Prelinguistic Primitives

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PRELINGUISTIC PRIMITIVES

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My research interest is in the foundations of the human conceptual system, and not in linguistics or language acquisition per se. However, in my reading of cognitive linguistics, I have been struck by the affinity between the image-schemas that cognitive linguists have proposed for representing certain semantic categories and the kinds of concepts that my research (and that of other developmental psychologists) indicates are being formed in infancy. As a developmental psychologist I am interested in finding an appropriate representational format for the concepts that are developing before any language has been acquired. Whatever their format, these concepts will shortly be augmented by language learning, and both psychologists and linguists have a stake in accounting for how language is mapped into the existing conceptual system. What I would like to do here is to present some hypotheses about prelinguistic conceptual primitives and to illustrate how they can be related to the semantic and grammatical notions that cognitive linguists have described in image-schema terms.

To relate conceptual development to language acquisition is hardly a new endeavor, but it is a daunting task and it has been difficult to find clearcut relations between the two. In particular, I have been dubious about the use of various sensorimotor accomplishments as indicators of the kind of cognitive development that is related to language acquisition. Sensorimotor schemas, as these have been described by Piaget (e.g., 1952), consist of perceptual and motor procedures for taking in information and acting on the world. In the early months, according to Piaget, these procedures are used to parse the world into objects and simple events. In the second half of the first year, procedures develop for recognition and manipulation of objects. By the second year, these procedures have become greatly differentiated and are applied to increasingly broad and varied event-contexts. But whether in the first month or the twelfth, a sensorimotor procedure is not conceptual in nature. This is why Piaget stressed that the infant is not able to think about the world, to recall the past, or to anticipate in a conceptual way what might happen next. Sensorimotor procedures, for all their complexity, are relatively low-level devices. By definition they do not require conceptual (symbolic) understanding; they are pattern-matching and motor control devices. Such devices deal with complex, continuous, analog information and seem ill-suited for mapping into the quintessential symbolic system of language.

Language is unlikely to be mapped *directly* onto sensorimotor schemas. There is a missing link: a conceptual system that has already done some of the work required for a mapping to take place. One of the functions of this early conceptual system, I believe, is to redescribe sensorimotor information into a form that is more compatible with the mapping process; that is, it forms an interface between analog sensorimotor functioning and the discrete symbols of language (see Karmiloff-Smith, 1986, for a related point of view). To illustrate, it would be extraordinarily difficult to go directly from the continuously varying physical parameters of the movement involved in picking up one object and placing it in another to the statement, "The marble is put into the cup." Some kind of conceptual summary of what is happening in this situation is needed; it is this conceptual summary that is mapped, rather than the sensorimotor schemas themselves.

But there is a surprising omission in developmental theory at this point, namely, discussion of what this conceptual level of representation is like. Piaget, of

course, recognized the difference between sensorimotor and conceptual representation; indeed his distinction between the two forms of representation was a major contribution to our understanding of development. The mistake he made, in my opinion, was to assume that a conceptual form of representation was such a late development (Mandler, 1988). In any case, he did not have a lot to say about this new form of representation, other than that it was symbolic and was a transformed version of the earlier sensorimotor schemas. Later workers, such as Uzgiris and Hunt (1975), developed sensorimotor scales that more or less ignored the distinction, in the sense that these were ordinal scales that moved from testing what are clearly sensorimotor schemas in the earliest items to a variety of items at the top of the scale that seem to require conceptual thought. Much of the work that went into relating language acquisition to prior cognitive development used these scales or variants of them, without a clear analysis of which items reflect perceptual procedures and either simple or advanced motor skills and which reflect a conceptual form of representation; often items are merely described as Stage 5 items or Stage 6 items, without specifying more exactly their conceptual status. (There have been a few analyses along these lines, e.g., Gopnik and Meltzoff, 1987, but to my knowledge no attempt has been made to partial out the motor components from the conceptual components required by various items).

Developmental linguists, on the other hand, have addressed the issue of the kinds of concepts that must be represented at the onset of language acquisition, particularly the acquisition of grammar, primarily from the point of view of what is expressed in early language. I take it that a consensus has been reached that concepts of actionality, objecthood, and agency are representations required for learning grammar (see Maratsos, 1983). And by the second half of the second year, other concepts, such as possession, plurality, pastness, and a variety of relations such as support and containment must be present to account for the acquisition of the morphemes expressing these ideas (e.g., Brown, 1973). However, most of these concepts have not been clearly related to the various items on the sensorimotor scales.

