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The Schema Paradigm in Perception

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The prevailing cognitive approach to perception is an intellectualist one. This paradigm conceives of perception and other mental states as products of previous, usually unconscious, inferences, computations, and similar reasoning processes found in abstract thinking. I suggest an alternative approach that may be termed the "schema paradigm." In this paradigm, the cognitive features are not added by previous, separate processes; they are expressed in perceptual schemas that are constantly participating in the ongoing activity of perception. The suggested paradigm is supported by both theoretical and empirical considerations.

Sense perception reveals a meaningful environment of great variety—green trees, towering buildings, the clamor of a crowd, the touch of love, a flight of birds, a happy child, attitudes of care and concern, and so on. The commonsense view toward the perceptual environment is naive: perceptual properties are assumed to be unaffected by being perceived. Consequently, the perceiver is, from a cognitive point of view, passive. The act of perceiving does not change the properties of the perceptual evironment, but merely reveals them as they exist independently outside the perceiver.

Regarded naively, perception would seem to be unproblematic, involving merely a passive awareness of the environment in which we live. However, difficulties arise once we realize that the agent is not passive in perception. An explanation of perception must therefore give an account of the relation between the perceiver and the environment, or, more generally, between subject and object. When the mere physical structure of the perceiving subject is considered, the relation between that subject and other physical entities in the world poses no special conceptual difficulties because they all belong to the physical level of description. Difficulties arise when we realize that complex organisms have developed cognitive (or epistemic) capacities by which they know something about their surroundings. These cognitive capacities may be exercised with varying degrees of success and from a variety of perspectives.

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Most modern theories of perception no longer hold a naive stand, but assign an active constructive role to the cognitive system involved in perception. Once the difference between the perceptual content and the physical stimuli is recognized, the active role of the perceiver in constructing that content should be acknowledged as well. Perception is considered to be constructive (or nonpure) if it contains information and features absent from the given physical stimulus. Indirect theories of perception often assume the existence of two types of perceptual content absent from the physical stimulus. The first is due to the loss of information in the transition from the distal stimulus (the object) to the proximal stimulus. The second is due to the existence of personal contributions in the perceptual content. James Gibson's (1966, 1979) broad notion of the stimulus was intended to abolish the need to add any content in the first case. It is doubtful, though, whether Gibson's view actually does dismiss that need. Anyhow, it seems that perception is constructive (nonpure) in the second case. Some evidence for this will be presented by showing the influence of personal characteristics—such as past experience, expectations, motivations, emotions, and values—upon perceptual content.

Perception is influenced by the agent's past experience. For instance, unfamiliar objects are often misperceived as more familiar ones, the missing information being filled in from within familiar patterns. Also, at times, similar objects will be perceived differently by people from varying backgrounds. Thus the sensitivity to various orientations of lines (and hence to illusions based upon them) depends, in many cases, on the agent's past experience. Similarly, when two lights, A and B, are flashed in quick succession, they are seen as a single light moving from the location of A to the location of B. The subjects see only a single light moving across the screen, not two flashing lights. The agent's categorization also has some influence upon the perceptual content. Thus equal-sized physical differences between stimuli are perceived as smaller or larger depending on whether the stimuli are in the same category or different ones. Two different shades of green look more like one another than like any shade of yellow, even when the latter is no more different in wavelength from one of the greens than are the wavelengths of the pair of greens from one another (Harnad, 1987). The influence of personal characteristics (such as one's expectations) on perceptual content is pronounced in the case of illusions, reversible and ambiguous figures, and similar patterns providing inadequate perceptual information. Generally speaking, if perception involves the acquiring of information or belief-like states, it is natural to assume that the new perceptual belief is influenced by perceivers' prior beliefs and by their capacity to form them.

The cognitive system no doubt plays an active role in perception and here I will deal with the nature of this system. In prevailing theories of perception, reasoning processes are the basic cognitive processes in perception. The perceptual process involves three basic mental stages: sensation, reasoning processes (such as inferences and computations), and perception. Sensation is the initial mental effect of the physical stimulus. It is "pure" in the sense that it is independent of active cognitive contributions of the perceiver. Sensation is therefore meaningless, consisting of unorganized signs needing interpretation. The interpretation is made by intellectual processes, thereby creating the rich "contaminated" stage of perception. This paradigm is also compatible with the causal theory of perception, which assumes a unidirectional causal chain beginning with physical objects and ending with mental percepts. In both views perception consists of various temporal processes connecting isolated stages, and both are related to a production paradigm. Perception here is a process in which the end-products are separate from the physiological and cognitive processes that produce them. Like production processes, reasoning processes, such as inferences and computations, precede their conclusions and are separate from them. Historically, this paradigm derives from the Cartesian psychological framework in which thinking is considered the essence of the mental realm (Ben-Zeev, 1984; Ben-Zeev and Strauss, 1984).

In the inferential paradigm the constructive (nonpure) nature of perception, that is, the active cognitive role of the perceiver in determining the perceptual content, is explained with reference to preparatory mediating reasoning processes. Hence, the indirect nature of perception in that paradigm. Such a preparatory model is neither the only nor the most adequate one. I will not discuss the difficulties of that paradigm here, but merely point out some of them. (a) The postulation of unconscious inferences does not add any explanatory force. Duplicating the conscious mental realm into the unconscious one is not an explanation. It only provokes a need to postulate the existence of a homunculus and, in addition, an endless inferential regression is created. (b) Perception is explained by the reasoning process typical of thinking. According to the evidence of evolution these thinking processes evolved only later. (c) There is a confusion between a rule-following behavior and a rule-described behavior. Consequently, there is a confusion between abstract mathematical relations and actual psychological processes. (For a detailed discussion see Ben-Zeev, 1987a; see also Costall and Still, 1987; Heil, 1981.)

In the face of such difficulties, perception could be considered to be devoid of reasoning processes such as inference, interpretation, and judgment, but to rely nonetheless on computation. This widespread view may avoid some, but not all, of the problems of the inferential paradigm. The basic disagreement involves not which types of thinking processes should be postulated to explain perception, but whether such processes are required in the first place. Answering negatively to the latter question reduces the attraction of the suggested solution.

The move from inferences to computations has additional significance. Inferences, interpretations, and judgments are intellectual activities related to cognitive content, whereas computations may be purely formal. If computations are purely formal, then part of my previous criticism is no longer relevant. However, a new difficulty emerges: the inability to explain a very important feature of psychological states, namely, meaningfulness (or semantic content). The proposed computations involve the manipulation of meaningless disembodied signs. The meaningless signs cannot be used to explain perception and cognition in general because cognition is meaningful. Meaning is not a formal feature. It belongs to the content of the mental state (Searle, 1980; Williams, 1985).

One may claim unintelligent computations to be commonplace. For example, a cash register can calculate the tax on a sale. If this claim refers only to purely formal computations, then it is true. As I have indicated, though, it has no relevance to meaningful semantic content. If the computations referred to deal with some meaningful content, then the above claim involves a confusion between the physical and the mental levels of description. We may look at the physical cash register as if it calculates the tax, when actually it knows nothing about calculations or tax. We are the ones attributing these meanings to the machine. Generally speaking, formal computational procedures have no meaningful content. We interpret these procedures and thereby attribute meaningful content to them. This act on our part, however, is extraneous to the computational procedures (Sayre, 1987). The replacement of inferences with computations does not improve the inferential paradigm. Therefore, I will continue to refer to the traditional formulation of the paradigm, to reasoning processes such as inferences. My claims, however, will be by and large valid regarding computations as well.

I do not suggest discarding the empirical findings of the inferential paradigm. I suggest placing (most of) them in a different conceptual framework. The reasoning process postulated by the inferential paradigm should be viewed as one way of describing the organism's behavior, not as actual internal processes inside its head.

I admit the active role of the perceiver in perception but reject the prevailing description of how this role is performed. Rather than assuming a preparatory intellectualist model, I suggest a constitutive perceptual model for explaining the agent's role in perception. In this way perception may remain direct despite its constructive nature.

