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How to Build a Baby: II. Conceptual Primitives

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A mechanism of perceptual analysis by which infants derive meaning from perceptual activity is described. Infants use this mechanism to redescribe perceptual information into image-schematic format. Image-schemas create conceptual structure from the spatial structure of objects and their movements, resulting in notions such as animacy, inanimacy, agency, and containment. These earliest meanings are nonpropositional, analogical representations grounded in the perceptual world of the infant. In contrast with most perceptual processing, which is not analyzed in this fashion, redescription into image-schematic format simplifies perceptual information and makes it potentially accessible for purposes of concept formation and thought. In addition to enabling preverbal thought, image-schemas provide a foundation for language acquisition by creating an interface between the continuous processes of perception and the discrete nature of language.

> When you keep putting questions to Nature and Nature keeps saying "no," it is not unreasonable to suppose that somewhere among the things you believe there is something that isn't true. (Fodor, 1981, p. 316)

One of the least understood developments in infancy is how children become able to think, that is, to go beyond perceptual categorization to form concepts. As Quinn and Eimas (1986) expressed this mystery:

> The categories of infants . . . are sensory in nature, whereas the categories and concepts of adults are often far removed from the world of sensory data. . . . Nor can it be readily envisioned how the attributes of adult concepts can be constructed from the attributes innately available to infants. Nevertheless, a commonly, if often tacitly, held view is that the nontransducible attributes of adult concepts are somehow derived from the sensory primitives available to infants. Adequate (that is, testable) descriptions of the developmental process remain to be offered, however. (p. 356)

My ultimate goal is to develop such a theory and to show how the attributes of adult concepts can be derived from the primitives of infants. I believe this can only be done, however, by abandoning a crucial assumption in Quinn and Eimas's (1986) formulation: that infants only engage in sensory (or perceptual) categorization. In a previous article (J. M. Mandler, 1988), I reviewed some of the evidence for nonsensory conceptual activity in infancy and outlined a mechanism of perceptual analysis by which such conceptual processing might be achieved. The goal of the present article is to specify this mechanism in more detail and to explore the nature of the format in which the resulting notions are represented. I propose that perceptual analysis results in redescriptions of spatial structure in the form of image-schemas. These redescriptions constitute the meanings that infants use to create concepts of objects, such as animate and inanimate things, and relational concepts, such as containment and support. I further propose that image-schemas provide a level of representation intermediate between perception and language that facilitates the process of language acquisition.

Concepts such as animacy or containment are complex and unlike sensory attributes, yet they appear early in infancy. At the same time, it is not necessary that they be innately given in order to account for their early appearance. As will be seen, many of the ideas I propose in this article are not couched in the traditional framework of concept formation and are somewhat speculative in nature. However, as Fodor (1981) pointed out, theories of concept attainment have been limited to a small range of theoretical options. Perhaps it is time to try a new approach.

The view that only sensory attributes are innately given and are used in conjunction with experience to derive the nonsensory concepts of adults has been the dominant view of conceptual development since the time of the British empiricists. In more recent formulations of this view, the term *perceptual* is apt to be substituted for *sensory,* but the general approach is the same. For example, during the second half of the first year of life, infants are said to begin to form so-called basic-level categories, such as faces, dogs, or cars, that enable them to recognize new instances (e.g., Cohen & Younger, 1983; Strauss, 1979). The ability to create such equivalence classes is thought to rest on responsivity to the correlated features that make up the objects (e.g., Rosch & Mervis, 1975). It is assumed that for infants these features are perceptual, however, leaving still unsolved the question of how nonperceptual understanding of objects develops.

These early categories are called perceptual because they need not have conceptual content (or in another terminology, these categories are not yet representational). Young infants, like lower organisms, industrial vision machines, and various connectionist programs, can form perceptual prototypes by

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learning to abstract the central tendencies of perceptual patterns. Forming discriminable categories, however, does not imply that the organism or machine has thereby formed any theory of what the objects being categorized *are* or can use this information for purposes of thought. Thus, the infant (or machine or program) that can differentiate between male and female faces (Fagan & Singer, 1979) or can discriminate trucks from horses (Oakes, Madole, & Cohen, 1991) could be doing so on a purely perceptual basis and is not thereby displaying conceptual knowledge about people or animals (J. M. Mandler, 1988; Nelson, 1985). To have a concept of animal or vehicle means to have at least some rudimentary notion of what kind of thing an animal or vehicle is.[1] There is ample evidence that even 3-year-old children have such concepts (e.g., Wellman & Gelman, 1988). How does the infant advance to this new kind of understanding?

Piaget's Theory of Concept Formation

The most widely accepted answer to the question of how concepts are first acquired is based on Piaget's (1952) theory of sensorimotor development. In his theory, much of the first year and a half of life is taken up with developing perceptual (sensorimotor) categories of objects, such as those described earlier. Piaget recognized that these categories need not be conceptual in nature; indeed, he posited that they are not conceptual, consisting instead of sets of perceptual-motor schemas that enable infants to recognize a variety of objects (and events) and to act appropriately in their presence. He saw no evidence that infants, during this period, have any conceptual representations that would enable thought *about* objects. In Piaget's analysis, concepts develop when sensorimotor schemas become "interiorized," "speeded up," and freed from ongoing perception and action. This transformation, which depends heavily on learning about objects through physical interactions with them, is said to occur at the transition from the sensorimotor to the preoperational period at about 1.5 years of age.

Piaget's (1952) theory of a sensorimotor stage in infancy has been widely accepted and seems to have escaped much of the critical response that has been directed toward other aspects of his theory. Nevertheless, his view of infant cognition faces a number of theoretical and empirical difficulties (e.g., J. M. Mandler, 1988; Sugarman, 1987). On the theoretical side, it does not provide a satisfactory description of *how* sensorimotor schemas are transformed into concepts. Piaget's theory states only that over the course of the sensorimotor period, action-schemas gradually become speeded up and freed from their sensorimotor limitations. The main avenue for this development is said to be imitation. Infants gradually become able to imitate more and more complex activities that eventually become interiorized in the form of images. How images are actually created by this process is not discussed, but in Piaget's view images constitute the first nonsensorimotor, conceptual form of representation. Imagery allows infants to re-present objects and events to themselves, and so it provides the foundation for the beginning of thought. However, the claim of a purely sensorimotor form of representation for the first year and a half of life depends on the assumption that there is no imagery during this period. If imagery could occur in younger infants, there would be nothing in principle to prevent them from engaging in conceptual thought. In fact, there *is* no evidence that imagery is such a late-developing process. In addition, the theory leaves unsettled how images come to have more than perceptual content. How does forming an image of an object conceptualize it? Thus, this view of concept formation begs the very question that was posed.

There are also empirical difficulties with Piaget's (1952) theory. Current evidence suggests that infants do not require such an extended period of experience to learn the most basic characteristics of objects. At least from 3 months of age they live in a stable perceptual world, consisting of objects that are seen as coherent, bounded things, separate from the background and behaving in predictable ways (Spelke, 1985). By 4 to 5 months they understand that objects are both solid and permanent (Baillargeon, in press), and they have begun to differentiate causal from noncausal object motion (Leslie, 1982). Some of this understanding may be sensorimotor in character and not require conceptual activity of the type defined earlier. Therefore, Piaget's theory could probably be adapted to fit this evidence, although it does create a puzzle as to why conceptual activity should be delayed so long.

More serious, however, is recent evidence that conceptual representation is *not* long delayed, that concepts are developing concurrently with the development of sensorimotor schemas. For example, one of the criteria that Piaget (1952) used to demonstrate conceptual activity was recall of absent objects or events. Recall requires the infant to re-present information not given by current sensorimotor activity. Piaget thought such recall did not occur until about the middle of the second year. However, recall has been demonstrated in the laboratory as early as 8 months of age (Baillargeon, De Vos, & Graber, 1989). Recall of past events over 24-hr delays has been shown at 9 months (Meltzoff, 1988), and two studies have provided evidence that events taking place before 10 to 11 months of age can be recalled up to 1.5 years later (McDonough & Mandler, 1990; Myers, Clifton, & Clarkson, 1987). Such findings indicate that a long-lasting declarative memory system is in place by about 8 months of age; its onset may be even earlier but the relevant research has not yet been conducted.

In addition, work on the acquisition of sign language has provided evidence for the beginning of symbolic functioning as early as 6 to 7 months of age (e.g., Bonvillian, Orlansky, & Novack, 1983; Meier & Newport, 1990; see J. M. Mandler, 1988, for a discussion of the symbolic character of these early signs). There has been some controversy over the linguistic status of these early signs (e.g., Bates, O'Connell, & Shore, 1987; Petitto, 1987), but the relevant point here is that children of this age are capable of using a gesture (probably associatively learned) to refer to or express a meaning. Along with recall, this hallmark of conceptual thought appears before infants have become skilled in manipulating objects or have begun to locomote through the environment. Thus, several lines of evidence indicate the presence of conceptual thought during the time when

[1] This view of concepts as ideas about kinds emphasizes their theoretical nature (Carey, 1985; Keil, 1989; Medin & Wattenmaker, 1987), as opposed to a view of concepts as distributions of features or properties.

Piaget posited it to be absent. Evidently, a great deal of conceptualization about objects and events in the world comes from observation rather than from physical interaction with objects.[2] Nevertheless, it must be determined how observation of objects forms the basis from which more abstract conceptual knowledge about those objects is derived.