It seems important, therefore, to look again at the genesis of the major concepts needed for language acquisition, and in particular to consider the prelinguistic format in which they are couched. Regardless of when in development one wishes to claim that conceptual representation has begun, one must face this issue. It is not sufficient merely to say that a sensorimotor schema has been transformed in some way and is now a concept. How does this happen and what is the resulting representation like? To my knowledge, Dan Slobin (1985) is one of the few people who have addressed the issue of the specific nature of prelinguistic representation. The ideas I am presenting here fit quite well with some of the work he has done, and both sets of ideas fit well with the work of cognitive linguists, such as Talmy and Lakoff.

Conceptual representation in preverbal infants

Before turning to the representational issue, I will briefly review the kinds of concepts that recent research suggests are present in the first year of life. Many of the notions that underlie language appear considerably earlier in infancy than Piagetian theory indicated. First, infants parse the world into coherent, bounded objects at least by 3 months and possibly earlier (e.g., Spelke, 1987). Thus, this particular sensorimotor achievement is quite early and possibly even innate.

Second, 3- to 4-month-olds understand that objects are permanent, in the sense that they expect objects to continue to exist when hidden; they also understand that objects are solid and cannot cohabit the same space (Baillargeon, in press). Various theorists in this area take these results to mean that central thought is already developing from the initial sensorimotor base (e.g., Leslie, 1988; Spelke, 1987). That is, at least some of the understanding involved in object permanence may be conceptual in nature rather than purely sensorimotor, even though it occurs early in infancy. Third, infants encode the causal relations that objects enter into as early as 4 to 6 months (Leslie, 1984; Leslie & Keeble, 1987). Although the extent to which this accomplishment, like that of understanding object permanence, is purely perceptual in character or involves conceptual thought is still unclear, it is clear that these kinds of information become available to the system very early and therefore are potentially available to be operated on. Fourth, infants have some understanding of containment relations by 5 to 6 months (Kolstad, 1991) and support relations by 8 months (Baillargeon & Hanks-Summers, 1990). Fifth, 9-month-old infants have also been shown to be able to recall something they have seen after a 24-hour delay (Meltzoff, 1988) and at least for short intervals at even younger ages (Baillargeon, in press). We have also found 24-hour recall of simple event sequences in 9-month-olds in our laboratory, and are just beginning to obtain data suggesting the ability to recall such events after a 2-month delay. The recall data are particularly important because the ability to bring to mind (re-present) absent objects or events is considered to be the hallmark of a conceptual system (e.g., Piaget, 1952).

The kinds of concepts I have just described are foundational in nature: concepts of what an object is, causality, support relations, and so forth. But there are other kinds of concepts that appear to develop in the first year that are more specific, and in some sense are closer to what we usually have in mind when we use the term "concept," namely, concepts about the *kinds* of objects and events there are in the world. In my laboratory we find that infants have begun to develop global concepts of animals and vehicles by 9 months of age (Mandler & McDonough, in preparation). One way we show the presence of such concepts is to hand infants little plastic models of a variety of animals to examine one at a time (e.g., a horse, a turtle, a bird, and a rabbit). Then we hand them a model of a vehicle. Infants will examine the vehicle for a longer period of time, indicating that it seems different to them. Similarly, if we give them a series of vehicles and then an animal, they examine the animal longer. Golinkoff and Halperin (1983) have also reported a concept of animal at 8 months of age, using a child's unique emotional response to a variety of toy and real animals of different sizes, shapes, and textures. Ross (1980) using a habituation-dishabituation technique similar to ours, showed the presence of animal, food, and furniture categories at 12 months. The exemplars of these categories were highly varied in their perceptual appearance.