A Constitutive Model

The word "preparatory" is defined as "that which makes ready beforehand for something following," whereas "constitutive" is "that which makes something what it is." Preparatory cognitive processes precede and are separate from the cognitive products; constitutive cognitive features exist together with the cognitive states.

The conceptual foundations of the constitutive cognitive paradigm I suggest may be clarified by referring to Kant's view. According to Kant (1787/1965), the world we know is organized by constitutive features of the knowing subject. These include a priori forms of perception ("intuition")—spatial and temporal relations—and a priori forms of cognitive thinking—concepts such as causality, substance, and plurality. Just as an event cannot be perceived if it is not located within a certain spatial and temporal framework, knowledge of an event is impossible without causal relations to other events. Those a priori forms constitute the conceptual framework necessary for empirical knowledge. The constitutive features in Kant's view are structural features—rules of organization. I choose to refer to all such consitutive rules of organization as "schemas." In Kant's philosophy the term "schemas" is limited to temporal rules (like succession and permanence) connecting pure concepts and sensible appearances. The schema itself is not an instance of perception, but the way (order, structure) in which the perceptual reality is organized: "It is a rule of synthesis of the imagination" (B177, 180).

Lewis (1948) compared a schema to a "mathematical rule generating a number series" (p. 110). Like such a mathematical rule, a schema can neither be reduced to nor constructed out of the particular series that has been generated (which in our case is a particular perceptual content). Nor can it be separated from what it generates. Just as the number series generated by the mathematical rule has the capacity for indefinite expansion, the cognitive rule expressed in the schema is not limited to a certain number of perceptual objects. The dispositional aspect of a schema, like that of the mathematical rule, enables us to extend the rule beyond the actual objects presented (see also Bourgeois and Rosenthal, 1987). This ability to extend means that we can perceive possibilities, or in James Gibson's (1979) terms "affordances," namely, behavior that is possible. In psychology Bartlett (1932) uses the notion of a "schema" in a similar way. For him, "schema" refers to an active principle of organization—an "organizing setting" in his terms—not merely to a static structural element.

A perceptual schema, then, is the way a perceptual experience is organized. The organization is shaped both by the agent's innate dispositions and by his or her acquired personal characteristics. In the inferential paradigm, reasoning processes precede and produce a finished perceptual product separate from the processes themselves. Therefore, in the inferential paradigm the reasoning processes function as preparatory and mediating elements in perception. A perceptual schema functions entirely differently in that it is not separate from the actual perceiving. The schema is constantly participating in the ongoing state of perceiving because it is the way the perceptual system is "tuned." Similarly, the plot is not another detail in a story, but the structure organizing the story's elements. A perceptual schema, then, is a constitutive structure implicit in our perception (Hanson, 1958, p. 13; Neisser, 1976).

On the perceptual level of discussion, perceiving and the exercise of a cognitive schema take place together within the same experience. The chain of sensory raw materials, reasoning processes, and percepts has no relevance in this paradigm. There is no perceptual raw material waiting to be organized by perceptual schemas. The initial perceptual awareness itself is already organized. As a type of direct understanding, perceiving does not take place over the course of time, but rather is happening at any point in time. Perceptual recognition is not a process going on behind the continual state of perceiving.

A perceptual schema is the organization of a perceptual experience. When such an experience does not occur the schema remains only a tendency to have this experience—a perceptual disposition. A subject has perceptual schemas in the way he or she has the ability to play the piano, not in the same way that he or she has eyes. To use Heil's (1983) expression, schemas are in the perceiver as "beauty is in a painting, or sadness is in a melody, not in the way (for example) an electronic circuit is in a computing machine, or a collection of neurons is inside a skull" (p. 144).

The inferential paradigm would have the subject's past experience, knowledge, emotions, values, and other personal characteristics stored in a separate, static warehouse. Accordingly, after sensory data are received, the reasoning processes take account of both the sensory data and the information stored in the warehouse. These activities result in meaningful perception. No real development of the cognitive system occurs during this process. The familiar phenomena of perceptual learning by gradual adaptation are hard to explain according to this paradigm because the very complicated reasoning processes, assumed to exist from early infancy, do not improve with use. As Markova (1982, p. 135) accurately indicates, the reasoning (or computational) system does not change as a result of its various activities, it only fills the empty shelves in the system with more information. Fodor (1985), an advocate of the inferential paradigm, confesses that "deep down, I'm inclined to doubt that there is such a thing as cognitive development in the sense developmental cognitive psychologists have had in mind" (p. 35). Fodor (1975) also denies the possibility of learning a new concept. Descartes (1628/1984) expresses a somewhat similar antidevelopmental view of cognitive capacities when he claims that the cognitive power involved in thinking, perceiving, imagining, and remembering "is one and the same power" (p. 42). This paradigm's postulation of an internal reasoning system is artificial. No wonder it cannot be involved in the organism's natural developmental processes (such as learning).

The schema paradigm is different. Past experience and other personal characteristics are not stored in a separate warehouse awaiting consultation by reasoning, they are ingrained into the constitution of the perceptual system. Prior intellectual processes are unnecessary because the influence of personal characteristics is part and parcel of perception itself. Therefore, the constructive character of perception does not imply that perception is indirect.

When we throw a ball against the wall, the "response" of the wall—expressed by the distance covered by the rebounding ball—is determined by the wall's structure. Any change in that structure (for instance, in its solidity) will immediately express itself in the wall's response. The change is not in hidden storage and cannot be attributed to unconscious reasoning; it is expressed in a change in the responsiveness of the wall. The new response may be said both to be direct and to have a constructive (or nonpure) nature. The human nervous system and immune system do not store new information in a separate warehouse either. Rather, the responsiveness of these systems expresses the new information. In the nervous system this phenomenon is learning (or, more precisely, its supportive basis), and it depends on the plasticity of the synaptic contacts. The neurological supportive basis of learning consists in the selective strengthening of excitatory connections among the neurons. Rather than the brain being viewed as a controlled system that solves problems, "the brain should be viewed as a self-organized process of adaptive interaction with the environment" (Skarda and Freeman, 1987, p. 170; see also Varela, 1979, p. 226). Mediated representations and computations are not required in order for this kind of system to behave adaptively. Neither does the fertilized ovum have to compute representations of adults in order to become one of them.

To cite another example, a tuning fork does not resonate by using inferences. Changes in the length of a fork cause changes in its resonance. Generally, resonators respond to stimuli according to their tuning. In this case knowledge is not the storage of information, but a change in the ability to resonate (Fields, 1985; Shepard, 1984). Similarly, instead of intricately calculating depth perception each time we open our eyes, through our evolution we have developed perceptual structures (schemas) sensitive to the presence of the particular features of depth perception.

In the schema paradigm perceptual learning, adaptation, and readiness are expressed as changes in the sensitivity of the perceptual system and not as changes in a stored data-base. Such changes are "not a matter of making an inner replica where none existed before, but of altering the perceptual schema so that the next act will run a different course" (Neisser, 1976, p. 57). Whereas inferences require a separate storage of "knowing that" statements, perceptual schemas take advantage of "knowing how" procedures.

Perceptual learning involves the acquisition of new abilities enabling further meaningful, perceptual discriminations. This learning enables us to perceive progressively more subtle aspects of the perceptual environment (E. Gibson, 1969; Neisser, 1976). In the schema paradigm acquired perceptions, like original perceptions, are direct; they are the immediate effect of the constitution of the perceptual system. The difference between original and acquired perception is not in the nature of two types of perception: direct (or pure) and indirect (or constructive) perception. The difference is historical, a factor of the time at which a certain perception evolved. Original perceptions are present at birth: acquired ones evolve later. Both, though, are direct and constructive. In this model, learning is a dynamic change of the whole system, not an addition of a certain part; it involves the continuous updating of the schematic rules.

In the schema paradigm the burden of explaining perception shifts from reasoning processes to developmental processes. Perceptual schemas have emerged and been modified throughout the development of the species as well as in the individual organism. In this sense, history is embodied in the schemas. This paradigm provides a more successful explanation of perception because the explanation is not limited to the fractions of seconds in which the perceiver is supposed to make the various calculations and inferences, but it takes into account many evolutionary and personal factors. We need not undergo the whole process of evolution and personal development each time we open our eyes. We assume this process has modified, or tuned, our perceptual system in such a way that our surroundings become meaningful.