Concept Formation by Perceptual Analysis

I have proposed that *perceptual analysis* is the mechanism by which concepts are first formed (J. M. Mandler, 1988). Perceptual analysis is a process in which a given perceptual array is attentively analyzed, and a new kind of information is abstracted. The information is new in the sense that a piece of perceptual information is recoded into a nonperceptual form that represents a meaning. Sometimes perceptual analysis involves comparing one object with another, leading to conceptualizing them as the same (or different) kind of thing, but often it merely involves noticing some aspect of a stimulus that has not been noticed before. The process is different from the usual perceptual processing, which occurs automatically and is typically not under the attentive control of the perceiver. Most of the perceptual information normally encoded is neither consciously noticed nor accessible at a later time for purposes of thought. Perceptual analysis, on the other hand, involves the active recoding of a subset of incoming perceptual information into meanings that form the basis of accessible concepts.

Perceptual analysis is a simple version of what Karmiloff-Smith (1986, 1991) calls redescription of procedural information. She has concentrated on how elaborate systems of procedural information, such as the pronominal system in language, become redescribed, eventually achieving a form that is accessible to consciousness. Perceptual analysis is a simpler kind of redescription, one that is often concurrent with perception itself; that is, redescription does not have to take place off-line on long established representations, as suggested by the data with which Karmiloff-Smith has worked, but can also take place on-line with the registration of perceptual information. In both cases, however, information is being recoded into a different format, and in the process some of the original information is lost. What people consciously attend to and store in a form that they can potentially think about involves a reduction and redescription of the huge amount of information provided by their sensory receptors. A great deal of the perceptual information that people process is stored in procedural (implicit) form, as illustrated by the fact that they readily learn complex perceptual categories such as faces, but cannot state what the information is that they use; that is, the information is not explicit (J. M. Mandler, 1988). Forming an explicit knowledge system requires a different format—what one might call a vocabulary of meanings. The process of redescribing perceptual information forms such a vocabulary. This vocabulary is both simpler than the original information and, at least to some extent, is optional as to whether or when it is formed. It is simpler because it contains less information than is processed by the perceptual system and is more coarsely grained. For example, representing a zebra as striped (either by language or by a sketch) is a coarse summary description of a specific complex grating. It is optional in the sense that it need not occur when perceptual processing goes on. It is the optionality of what one attends to that accounts for much of the variability in conceptual development, as opposed to the nonoptional, automatic processing of perceptual information that takes place most of the time.

Although perceptual analysis is not necessary for much of one's traffic with the environment, adults seem to do a good deal of it, or more precisely, engage in a process that is similar. For example, someone may consciously notice that an acquaintance has started wearing glasses, a fact that may have been missed for several weeks in spite of looking at this person every day. A few years ago, during a boring seminar, I discovered that most people's ears are at the same level as their eyes, which is something I must have processed perceptually since infancy but that I had not analyzed and made part of my concept of a face in the past. The results of such analysis can be expressed in verbal or in imaginal form and are then available for purposes of recall, planning, making choices, and so on. It is important to note, however, that these examples from adult experience take place in a processing system that already has a large conceptual vocabulary that can be used to add new facts to its accessible knowledge store. In that sense, they are somewhat misleading vis-à-vis the more basic process of perceptual analysis that infants must carry out. Infants have to create the meanings from which the conceptual base is formed in the first place. These meanings are unlikely themselves to be consciously accessible, but must be redescribed once again into imagery or words. This issue is discussed further in the section on image-schemas.

In principle, perceptual analysis could begin quite early in life even though it might initially be rather primitive in form. That is, I assume that the capacity to engage in perceptual analysis is innate. However, it also seems likely that such analysis requires the development of at least some stable perceptual (sensorimotor) schemas. As mentioned earlier, research (e.g., Baillargeon, in press; Kellman, Gleitman, & Spelke, 1987; Spelke, 1985) suggests that stable schemas of three-dimensional objects, seen as coherent, solid, and separate from the background, are formed by 3 to 4 months of age. It is about the same time that the first indications of perceptual analysis appear (J. M. Mandler, 1988). The measures are necessarily indirect, but are implicated in many accounts of behavior after the first few months of life. For example, Werner and Kaplan (1963) described the development of a contemplative attitude between 3 and 5 months; Fox, Kagan, and Weiskopf (1979) and Janowsky (1985) reported an increase in vicarious trial and error (VTE) behavior, or active comparison of stimuli, between 4 and 8 months; Ruff (1986) described the "examining schema" as already well developed by 7 months, the earliest age she studied. Perceptual analysis can also be inferred from Piaget's (1951) account of early imitation in which he described his

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[2] It is sometimes claimed that Piaget means *action* in a more abstract sense, for example, as eye-movements or even as anything that transforms reality (Sinclair, 1971, p. 134). Even if the latter abstract definition can be meaningfully included under the rubric of action, Piaget is quite clear that the roots of conceptualization lie in infants' physical interaction with objects (Piaget, 1951, 1952). In any case, this more typical usage of the term *action* has been the predominant understanding of Piaget's theory among developmental psychologists.

children as young as 3 to 4 months as displaying intense concentration on the models he provided.[3]

A Vocabulary for Preverbal Concepts

In an earlier article (J. M. Mandler, 1988) I emphasized the process of perceptual analysis, but had little to say about the format of the resulting representations. If perceptual analysis results in concept formation, there must be some vocabulary, or set of elementary meanings, from which the concepts are composed. Whatever meanings infants derive from perceptual analysis, they seem likely to be rather global in character. Even for adults, conscious conceptualizations about objects and events tend to be crude and contain vastly less information than the perceptual knowledge used for recognition. Infants' concepts are apt to be cruder still and may not even be couched in propositional form as many adult concepts appear to be.

The problem of specifying a conceptual vocabulary is not one that can be avoided, regardless of the nature of one's theory of conceptual development. However, with the exception of Leslie (1988), who discussed the primitives involved in the first causal concepts, about the only researchers working on the problem are those in the area of language acquisition who talk about preverbal conceptualizations or semantic primitives. It has long been assumed that the notions of objecthood, agency, actionality, and location expressed in the earliest speech are drawn from nonlinguistic representations (e.g., Bloom, 1970; Bowerman, 1973; Brown, 1973; see also Sinclair, 1971). However, the precise nature of these preverbal representations has not yet been addressed. One of the rare discussions of what these representations might be like is found in Slobin (1985), who suggested that young language learners not only have concepts of objects and actions but also make use of sets of more abstract relational notions. He discussed these notions in terms of prototypical scenes that highlight various components and the paths that they take.[4]

If language acquisition depends in part on preverbal concepts, they must already be present by 10 months when children begin to acquire their first spoken words and use them for communication. The work on sign language in 6- to 7-month-old deaf infants suggests that the relevant conceptualizing process begins even earlier. What is needed is to find ways of characterizing the representation of these preverbal concepts. It is not sufficient to say, as has traditionally been done within the Piagetian framework, that a concept is formed by transforming a sensorimotor schema; the format in which the concept is represented must be specified as well. The initial conceptual representation seems likely to be perceptually based but not in the format that is used by the procedural workings of the perceptual systems.

For example, consider possible sources for a primitive concept of animate thing or animal. There is an excellent source in perception to deliver some of the information needed for this basic notion, namely, the perceptual categorization of motion. Adults easily differentiate animate from inanimate (or mechanical) motion (Stewart, 1984). The data have not yet been collected to determine whether infants do so as well, but it is known that infants differentiate caused from noncaused motion (Leslie, 1982, 1988). In addition, infants are highly responsive to motion; not only do they look longer at moving stimuli than at motionless stimuli, but various perceptual achievements are first attained when moving stimuli are used (e.g., object parsing: Spelke, 1985; face recognition: M. H. Johnson & Morton, 1991). Of particular relevance, infants perceptually differentiate the motion of people from similar but biologically incorrect motion as early as 3 months of age (Bertenthal, in press). This work suggested that it is likely that infants can make the more general categorization of animate versus inanimate (mechanical) motion. I make the assumption that they can and that the perceptual categorization of motion is one source for dividing the world into classes of things that move in different ways. More is needed, however. To form a *concept* of animal, as opposed to a perceptual category of a particular type of motion, the infant needs to notice and conceptualize something like the following: Those things that move in one way start up on their own (see Gelman, 1990; Premack, 1990) and sometimes respond to the infant from a distance, whereas those things that move in another way do not start up on their own and never respond to the infant from a distance. (There may be other important bases. I have tried to use a minimum set that would be sufficient to understand something about what kind of thing an animal is above and beyond what it looks like.)

Such simple meanings are sufficient to constitute an early concept of animal, a concept that is present in some form before the end of the first year of life. Several experiments have shown that infants respond to animals in a way that cannot be accounted for on the basis of perceptual categorization alone. For example, Golinkoff and Halperin (1983) found that an 8-month-old produced a unique emotional response to both real and toy animals that varied widely in shape, features, and texture. In my laboratory we have found that 9-month-olds dishabituate to a vehicle after seeing various models of animals (and vice versa) even when the individual animals vary greatly in their perceptual appearance (McDonough & Mandler, 1991). (Ongoing work indicates this is true of 7-month-olds as well). Furthermore, 9-month-olds also dishabituate to models of birds after seeing airplanes (and vice versa), even though, in this case, the shapes of the airplanes and birds are similar (McDonough & Mandler, 1991). It is usually assumed that similar shapes and features form the basis of early perceptual categorization (e.g., Cohen & Younger, 1983). If true, then perceptual categorization is insufficient to account for these kinds of responses; some conceptual basis is required. (This issue is discussed further in the last section of this article.)

To further this account, it is necessary not only to specify the meanings involved in an early concept of animal (such as "moves on its own" and "responds to other objects") but also to specify the format in which they are represented. Whatever their exact nature, these meanings are unlikely to consist of sensory descriptions, as the British empiricists would have had it. "Brown" and "square" are not the sorts of attributes that lead to understanding what an animal is. Nor are the features talked

[3] These measures are discussed in more detail in J. M. Mandler (1988).

