PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Precursors of Linguistic Knowledge

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Precursors of linguistic knowledge

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SUMMARY

It is agreed that infants require pre-existing conceptual meanings to learn language, although little is known about what those meanings are. By default they have been assumed to be the sensorimotor schemas described by Piaget. However, sensorimotor schemas are not concepts and are not the right sort of representation for learning language. Recent research shows that along with sensorimotor schemas infants are simultaneously developing a rich conceptual system. I have proposed that these concepts are represented by sets of image-schemas, each of which represents a meaning. Image-schemas are created by a process of perceptual analysis that redescribes perceptual information into simplified spatial representations. These representations allow language to be learned by providing an analogue–digital interface between the continuous process of perception and the discrete propositional forms of language.

1. PREVERBAL REPRESENTATION

Until recently it has been widely assumed that the first year and a half of human life consists of a sensorimotor period during which a conceptual system does not yet exist. This assumption comes from Piaget's theory of cognitive development (Piaget 1952), in which infants are said to be capable of learning perceptual categories and motor routines, but incapable of forming either concepts or images. These restrictions on early mental life imply that babies cannot think, recall the past or anticipate the future. However, both experimental and theoretical work during the past decade suggests that this view of the foundations of mind is too narrow. The first year of life is far from an exclusively sensorimotor stage of development. Instead, the higher cognitive functions are already developing, simultaneously and in parallel with the sensorimotor system (Mandler 1988).

During infancy the foundations of the major conceptual domains are laid down (Mandler & McDonough 1993). For example, by seven months of age infants are beginning to distinguish conceptually between animate and inanimate things, and within a few months have carved out domains that separate animals from plants, vehicles from furniture, and so forth. By the end of the first year infants are making inductive generalizations about these domains, and showing at least some signs of inferential thought. The episodic memory system is also being laid down during this time; for example, by 11 months infants can recall novel events after long delays (Mandler & McDonough 1994).

Such data indicate that the higher cognitive functions are operational before the end of the first year. This description will not surprise those working in language acquisition, because both comprehension and production of language have begun by a year and it is generally assumed that language is mapped onto a conceptual base. However, the description does reveal a conflict between traditional views of cognitive development and language learning. If year-old infants do not yet have a conceptual system, how is it that they can learn language? Because Piaget also assumed that language rested on a conceptual base, the fact that infants begin to talk before the end of the sensorimotor stage was inconvenient for his theory. His solution was to describe early language as just another type of sensorimotor schema, but this approach does not seem entirely satisfactory.

Piaget did discuss at length how sensorimotor schemas might be transformed into conceptual (symbolic) representation, but he did not specify how this new form of representation differed from the old, nor did he relate it in any detailed way to language learning. The result is a gap in his theory that is only now beginning to be filled. Developmental psychologists for the most part did not investigate concept formation during the prelinguistic period, because it was not supposed to exist. Linguists, on the other hand, tended to take such descriptions as were available as the base for language acquisition. By default these tended to be descriptions of sensorimotor schemas, not conceptual descriptions. For example, Uzgiris & Hunt (1975) developed sensorimotor scales to measure developmental accomplishments from early infancy into stage 6 of the sensorimotor period (18–24 months), when conceptual thought was supposed to begin. Unfortunately, these scales do not differentiate sensorimotor from conceptual functioning; early items are clearly sensorimotor in character and later items are a mixture of sensorimotor and conceptual processes. As a result, statements about the concepts onto which language is mapped were often

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vague, and it was not clear exactly which linguistic function each of the scales was to support. Not surprisingly, then, this line of research did not turn out to be very informative.