The constitutive nature of the perceptual system implies that the system's basic cognitive activities are constitutive activities such as discriminating, discerning, integrating, identifying, adjusting, or equilibrating, rather than mediating processes such as reasoning, inferring, or computing. An examination of the differences between discriminating and inferring can serve to clarify the two different types of activities.

To discriminate (in the sense used here) is "to make or constitute a difference"; to infer is "to reason from one thing to another." The essential difference between these two activities is that discriminating is a constitutive activity whereas inferring is a preparatory one. Discrimination is an activity for whose completion time is irrelevant. Inferring, on the other hand, is an intellectual process involving the use of symbols. Discriminating, as a perceptual activity, does not presuppose the use of symbols. Accordingly, the cognitive claims involved in inferring are usually explicit, like most other intellectual claims. Those claims involved in perceptual discrimination are implicit, as there is no use of explicit symbols.

Similar differences are expressed in the distinction between understanding and interpretation. Interpretation is a temporal process rendering meaning to something that previously did not have this meaning. Although understanding can be the product of a previous intellectual process, it is not in itself a process. In understanding we comprehend the meaning of something, and for this act time is not a relevant factor. Whereas interpretation is always a mediated intellectual activity, we can speak about direct perceptual understanding.

Discriminating (or discerning) is the fundamental cognitive activity in perception. Although the energy waves surrounding us are physically mixed, perceptual content consists of separate, distinct objects and events. In perception the mixed waves become meaningful, separate units (objects, events) that are discerned from their background and identified as distinct wholes (see Efron, 1969; E. Gibson, 1969; Kelley, 1986; Pitson, 1984).

Some scholars (mainly those who favor the direct approach) assume identification, rather than discrimination, to be the basic activity in perception. This assumption emphasizes the realistic aspect of perception. Discrimination and identification, however, are basically similar cognitive activities. Discriminating between one thing and another requires identifying the one as distinct from the other, and identifying something requires discriminating between it and other things. Perhaps it is preferable to call the basic cognitive activity in perception "discerning" rather than "discriminating" or "identifying." To discern is "to recognize something as distinct." These activities, however, all resemble one another because they all involve a certain isolation and integration of the content. Sometimes we speak about intellectual discrimination, identification, and discernment, but these are different types of cognitive activities.

Often perception is described as involving an application of concepts. This description can be misleading if concepts are understood to mean intellectual concepts. If, however, as Heil (1983) argues, by having a concept X, one means having the *capacity* to distinguish X's from non-X's (under favorable conditions) then this description is adequate. This capacity, though, does not require the ability to define X's. In this sense a perceptual concept is somewhat similar to background knowledge, or belief-like cognitive states. Having a perceptual belief is like having an ability, whereas having an intellectual belief involves the capacity to explicate and explain the belief. A perceptual belief is not an internal mediating entity, but a capacity. The employing of a capacity, or being shaped in light of a certain tendency, is not a mediating, temporal process. Consequently, perceiving can be regarded as direct understanding that, like other types of understanding, is influenced by the agent's cognitive framework.

So far I have suggested the existence of a cognitive system whose activity does not make perception indirect. Yet, perception may be claimed to be indirect even in this proposed paradigm because it is preceded by neurophysiological processes. This claim involves a confusion in levels of description. For example, an analysis of the content of a meaningful conversation between two people will not refer to the neurophysiological processes comprising the necessary supporting basis of that conversation. These processes are also irrelevant in analyzing the meaningful content of perception because they do not belong to the meaningful, perceptual realm and are not mediators in this realm.

The inferential paradigm is related to the causal theory of perception in that perceptual states are treated as products of previous physiological and mental processes. The schema approach relates to the ontological paradigm of emergent properties. Perceptual states emerge out of complex lower-level neurophysiological states, the latter being the supportive basis for the former. They neither precede nor are separate from them; they simply exist simultaneously. Just as the liquidity of water necessarily emerges out of a certain arrangement of H_2O molecules, a perceptual state necessarily emerges out of a certain neurophysiological arrangement. In both cases there is a type of ontological unity (Belli, 1986; Ben-Zeev, 1986a).

In brief, some of the basic differences between inferential processes and perceptual schemas are: (a) Inferential processes are *separate* from their perceptual conclusions; schemas are *not separate* from the perceptual states, though they can be conceptually distinguished from them. (b) Inferential processes are on the *same causal chain* as their perceptual conclusions; schemas, the rules of organization of the perceptual states, belong to a *different level* than the perceptual content. (Though both perceptual schemas and perceptual states belong to the mental realm, they represent different sublevels within that realm.) (c) Inferential processes are those that *produce* the perceptual conclusions; schemas are those that *maintain* perceptual states. The schema paradigm combines the paradigm of emergent properties and a constitutive cognitive system, thus avoiding the difficulties typical of the inferential paradigm. The schema paradigm does not deny the existence of cognitive elaborations or of constructive elements in perception, it merely rejects the current explanation for them.

The dichotomy between direct and constructive perception is unwarranted when the cognitive system involved in perception is constitutive and not preparatory. Cognitive elaboration does exist in this case, but there are no mediating cognitive processes preceding the perceptual state.

Development and Organization of Schemas

After presenting the basic theoretical framework of the schema paradigm in the last section, I now turn to some more concrete issues. First, I indicate some features typical of the development and organization of schemas, then I consider empirical evidence demonstrating the usefulness of the schema paradigm.

Piaget's approach exemplifies one in which schemas, rather than unconscious inferences, are the basic explanatory units. For Piaget a schema is a psychological structure found in action, perception, intelligence, memory, and other mental phenomena. A schema is a form, a repeated pattern, underlying one's behavior. Schemas involve two major types of processes: assimilation and accommodation. Assimilation is the integration of something new into an existing schema. For instance, during the first three months of life the sucking schema applies only to objects in contact with the mouth. Later on, when vision and grasping are coordinated, the schema is generalized and infants try to put everything they can see into their mouths. At this point visual objects also have the meaning of "objects to suck." An accommodation is a process in which a schema adjusts itself to the objects (because it cannot assimilate them). For example, in the case of the sucking schema, infants realize that not all objects can be sucked, that is, can be assimilated into the sucking schema (because, for instance, some of them are too large), so the schema is changed to apply to only some of the objects.

Along these lines Rumelhart (1980) suggests three different modes of learning to be possible in a schema-based system: accretion, tuning, and reconstructing. Whereas accretion can be equated to Piaget's process of assimilation, tuning and reconstructing involve many features belonging to Piaget's process of accommodation. *Accretion* means the absorption of new information into existing schemas. The new information may be retained in the form of new specific schemas that have particular constants instead of the general variables of the original schema. *Tuning* involves the actual modification or evolution of existing schemas. This can be done in three ways: (a) making the schema more sensitive to slow changes in the situations to which the schema is applied; (b) adding a new variable to a schema, thus making it more generally applicable; and (c) dropping a variable from a schema, thus making it more specialized. *Reconstructuring* is the process of creating new schemas or abolishing existing ones. New schemas can be created either by copying an old one, with a few modifications, or by inducing a new one on the basis of a repeated particular configuration.

In the schema paradigm the agent's knowlege is packaged into hierarchical schema assemblages. Exercising the perceiver's cognitive capacities activates these assemblages. Each schema consists of subschemas that in turn may consist of their own subschemas. The schema for a face may consist of subschemas for mouth, nose, ears, eyes, and cheeks. The eye subschema would include, for example, subschemas for pupil, iris, eyelashes, and eyebrow. Not only objects but activities and events are also arranged in hierarchical schema assemblages. The schema of buying—which usually consists of the variables of purchaser, money, seller, merchandise, and bargain—is a subschema of doing and has a subschema of buying clothes in a fashionable store. The lower the schema, the more specific its variables. The essential relationship between schemas in different levels is one of nesting (or embedding) rather than one of causation; the former is not successive (Neisser, 1976; Rumelhart, 1980; Rumelhart and Ortony, 1977).