[4] Slobin based some of his notions on the work of Talmy (e.g., 1983), who was also one of the root sources for some of the ideas in this article.

about in the classical theory of concepts (see E. E. Smith & Medin, 1981), such as "has wings" or "four legs," likely to lead to conceptual understanding either, for the same reason that feature theories have failed as an approach to understanding semantic development (Armstrong, Gleitman, & Gleitman, 1983; Medin & Ortony, 1989; Palermo, 1986). It seems likely that early conceptual understanding will be of a global (i.e., shallowly analyzed) character, with analysis of features ("brown," "has wings," etc.) a later intellectual achievement (J. M. Mandler, Bauer, & McDonough, 1991; Nelson, 1974; L. B. Smith, 1989a). Thus, an approach is needed that does not require detailed featural analysis but at the same time allows the formation of some global conceptions about what is being perceived.

Image-Schemas as Conceptual Primitives

The approach to preverbal conceptual representation that I take here is derived from the work by cognitive linguists on image-schemas (M. Johnson, 1987; Lakoff, 1987; Langacker, 1987; Talmy, 1983, 1985). Although not developmental psychologists, these researchers have been led by their linguistic concerns to seek the underlying basis of the concepts expressed in language. It is claimed that one of the foundations of the conceptualizing capacity is the image-schema, in which spatial structure is mapped into conceptual structure. Image-schemas are notions such as PATH, UP–DOWN, CONTAINMENT, FORCE, PART–WHOLE, and LINK, notions that are thought to be derived from perceptual structure. For example, the image-schema PATH is the simplest conceptualization of any object following any trajectory through space, without regard to the characteristics of the object or the details of the trajectory itself. According to Lakoff and to Johnson, image-schemas lie at the core of people's understanding, even as adults, of a wide variety of objects and events and of the metaphorical extensions of these concepts to more abstract realms. They form, in effect, a set of primitive meanings. (Primitive in this sense means foundational; it does not mean that image-schemas are atomic, unitary, or without structure.)

A good deal has been written about image-schemas, although, with the exception of formal linguistic treatments (e.g., Langacker, 1987), most discussions have been relatively informal and have been directed primarily to showing how image-schemas function within semantic theory. My focus here is somewhat different because I am interested in the origins of such meanings and the larger role they play in psychological functioning. Therefore, after providing a definition of image-schemas, I will discuss various aspects that have not been stressed by cognitive linguists, including the role that image-schemas play in preverbal concept formation.

Even though image-schemas are derived from perceptual and (perhaps to a lesser extent) motor processes, they are not themselves sensorimotor processes. I characterize them as condensed redescriptions of such processes. Perceptual analysis involves a redescription of spatial structure and of the structure of motion that is abstracted primarily from vision, touch, and one's own movements. In this view, perceptual analysis involves recoding perceptual inputs into schematic conceptualizations of space. Hence, image-schemas can be defined as dynamic analog representations of spatial relations and movements in space. They are analog in that they are spatially structured representations. They are dynamic in that they can represent continuous change in location, such as an object moving along a path. Their continuous, as opposed to discrete, nature means that they are not propositional in character, although due to the simplicity of the information they represent, it should be a relatively simple task to redescribe them into propositional form. They are abstracted from the same type of information used to perceive, but they eliminate most details of the spatial array that are processed during ordinary perception. At the same time they are redescriptions because they use a different vocabulary (described in the next section). These new representations are the primitive meaning elements used to form accessible concepts.[5]

To illustrate, the perception of movement trajectories through space is recoded into the image-schema PATH. The infant sees many objects moving in many different ways, but each can be redescribed in less detailed form as following a path through space. In many cases, the infant sees the object beginning to move and also coming to rest, and these aspects of the event can be represented in image-schematic form as well. Because image-schemas are analog in nature, they have parts. One can focus on the path itself, its beginning, or its ending. In this sense, image-schemas embed. BEGINNING-OF-PATH can be embedded in PATH; each can be considered an image-schema in its own right. Similarly, perception of contingent motion is recoded into the notion of coupled paths or LINK (discussed later). I propose that image-schemas such as PATH (with the focus on BEGINNING-OF-PATH) and LINK constitute the meanings involved when a concept such as animacy is formed. Thus, a first concept of animals might be that they are objects that follow certain kinds of paths, that begin motion in a particular kind of way, and whose movement is often coupled in a specific fashion to the movement of other objects. Notice that several image-schemas have been combined to form the concept of animal. That is, the concept of animal is complex, involving more than one meaning.

This article describes a format to represent the meanings that make up several such concepts. To carry out thought with these concepts requires relating one to another. Whether thinking in this sense requires a propositional form of representation or can be carried out by constructing a mental model of an image-schematic nature (e.g., along the lines of Fauconnier's, 1985, mental spaces) is an open question and one that is beyond the

[5] It will be noted that I am emphasizing spatial rather than temporal analysis. I am assuming that temporal concepts are at least partly derived from spatial ones. Many linguists have noted that in all languages studied, most if not all temporal terms have a spatial sense as their primary meaning (e.g., Clark, 1973; Fillmore, 1982; Traugott, 1978). Even though movement trajectories have both spatial and temporal extent, it seems easier to analyze movement through space than movement through time; for example, a nonverbal analysis of a change in location can be expressed by pointing or moving the hand, an option not available for a change in time. Of course, even very young infants *use* temporal parameters in their processing but that does not mean they conceptualize them. I suggest that temporal concepts are in the first instance represented as analogical extensions of spatial schemas.

scope of this article. However, it is worth noting that both Lakoff (1987) and M. Johnson (1987) have argued that the structure of image-schemas gives rise to various entailments, suggesting that at least some inferences do not require a propositional form of representation. That is, the dynamic and relational nature of image-schemas provides a kind of syntax, although not couched in predicate-argument structures that specify truth conditions. If this view is correct it suggests that an infant equipped with image-schemas could begin to think about the world without a propositionally based language of thought.

An alternative architecture to a built-in propositional language, such as described by Fodor (1975), is one in which the infant has the ability to simplify perceptual input, including objects participating in events, thus creating analog sketches of what it perceives. The resulting image-schemas provide the earliest meanings available to the infant for purposes of preverbal thought (leaving open the issue of how they are concatenated) and form the basis on which natural language rests.[6] This formulation does not imply that image-schemas are themselves accessible to consciousness; no language of thought is directly accessible. Image-schemas represent the meanings from which accessible concepts are formed. (See G. Mandler, 1985, for a discussion of the processes involved in conscious constructions.) Hence, this architecture agrees with Karmiloff-Smith's (1986) proposal that more than one level of redescription is required before conscious access can be achieved. In the present case, the levels consist of inaccessible perceptual processing, redescription into image-schematic meanings, followed by further redescription into conscious imagery or language.

An appealing aspect of an image-schema architecture is that it provides a natural grounding for symbolic representation. One problem that rarely appears in discussions of the language of thought is how contentless symbols are chosen to represent its meanings (see Harnad, 1990). Unless a symbol has been innately assigned to a meaning, such as animacy, it is difficult to understand how it becomes assigned. An image-schema avoids this problem because its meaning resides in its own structure; it does not require other symbols or another system to interpret it. Furthermore, this architecture avoids positing an enormous list of innate meanings. Forming an image-schema requires only an innate mechanism of analysis, not innately known content. New content can be added to the system whenever perceptual analysis takes place on aspects of the input not previously analyzed.

The issue of why particular image-schemas are derived from perceptual structure rather than others has rarely been discussed by cognitive linguists, and it certainly has not been resolved. Why, from observing an object in motion, should its path be abstracted rather than some other aspect of the input? One possibility is that our perceptual input systems are prewired or weighted to form schematic summaries of certain types of perceptual information rather than others. On this account one could say that the infant has an innate predisposition to form image-schemas of a certain type. However, it is equally plausible that certain types of redescription are simply the outcome of the way an infant's immature input systems process the spatial structure that exists in the world. On this account, one would not need to bias or preset the system that processes spatial information. As a hypothetical example, a newborn might not perceive much more in a rapid perceptual encounter than a blurry object moving along a path. If so, a mapping of Euclidean structure into topological structure might be a predictable type of schematization for a processor that is not yet skilled at analyzing the fine details of shape or angular distance. This result would happen even though it was not preset to abstract topological, rather than Euclidean, information. Although the resolution of this issue will ultimately be of great importance, it seems premature to try to do more than speculate about it at this time. First, it needs to be determined whether a theory of early concept formation in terms of image-schemas is feasible and productive.

M. Johnson (1987) and Lakoff (1987) stressed that image-schemas are not the same as "real" images (what they called "rich" images). Image-schemas are more abstract than images; they consist of dynamic spatial patterns that underlie the spatial relations and movements found in actual concrete images. It should be noted, however, that real images are typically not as rich as Johnson and Lakoff implied. Furthermore, they are not mental pictures if a mental picture means a copy of what has been perceived. Visual imagery is constructed from what a person knows; images are not uninterpreted copies of reality but rather are constructed from the underlying concepts the person has already formed (Chambers & Reisberg, 1992; Intons-Peterson & Roskos-Ewoldsen, 1989; Intraub & Richardson, 1989; Piaget & Inhelder, 1971). If concepts were represented largely in propositional form, then one would need a complex theory such as that proposed by Kosslyn (1980) to show how analog images could be constructed from discrete information. However, if concepts, perhaps especially preverbal concepts, are couched in image-schematic form, then the process of forming images should be considerably simplified. The image-schema itself structures an image space in which specific objects and more detailed paths and spatial relationships can be filled in. It is these concrete, or rich, images that appear in awareness, not the image-schemas themselves. That is, when one consciously thinks about what an animal is, the meanings from which this concept is composed come to mind as specific images, words, or both. Image-schemas, therefore, are a crucial part of our mental architecture. They are not only used to create meanings but also to help form the specific images that instantiate them and to understand the words that refer to them. In summary, then, perceptual analysis operates on perceptual information, leading to image-schemas, which in turn form the foundation of the conceptual system, a system that is accessible first via imagery and later via language as well.

