that it creates more smoke than fire in helping us understand intellectual development.

Combining the Questions

One could argue that the role of a complete theory of intelligence should not be to address any one of the three questions posed above, but to answer all of them: What is the relation of intelligence to the internal world, the external world, and the experience of the individual? My triarchic theory of human intelligence (*28*) is one such attempt to answer all three questions simultaneously. Of course, this attempt, described briefly below, is only a first pass at defining a relatively complete theory of human intelligence.

A political model: Intelligence as mental self-government. According to this theory, intelligence can be understood as a kind of mental self-government (*44*). As is the case with a government, understanding of intelligence requires an examination of internal affairs (relation of intelligence to the internal world of the individual), external affairs (relation of intelligence to the external world of the individual), and the processes of government as they evolve over time (relation of intelligence to experience).

The internal affairs of mental self-government are dealt with in a "componential subtheory," which specifies the mental processes used to deal with a large variety of problems. According to the subtheory, mental processes are of three kinds: metacomponents, or executive processes, through which one plans what to do, monitors it while it is being done, and evaluates it after it is completed; performance components, through which one executes the instructions of the metacomponents and provides feedback to them; and knowledge-acquisition components, through which one learns how to solve the problems in the first place. For example, solving even a simple analogy problem requires one to decide on a set of steps toward solution and a strategy into which to combine these steps (metacomponents), actually to execute the steps by inferring relations, applying them to new situations, and so forth (performance components), and initially, to learn the steps required for analogy solution (knowledge-acquisition components).

The external affairs of mental self-government are specified by a contextual subtheory of intelligence. According to this subtheory, the components of intelligence serve three functions in the everyday world: adaptation to existing environments, selection of new environments, and shaping of existing environments so as to transform them into new ones. In this view, a test of intelligence must measure the individual's ability to solve abstract and academic problems for which performance may or not may transfer to everyday life. The test should assess as well the individual's ability to apply the components of intelligence to the kinds of problems the individual encounters in everyday life, from selecting a house to performing on the job to getting one's children through the age of diapers. Intelligence is not all that is involved in these practical tasks, but it is an important element of what is involved.

Intelligence, like any other form of government, evolves over time, and according to the third, experiential subtheory of intelligence, one must examine the components of intelligence as they are applied to the everyday world at varying levels of experience. In particular, the ability to cope with relatively novel situations, and the separate ability to render coping with situations automatic and relatively effortless, are critical aspects of intellectual functioning. In this view, therefore, one's intelligence would be aptly measured by one's ability to deal with a relatively new task—for example, learning to read—and later, by one's ability to render this intelligent performance automatic and almost effortless.

Because the triarchic theory, and the governmental model that generates it, address all three of the questions that have been critical in the study of intelligence, the theory and model in some sense subsume certain other theories and models as special cases. For example, part of a governmental system resides in the political regions it encompasses (map model), part in the processes of government (computational model), and part in the social functioning of its citizens (sociological model). Moreover, the system of government is clearly a cultural invention (anthropological model). The governmental model and the one particular instantiation presented here—the triarchic theory—are obviously not final answers. But they may be useful in achieving a greater integration of concepts of and approaches to intelligence than has been achieved before.

The triarchic theory provides only one of the many possible ways in which the three questions that have motivated intelligence research might be addressed. As the field progresses, there will undoubtedly be multiple alternative attempts to answer these questions. For example, Carroll (*45*) is currently undertaking a massive integration of the research literature on intelligence. If there is a trend in current research, however, it is toward a broader conceptualization of intelligence and toward broader theories of the phenomenon that explain large parts of it, rather than just small sections. Intelligence researchers are realizing more and more that the answer may not be the question, but that the answer is constrained by the question. Models should be our servants rather than our masters. Hence, researchers are broadening their conception of just what the questions are that they should ask.

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The International Decline in Household Oil Use

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The oil price shocks of 1973 and 1979 caused many difficulties in households in Europe and Japan, as well as in parts of the United States and Canada, where oil products dominated home energy use. Most of the industrialized nations of the Organization for Economic Cooperation and Development (OECD) (*1*) adopted pricing and policy strategies to lower the dependency of indoor comfort on oil. Conservation programs were launched in most countries, and large sums of public and private funds were spent to help reduce home oil use. These strategies and expenditures raise important policy questions:

1) By how much has home oil use been reduced, and how?

2) How much of the reduction might be reversed if oil prices decline?

3) Will oil continue to lose its share of the residential market?

4) Given the change in oil use that did occur, how much was caused by higher prices or lower incomes, and how much by conservation programs or new technologies?

We study here the use of oil products in the residential market of the largest OECD countries. International comparisons of changes lead to conclusions that may apply to countries outside the study, while allowing assessment of future trends in world oil use. The aggregate energy use in the countries studied makes up a substantial share of world oil demand.

The study examines the evolution of the structure of the oil-heated dwelling stocks, their type (single or multiple-family), heating system (central or noncentral), and the presence of hot water based on oil. We combine these observations with information on energy intensity provided by oil suppliers and national surveys that follow oil consumption per household. We then decompose changes in oil use into those caused by changes in the number and characteristics of oil-using households ("structure") and those caused by changes in the amount of oil used per household ("intensity"). Reduced intensity is most often associated with conservation.

Switching from oil to other fuels and conservation are two complementary responses to higher oil prices that must be addressed separately. Changes in intensity can be brought about rapidly by occupants in response to higher prices, aided, in many countries, by subsidies for insulation or other oil-saving techniques. Fuel switching, on the other hand, depends on the price distribution of alternative fuels as well as on the expansion of large-scale networks of natural gas and district heating (a centralized system supplying heat to several buildings). With few exceptions, fuel switching involves long-run changes, while conservation involves both short-run and long-run changes in the dwelling stock. Because our analysis examines the rate of change in both structure and intensity, we can estimate the components of change that may be long-run (and virtually permanent) or short-run and therefore easily reversible if, for example, the decline in world oil prices were to continue.

To understand the changes in household oil use, we must analyze the components of oil use at a very disaggregated level. Data problems have hindered previous quantification of changes in residential energy use. Few countries counted residential consumption (or even deliveries) of oil products separately from the "other" or "residential-commercial" sector, a residual left over when industrial and transportation uses were accounted for in national energy balances. We therefore developed a database on residential energy use in the major OECD countries, built from a variety of official and private sources (*2–10*). In this article we include important new data on oil use.

The key difference between this study and previous ones, then, is one of detail. Previous international studies of the residential sector, as well as statistical estimation of the factors influencing residen-

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