There are, of course, many aspects of language learning. The ones I consider here have to do with meaning, not only the meanings of individual words but also the meanings involved in the syntax that puts words in relation to each other. It is generally assumed that learning names for things is the easiest linguistic task. It is also one of the few tasks that may be accomplished mainly on the basis of sensorimotor schemas. Learning labels for the objects commonly found in the child's environment presumably makes use of perceptual categories, which are a part of sensorimotor functioning. Children have perceptually categorized a great many types of objects by the time language begins. Perceptual categorization does not require much if anything in the way of conceptualization; it is simply part of the way that the perceptual system functions. Such perceptual categories may be sufficient for the ostensive learning of nouns. That is, it may be possible to attach labels to objects that look alike in the absence of meaning. It is quite another matter, however, to put these labels into sentence frames.

Sensorimotor knowledge is not the right sort of representation for learning the relational aspects of language. Sensorimotor schemas are dynamic structures controlling perception and action, not meanings onto which relational morphemes can be mapped. The following example illustrates the difficulty. Two of the earliest grammatical morphemes to be learned in English are the prepositions 'in' and 'on'. What are the preverbal meanings the child uses to understand these prepositions during their acquisition? Let us assume for purposes of the argument that the child has no concepts of containment, contact, or support, only a variety of sensorimotor schemas controlling actions such as pouring liquid into a container or putting an object on a surface. These schemas do take knowledge of containment, contact, and support into account in the sense that they monitor whether a container is filling up or an object is making contact with a surface with the right amount of force. But these are continuous and context-bound parameters and not relationships that have been isolated from the particulars of the stream of action and generalized as moveable units applicable to other situations. Unless the child has analysed these notions as units, separable from the context in which they are instantiated, there cannot be said to be meanings onto which the linguistic expressions can be mapped.

Thus, sensorimotor knowledge is not sufficient to the task at hand. An interface is needed between sensorimotor activity, with its continuously changing dynamic parameters, and the discrete propositional system of language. There are at least two characteristics such an interface should have. First, it should provide a simplification of preverbal experiences. The experiences themselves are both too rich and too particular; their generalizable aspects need to be distilled and summarized. This simplification is needed not only because language must squeeze meanings into very small packages but also in order to be able to think. The infant does not wait for language to begin thinking, and thus the problem of packaging meanings into manageable form is a prelinguistic one.

Second, the interface should be in a form onto which a discrete symbolic system can be mapped. Although a popular assumption about this second criterion is that to meet it requires positing a propositional language of thought (Fodor 1975), a propositional preverbal system does not seem to be necessary. It is not necessary for purposes of concept formation, as will be discussed below. Nor is it necessary for image formation, preverbal recall, or simple analogical reasoning either. In fact, it is quite possible that propositional representation simply does not exist in the human mind until language is learned.

2. IMAGE-SCHEMAS REPRESENT PREVERBAL MEANINGS

Most of the time when people look at things, they do not attend to the details of what they see. The information that is encoded during the course of this ordinary kind of perception is stored, of course, whether or not we attend to it; indeed, it is this information that accumulates to form perceptual schemas and prototypes. However, a different process occurs when we attend to what we are looking at and analyse what we are seeing. I have hypothesized that it is during such attentive looking that babies first create meanings (Mandler 1992). A process that I call perceptual analysis allows them to abstract salient spatial relations and movements from the displays they observe. This mechanism operates throughout life, but the difference between babies and adults is that adults have an existing conceptual system to use to redescribe what they are seeing into conceptual terms. For babies it is a way of gaining conceptual knowledge in the first place. Indeed, until they can learn by means of language it is the only way for them to create concepts.

It is easy enough to observe the difference between looking and attentive looking in babies; a number of psychologists have commented on it (see, for example, Werner & Kaplan 1963). However, at present we can only speculate as to exactly what is happening during those episodes when babies are analysing an object or scene. Piaget (1951) provided a few descriptions of perceptual analysis and its outcomes in his account of his infants learning to imitate. For example, he observed on several occasions that they were first able to imitate a complex gesture shortly after having analysed similar movements that they made themselves. Even if preverbal meanings are acquired in some other way, however, the issue of their representation must be faced. Whatever one's theory of concept formation in infancy, one cannot simply say that sensorimotor knowledge has been transformed into conceptual knowledge. One must specify the format of the new kind of representation; there must be some vocabulary or set of elementary meanings from which concepts are composed.