In the following sections, I will characterize several image-schemas used to create concepts that appear to be early developmental achievements: animacy, inanimacy, causality, agency, containment, and support. To the extent that the relevant image-schemas involve simplifying and redescribing percep-

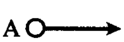
[6] This theory of the basis of thought is more or less the opposite of that proposed by Piaget (1951). Piaget claimed that imitation of the actions of others produces imagery, which then enables thought. My position is that image-schemas provide the meanings that enable infants to imitate actions in the first place.

tual input, they seem compatible with what is known about infant capabilities. As discussed earlier, perceptual schemas are formed during the first few months of life and are therefore available to be operated upon. There is no a priori reason why redescribing these perceptual schemas into image-schematic form should require another year of sensorimotor learning. However, the time of onset of these concepts is not crucial for the arguments I make. The issue is not the exact age at which conceptualizations of the world begin to be constructed but whether, in principle, an image-schema formulation can account for the preverbal conceptualization that occurs.

The Concept of Animacy

It seems that people judge motion to be animate on the basis of perceptual characteristics of which they are not aware. Some of the bases that adults use, primarily involving violations of Newton's laws of motion, have been described by Stewart (1984). Judging motion to be animate is similar to judging that a face is male or female—people easily make this categorization but have little idea about the kinds of information they use (J. M. Mandler, 1988). So, if someone is asked how they know that a briefly viewed moving object is an animal, they might say, "It moved like an animal," or "It started up on its own." What is meant by such statements?

There are two broad types of onset of motion, self-instigated motion (called *self-motion* here) and caused motion (see Premack, 1990). From an early age infants are sensitive to the difference between something starting to move on its own and something being pushed or otherwise made to move (Leslie, 1988; see the discussion later on causality). In its simplest form, self-motion means that an object is not moving, and then, without any forces acting on it, it starts to move. If one were asked to express this notion without using words, the best one might be able to do is to put one's hand at rest and then move it. Thus, an image-schema SELF-MOTION might be graphically expressed as in Graphic 1: a vector extending from a point A where A represents an entity at the beginning of its path. (This and the following diagrams are obviously not meant to be literal interpretations of image-schemas; they are merely attempts to illustrate nonverbal notions.)

SELF-MOTION A  (1)

This is basically the notion of a trajector (M. Johnson, 1987; Langacker, 1987; Lindner, 1981). Self-motion is the start of an independent trajectory; that is, no other object or trajectory is involved. By itself an object starting to move without another visible trajector acting on it is not a guarantee of animacy. A windup toy with a delay mechanism might appear to start itself, or an unfelt tremor might cause a precariously balanced object to fall from a surface. Although any such occurrence could cause a mistaken judgment of animacy, perhaps especially by an infant, the concept of animacy involves more than one meaning, not self-motion alone. As just discussed, moving objects can be perceptually categorized into two kinds, and the motion of a mechanical toy or a falling object does not fit into the appropriate class on grounds other than the onset of its motion, namely, the type of trajectory it follows. I address this issue further in the following paragraphs.

My claim is that Graphic 1 is the most primitive characterization of what "moves by itself" means. It is a schematic representation abstracted from a class of varied and complex movements. The schematization could be achieved merely by analyzing observed movement in the environment. It might also be abstracted from felt movement of the self and therefore have a kinesthetic base. Nevertheless, the same representation should result: a kind of spatial representation of movement in space. This representation can be redescribed once again into language, of course, but the basic meaning is not propositional in form.

I assume that in addition to self-motion, infants represent something about the form of the trajectories that self-moving things follow. I also assume that whatever analysis infants carry out is rather simple. Perceptual discrimination of biological motion (Bertenthal, in press), like perceptual categorization of faces as male or female, is something one's perceptual recognition system easily does, but this information is represented at best crudely and often inaccurately. Biological motion is extremely complex; even theoretical psychologists are not yet certain which parameters are crucial to judgments of animacy (Stewart, 1984; Wilson, 1986). Similarly for faces: Our perceptual mechanisms use complex information about the texture and proportions of the face to distinguish male from female (Bruce et al., 1991), but that information is not part of our *concept* of what a male or female looks like. We do not seem to have a sufficiently large image-schema vocabulary to accomplish detailed analyses of such complex phenomena and must rely instead on simpler conceptualizations to think about them.

I assume that perceptual analysis of biological motion results in little more than the notion that it does not follow a straight line. Adults think of biological motion as having certain rhythmic but unpredictable characteristics, whereas mechanical motion is thought of as undeviating unless it is deflected in some way. Therefore, an image-schema of ANIMATE MOTION may be represented simply by an irregular path, as illustrated in Graphic 2.

ANIMATE-MOTION  (2)

Although crude, this image-schema of an animate trajectory is sufficient for its purpose. In order to understand what animals *are,* it is not necessary to analyze in detail the movements that set up the perceptual category in the first place. Nevertheless, because of the concentrated attention that infants give to moving objects, I assume that some analysis of animate trajectories takes place along with the analysis of the beginning of their paths. An example would be noticing that dogs bob up and down as well as follow irregular paths when they move. In this regard, we have observed an illuminating bit of behavior by some of the 1- to 2-year-old children who have taken part in our studies of early concepts (e.g., J. M. Mandler, Bauer, & McDonough, 1991). In a typical experiment, the children play with little models of a variety of animals and vehicles, and we record the sequences in which the children interact with them. Occasionally a child will respond to the animals by making them hop along the table and to respond to the vehicles by making them scoot along in a straight line. Making a fish or a turtle hop is a graphic example of a representation of animate movement that is faithful to the analysis in Graphic 2, no matter how inaccurate it is in detail.

The image schemas for SELF-MOTION and ANIMATE MOTION can be combined; that is, an image-schema embedding Graphic 1 and Graphic 2 represents an object starting up on its own and then moving on an animate path. In Graphic 1 the focus is on the onset of the motion (the straight line in the diagram is merely a default representation for a path), whereas in Graphic 2 the focus is on the path itself. Combining the two gives an image-schema that might be called SELF-MOVING ANIMATE, as illustrated in Graphic 3.

SELF-MOVING ANIMATE  (3)

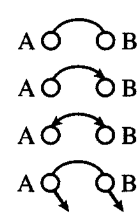
Graphic 3 illustrates the nonunitary and relational character of most image-schemas. It has two parts (BEGINNING-OF-PATH and PATH) and a simple kind of syntax in the sense that one can move from one part to the other.

In addition to self-motion and animate motion, a third notion that I propose that contributes to the concept of animacy is contingency of motion between objects, especially contingency that acts at a distance rather than through direct physical contact. The motor limitations of young infants severely restrict their manipulation of objects (although they have ample opportunity to watch others do so). However, they are surrounded by people who interact contingently among themselves and who respond from a distance to the infant's actions and vocalizations in a way that inanimate objects do not. The seminal experimental work on this topic was that of Watson (1972). He showed that at 2 months of age infants learned to make a mobile hanging above their crib turn when the movement was contingent on their pressing their heads on a pillow. When the mobile did not turn or turned noncontingently vis-à-vis the pillow action, head presses did not increase. The most interesting response of the contingent group was that by the 3rd to 4th day of exposure to the contingent mobile, the infants began to smile and coo at it. Watson hypothesized that the mobile began functioning as a social stimulus and that the initial basis of a social stimulus is limited to some set of contingency experiences. It is not clear how one would differentiate between a concept of a social stimulus and an animate stimulus in infancy; perhaps a social stimulus is one that reacts contingently to one's own movements, as opposed to reacting contingently to the movement of other objects. In either case, one should expect to see infants reacting to contingent toys or mobiles as if they were animate.

The hypothesis is supported in research by Frye, Rawling, Moore, and Myers (1983). These investigators used signal detection analyses of videotapes of infants responding either to their mothers or to a toy; in addition, the mothers and toy interacted with the infants in either a contingent or noncontingent fashion. Observers had to discriminate among the tapes, on which only the infants could be seen. Three-month-olds were judged to behave similarly when either their mothers or a toy reacted contingently to them (i.e., the observers could not tell these tapes apart) and to behave differently in those situations in which there was no contingent interaction. Ten-month-old infants, on the other hand, were judged also to differentiate contingent mothers from contingent toys, suggesting that by this age infants have developed a more detailed conception of persons or animate things.

Poulin-Dubois and Shultz (1988) suggested that infants only learn about the notion of independent agency in the last quarter of the first year; they found that 8-month-olds habituated more to the sight of a chair acting as an independent agent than to a person acting as an independent agent. Although it is not clear exactly how to interpret this result, it seems reasonable to suppose that if contingent motion and self-motion define animacy for infants in the first months of life, then the "mistakes" that young infants make may not be because they do not have a concept of animacy but because it is too broad. Infants who smile and coo at a mobile that is contingent on their behavior or infants whose interactions with an animated toy cannot be distinguished from interactions with their mother, may be revealing that they think those things are animate, and so they react accordingly.