Such global categories do not appear to be mere sensorimotor accomplishments. Forming perceptual categories of things that look alike can be accomplished by sensorimotor processes, but there is too much perceptual variation in the classes of animals, vehicles, food, and furniture to be easily accounted for on a purely perceptual basis. At the least, one would expect overall shape to play a major role in purely perceptually based categorization of objects. Yet, in our work, we find that 9-month-olds differentiate models of birds and airplanes, even when both have outstretched wings. That is, when we make overall shape as similar as possible, infants nevertheless do not confuse exemplars from the animal and vehicle domains. At the same time, our current data, (still in progress) also suggest that 9-month-olds are not making clear categorical distinctions between dogs and fish,

objects whose shape obviously varies a good deal. Perceptual categorization of dogs and fish should be an easy sensorimotor task (e.g., Cohen & Younger, 1983). Therefore, the data suggest that performance on this object-examination task is based on conceptual considerations, rather than on ability to perceptually discriminate the categories involved. The data also suggest that infants of this age have a global conception of animals, but one that is not yet well differentiated. This view is in accordance with other data showing that 1- to 2-year-olds also demonstrate global conceptions of animals, vehicles, and plants, often without showing basic-level differentiation of these domains (Mandler, Bauer, & McDonough, 1991).

As a result of these considerations I take as a working assumption that preverbal infants have developed concepts of animals and vehicles, (and quite likely concepts in other domains as well), and so we need to ask the basis on which such concepts are formed and how they might be represented. I have suggested (Mandler, 1988) that a conceptual system develops in parallel with the acquisition of object and event schemas during the first year of life, rather than beginning as a transformation of such schemas after a prolonged sensorimotor stage, as suggested by Piagetian theory. I have proposed that the mechanism by which preverbal concepts are formed is one of perceptual analysis. Perceptual analysis is an active process whereby infants selectively attend to certain aspects of the objects and events they are perceiving, and redescribe this information into a simplified format that provides their meaning. In principle there is no reason why such redescription cannot occur as soon as object and event perceptual schemas begin to be formed. As I have already indicated, many such schemas are formed early in infancy, and therefore, we should look for conceptualizations related to them at least as early as five to six months.

Image-schemas as a prelinguistic representational format

The main issue I wish to address here is the format that might be used by a preverbal infant to conceptualize what is being learned about the world. The format should be one derivable from perceptual information, and one that does not require detailed featural analysis. At the same time, the format should be appropriate for later mapping into the propositional forms of language. It should be obvious from this description that image-schemas as formulated by cognitive linguists fit the requirements rather neatly (e.g., Johnson, 1987; Lakoff, 1987; Langacker, 1987). Image-schemas are said to consist of mappings from spatial structure to conceptual structure. The spatial structure that is used for the mapping consists of very general aspects of the trajectories of objects and their interactions in space, ignoring most of their details. The conceptual structure that results consists of the meanings of what objects are and the kinds of events objects participate in.

From the point of view of a linguist, image-schemas are useful to represent relationships among concepts expressed in language and to show how and why words are imported from one domain to another (e.g., Fauconnier, 1985; Lakoff, 1987). From the point of view of a developmental psychologist, image-schemas are also suitable as a representational format for an organism that is perceptually sophisticated but as yet has no discrete vocabulary or other symbol system to describe what it perceives. I propose that it is a capacity to summarize the spatial structure it is encoding into a schematic form that allows the infant to develop preliminary meanings of objects and events. These schematic sketches serve two

functions. First, they allow the formation of the concrete memory images that are used in recall. (I follow Piaget here in assuming that images are conceptually interpreted, not raw recreations of past perceptions). Second, they provide a conceptual format that allows further redescription, this time into language. Now, however, the material to be redescribed is easier to put into a propositional format than would be the case for uninterpreted perceptual schemas. For example, some contrasting image-schemas seem to provide an essentially binary distinction, as in the case of SELF-MOTION and CAUSED MOTION that I discuss below, and are therefore tailor-made to be "propositionalized." It may also be noted that image-schema redescription requires only perceptual experience; it does not require the physical manipulation of the environment that Piaget thought was necessary to transform sensorimotor schemas into thought. Skill in handling objects *is* a slow development in infancy and one that may have misled us about the conceptual accomplishments that are taking place.

Thus, I am proposing a three-tier architecture that develops during infancy: perceptual (sensorimotor) procedures used to recognize objects and events, redescrptions of the information so encoded into image-schemas, followed by further redescription of the image-schemas into language. The mapping of objects and events into image-schemas involves the loss of detailed information but preserves selected aspects of their spatial structure. The simplified, but still analog, schemas that result constitute the essence of the prelinguistic understanding of objects and events. The mapping of spatial structure into image-schematic form does not seem like an unduly difficult processing task; indeed, I understand that Lakoff (personal communication) has developed a connectionist program that derives image-schemas from perceptual input. Thus, it is plausible that this kind of redescription could accompany the type of perceptual learning that is taking place during infancy. Further, as I will try to show, the kinds of concepts that we have reason to believe are being formed in infancy are remarkably well represented by image-schema notions.