One important advantage of a schema-based system is that it economizes on representational variables because it packages knowledge into hierarchical units. Thus instead of requiring many separate variables for the schema of apple, orange, and olive, the variables common to all of these are combined in the schema "fruit." These schemas, in allowing items to be treated together, are effort-saving structures. Often the items belonging to a certain schema are arranged in a prototype order, that is, they are arranged in their order of similarity to the most typical member of the category. Thus there are many innate schemas that have a prototypical structure whose parameters are fine-tuned by learning. The hierarchical order of schemas enables the system to handle novel situations by using higher-level abstract schemas without the creation of many more specific schemas. The common schema can be sensitive to deviations from its own rules of organization. Perception occurs by understanding the particulars as deviations from an underlying general structure, not by abstracting common elements from many particular instances. This structural economy of a schema-based system restricts the number of the required schemas (Arnheim, 1969; Evans, 1967; Mohanty, 1986; Rumelhart and Ortony, 1977).

Flexible variable constraints are another very significant characteristic of schemas. This feature allows us to understand a story about one-eyed people even though, in a typical schema of face, people have two eyes. The prototypical nature of a schema enables it to tolerate deviations and distortions from the typical situation. Rumelhart (1980) argues that a schema, like the script of a play, does not completely specify every detail, but rather allows room for irrelevant variation. The schema constraints are not all-or-nothing constraints that require certain variables to have a fixed range of values. They are themselves the specifications for the normal range of values. The schema, Rumelhart maintains, is a skeleton for understanding the situation.

Acquiring perceptual schemas is like acquiring skills. Learning to ride a bicycle, to type, or to play a piano involves the acquisition of new schemas. Before the schemas are acquired riding, typing, or playing are controlled activities done in stages; the transition from one stage to another is usually accompanied by conscious reasoning processes. Once the schemas are acquired, the mediating stages disappear along with the reasoning processes. These activities are then performed automatically without the intentional deliberation typical of reasoning processes. In situations where the schemas are not adequate, the expert returns to the mediating reasoning processes. As a certain skill is acquired, the conscious inferences are not internalized and made faster; rather, the rules underlying the skill become embodied in the agent's physiological and cognitive structures. Consequently mental effort is conserved. Therefore, a beginner's behavior is a rule-following behavior, whereas the expert's behavior is a rule-described behavior (see Searle, 1983, pp. 150–151). An experiment involving training dogs seems to suggest a neurophysiological indication for this:

> before the dog has learned to handle the problem facing him, the electrical activity accompanying the effort is spread over large portions of the brain. In the fully trained animal the active site has shrunk to a small focus responding to the challenge. The learned behavior is then fully automatized and the voluntary effort is restricted to a trigger function. (Granit, 1982, p. 102)

These considerations apply to wine tasting as well. Many people cannot distinguish between different types of a certain wine. Yet after repeated tasting of this same wine, they may acquire the perceptual schema—or the ability—to distinguish between them. This improvement in tasting ability is not an intellectual improvement in performing reasoning processes. It is an improvement in the perceptual sensitivity to various attributes of these tastes. Similarly, a trained musician can selectively focus upon a particular instrument in an orchestra, something an inexperienced listener cannot do (Efron, 1969). As Kelley (1986) puts it, if the perception of something "with any degree of specificity is direct, then the capacity to discriminate its degrees with greater specificity should also be regarded as direct, unless there is some other reason for doubting this" (p. 65).

The initial evaluation of other people is also essentially an application of evaluative schemas in the form of stereotypes. Emotional attitudes, like perceptual states, can occur without previous inferences and calculations (Ben-Zeev, 1987b; Zajonc, 1980). The same holds true for other attitudes in humans and animals. For this reason the friendly, or hostile, attitudes of a dog toward family members, or strangers, can be explained more naturally by assuming the existence of a certain schema for each group than by referring to unconscious inferences. Illness can also be explained as stemming from a flaw in the neurophysiological or mental organization rather than from the miscalculation of reasoning processes.

The schema paradigm does not require the assumption of a homunculus. What is called the "self" is a structure of relationships: a system of abstract rules that govern mental regularities (Hayek, 1978). The "self" is the general schema of the various particular schemas. This is not only a synchronic but also a diachronic schema—the "self" has some sort of continuity over time. The "self" belongs to a higher level of description and therefore is not an internal entity separate from the mental states. It is not a mediator between different mental states because it does not belong to the same level of description of those states. Just as we do not assume the presence of a little person in our heads who pulls strings to make us play a piano or throw a ball, we should not need a homunculus to make us see, think, remember, or attend to something. Mental properties are properties of the whole organism and not of an internal mind.

In explaining perception the schema paradigm focuses on cognitive structures rather than cognitive processes. Yet the question still remains whether cognitive processes play any role at all in explaining perception according to this paradigm. Two of the kinds of cognitive activity that are assumed in the schema paradigm may be compared to mediating cognitive processes: (a) modification of perceptual schemas, and (b) a choice of which schema to activate. The first includes the developmental processes of acquiring new schemas and modifying existing ones. Although such processes, discussed above, are clearly preparatory they are not cognitive mediators because they do not involve a cognitive elaboration of a perceptual content. The second type of cognitive activity is required because although there are many schemas, only a few of them are activated in each perceptual state. How, then, does the system "know" which schema to activate? The literature suggests a few principles for such a choice: the simplest or most economical schema, the one most frequently associated in the past with this situation, the one in which the object remains constant or rigid as a thing while changing its orientation, location, or the like, or a schema in which seeming coincidences and unexplained regularities are related to a common cause (see Rock, 1983, chap. 6). Determining which way (or ways) is implicit in the structure of the perceptual system is an empirical task. Probably, elements are combined from a number of the above suggestions. The fact that a preference is made, however, does not imply the existence of mediating cognitive processes or a homunculus. We should view this activity as a procedure implicit in the structure of the perceptual system, that is, as being the order underlying the operation of the perceptual system. Perceptual procedures are presumptive, not deductive. They are not actual deductions carried out by the perceptual system.

The activities of modifying and choosing schemas are different from mediating cognitive processes because they do not involve cognitive elaborations; they merely determine the cognitive tools required for cognitive elaborations. The preparation and choice of cognitive tools, though they determine the kind of cognitive elaborations that will take place, are not in themselves cognitive elaborations. Therefore, these tools cannot be regarded as cognitive mediators. A cognitive mediator in perception should fulfill two conditions: (a) it must precede the perceptual state—be preparatory, not constitutive—and (b) it must involve cognitive elaborations. Activities of modifying and activating schemas do not fulfill the second condition. Constitutive cognitive activities do not fulfill the first condition. Accordingly, neither of them makes perception indirect.

The activities of modifying and activating schemas may be considered as part of the active and time-extended structure of the perceptual system. As such they are a type of process. In this case, the distinction between structures and processes becomes blurred (see Rumelhart and Ortony, 1977). Also the direct-indirect distinction (as it applies to mediating cognitive processes) becomes less important when we assume the existence of mental activities preceding perception, and of cognitive elaborations at the time of perception (see also Bruce and Green, 1985; Fields, 1985). Although perception is direct, its directness has no special epistemological significance: it is not a pure starting point of cognition.

The preparatory-constitutive distinction is more important in describing the difference between my approach and the inferential (computational) one. The existence of a preparatory cognitive system in perception is compatible with the production paradigm and is usually associated with the various traditional difficulties. These difficulties are avoided in my approach, which combines a constitutive cognitive model with the paradigm of emergent properties. Thus my approach does not posit homunculi, does not invert the order of perceiving and thinking by postulating reasoning processes before the perceptual states, allows a clear distinction between following and merely satisfying rules, does not allow the ascription of reasoning processes to inanimate things, and provides a suitable framework for describing the meaningful nature of perception. Although a preparatory cognitive model can be modified so as to diminish the force of such difficulties, the constitutive model more successfully accomplishes this task, for in it most of these difficulties do not arise in the first place.