How might the notion of contingency be conceptualized by a young infant? This is a difficult question because the extent to which infants interpret contingency as involving a causal relation is not known. It seems plausible that in the first instance they do not and that the initial representation of contingency is a simpler notion. A simple derivation of a notion of contingency is possible from a redescription of spatial structure in terms of the LINK image-schema. Lakoff (1987) discussed this schema only briefly, noting that its structure consists of two entities and a link connecting them. To my knowledge, there has not been much analysis of this kind of image-schema, but there appears to be a family of LINK schemas with related meanings, much as Brugman (1988) and Lakoff (1987) used a family of schemas to represent the various meanings of the term "over." The simplest version of the LINK image-schema is illustrated in Graphic 4. Other versions of LINK schemas are listed below it.



LINK (4)
ONE-WAY LINK (4a)
TWO-WAY LINK (4b)
LINKED PATHS (4c)

In Graphic 4 the link (which is not the same as a path) means that two entities or events, A and B, are constrained by, or dependent on, one another even though they are not in direct contact. Links can occur across both spatial and temporal gaps and can be one-way or mutual. For example, to express the contingency in the Watson (1972) experiment described earlier in which the infant A acts and the mobile B turns, one might use a LINK schema in which the contingency is one-way, as in Graphic 4a. (The arrow is meant to represent the direction of the contingency.) This kind of contingency seems likely to require a number of repetitions before an expectation is set up, as occurred in the Watson experiment. Presumably, therefore, analysis of the contingency would not happen on the first occasion. Repetition may also be required for Graphic 4b, which represents the back-and-forth interaction between an infant and its mother described in the Frye et al. (1983) experiment. In addition, there are linked paths, in which two objects move in tandem as linked trajectories, shown in Graphic 4c; if A moves, then B moves too. It may be possible to analyze this kind of contingency on the first exposure to it. Notice that in all these cases motion is involved, not in the link but by the entities themselves; that is, the entities are parts of events.

Responsivity to contingency is one of the most basic predispositions of infants (or, for that matter, of organisms in general). For example, conditioning would not be possible without it. Whether active analysis, or awareness, of contingency is required for conditioning to occur is a disputed issue and would take us too far afield to discuss here, but responsivity to contingency, even in neonates, is not in doubt (Rovee-Collier, 1987). One of the first kinds of contingency to be learned is that involved in S–S conditioning, that is, a contingency occurring between two entities (or events) in the environment, rather than a contingency occurring between an entity (or event) and the neonate's own responses (see Sameroff & Cavanaugh, 1979). Therefore, it should be possible to analyze contingent motion on the basis of the structure of environmental events alone. The evidence to date is mostly about contingencies between self and the environment; for example, Greco, Hayne, and Rovee-Collier (1990) suggested that 3-month-olds use motion that is contingent on their responses to categorize dissimilar appearing objects. However, analysis of objects' movements vis-à-vis one's own responses, though useful, may not be required for analysis of contingent motion to take place. Whether very young infants actually engage in perceptual analysis of such environmental contingencies is another issue. My point here is only that it is possible to associate contingent motion with a particular category of moving objects without having to observe their responsivity to self. Such a situation would allow infants to conceptualize birds or animals in a zoo as animate things without having to interact with them in a personal way.

The contingency of animate movement not only involves such factors as one animate following another, as described by LINKED PATHS, but also involves avoiding barriers and making sudden shifts in acceleration. Stewart (1984) showed that adults are sensitive to all of these aspects of animate movement, but even though they appear to be perceptually salient, it is not yet known whether infants are responsive to them or not. Nor has anyone considered how factors such as barrier avoidance might be represented in image-schema form. M. Johnson (1987) described several FORCE schemas, such as blockage and diversion, that may be useful in describing barrier avoidance, but they need to be differentiated into animate and inanimate trajectories. One might represent animate and inanimate differences in response to blockage as a trajectory that shifts direction before contacting a barrier versus one that runs into a barrier and then either stops or bounces off from it.

I have outlined here some simple kinds of perceptual analysis that give conceptual meaning to a category of moving things. The claim is that infants generalize across the particulars of perception to a representation that encompasses some abstract characteristics the experiences have in common. Things that move in one way can be conceptualized as starting up on their own and interacting with other entities in a contingent way without having to make contact with them. Such things can be contrasted with another category of moving things that not only move differently, but do not start up on their own and do not interact contingently with other entities from a distance. These analyses can be characterized as redescriptions of varied and exceedingly complex perceptions into a few different kinds of trajectories. Some of the trajectories imply self-motion; others imply contingent response to objects taking part in events in the environment. Such redescription could in principle be carried out from a very young age by analysis of spatial structure into image-schematic form. It would provide the beginnings of a concept (or theory) of what an animate thing *is*, above and beyond what it looks like.

So far I have concentrated on the conceptualization of animate things, saying little about the contrasting class of inanimates. Even though animates are the class of things that seem to attract infants' interest and attention the most, infants do attend with interest to all moving things, many of which are inanimate. Therefore, I assume that conceptualization of inanimacy takes place concurrently with the formation of notions about animacy; that is, there is no reason to assume that inanimates are merely a default class. A likely starting point is the fact that inanimates involve caused motion rather than self-motion. How might caused motion be represented?

The Concepts of Causality and Inanimacy

The difference between self-motion and caused motion is that in the latter case the beginning-of-path involves another trajector. A hand picks up an object, whose trajectory then begins, or a ball rolls into another, starting the second one on its course. An image-schema of CAUSED MOTION could be graphically represented as in Graphic 5: a vector toward an object A, with another vector leaving the point. The two trajectories are not independent; the first one ends (or shifts direction) at the point and time at which A begins its motion. The illustration here, as in Graphic 1, is meant to emphasize the onset of motion. The trajectories are drawn as straight lines, again as a default case (although they are appropriate for many kinds of caused motion). In the case of the hand, the trajectories are more complex; this issue is discussed in the following paragraphs.

$$\text{CAUSED MOTION} \qquad \longrightarrow\overset{A}{\circ}\longrightarrow \qquad (5)$$

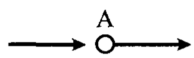
Just as for animate motion, perceptual analysis of the paths of objects caused to move, such as a launched ball or a car, results in a representation of inanimate (or mechanical) motion. The simplest way to express this notion is by a straight line as in Graphic 6.

$$\text{INANIMATE MOTION} \qquad \longrightarrow \qquad (6)$$

Again, combining the beginning-of-path with the path itself forms an image-schema that might be called CAUSED-TO-MOVE INANIMATE, as in Graphic 7. (The only difference between Graphics 7 and 5 is that the beginning-of-path and the path itself have been given equal emphasis in Graphic 7.)

$$\text{CAUSED-TO-MOVE INANIMATE} \qquad \longrightarrow\overset{A}{\circ}\longrightarrow \qquad (7)$$

Leslie (1982, 1988) has provided data on the perception of causality in infancy, with findings similar to those found by Michotte (1963) for adults. Leslie speculated that a concept of causality is derived from this kind of perception. He found that infants as young as 4 months distinguish between the causal movement involved in one ball launching another and very similar events in which there is a small spatial or temporal gap between the two movements. In launching, the end-of-path of the first trajectory is the beginning-of-path of trajector A, as illustrated in Graphic 7. In the noncausal case there is no connection between the end of one trajectory and the beginning of the next, as illustrated in Graphic 8.[7]



(8)

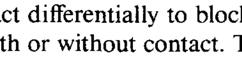
It is probably no accident that Leslie used films of balls being launched that look similar to the sketch shown in Graphic 7 and contrasted them with films that looked much like Graphic 8. Launching is a paradigm case of causal motion, and the image-schema underlying it may be used as the foundation of causal understanding of all sorts. It also represents the paradigm case of the motion of inanimate objects. Inanimate objects are objects that typically do not move at all, but when they do they are caused to move. The cause of motion can itself be either animate or inanimate. In Graphic 7, A represents an inanimate object; not only is it caused to move, but it follows an inanimate trajectory. In Graphic 8, A also moves in an inanimate fashion, but creates an anomalous impression because it starts up on its own.

If spatial analysis results in an early representation of causality, it would suggest that physical causality might be represented before psychological causality. This progression would be the opposite of that usually assumed in development. According to Piaget (1954), psychological causation, or the awareness of one's own intention or efforts to make something happen, is the basis on which the later understanding of physical causality rests. The spatialization of causal understanding is said to begin only after infants experience many occasions of drawing objects to themselves or pushing them away. However, both Leslie's (1982, 1984) data and an approach to concept formation in terms of redescription of spatial structure suggest that the ontogenetic ordering may be the other way around. The experience of intention or volition may not be required to form an initial conception of causality. Indeed, internal states are notoriously difficult to conceptualize, and children may require a good deal of experience before they begin to do so. We have no evidence for any analysis of internal states by 4-month-old infants. In contrast, some analysis of the spatial structure of moving objects has apparently begun by this age.[8]

The Concept of Agency

Leslie (1982) provided other data on causal perception that are relevant to the issue of how a concept of agency can be represented. He showed that both 4- and 7-month-olds were surprised when a hand appeared to move an object without touching it. That is, the image-schema of CAUSED MOTION was violated because the first trajector did not reach the point where the second trajector began its path. Thus, an object *started up on its own* but did not move in the way that animate objects usually do; rather, it moved in an inanimate fashion as in Graphic 6. Such a display creates an anomaly, similar to that illustrated in Graphic 8. Related data (Leslie, 1984) indicated that infants have also learned something about animates as agents at an earlier age than Poulin-Dubois and Shultz (1988) suggested. In this experiment, 7-month-olds dishabituated when a hand appeared to pick up an object without contacting it, but they did *not* react differentially to blocks of wood that "picked up" objects with or without contact. The infants may have found the sight of a block of wood picking up an object difficult to interpret whether it contacted the object or not and so did not differentiate between the two. (Even 3-month-olds have already learned some of the characteristic behavior of hands. Needham and Baillargeon, 1991, found that 3-month-olds were surprised when a hand pushed an object off a surface and the object did not fall; a similar display in which the object was grasped by a hand, did not surprise them.)