The kind of format that I have found useful for describing preverbal meanings is that of the image-schema (see, for example, Johnson 1987; Lakoff 1987). Image-schemas are analogue representations of spatial relations and movements in space. Depending on the particular writer, their dynamic or kinetic qualities have been emphasized. For example, Johnson emphasizes the kinesthetic and forceful basis of image-schemas, grounding them in our experiences of moving through the world, encountering and overcoming obstacles, feeling our bodies as containers with insides and outsides, and so forth. I, on the other hand, believe that a developmental account of meaning is necessary, and so I have emphasized the properties of the world that even very young babies can analyse (Mandler 1992). Young babies are not yet capable of manipulating objects or moving through the world, and I believe they would find it difficult to analyse their internal experiences. In contrast, there are many salient spatial properties of visual experiences that should be relatively easy to isolate and extract from a given display. This may be especially true for the analysis of moving objects, since babies are adept at deriving structure from motion (Kellman 1993).

If babies are to derive a concept of containment, for example, I would expect it to be easier to accomplish by watching things going in and out of containers than by analysing what happens to food when it enters their mouths or by analysing static containment configurations. The image-schema CONTAINMENT has most often been discussed as consisting of an inside, an outside, and a boundary between (see, for example, Lakoff 1987). For this image-schema, as for many others, there appear to be families of related meanings, such as 'in', 'out', 'going in', 'going out', etc. It may not be possible to say which of these notions is primary, but the earlier an image-schema is formed, the more likely it is to be based on kinetic rather than static or dynamic information, because infants process kinetic information most easily. Similar comments can be made about image-schemas of CONTACT and SUPPORT. Although information about these notions is available to babies from static displays, it seems most likely that the occasions that provoke the analysis necessary to extract these meanings are those in which objects come into contact or are put on or taken off a supporting surface. For example, by three months of age babies have already begun to learn that objects that lose contact with a surface will fall unless they are supported by something else, such as a hand (Baillargeon *et al.* 1992). As for analysing their own bodies moving off a supporting surface, the dramatic results of such movements might preclude perceptual analysis!

Each of the relations of contact, containment and support (along with many others) can be represented by separate image-schemas. That is, each image-schema provides a representation of a single preverbal meaning. However, meanings combine and do so in different ways in different languages. For example, Korean is a language that tends to use verbs where English uses spatial prepositions. In Korean, containment, contact, and support are combined to form a trinary set of related verb meanings representing 'putting in loosely', 'putting on loosely', and 'fitting together tightly' (Choi & Bowerman 1992). Here the contrasts that are made are between containment and support, just so long as the contact is a loose one. When the contact is tight-fitting, and thus both containment and support are involved at the same time, Korean emphasizes only the tightness of the relation. I have hypothesized that preverbal infants are quite familiar with all these relationships, but of course they must learn which ones their language packages together (Mandler 1992).

One of the simplest image-schemas is that of PATH, representing any object moving through space on any kind of trajectory. Because motion is so prominent in analyses of objects in space, we should expect PATH to combine in many ways with other preverbal meanings. A good example is the combinations that form a beginning concept of animal. Even very young babies parse the world into objects as bounded things, separable from the background, and watch them move through space. Indeed, for the youngest infants perhaps all they encode from a typical perceptual encounter is that some thing went from here to there. By three months of age, the characteristics of the trajectories that are associated with animate objects have begun to be perceptually categorized (Bertenthal 1993). I assume that a similar categorization takes place with inanimate objects, although the relevant data have not yet been collected. Once categories of animate and inanimate movement have been formed, they can then be used as the perceptual bases around which other characteristics of animate and inanimate objects are organized. For example, one characteristic of a moving object that is easy to isolate is the way it begins movement; it can either start up on its own or start up only when another object contacts it. An analysis of these aspects of moving objects would result in image-schemas of SELF-MOTION and CAUSED MOTION. By four months babies are responsive to this difference (Leslie 1984).