Some Empirical Considerations

This section describes some empirical research that, I believe, substantiates the plausibility of the schema paradigm. The empirical results presented may be interpreted otherwise, but, I think, less cogently. The different studies to be described are not intended to exhaust all perceptual phenomena, but merely to exemplify the use of the schema paradigm in explaining various perceptual phenomena.

Michotte's research (1963) on the perception of causality indicates the exact conditions activating the perceptual schemas of causality. These conditions are of two types: (a) integration and segregation, and (b) dominance. The perceived causality emerges when certain relations of integration exist (indicating that the perceived objects have some connections between them) as well as of segregation (suggesting that despite their connections, the two objects are still separate). The integration factors are: temporal affinity, spatial affinity (when the temporal or spatial distance between the two objects is too large there is no causal impression), and affinity in direction and speed. The segregation factors are: two distinct objects, movement and presence of both objects at the time of causality, and (preferably) a difference in their speed. All these factors should be at a certain equilibrium in order for causality to be perceived. When the integration factors are too strong, movement of only one object is observed. When the segregation factors are too strong, the two movements are seen as independent. Dominance constitutes the second type of condition for perceptual causality: the movement of the "cause" has to be dominant over the other movement. Dominance emerges from the following factors: time priority, greater speed, and fixation. Michotte details the exact proportion of all these factors. Consequently, the situations in which causality is perceived can be predicted (even when it seems to be contrary to physical causality). Michotte achieved similar results in his research concerning object permanency (see Strauss, 1984).

Throughout his research Michotte (1963) does not refer to reasoning processes as explanatory factors. On the contrary, he claims perception of causality to be immediate, requiring no interpretation. The phenomenal given includes the relation of causality, it "requires no further elaboration in order to acquire significance, but carries this significance already" (p. 223). Once all the minute details of the conditions for the emergence of perceptual causality are described, the only cognitive task left is to present an overall schema compatible with the various details. This schema is neither separated from, nor preceded by, the above details; it simply expresses their regularity. Weir (1978) presents such schemas and translates them into a computer program. Mistakenly, though, she assumes her findings to support the inferential approach, and to be contrary to Michotte's approach. This happens because she considers direct perception to be incompatible with the constructive nature of perception. I have rejected this assumption (see also Ben-Zeev, 1988), and described the differences between schemas and inferences.

Evidence for another sort of schematic mechanism is found in research by Regan, Beverly, and Cynader (1979) concerning the optical changes associated with radial motion. If a ball is thrown directly toward the perceiver, its expansion patterns on each retina differ from those of a ball that will miss the head. We should develop the greatest sensitivity to collision patterns (Regan et al. argue) because, as perceivers, we care most about objects that might collide with us. Therefore, we must have specialized detectors just for these stimulus features. Regan et al. did indeed find such detectors. In experiments with cats they found cells in their visual cortex that were responsive only to collision movement. This explanation of perceiving collision and noncollision motion also has no need to postulate mediating inferences. The finding, on the neurophysiological level, of special detectors and the describing, on the perceptual level of related schemas (rules of organization) complete the explanation.

Similar conclusions can be drawn from Warren's (1984) research concerning the "climbability" of stairs. His observers viewed slides of stairs and were asked to judge (a) whether or not the stairs could be climbed at all, and (b) which stairs would be most comfortable to climb. In each case biomechanical constraints were independently calculated and then compared to the perceptual judgments. Concerning the first issue, biomechanical calculations, which took into account how much a person can raise the body's center of gravity over the foot serving as a base of support, indicated that for people of different heights the limit of climbability is a constant of .88 for the ratio of the stairs' height to leg length. In a perceptual task involving both tall and short people, the subjects did actually indicate a value of about .88 as the perceived limit of the stairs' climbability. Finding an optimal stair height was more complex. As riser heights increase, the effort to climb an individual step increases. The lower the risers, however, the more step cycles are required to climb a given distance. Warren determined the optimal riser height in tall and short people by measuring their oxygen consumption (a good index of energy used) as they walked on a staircase treadmill with variable risers. The optimal riser height expressed as a ratio of riser height to leg length was .26 for both tall and short people. In corresponding perceptual tasks, people judged the maximally comfortable stairs to be those with riser heights about .25 of one's leg length—very close to the above optimal values.

Warren's results can hardly be interpreted in light of the inferential paradigm. For his subjects to have unconsciously computed all of the complicated biomechanical calculations described above is highly improbable. For one thing, they did not know all the relevant variables, such as the measurement of oxygen consumption. The results of the study are more plausible if we assume that during development one develops a perceptual schema for detecting the optimal climbability of stairs. When the subjects encounter stairs similar to, or different from, the optimal organization expressed in this schema, they immediately perceive the stairs as easy or hard to climb. It is simpler to assume a perceptual structure "wired" for this optimal ratio than to assume the completion of complex calculations of unknown variables.

The development of schemas takes place through constant mutual interaction between the perceptual system and the system controlling the activity of the animal. In this way, energetic efficiency can be detected and, accordingly, guide the animal activity. Warren argues that energetically efficient visually-guided activities are performed by many species. The animal acts according to the perception of the best energetic fit between its properties and those of the given environment. For instance, Warren refers to Branch's (1979) study showing that South African East-Coast limpets (clams) less than 30 mm long retreat from a predatory whelk, whereas larger individuals attack the predator by battering it with their shells. This size limit increases to 43 mm for limpets on the West Coast where the whelks are larger. Thus attack and retreat are shown to be determined by the relative sizes of predator and prey. Again, it seems highly improbable to postulate the workings of mediating reasoning processes inside those creatures.

The schema paradigm also gives a more adequate account of the findings regarding the meaningful character of the perceptual world of human and nonhuman neonates. It is implausible to explain the neonates' meaningful perception by referring to mediating reasoning processes. Consider, for example, Fantz's (1961) research concerning the original of form perception. Fantz took chicks who were hatched in the dark and tested their visual discrimination at their first exposure to light, before their first experience with real food. He presented the chicks with a number of small objects of different shapes. Each object was enclosed in a clear plastic container to eliminate the possible influence of touch, smell, or taste. This packaging did not prevent the chicks from pecking, most of the time, at round three-dimensional shapes about the size of grain or seeds. These preferred objects are also those most likely to be edible. In light of the fact that the chicks pecked in a meaningful manner, it is plausible that they possess an unlearned perceptual structure (schema) ensuring that the form of edible objects would be more meaningful. It is hard to imagine the chicks conducting intellectual inferences before enacting their meaningful pecking. For one thing, they did not have all the required data—not to mention the required capacity. In a similar experiment Fantz showed the preference young infants have for looking at human faces over other patterns. Again, it is difficult to assume the infants are making the necessary inferences. Although infant perception is meaningful, it is not the result of intellectual processes (see also E. Gibson, 1987).

The inferential paradigm is compatible with the traditional approaches to perception that do not consider temporality a real perceptual dimension. These approaches treat perception as timeless, and motion perception is described as the result of a temporal process of passing from one timeless image to another. An inference is also assumed to be the result of a temporal process of passing from one timeless body of data to another. Schemas, because they are dynamic structures, are far more suitable for being the cognitive organizing principles of an alternative flow paradigm in which the temporal flow of events is a fundamental perceptual feature. The plausible shift from a static, snapshot paradigm of perception to a more dynamic, flow paradigm should be accompanied by a shift from the inferential to the schema paradigm.

In addition, the schema paradigm is better suited to the task of explaining the phenomena of perceptual interpolation (filling in the missing elements when some other elements are given to form a meaningful whole) and amodal completion (completing the part of an object that is not directly visible because it is covered by other objects). These common phenomena of perception are present when we find ourselves in front of an organized field. For example, when confronted with a circle whose edges are slightly disconnected, we actually fill in the missing part and perceive a perfect circle. Similarly, a person sitting in front of us, behind a desk, appears to be a complete person even if only the head, arms, and parts of the trunk are directly visible. When the basic cognitive units of perception are cognitive structures like schemas, the presence or absence of certain features is significant. Such an absence is incompatible with an assumed overall structure. In cases where the structure actually is not present we get illusory structures such as the subjective contours presented by Kanizsa (1979).