Leslie's (1984) data suggest that perceptual analysis of causal and noncausal motion is involved not only in the formation of concepts of animacy and inanimacy but also in the development of the concept of an agent. Animate objects not only move themselves but cause other things to move; it is the latter characteristic, of course, that turns animates into agents. I offer a representation of an image-schema of AGENCY in Graphic 9. AGENCY is represented as an animate object, A, that moves itself and also causes another object, B, to move. This image-schema is hardly more complex than the image-schema of CAUSED-TO-MOVE INANIMATE (Graphic 7). The only difference is that two objects are represented, and the object A that causes B to move follows an animate path.

AGENCY 

(9)

One of the most frequent sights in early infancy is that of people manipulating objects. These are typically objects that rarely move at all under other circumstances. The trajectories taken by manipulated objects in these cases are those of the agent that is holding them. This complicates the analysis that must be carried out but perhaps not so greatly as to be necessarily a late development. Inanimate objects are those that often do not move at all, but when they do the beginning-of-path is caused motion, not self-motion. The paths they follow are inanimate paths, unless the cause of motion is an agent picking them up. In that case, their paths are contingent on the path of the agent. If the paths part company (i.e., the agent lets the object go), the path of the manipulated object reverts to that of inanimate motion.

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[7] Note that the separation between the two trajectories in Graphic 8 can represent either a spatial or a temporal gap; that is, a spatial or a temporal separation results in the assessment that A begins on its own. Using a temporal gap to judge that an independent trajectory has begun is an example of using temporal information without necessarily conceptualizing it as such.

[8] If this argument is correct, it provides an ontological basis for our pervasive tendency to conceptualize the mental world by analogy to the physical world, rather than the other way around. Extensive analyses of this tendency have been provided by cognitive linguists such as M. Johnson (1987), Sweetser (1990), and Talmy (1988).

I have discussed several kinds of spatial movement that might be important in early concepts about objects, but there are certainly a number of others. For example, Wagner, Winner, Cicchetti, and Gardner (1981) found that 9- to 13-month olds were able to make a "metaphorical" match between certain auditory and visual patterns. Specifically, the infants were more apt to look at a broken line or a jagged circle when listening to a pulsing tone and to look at a continuous line or a smooth circle when listening to a continuous tone. Similarly they looked more at an upward pointing arrow (which may tend to make the eyes move upwards) when listening to an ascending tone and to a downward arrow when listening to a descending tone. This finding is of particular interest because it appears to be the same phenomenon described by M. Johnson (1987) and Lakoff (1987) as the way in which adults project image-schemas from one domain to another, for example, conceptualizing quantity in terms of verticality (more is up, less is down).

The Wagner et al. (1981) data are also interesting because of their potential application to the debate over the basis of cross-modal matching in infancy. For instance, when listening to a single sound track while being presented with two different films, 4-month-old infants are more apt to look at the film that matches the sound track (e.g., Spelke, 1976). Kellman (1988) suggested that the auditory and visual transducers output the same pattern of information in an amodal form, which could account for the matching behavior. Spelke (1988), on the other hand, suggested that a more "thoughtful" central process is required. Although Spelke did not describe this process in terms of image-schemas, her suggestion could be so interpreted. In such an account, the matching behavior would not be due to the transducers resulting in the same amodal output; rather, the infant would be described as creating the same image-schema to represent the two outputs.

The Concepts of Containment and Support

The last concept I will discuss is containment, along with a cluster of related notions: going in or out, opening and closing, and support. Containment in particular is an important notion to consider because of its potential relevance to preverbal thinking. The data that are available suggest it is an early conceptual development. Some concept of containment seems to be responsible for the better performance 9-month-old infants show on object-hiding tasks when the occluder consists of an upright container, rather than an inverted container or a screen (Freeman, Lloyd, & Sinha, 1980; Lloyd, Sinha, & Freeman, 1981). These authors suggested that infants already have a concept of containers as places where things disappear and reappear. More direct work on containment has been conducted by Kolstad (1991), who showed that 5.5-month-old infants are surprised when containers without bottoms appear to hold things. This finding suggests that the notions of containment and support may be closely related from an early age.

According to Lakoff (1987), the CONTAINMENT schema has three structural elements: interior, boundary, and exterior. Such a notion seems likely to arise from two sources: first, perceptual analysis of the differentiation of figure from ground, that is, seeing objects as bounded and having an inside that is separate from the outside (Spelke, 1988), and second, from perceptual analysis of objects going into and out of containers. The list of containment relations that babies experience is long. Babies eat and drink, spit things out, watch their bodies being clothed and unclothed, are taken in and out of rooms, and so on. Although M. Johnson (1987) emphasized bodily experience as the basis of the understanding of containment, it is not obvious that bodily experience per se is required for perceptual analysis to take place. Infants have many opportunities to analyze simple, easily visible containers, such as bottles, cups, and dishes, and the acts of containment that make things disappear into and reappear out of them. Indeed, I would expect it to be easier to analyze the sight of milk going into and out of a cup than milk going into or out of one's mouth. Nevertheless, however the analysis of containment gets started, one would expect the notion of food as something that is taken into the mouth to be an early conceptualization.

In the same way as discussed for LINK, there appears to be a cluster of related image-schemas used to form the concept of a container. One expresses the meaning of CONTAINMENT itself. Thus, Graphic 10 represents the meaning of one thing being inside another, by showing an object, A, in an at least partially enclosed space.

CONTAINMENT 

(10)

Related image-schemas express the meaning of going in or going out in which a trajector goes from outside a container to the inside, as in Graphic 10a, or vice versa, as in Graphic 10b.

GOING IN  (10a)

GOING OUT  (10b)

As Kolstad's (1991) data suggest still another aspect that seems to be involved in an early concept of a container is that of support: true containers not only envelop things but support them as well. I have already mentioned work by Needham and Baillargeon (1991) showing that infants as young as 3 months are surprised when support relations between objects are violated. A primitive image-schema of SUPPORT might require only a representation of contact between two objects in the vertical dimension. An image-schema of SUPPORT is represented in Graphic 11 in the form of an object, A, above and in contact with a surface.

SUPPORT 

(11)

Baillargeon, Needham, and DeVos (1991) documented some of the changes that occur in understanding support over a period of a few months. At 3 months infants expect objects to be supported if they are in full contact with a surface, and otherwise they expect objects to fall. By 5 months they expect an object to be supported if any part of the object rests on the surface. By 6 months they have begun to differentiate between partial but inadequate support (15% overlap between the object and the supporting surface) and adequate support (70% overlap). These data suggest that the earliest notion of support does not include considerations of gravity or weight distribution, but at least some aspects of these characteristics are learned within a few months.

Still another example of early understanding related to containment is that of opening and closing. Piaget (1951) documented in detail the actions his 9- to 12-month-old infants performed while they were learning to imitate acts that they could not see themselves perform, such as blinking. He noticed that before they accomplished the correct action they sometimes opened and closed their mouths, opened and closed their hands, or covered and uncovered their eyes with a pillow. His account testifies both to the perceptual analysis in which the infants were engaging and their analogical understanding of the structure of the behavior they were trying to reproduce. Such understanding seems a clear case of an image-schema of the spatial movement involved when anything opens or closes, regardless of the particulars of the thing itself. The image-schema is not easily representable in a static sketch, but it involves an operation on the boundary of a container, such that something can move in or out of it, as in Graphics 10a and 10b.

Lakoff (1987) pointed out that the CONTAINMENT image-schema forms a gestalt-like whole that has meaning by virtue of the relationships among the parts. *In* does not have meaning without considering *out* and a boundary between them. Lakoff went on to suggest that the CONTAINMENT schema forms the basis for the later meaningfulness of certain logical relations, such as P or not P (in or not in), and for the Boolean logic of classes ("if all As are Bs and x is an A, then x is a B" deriving from "if A is in container B and x is in A, then x is in B"). He claimed that our intuitive understanding of the meaning of a set (even though it is defined formally in set-theoretical models of logic) is due to the CONTAINMENT schema. In this view, meaning postulates are meaningful because they are propositional translations of the schemas that structure our nonverbal thought.

Lakoff's (1987) claim about the basis of our intuitive understanding of logic is attractive insofar as it suggests how representing early concepts in image-schematic terms can provide a grounding in preverbal thought for aspects of later language learning and reasoning. As Braine and Rumain (1983) pointed out, it is difficult to imagine how children could understand sentences containing logical connectives such as *or* if they did not already have what Braine and Rumain called *inference schemas.* Although Braine and Rumain did not suggest that such schemas are within the competence of infants, it becomes easier to see where they might come from if they consist of understanding the meaning of simple notions like CONTAINMENT. The implication that something is either in or out of a container and is not both in and out at the same time is spatially evident from examining a container and can be projected by means of the CONTAINMENT image-schema to other *or* and *not* relations. A similar kind of analysis of *if–then* may be derived from the LINK schemas in Graphics 4a and 4b. Such image-schema implications are nonpropositional; they do not consist of strings of discrete symbols, yet they allow the meaning of certain inferences to be understood. Because these kinds of analog representations have a relational structure, one might say that they contain within themselves the basis of what will become in language (or logic) a predicate–argument structure.