Animacy

I will use the notion of animal to illustrate the function that image-schemas can serve for the preverbal infant. On what basis do infants distinguish animals from non-animals? Although we do not know exactly, I propose the following hypothesis. First, infants on a purely sensorimotor basis learn to distinguish objects that engage in biological motion from those that do not. Work by Bertenthal and his colleagues (e.g., Bertenthal, Proffitt, Kramer, & Spetner, 1987) shows that infants can distinguish the motion of people from related but nonbiologically correct motion as early as 3 months. I am taking a further step here by suggesting that perceptual categorization of biological motion in general may occur, much in the way that categorization of phonemes or faces occurs. These categories are perceptual, i.e., sensorimotor, in nature, however, and we are searching for a conceptualization of them. How might the category of animal be conceptualized? We know from Leslie's work that infants are also sensitive to the difference between caused and noncaused motion. I suggest that infants, through the process of perceptual analysis, notice that those objects which move in one way start up on their own and that objects which move in another way do not, but instead are caused to move. Here is a beginning redescription of the class of biologically moving objects. The

infant may not be able to conceptualize the motion itself very well, but can conceptualize that these are the kind of things that start up on their own.

There are other important aspects of motion that may enter into the initial conceptualization of animate objects, such as the fact that the self-starters engage in contingent motion vis a vis other objects from a distance, whereas the nonself-starters never respond contingently from a distance. I have described this aspect of the concept of animacy elsewhere (Mandler, 1990). Here I want to develop the notion of "start up on its own" or "caused to move" in a little more detail.

To say that an object starts up on its own is to concentrate on the beginning of its trajectory. Many of the image-schemas that cognitive linguists have described involve trajectories; indeed, the simplest image-schema seems simply to be that of PATH: an object moving through space without regard for the nature of the motion. However, a trajectory must begin motion in some way, and there seem to be two crucial ones: either it starts independently of any other object, or another object (trajector) "runs into" it. I am proposing that one aspect of subjecting a trajectory to perceptual analysis is to describe its beginning in one of these two ways. In the case of the class of animate objects, the description is an image-schema representing SELF-MOTION. This schema, which I illustrate below in a crude sketch, is what self-motion means; there is no simpler or more direct representation of the idea. For example, if you are not allowed to use words, about the best thing you can do to communicate the meaning of self-motion is to put your hand (A, in this example) at rest and then move it. It is something like that I am attempting to illustrate in this sketch. (Needless to say, the sketch itself is only for communicative purposes and is not meant to delineate the actual image-schema representation. Although I assume that image-schemas are used in the formation of imagery, they are not themselves images).

SELF-MOTION
A

It seems likely that in addition to redescribing the way that animate objects begin their trajectories, infants also redescribe something about the character of the trajectory itself. Such redescription may be optional and in any case it must be fairly crude. Even as adults we are poor at describing how animate objects move. The parameters that are involved are apparently still not well understood even by workers in the field of robotics, although I understand they involve such factors as coupled oscillations of limbs and various changes in the center of gravity as motion proceeds (see Wilson, 1986). The point is that if these aspects of motion are not known to the average adult, they cannot be part of a *concept* of what animate motion looks like.

In spite of not being able to conceptualize animate motion accurately, adults can make detailed perceptual judgments as to whether something is moving in an animate fashion or not. Stewart (1984) has shown that we make such judgments in part on the basis of the contrast between motion that is in accord with or violates Newton's laws of motions. One type of violation of Newtonian motion involves irregular or unpredictable paths, and that may be all that infants conceptualize. Thus, if we assume that infants analyze something about the nature of a trajectory in addition to its onset, we would have an image-schema representing ANIMATE MOTION that can be summarized by the following sketch:

ANIMATE MOTION

Caused motion and inanimacy

Infants appear to be inordinately attracted by all moving objects, and of course, many of these are inanimate. Inanimate objects are those that begin motion only through the interaction of other objects; specifically, they are caused to move. The following sketch illustrates an image-schema of a simple case of caused motion: that of launching. A trajectory ends (or shifts) its path at the place and point in time that trajectory B begins its path.