Many researchers interpret these phenomena to be conclusions of unconscious inferences, but this interpretation is unlikely. In the inferential paradigm the unconscious system receiving the data carefully analyzes them. There is no reason for assuming it would not notice the missing parts and present the situation without these parts. If, however, our basic explanatory unit is a cognitive structure such as a perceptual schema, it is plausible that when many aspects of a situation already fit a certain schema this schema will be activated without further exploration of the situation. Likewise, a resonant system can be excited not only by the pattern of energy for which it is tuned, but also (though to a lesser degree) by a slightly different stimulus (Shepard, 1984).

The tendency of the perceptual system to form meaningful structures such as those involved in perceptual interpolation and amodal completion is compatible with my assumption that the basic cognitive units in perception are structures (schemas). Contrarily, in the inferential paradigm the reasoning processes are merely supposed to present the perceptual information as it is, not to complete it into structured meaningful wholes. If reasoning processes were involved in the perceptual activity there would be no reason for such completion to occur. Even if it did occur, the completion would not be done in this structural manner, but in any one of the other theoretically possible ways (see Kanizsa, 1979, 1985; Kanizsa and Gerbino, 1982).

The phenomena of perceptual enhancement and perceptual interference are also more compatible with the schema paradigm than with the inferential one. Perceptual enhancement occurs when, for example, a prior presentation of something, say a word, enhances its later perceptual identification. Perceptual enhancement may persist over days and sometimes even over a year (Jacoby, 1983). An example of perceptual interference can be found in the following experiment by Bruner and Potter (1964). In their research, adult observers viewed pictures of common objects coming slowly into focus. Recognition was delayed when the subjects first observed the out-of-focus pictures. The greater or more prolonged the initial blur, the slower the eventual recognition. Thus the subjects continued to misidentify the object long after naive subjects (those subjected to less severe amounts of defocusing) were able to readily identify the object in question. If inferences did precede perceptual states there would be no reason why a prior presentation, or expectation, of something would enhance its later perception or interfere with it. Inferences are concerned with logical relations, not with temporal affinity. In the schema paradigm such phenomena make sense. The prior activation of a certain schema could encourage subsequent activation of that same schema, thereby interfering with the activation of a more suitable schema. Applying the correct perceptual schema is much easier when no schema previously exists than in circumstances where it needs to replace an established schema. These considerations are at odds with the reasoning processes that supposedly take into account only the relevant data presented.

Now I will suggest some applications of the schema paradigm to domains associated with the perceptual one. I begin by suggesting the usefulness of the schema paradigm in understanding the knowledge underlying the performance of actions. Rumelhart and Ortony (1977) see three reasons for this. (a) The existence of variables in action schemas permits the flexibility required for the performance of actions. (b) The embedding of action schemas within one another is compatible with the fact that a single activity—say, playing tennis—is also composed of complex subactions arranged in a certain order. (c) The existence of action schemas at all levels of abstraction allows us to account for the existence of actions at various levels of complexity. In the schema paradigm there is an emphasis on the activity of the perceiver. By contrast, in the Cartesian approach (where priority is given to consciousness and thought over action), the perceiver is a thinker rather than an actor or doer (Eckblad, 1981; Fischer, 1980; Markova, 1982; Neisser, 1976; Wood, 1983).

The behavior of schizophrenic patients seems to be connected to the exercise of perceptual as well as other types of schemas. As McGhie and Chapman (1961) show, schizophrenic patients experience self-regulative activities as uncertain and requiring of deliberate coordination. Each action has to be planned and executed step by step, with a great deal of conscious deliberation. Nothing is automatic; everything has to be considered. One patient says "people just do things, but I have to watch first to see how you do things." Other patients remark that they "have got to see ahead" and that they prefer to think out movements first before they do anything. These patients clearly suffer from a loss of certain schemas. Other changes also exist in the perceptual schemas of schizophrenic patients. For example, they involuntarily attend to features of their perceptual environment that have hitherto occupied a background position. This disturbs the constancy and stability of their perceptual environment. Patients complain of being distracted by too much noise and of being unable to stop listening. They also experience a disturbance in the perception of speech stemming from the fact that their perceptual schemas underlying conscious attention are directed at the form rather than the content of the communication. In addition, depression has a plausible explanation according to the schema paradigm. Depressed persons are captives of their schematic frameworks, and from this negative viewpoint they are bombarded by negative self-judgments and ideas (see Beck, 1967).

The schema approach has also been useful in explaining emotional preference for music. The frequency of listening may by itself increase preference for music, according to empirical evidence. This has been explained by assuming the continuous activation of relevant schemas. A more careful interpretation of the relevant data suggests that "we like what is closest to the central tendency—the prototype—of a relevant schema. In other words, we tend to like music that is typical of its kind" (Gaver and Mandler, 1987). Although typicality is highly correlated with preference, it is negatively correlated with interestingness. We like what we know, namely, what is compatible with our schemas. What deviates from our schemas may be interesting, but we do not like it as long as we have not developed a new schema for it.

Use has been made of the schema paradigm in memory research as well (for example, Bartlett, 1932). Recognition is explained by assuming the reactivation of a particular schema. Recognition usually takes place without any scanning or comparison, and hence there is no need to postulate an unconscious search or inference. Only when we are uncertain—either in recognition or in exercising a skill—do we try to compare and calculate the relevant data. The case of a singer recalling the words of a song perfectly while singing, but failing to do so if asked to recite them, is an expression of the schematic nature of memory. A speech or a poem may be perfectly spoken from beginning to end, but the speaker may be unable to recite the second verse without reciting the first (Arnold, 1984, p. 35). These cases all indicate that we are not dealing with a search for, or an inference from, isolated bits of information, but with a reactivated schema (see also Ben-Zeev, 1986b).

The schema paradigm can be quite useful in explaining humor as well. Something usually amuses us because it does not match up with our expectations, or because it is out of place in its setting. In other words, something amuses us if it violates one of our schemas, and if we enjoy this violation.

A new approach seeming to share many basic assumptions with the schema approach is connectionism (also called the Parallel Distributed Processing [PDP] approach). Though its advocates consider themselves part of the more general computational approach, they consider relaxation as the dominant mode of computation, not calculation. The cognitive system "should be thought of more as *settling into a solution* than calculating a solution" (Rumelhart and McClelland, 1986, p. 135). In this model, what is stored is not explicit entities such as internal representations, but "a set of connection strengths." Learning does not require actual computations, but "simply proceeds by connection strength adjustment, according to some simple scheme" (McClelland and Rumelhart, 1986, p. 21). They argue that "*knowledge is in the connections* rather than in the units themselves" (Rumelhart and McClelland, 1986, p. 132). This shifts the emphasis from calculations to biological architecture. The profound difference between connectionism and the conventional computational approach is that

> almost all knowledge is *implicit* in the structure of the device that carries out the task rather than *explicit* in the states of units themselves. Knowledge is not directly accessible to interpretation by some separate processor, but it is built into the processor itself and directly determines the course of processing. It is acquired through tuning of connections as these are used in processing, rather than formulated and stored as declarative facts. (Rumelhart and McClelland, 1986, pp. 75–76)

The basic cognitive activity is not the application of a rule, but the activation of cognitive units. In this model, single units do not make decisions, but "decisions are the product of the cooperative action of many somewhat independent processing units" (Rumelhart and McClelland, 1986, p. 131). There is no central executive making decisions. The advocates of connectionism "do not assume that the goal of learning is the formulation of explicit rules." Rather "it is the acquisition of connection strengths which allow a network of simple units to act *as though* it knew the rules" (p. 32). Like the schema paradigm, connectionism assumes the ontological paradigm of emergent properties. In connectionism emergent properties "could never be understood or predicted by a study of the lower level elements in isolation." This, however, does not mean that "the nature of the lower level elements is irrelevant to the higher level of organization" (p. 128).

The above assertions may suggest that connectionism provides a method to explicate what is involved in the having of a schema. Connectionism and the schema paradigm can be considered to refer to the micro- and macrolevel of description of the same phenomena. Both views originate in a discontent with the prevailing computational (inferential) paradigm and have many assumptions in common, though connectionism concentrates on lower-level states and considers itself as part of the computational approach. Although it is possible that my discontent with the term "computation" here is merely terminological, it may, on the other hand, reflect a substantial difference in orientation.