Image-Schemas and Language Acquisition

Bowerman (1987) noted that there are two important aspects of the role of meaning in learning to talk that must be solved before one can claim to have an adequate model of language acquisition. The first is a plausible theory of where children's meaning representations come from, and the second is how they are used to facilitate language learning. (Bowerman also noted that we have not made much progress on either problem.) The previous sections of this article addressed the first of these issues, by showing how preverbal meanings might be formed and doing so in a language-independent way. That is, the motivation for the characterization of the image-schemas I have described was not to explain language learning but to account for the kind of conceptual activity that occurs in preverbal children. In this section, however, I will discuss some of the ways in which image-schemas should be useful in language acquisition.

Image-schemas, which are based on a redescription of the spatial structure infants experience every day, would seem to be particularly useful in the acquisition of various relational categories in language. On the basis of linguistic analyses, cognitive linguists have proposed image-schemas and mental spaces as the roots of our understanding and use of modals (Sweetser, 1990; Talmy, 1988), prepositions (Brugman, 1988; Talmy, 1983), verb particles (Lindner, 1981), tense and aspect (Langacker, 1987), and presuppositions (Fauconnier, 1985). Some of these categories have seemed more problematical for young language learners than learning the names for things. Even to learn names, it has been thought necessary to propose that children have a bias to assume that labels refer to whole objects rather than to object parts (Markman, 1989; Quine, 1960). A similar kind of bias may operate with respect to various relational constructions.

Brown (1973) and others showed that a number of relational morphemes, such as the prepositions *in* and *on,* are early acquisitions. The meaning of these relational terms is given by the relevant image-schemas, just as the objects that enter into the relations are given by the perceptual parser. It is true that objects can be identified ostensively in a way that relations cannot. However, because of image-schematic analyses that have already been carried out, it should not be difficult for the child to learn that *in* expresses a containment relation or *on* a support relation. Take for example a 20-month-old child hearing the phrase "the spoon in the cup." On the basis of the data and image-schema analysis of containment discussed in the last section, it can be assumed that the child will already have had more than a year's experience in analyzing one thing as being in another. A single image-schema can be used to join the two objects in a familiar relation. Hence, even though *in* cannot be pointed to, it can nevertheless be added to the semantic system. Support for this view can be found in the fact that *in* and *on* are the earliest locative terms to be acquired in all the relevant languages that have been studied (Johnston, 1988) and are acquired (at least in English) in virtually errorless fashion (Clark, 1977).

The distinction between *in* and *on* is not a perceptual one. The perceptual system makes many fine gradations where languages tend to make categorical distinctions. Linguistic distinctions are often binary oppositions, and when further subdivisions are made they tend to be few in number. Languages vary as to where they make these cuts, and these the child must learn from listening to the language. But the hypothesis I am operating under is that however the cuts are made, they will be interpreted within the framework of the underlying meanings represented by nonverbal image-schemas. That is, some of the work required to map spatial knowledge onto language has already been accomplished by the time language acquisition begins. Children do not have to consider countless variations in meaning suggested by the infinite variety of perceptual displays with which they are confronted; meaningful partitions have already taken place. Some of the image-schemas I have been describing provide roughly binary distinctions, as in the case of self- versus caused motion, and therefore tailor-made to be propositionalized. Others are not binary oppositions but represent fundamental concepts in human thinking, such as containment and support. What remains for children to do is to discover how their language expresses these partitions.

To take an example from Bowerman (1989), languages vary as to how they treat containment and support relations. English speakers make an all-purpose distinction between *in* and *on*. These map easily onto the CONTAINMENT and SUPPORT image-schemas described in the previous section. According to Bowerman, Spanish speakers typically use *en* for both the English meanings. This cut may emphasize the notion of support over the notion of containment, but in any case the lack of a distinction here should not cause young language learners any particular difficulty. Dutch, on the other hand, divides *on* into two kinds of support relations. *Op* is used to express horizontal support, as characterized by the image-schema described in the previous section, as well as to express certain kinds of nonhorizontal support, as in a poster glued to a wall. *Aan*, another term for *on*, is used to express a variety of other support relations in which only part of an object is attached to a supporting surface, as in a picture hanging on a wall. I would predict that this finer distinction, depending as it does on some understanding of gravity, might cause production errors. (Such errors need not occur in the earliest usage of a term. To the extent that children learn commonly used, fixed phrases for many situations, confusion among the various uses of *on* might not be evident until the child attempts to describe a new situation.)

In these three languages (as well as many others) containment and support relations are expressed by prepositions that are used quite generally with many different verbs so that children hear them in a great many situations. In addition, using the prepositions alone (as children do in the one-word stage of language production) is often sufficient to convey the appropriate meaning. There are languages, however, that have no all-purpose morphemes equivalent to English *in* or *on* but express spatial meanings primarily by means of a variety of different verbs of motion (and sometimes by nouns such as *top surface* or *interior*). Korean is one of these languages, and as Choi and Bowerman (1992) documented, it presents a somewhat different task for the young language learner. In Korean there are verbs that mean roughly *to put into a container* or *to put on a surface*, but also a verb that means roughly *to fit tightly together* that cuts across the English usages of *in* and *on*. My interpretation of this three-way split is that the language provides a distinction between things going in or things going on, but supersedes this distinction in the case in which the thing going in or on results in a tight fit (as in a cassette tape going into its case, or a lid being snapped onto a container). Choi and Bowerman noted that these distinctions do not give Korean children any difficulty, in the sense that the word for *fit tightly together* is one of the first words they learn.

Bowerman (1989) and Choi and Bowerman (1992) suggested that this kind of example casts doubt on *in* and *on* as privileged spatial primitives that can be mapped directly onto language. They suggested instead that children must be sensitive to the structure of their input language from the beginning. At the same time, they noted that how children figure out language-specific spatial categories remains a puzzle. Although I agree that their data provide strong evidence that young children are sensitive to the structure of their language from an early age, the mapping is only a puzzle if one assumes that *in* and *on* are the only kinds of spatial analyses of containment and support that have been carried out.

It may well be that *in* and *on* appear as early as they do in English because of their status as separate morphemes, their frequent usage, and their relatively straightforward mapping onto two simple image-schemas. Korean children in the one-word stage cannot get by with *in* and *on* because these all-purpose morphemes do not exist in their language. Because children add only a few words at a time in the early months of language production, Korean children express only some of the many usages that English-speaking children manage with their more general *in* and *on*. One of the words they do use means *to fit together tightly*. Such a concept does not appear in English samples of early speech, because there is no single morpheme in the language to express it. However, this does not mean that English children do not have such a concept until a later stage when they begin to combine several morphemes together. I suggest that this is an easy word for Korean children to learn because its meaning reflects the kinds of spatial analyses that preverbal infants everywhere are carrying out. *To fit tightly* (or for that matter, *to fit loosely*) does not seem an unduly difficult notion for infants who are engaged in analyzing many kinds of containment and support relations.

Unfortunately, there is not yet a rich enough database to provide a definitive answer to the conceptual distinctions children have mastered before language begins. The work of Baillargeon and her colleagues, discussed earlier, indicates that a good deal of analysis of support relations has already taken place by 6 months. A further year will elapse before particles expressing support enter the child's vocabulary, during which time a great many more distinctions are likely to have been conceptualized. However, it is not yet known whether various kinds of horizontal support are understood before vertical support or the age at which infants learn about the kinds of attachment necessary for the vertical support indicated by the word *aan*. Before it is possible to make detailed predictions about the course of mastering Dutch versus English in this regard, then, much more data are needed on infants' preverbal concepts. Similar comments can be made about the concept of *tight-fittingness* in Korean. Because most of the existing research has been conducted by speakers of languages that do not have a single morpheme expressing *tight-fittingness*, the development of this concept in infancy has not even begun to be investigated. Until such research is carried out it will not be possible to determine whether a given language merely tells the child how to categorize a set of meanings the child has already analyzed or whether the language tells the child it is time to carry out new perceptual analyses.

Containment and support may be more complex than would at first appear, but they are spatial relations and therefore clearly require spatial analysis. However, there are other linguistic categories that are less obviously spatial in character and even more complex, yet in spite of this, they are early linguistic achievements. One example is linguistic transitivity (how subjects and objects are marked in transitive clauses, such as *Mary throws the ball,* versus intransitive clauses, such as *John runs*). As Slobin (1985) discussed, linguistic transitivity is among the first notions marked by grammatical morphemes in the acquisition of language. Although it is an abstract linguistic notion, it nevertheless depends on concepts of animacy, inanimacy, agency, and causality, and I have argued that these concepts also result from spatial analysis. Because the relevant image-schemas occur preverbally, linguistic transitivity should not present the young language learner with undue difficulty. One might even argue that language *ought* to make some distinctions between these notions if their presence in the infant's representational system is as prominent as I have suggested. At the same time, to the extent that a particular language goes beyond preverbal image-schemas one can predict particular kinds of difficulties in early acquisition.

Slobin (1985) gave a detailed example of this kind of difficulty in the case of transitivity. He pointed out that whether expressed in the child's native language by accusative inflections, direct object markers, or ergative inflections, marking of transitive phrases is underextended in early child language.[9] The marking occurs at first only when the child is talking about an animate agent physically acting on an inanimate object; only later is it extended to less prototypical cases of transitivity. Slobin referred to this underextension as children first using the relevant morphemes to talk about a *manipulative activity scene.* This scene requires the child to represent a cluster of notions, such as the concepts representing the objects involved, concepts of physical agency involving the hands, and concepts of change of state or location. Although Slobin suggested that there is no basis for proposing any particular analysis of this complex of notions, they fit remarkably well with the image-schemas that were described earlier.