CAUSED MOTION

This is exactly the type of causal motion that Leslie (1988) showed infants to be sensitive to. That is, they categorize this kind of motion as a different type from one in which there is a gap (either spatial or temporal) between the end of the first trajectory and the beginning of the second. Leslie suggests that this "causal perception" is the foundation on which a concept of causality develops. In addition, I am suggesting it is also one basis on which the concept of inanimacy develops. Of course, there are inanimates, such as cars, that appear to move on their own. Although one might expect this to lead to a mistaken opinion of the animacy of cars by young infants, it should be noted that cars move on nonbiological paths, (i.e., they do not follow the image-schema for animate motion) so any such mistake should not be long lasting. If such a mistake does occur, our data suggest it has been corrected by 9 months of age (Mandler & McDonough, in preparation).

The concept of agency

The type of launching I have been discussing is mechanical in nature, as in the case of one billiard ball hitting another. But of course animate objects can cause objects to move as well, and it seems likely that this is observed even more frequently by young infants. An image-schema representation of agency can be constructed fairly simply by combining the image-schemas of ANIMATE MOTION and CAUSED MOTION. The following is a rough illustration of an image-schema of AGENCY:

AGENCY

We do not know when such a conceptualization might arise in infancy. It has usually been suggested that a concept of agency is a fairly late development. However, this image-schema does not seem markedly more complex than the others I have described, so we can speculate that the notion might be created from perceptual analysis relatively early. Leslie (1982, 1984) has provided some data that support such an assumption. He studied infants' reaction to hands that picked up objects. In one experiment, 4- and 7-month-olds watched a film of a hand picking up an object. When they then saw another film of the hand picking up the object without making contact with it, they appeared to be surprised. Of course, even by 4 months of age, infants must have begun to form perceptual schemas of hands

interacting with objects and so we perhaps should not be surprised at this reaction to a violation of expectations. Yet, in another experiment Leslie (1984) found that 7-month-olds did not show the same reaction when a block of wood was involved. They watched a film of a block of wood picking up an object. When the film changed to a block of wood picking up the object without making contact they did not show any particular surprise. Such an event should also create a violation of expectations, if the infants had not already been habituated to an equally anomalous event: blocks do not pick up objects with or without contact. Taken together, these findings suggest that by 7 months, infants have learned something about the notion of agency.

The concepts of containment and support

Before returning to the issue of language acquisition, I will briefly discuss two other early concepts that can be represented in image-schema form. These are the concepts of containment and support relations, or "in" and "on". Lakoff (1987) and Johnson (1987) have presented analyses of the image-schemas involved in the notion of containment, and Brugman (1988) in her work on the linguistic uses of the term "over" includes image-schemas that describe support relations. All I want to add here is that these notions also appear early in infancy. Freeman, Lloyd, & Sinha (1980) showed that 9-month-olds are less apt to become confused in an object-hiding task when a container is used as the hiding place; they suggest that infants have learned that containers are places where things disappear and reappear. Similarly, Kolstad and Baillargeon (1990) showed that 10-month-olds understand that containers must have bottoms to hold things. The latter is actually rather sophisticated; one might speculate that an earlier notion of containment would more likely be that described by Lakoff (1987) as the CONTAINER image-schema: merely an interior, exterior, and a boundary between. Thus, a simple CONTAINMENT schema might be represented as an object, X, in an at least partially enclosed space:

CONTAINMENT

However, the most recent research on this issue (Kolstad, 1991) shows that even 5.5-month-olds are surprised when containers without bottoms hold things. This finding suggests that the earliest notion of containment may include a notion of support as well as the aspect of being (largely) surrounded. Containers, of course, often have the property of opening and closing, which means the degree of surroundingness varies from time to time. Piaget (1951) documented the way in which his children from 9 to 11 months used the notion of opening and closing in an analogical fashion to understand what was happening when he blinked his eyes. In response to his modeling this action they sometimes opened and closed their hands and mouths before they learned to perform the correct imitation. It appears that they were using an already formed image-schema as an analogical aid in learning to imitate a bodily action they could not see themselves perform.