Perceiving and Thinking

In light of the evidence differentiating between the reasoning processes typical of thinking and the functioning of the perceptual system, one may concede that perception and thinking are two different types of cognitive systems. Fodor (1983, 1985) takes this stand but continues to claim that they are both inferential (or computational). The perceptual system involves informationally encapsulated processes, whereas thinking involves unencapsulated processes. The perceptual processes are encapsulated, or cognitively impenetrable, because they have no access to all of the agent's background knowledge. For Fodor the existence of these processes explains, for instance, cases where despite our knowledge of the falsity of the perceptual content we cannot change that content. A classic example of this is seeing the sun as smaller than it actually is. The perceptual system does not replace the false perception of the sun with the correct one because it has no access to information about the real size of the sun. The perceptual system, Fodor claims, is mainly an automatic, autonomous, *unintelligent,* and informationally encapsulated system.

The existence of such an autonomous system has obvious biological advantages, and it is particularly significant in situations of extreme urgency where it is more important to be quick than precise. The system can provide fast and, by and large, very reliable information because it is well suited to normal, and frequently occurring, conditions in the environment. If the system had to take into account every item of newly acquired information, the system would be slower and more susceptible to error—because the new information might be wrong. The same would be true for reflexes underlying some of our activities. Thus the explanation for why we pull our hands away from a hot object refers to a certain autonomous reflex having obvious biological advantages.

It certainly makes sense to consider the perceptual system, or at least some of its subsystems, as autonomous to a certain degree. The question, however, is whether such a system should be described—as Fodor suggests—as consisting of unconscious inferences (or computations), or whether it should be described differently. A typical feature of inferences is intentional deliberation. In this process the subject analyzes the data and reaches a conclusion after deliberation involving a consideration of other sources of information. The putatively autonomous, *unintelligent*, and unconscious inferences lack this feature of deliberation and it is doubtful whether without it we can speak about inferences. In ordinary usage, inferring is conscious, explicit, deliberate, and considered. These are not the properties of Fodor's autonomous system or any perceptual system (see Hirst, 1959, pp. 226–231; Ruegsegger, 1983). To speak about unintelligent computations and inferences seems to be a contradiction in terms. Computations and inferences are intelligent processes. They may be simple or complex, trivial or sophisticated, but they cannot be unintelligent.

Instead of postulating unintelligent inferences it is preferable to assume that the forces of perceptual organization expressed in some perceptual schemas, for example, remain unchanged despite the contrary influence of one's knowledge and past experience. The more natural assumption considers a perceptual structure to be unchanged by such knowledge and experience, rather than concluding that a deliberative, inferential process is unchanged in these circumstances. Whereas a schema, at any point of time, is a well-defined stable structure, an inference is a product of a process that takes much of the available data into account in its intentional deliberation.

One way to evaluate the adequacy of the two opposing approaches is to examine whether there are cases of perceptual content that are incompatible with the content that is typical of thinking. Kanizsa (1979, 1985) and Strauss (1984) maintain the existence of such cases. Thus Kanizsa argues that simplicity in thought means maximum symmetry, whereas in perception simplicity is expressed in the principle of continuity of direction. To take another example, Strauss claims that in thought the border of an object is a relation between two objects belonging to neither, whereas in visual perception the border (contour) belongs to one object. It is more a property of that object than a relation between two objects. Thus we see the contour between the table and the air surrounding it as belonging to the table. In cases of reversible figures the contour is always seen as belonging to one of the figures, not to the backgroud. The contour is experienced as an edge defining depth. It is as if the background of the figure is behind it and the border belongs to the front figure. Such perceptual rules of organization are clearly different from the rules of scientific thinking (Kelley, 1986, p. 159). As Kanizsa (1985) concludes, in light of his long empirical research:

> the visual system, in the cases in which it is free to do so, does not always choose the solution that is most coherent with the context, as normal reasoning would require. This means that seeing follows a different logic—or, still better, that it does not perform any reasoning at all but simply works according to autonomous principles of organization which are not the same principles which regulate thinking. (p. 33)

At times everyday thinking also uses rules of organization different from those involved in scientific thinking. Everyday thinking is closer to the perceptual rules of organization than is scientific thinking. Whereas everyday thinking, like ancient thinking, organizes its world from materials provided by perception, modern scientific thinking goes beyond the perceptual content. For instance, the most basic law of probability, the conjunction rule, is not always abided by in everyday thinking, according to Tversky and Kahneman (1983). This rule determines that the probability of a conjunction, $p(A\&B)$, cannot exceed the probabilities of its constituents, $p(A)$ and $p(B)$, because the extension of the conjunction is included in the extension of its constitutents. In everyday life, however, a conjunction can be more representative than one of its constituents, such that the conjunction appears more probable. Take for example their experiment in which subjects received the following description: "Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice and also participated in anti-nuclear demonstrations." The subjects responded that there is a greater probability of Linda being a bank teller and active in the feminist movement (T&F) than of her being a bank teller (T). In the same vein, Tversky (1977) shows judgments of similarity in everyday thinking to be based upon rules other than those used in theoretical scientific thinking. In the latter, similarity between objects is a linear combination of the measures of their common and distinctive features. In the former, similarity is analyzed in terms of prototypicality (terms that are commonly used in describing the perceptual realm too). Therefore, in scientific thinking similarity is a symmetrical relation, and in everyday thinking it is not. In everyday thinking, North Korea is more similar to People's Republic of China than the People's Republic of China is to North Korea. Likewise, an ellipse is more similar to a circle than a circle is to an ellipse. Everyday thinking, then, developed after the development of perceptual cognition and is the basis for the development of scientific thinking.

The rules of organization typical of primitive thinking are also, evidently, closer to those employed by the perceptual system than are the rules typical of scientific or even everyday thinking. The rules underlying the thinking system are more easily changed than those underlying the perceptual system. The perceptual rules are more basic: they have barely changed during the evolution of human beings. The rules of scientific thinking change faster than those of everyday thinking, which is what accounts for the difference between them. Perception and the various types of thinking are each a cognitive perspective of the world. Each has its own value and uses, but the scientific perspective is more advanced and closer to a more accurate description of a world independent of the agent.

The distinction between perception and thinking can be presented according to the following features: (a) the rules of organization underlying the two systems, and (b) the type of cognitive activity used in each system. There are rules of organization common to the two realms (as when a certain prototype is perceptually salient and is also assumed in our thinking [see Lakoff, 1987]), whereas other rules are unique to each realm. The existence of unique rules in itself does not prove that the two systems employ different types of cognitive activity, but in light of the preceding discussion this is a plausible conclusion. The difference here is between reasoning processes working with symbols and preceding intellectual conclusions, and schemas underlying perceptual discrimination (and similar constitutive activities) activated at the point of perception. This difference also explains the difference in the nature of the cognitive claim in each case: implicit, in perception, and explicit, in thinking.

In this paper I have presented a brief survey of issues related to the schema paradigm. The survey points out the usefulness of the paradigm, but also indicates the need for further research in order to clarify the details of the paradigm. The paradigm, however, does seem to have promising conceptual foundations.

References

Arnheim, R. (1969). *Visual thinking*. Berkeley: University of California Press.

Arnold, M.B. (1984). *Memory and the brain*. Hillsdale, New Jersey: Erlbaum.

Bartlett, F.C. (1932). *Remembering*. Cambridge: Cambridge University Press.

Beck, A. (1967). *Depression*. Pittsburgh: University of Pennsylvania Press.

Belli, R.F. (1986). Mechanist and organicist parallels between theories of memory and science. *Journal of Mind and Behavior*, *7*, 63–86.

Ben-Zeev, A. (1984). The passivity assumption in the sensation-perception distinction. *British Journal for the Philosophy of Science*, *35*, 327–343.

Ben-Zeev, A. (1986a). Making mental properties more natural. *The Monist*, *69*, 434–446.