Thus, one of the earliest grammaticized relational notions can be characterized as a linguistic redescription of the image-schemas I have described for representing an animate acting causally on an inanimate. It is particularly interesting that at first only inanimate patients (such as ball) are given accusative marking, even when the native language uses distinct accusative forms for animate and inanimate objects. Slobin (1985) reported that children are slow to learn this accusative subdistinction. I would suggest that the difficulty is due in part to the initial conception of what an inanimate is: It is something acted upon and that does not act by itself. So the child may first interpret the accusative marker as a marker for inanimacy, rather than as a marker for a patient. This is a case in which syntactic bootstrapping (Gleitman, 1990; Landau & Gleitman, 1985) seems to be required if the child is to realize that it is not just inanimates that are marked in the abstract role of patient.

These underextension errors are relatively minor, but indicate that a grammatical notion combining several image-schemas in a complex way may require some trial and error before the particular set the language expresses is fully mastered. There are other cases in which a grammatical distinction matches early image-schemas more exactly. An example is the distinction in Korean between intransitive verbs involving self-motion and transitive verbs involving caused motion (Choi & Bowerman, 1992). English does not mark these distinctions; for example, English uses the same verb to say either that the door opened or that Mary opened the door. Korean, however, uses quite different verb forms for these two cases. Choi and Bowerman reported that this distinction is respected by children as soon as they begin to use such words; the children they studied never made a cross-category confusion between these two types of verbs. Thus, learning this grammatical distinction in Korean appears to be comparable to the acquisition of *in* and *on* in English; a straightforward match between the underlying image-schemas and the linguistic distinctions makes learning rapid and easy.

Another example of a spatial analysis underlying a seemingly nonspatial concept is that of possession. A number of writers have noted this affinity (e.g., Brown, 1973; Lyons, 1968). Slobin (1985) defined possession as a locative state in which an animate being enjoys a particular socially sanctioned relationship to an object. He pointed out that young children may not yet understand the social aspects of this concept and attend primarily to its locative aspects. In support of this view, he cited Mills (1985), who found that German children sometimes conflate locative and possessive functors. For example, locative functors such as *to* are sometimes used to mark possession, as in the case of using *zu* (to) to express both *going to* and *belongs to.* Slobin's analysis suggests that this conflation (or better, underextension of the adult use of the term) comes about because an image-schema of a trajector has not yet been projected into the social realm. The earliest meaning being expressed by a child using the locative term *to* may well be spatial destination, represented as END-OF-PATH. In the same way that focus on BEGINNING-OF-PATH emphasizes the animate or inanimate character of a moving object, focus on END-OF-PATH emphasizes its destination: In the simplest sense, the place where an object comes to rest is where it "belongs." A too complex notion of possessiveness is probably ascribed to young children who pepper their conversations with "my book," "my chocolate," "my watch," regardless of whose book, chocolate, or watch is under discussion. In observing a 2-year-old child exhaustively use this construction, it seemed to me that nothing like possession in the adult sense was being claimed; rather, a request for a movement of the item to the child as destination was being expressed. Indeed, at the time of these observations the child had yet to learn the construction *Ben's book,* which might indicate a notion of possession closer to the full adult sense (Deutsch & Budwig, 1983).

Slobin (1985) discussed the acquisition of a large number of nonreferential grammatical morphemes. At first glance, many of them, such as distinguishing between transitive and intransi-

[9] In inflectional accusative languages, a marker is put on the direct object in a transitive clause, whereas in ergative languages, transitivity is marked on the subject noun (the agent).

tive activities or use of the progressive aspect of verbs, not only seem impossibly abstract for the very young child to master, but also slightly odd.[10] Of what value to communication or understanding is it to make these distinctions? Indeed, some languages do without them. They may occur in most languages partly because of analyses that have been carried out by preverbal organisms. In any case, when the notions that underlie these linguistic devices are analyzed in image-schematic terms, some of the linguistic problems facing the child seem more tractable. This is a serendipitous result of an analysis that was originally motivated by quite a different problem, namely, how to account for the appearance in infancy of concepts such as animacy and causality.

Perception and Conception Revisited

My analysis of redescription of spatial structure into an image-schematic form of representation can also account for why it is often difficult to tell whether perceptual or conceptual categorization is occurring in infancy. The relationship between perception and conception has long been an arena of argument among psychologists. I have tried to make a firm dividing line between the two in order to highlight differences that are often ignored or glossed over. However, if the earliest conceptual functioning consists of a redescription of perceptual structure, there may be no hard and fast line. The reason why there have been so many arguments over whether it is possible to separate percepts and concepts is that there are great similarities between the two, even though they are considered to involve different kinds of processing. For example, when we showed in my laboratory that infants respond to a global category of animals (J. M. Mandler, Bauer, & McDonough, 1991; McDonough & Mandler, 1991), some of our colleagues tried to convince us that this was merely a perceptual category—that all animals look more alike than they look like plants or artifacts. So what we were calling the concept of animal was really just an extended "child-basic" category whose acquisition could be explained by perceptual factors alone. However, the perceptual characteristics of animals are too varied to make such a characterization useful. To be sure, at a high level of description there are some perceptual commonalities across animals; for example, it can be observed that animals all move by themselves, even though they move in physically different ways. Self-motion, however, is not the same type of description as the parameters that describe movement; on the contrary, it is the concept of self-movement that relates different perceptual descriptions of the motion. The high-level parameters of motion that are common to the hopping of a kangaroo and the gliding of a shark are as yet only partially known. The perceptual system may make use of such parameters to form a broad perceptual category of biological motion, but the conceptual system constructs a simpler notion to express this commonality.

In our studies (J. M. Mandler & Bauer, 1988; J. M. Mandler, Bauer, & McDonough, 1991; McDonough & Mandler, 1991) of the development of the concept of animals we have typically used small plastic models of animals and other objects. In one of our tasks, we put a number of varied animals and vehicles in front of the children and observe the way the children interact with them. If a child touches the animals in sequence more often than would occur by chance, we say that the child has a category or concept of animals, in the sense that the animals are seen to be related to each other. However, because the models do not move one might ask, if movement is the basis for the concept of animals why does the child respond systematically in the absence of the cue to the conceptual meaning? Having a concept of what an animal *is* is not the same thing as identifying one. There are undoubtedly a number of perceptual bases used to recognize something as an animal. For example, things that move themselves have appendages of various sorts that are involved in the movement (legs, wings, or fins). These shape characteristics can serve to identify something as an animal in the absence of movement. Thus, shape is a good identifier of a categorical exemplar, even though shape only specifies what the exemplar looks like, not what it is. Most important, the shapes of various appendages do not themselves look alike. They are alike only because they all signify self-motion. If the basis for sequential touching of animals were merely the physical appearance of appendages, it would be difficult to understand why winged creatures are associated with legged and finny ones, but not with winged airplanes (McDonough & Mandler, 1991).

There is a limit to the usefulness of characterizing knowledge as perception. It is true that to the extent that concepts are derived from percepts, there must often be perceptual bases for conceptual decisions. The same image-schema can be used to give a brief structural description of a percept or to give a brief description of the meaning of a simple concept. Thus, the image-schema of SELF-MOVING ANIMATE shown in Graphic 3 can be used to describe in part what a fish looks like as it begins to swim away or what a cat standing on a mat looks like as it walks off the mat. The details of the paths vary, but Graphic 3 describes their commonality. At the same time, Graphic 3 describes the conceptual meaning of what has happened in the two situations. In spite of its perceptual roots, however, what I have been calling the concept of animal brings together a number of diverse perceptual analyses into a more abstract characterization of what an animal is, that is, what Wellman and Gelman (1988) called the nonobvious aspects of something seen. It is these nonobvious characteristics that 3-year-olds use conceptually to differentiate pictures of statues from pictures of animals they have never seen before (Massey & Gelman, 1988). They say such things about a new animal as, "It can go by itself because it has feet," even when no feet are visible in the picture.[11] Such inferential ability (in this case, the use of inheritance properties) is the hallmark of concepts and cannot be characterized as perceptual knowledge. The claim that I have made here is that 2- to 3-year-olds can only make such inferences because they have previously formed concepts through

[10] Focus on an object's path, rather than its beginning or end, emphasizes the ongoing trajectory itself. An image-schema of TRAVERSAL-OF-PATH could provide the basis for the early understanding of the progressive aspect of verbs.

[11] The claim that the animal has feet is a conceptual justification. The actual basis of recognition of the animals versus the statues may be their different textures. Massey and Gelman (1988) reported children saying such things as, "The statue can't go by itself because it is shiny." Smith (1989b) made a similar point about the importance of texture in object recognition.

the redescription of perceptual information into image-schematic form. The image-schemas allow them to represent the idea of animacy, which in turn allows the inference of unseen appendages. It is also what allows infants to categorize winged and legged creatures together.

In conclusion, I have proposed that human infants represent information from an early age at more than one level of description. The first level is the result of a perceptual system that parses and categorizes objects and object movement (events). I assume that this level of representation is roughly similar to that found in many animal species. In addition, human infants have the capacity to analyze objects and events into another form of representation that, while still somewhat perception-like in character, contains only fragments of the information originally processed. The information in this next level of representation is spatial and is represented in analog form by means of image-schemas. These image-schemas, such as SELF-MOTION and CONTAINMENT, form the earliest meanings that the mind represents. The capacity to engage in this kind of perceptual analysis allows new concepts to be formed that are not merely combinations of earlier image-schemas; in this sense, it is a productive system. This level of representation allows the organism to form a conceptual system that is potentially accessible; that is, it contains the information that is used to form images, to recall, and eventually to plan. A similar level of representation apparently exists in primates as well (Premack, 1983) and perhaps in other mammals too (although the format would presumably vary as a function of the particulars of the sensory systems involved). Humans, of course, add still another level of representation, namely, language. Whatever the exact nature of the step required to go from image-schemas to language, it may not be a large one, at any rate not as large as would be required to move directly from a conceptless organism to a speaking one.

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