About the only information we have on the development of a concept of support is a study by Baillargeon and Hanko-Summers (1990) showing that 8-month-old infants are surprised when support relations between blocks are violated. A primitive SUPPORT image-schema might require only a representation of contact

between two objects in the vertical dimension. I offer here a sketch of a primitive image-schema of SUPPORT, in the form of an object, X, above and in contact with a surface:

SUPPORT X

According to Baillargeon, 8-month-olds only represent the presence or absence of contact and not until later do they represent how much overlap in surfaces is required to maintain support. That is, considerations of gravity or weight distribution do not yet appear to be involved. Thus, the earliest notions of both containment and support may be quite simple, and in my opinion could be derived from equally simple redescriptions of the events that infants experience on a daily basis.

Image-schemas and language acquisition

Image-schemas, based on a redescription of the spatial structure infants experience every day, would seem to be particularly useful in the acquisition of various grammatical notions in language. Cognitive linguists have proposed image-schemas as the basis of understanding modals (e.g., Sweetser, 1990; Talmy, 1988), prepositions (e.g., Brugman, 1988), verb particles (Lindner, 1981), tense and aspect (Langacker, 1987) and presuppositions (Fauconnier, 1985). These are some of the aspects of language acquisition that have seemed most difficult to explain in accounts that assume a relatively impoverished conceptual base in infancy. Yet Brown (1973) and others showed that a number of relational morphemes, such as the prepositions "in" and "on", possession, and the progressive aspect of verbs, are early acquisitions. Others, such as linguistic transitivity, follow shortly thereafter. Each of these seems relatively easy to account for if we assume that image-schemas representing these notions are well established at the time that language begins. For example, image-schemas of CONTAINMENT and SUPPORT should make the use of the prepositions "in" and "on" just as obvious to a child as that a particular object is called by a given name. Indeed, "in" and "on" are not only the earliest prepositions to appear in child speech, but apparently are learned in errorless fashion (Clark, 1977; Johnston, 1988).

The acquisition of quite abstract notions, such as linguistic transitivity, also seems less difficult to understand when their image-schematic basis is emphasized. Slobin (1985) has pointed out that linguistic transitivity tends to be underextended in early child language. In its first appearances in speech, transitive marking occurs only when the child is talking about someone manipulating inanimate objects. Slobin calls this situation the prototypical manipulative scene. According to the account given here, an animate object causing an inanimate object to move is the easiest to represent because it conforms most closely to the image-schema of AGENCY; no metaphorical extension to less movement-like paths is required.

Similarly, Slobin notes that at first only inanimate patients are given accusative markings, and that when a language uses different accusative forms for animate and inanimate objects, this is a difficult distinction for children to learn. Such difficulties are potentially as informative as the ease with which the prepositions "in" and "on" are learned. The simplest image-schema for an inanimate is that it is something acted upon and that does not act itself. It must take further analysis to think of animates as objects that can be acted upon as well.

Many other early grammatical morphemes, such as possession and the progressive aspect, can be simply described in terms of image-schemas that represent END-OF-PATH and TRAVERSAL-OF-PATH. Just as focus on the beginning of a path emphasizes the animate or inanimate character of an object, focus on the end of the path emphasizes its destination. In a primitive sense, the location where an object comes to rest is where it "belongs." The destination of an object is often expressed by the dative, and it is of interest that confusions between the going-to and the belongs-to sense of "to" have been reported in young German speakers (Mills, 1985). I have observed an English speaking child whose first use of the term "my" appeared to refer to himself as destination for an object, rather than to the more complex social aspects of possession found in adult meanings (Slobin, 1985). Such observations suggest that destination, in the sense of where objects end up, may form the earliest meaning of possession. In similar fashion, focus on an object's path, rather than its beginning or end, emphasizes the ongoing trajectory itself, and could well form the basis for the early understanding and acquisition of the progressive aspect of verbs in English.

I have discussed only the simplest of image-schemas here. Yet these very simple notions can be used not only to represent early conceptual constructions, but they also form the foundations for more sophisticated variants that occur slightly later in development. They also appear to be useful in understanding early grammatical acquisitions. So in a search for a representational format for preverbal concepts, we find a representational format that also can serve as a bridge to language. This is a serendipitous result of a quest that was originally motivated by the need to account for the appearance in infancy of concepts such as animal and vehicle. If we can find a single mechanism that relates the course of learning in two different fields, we may be able to develop a comprehensive theory that encompasses both.

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