Ben-Zeev, A. (1986b). Two approaches to memory. *Philosophical Investigations*, *9*, 288–301.

Ben-Zeev, A. (1987a). A critique of the inferential paradigm in perception. *Journal for the Theory of Social Behaviour, 17*, 243–263.

Ben-Zeev, A. (1987b). The nature of emotions. *Philosophical Studies, 52*, 393–409.

Ben-Zeev, A. (1988). Can nonpure perception be direct? *Philosophical Quarterly, 38*, 315–325.

Ben-Zeev, A., and Strauss, M. (1984). The dualistic approach to perception. *Man and World, 17*, 3–18.

Bourgeois, P.L., and Rosenthal, S.B. (1987). Schemata: Heidegger and Lewis. *International Philosophical Quarterly, 27*, 135–149.

Branch, G.M. (1979). Aggression by limpets against invertebrate predators. *Animal Behavior, 27*, 408–410.

Bruce, V., and Green, P. (1985). *Visual perception: Physiology, psychology and ecology.* London: Erlbaum.

Bruner, J.S., and Potter, M.C. (1964). Interference in visual recognition. *Science, 144*, 424–425.

Costall, A., and Still, A. (1987). *Cognitive psychology in question.* Brighton, England: Harvester.

Descartes, R. (1984). *Rules for the direction of the mind.* In J. Cottingham, R. Stoothoff, and D. Murdoch [Trans.], *The philosophical writings of Descartes.* Cambridge: Cambridge University Press. (Original work published 1628)

Eckblad, G. (1981). *Scheme theory.* London: Academic Press.

Efron, R. (1969). What is perception? In R.S. Cohen and M.W. Wartofsky (Eds.), *Boston studies in the philosophy of science* (Vol. 4). Dordrecht, The Netherlands: Reidel.

Evans, S.H. (1967). A brief statement of schema theory. *Psychonomic Science, 8*, 87–88.

Fantz, R.L. (1961). The origin of form perception. *Scientific American, 204*, 66–72.

Fields, C.A. (1985). *Explaining perception: An assessment of current ecological and cognitivist approaches.* Unpublished doctoral dissertation, University of Colorado, Boulder.

Fischer, K.W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review, 87*, 477–531.

Fodor, J.A. (1975). *The language of thought.* New York: Crowell.

Fodor, J.A. (1983). *The modularity of mind.* Cambridge, Massachusetts: MIT Press.

Fodor, J.A. (1985). Précis of *The modularity of mind. Behavioral and Brain Sciences, 8*, 1–42.

Gaver, W.W., and Mandler, G. (1987). Play it again, Sam: On liking music. *Cognition and Emotion, 3*, 259–282.

Gibson, E. (1969). *Principles of perceptual learning and development.* New York: Appleton.

Gibson, E. (1987). Introductory essay: What does infant perception tell us about theories of perception? *Journal of Experimental Psychology: Human Perception and Performance, 13*, 515–523.

Gibson, J.J. (1966). *The senses considered as perceptual systems.* Boston: Houghton Mifflin.

Gibson, J.J. (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin.

Granit, R. (1982). Reflections on the evolution of the mind and its environment. In R.Q. Elvee (Ed.), *Mind in nature.* San Francisco: Harper & Row.

Hanson, N.R. (1958). *Patterns of discovery.* Cambridge: Cambridge University Press.

Harnad, S. (1987). *Categorical perception.* Cambridge: Cambridge University Press.

Hayek, F.A. (1978). The primacy of the abstract. In *New studies in philosophy, politics, economics and the history of ideas.* London: Routledge & Kegan Paul.

Heil, J. (1981). Does cognitive psychology rest on a mistake? *Mind, 90*, 321–342.

Heil, J. (1983). *Perception and cognition.* Berkeley: University of California Press.

Hirst, R.J. (1959). *The problems of perception.* London: George Allen and Unwin.

Jacoby, L.L. (1983). Perceptual enhancement: Persistent effects of an experience. *Journal of Experimental Psychology: Learning, Memory and Cognition, 9*, 21–38.

Kanizsa, G. (1979). *Organization in vision.* New York: Praeger.

Kanizsa, G. (1985). Seeing and thinking. *Acta Psychologica, 59*, 23–33.

Kanizsa, G., and Gerbino, W. (1982). Amodal completion: Seeing or thinking? In J. Beck (Ed.), *Organization and representation in perception.* Hillsdale, New Jersey: Erlbaum.

Kant, I. (1965). *Critique of pure reason.* New York: St. Martin's. (Original work published 1787)

Kelley, D. (1986). *The evidence of the senses.* Baton Rouge: Louisiana State University Press.

Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind.* Chicago: University of Chicago Press.

Lewis, C.I. (1948). *An analysis of knowledge and valuation.* La Salle: Open Court.

Markova, I. (1982). *Paradigms, thought, and language.* Chichester, England: Wiley.

McClelland, J.L., and Rumelhart, D.E. (1986). *Parallel distributed processing* (Vol. 2). Cambridge, Massachusetts: MIT Press.
McGhie, A., and Chapman, J. (1961). Disorders of attention and perception in early schizophrenia. *British Journal of Medical Psychology, 34*, 103–117.
Michotte, A. (1963). *The perception of causality*. New York: Basic Books.
Mohanty, J.N. (1986). Perceptual meaning. *Topoi, 5*, 131–136.
Neisser, U. (1976). *Cognition and reality*. San Francisco: Freeman.
Pitson, A.E. (1984). Basic seeing. *Philosophy and Phenomenological Research, 45*, 121–129.
Regan, D., Beverly, K.I., and Cynader, A. (1979). The visual perception of motion in depth. *Scientific American, 241*, 136–152.
Rock, I. (1983). *The logic of perception*. Cambridge, Massachusetts: MIT Press.
Ruegsegger, R. (1983). Judging, believing and taking: Three candidates for the propositional attitude in perception. *Philosophy Research Archives, 9*, 535–559.
Rumelhart, D.E. (1980). Schemata: The building blocks of cognition. In R.J. Spiro, B.C. Bruce, and W.F. Brewer (Eds.), *Theoretical issues in reading comprehension*. Hillsdale, New Jersey: Erlbaum.
Rumelhart, D.E., and McClelland, J.L. (1986). *Parallel distributed processing* (Vol. 1). Cambridge, Massachusetts: MIT Press.
Rumelhart, D.E., and Ortony, A. (1977). The representation of knowledge in memory. In R.C. Anderson, R.J. Spiro, and W.E. Montague (Eds.), *Schooling and the acquisition of knowledge*. Hillsdale, New Jersey: Erlbaum.
Sayre, K. (1987). Cognitive science and the problem of semantic content. *Synthèse, 70*, 247–269.
Searle, J. (1980). Minds, brains, and programs. *Behavioral and Brain Sciences, 3*, 417–424.
Searle, J. (1983). *Intentionality*. Cambridge: Cambridge University Press.
Shepard, R.N. (1984). Ecological constraints on internal representation. *Psychological Review, 91*, 417–447.
Skarda, C.A., and Freeman, W.J. (1987). How brains make chaos in order to make sense of the world. *Behavioral and Brain Sciences, 10*, 161–195.
Strauss, M. (1984). *Empfindung, Intention und Zeichen: Typologie des Sinntragens*. Freiburg: Alber.
Tversky, A. (1977). Features of similarity. *Psychological Review, 84*, 327–352.
Tversky, A., and Kahneman, D. (1983). Extensional versus intuitive reasoning: The conjunction fallacy in probability judgment. *Psychological Review, 90*, 293–315.
Varela, F.J. (1979). *Principles of biological autonomy*. New York: North Holland.
Warren, W.H. (1984). Perceiving affordances: Visual guidances of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance, 10*, 683–703.
Weir, S. (1978). The perception of motion: Michotte revisited. *Perception, 7*, 247–260.
Williams, M. (1985). Wittgenstein's rejection of scientific psychology. *Journal for the Theory of Social Behaviour, 15*, 203–223.
Wood, G. (1983). *Cognitive psychology: A skills approach*. Monterey, California: Brooks.
Zajonc, R.B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist, 35*, 151–175.