In addition to moving in a particular kind of way and starting themselves, some objects interact with other objects from a distance. Other objects, those that move in more regular ways and get started only when something else contacts them, never respond to other things from a distance. This particular set of meanings depends on observing contingent movement in the environment, something that babies also begin to do from an early age. I have suggested that this kind of contingent movement is represented by a LINK image-schema, consisting of linked paths. As early as two months babies are responsive to this difference between animate and inanimate objects (Legerstee 1992).

A combination of these simple meanings is sufficient to provide a beginning concept of animal. In my laboratory we find that from about seven months, infants are able to conceptualize animals as a class and as different from vehicles, whereas they typically have difficulty conceptualizing one kind of animal as different from another (Mandler & McDonough 1993). We also find that by eleven months, babies conceptualize animals as different from plants, whereas other data on slightly older infants indicate that they do not yet conceptualize differences between one kind of plant and another (Mandler *et al.* 1991). A similar process happens with utensils and furniture. It seems that babies begin their concept formation by making global cuts in the environment, dividing the world into broad conceptual domains, such as animals, plants, and vehicles. It is not yet known how rapidly such differentiation takes place, although our work suggests that it may be well into the second year before a great deal of progress is made.

Our current work on induction of animal and vehicle properties reinforces this interpretation of early concept formation. At 14 months of age, infants generalize animal properties such as sleeping and eating across the entire animal domain, without being influenced by the similarity of one exemplar to another. For example, if we show children a dog sleeping in bed, they will generalize this action to rabbits or birds, but not to vehicles. Similarly, they will generalize properties such as giving a ride or being opened with a key from cars to motorcycles and airplanes, but not to an animal. We do not yet know when children begin to narrow the categories they use for inductive generalization, although the work of Gelman & O'Reilley (1988) indicates that subclasses begin to be preferred over superordinate classes for purposes of generalization by the preschool years.

This picture of concept formation in infancy is quite different from the currently popular view that the first kinds of concepts to be formed are so-called basic-level concepts, such as dog and rabbit. Mervis & Rosch (for example, in 1981) claimed that basic-level concepts are primary and only later are superordinate concepts such as animal formed out of their basic-level constituents. Aside from the fact that there has been no satisfactory definition of 'basic-level', the notion that concepts such as dogs and rabbits are the first to be formed mistakes perceptual categorization for concept formation. It is true that babies of even a few months can see the difference between dogs and other animals (Quinn *et al.* 1993). However, our data indicate that infants begin by conceptualizing both dogs and rabbits as animals before knowing enough to conceptualize them as individual classes in their own right. Of course, the kind of concept of animals I have been describing is a far cry from a true superordinate class. Since babies initially understand animals as a relatively undifferentiated category, we call it a global concept, rather than a superordinate one. This global concept, as I have indicated, probably consists of a very simple set of meanings, such as something that moves in a particular kind of way, starts up by itself, and interacts with other objects from a distance. Nevertheless, these simple meanings appear to be the core around which later knowledge about animals is organized. It also appears that this kind of basic core is the last bit of knowledge to be lost in cases of semantic dementia (Saffron & Schwartz 1994).

3. MAPPING IMAGE-SCHEMAS INTO LANGUAGE

If global concepts such as animal and vehicle are the first to be formed, with conceptual differentiation into subclasses lagging well behind, then why are the first labels to be learned those for subclasses such as dog or rabbit? First, children can only learn the language they hear and when parents begin labelling objects for children they almost invariably use basic-level terms. Second, I suggested earlier that object labelling is the case in which language can be mapped directly onto perceptual schemas. Depending on exposure, infants as young as three months have acquired perceptual schemas of a variety of animals such as dogs and rabbits. These schemas are perceptual patterns with prototype structure that have little if any meaning associated with them. Over the next few months the global concept of animal is acquired, thus bestowing some very general meaning to dog-patterns and rabbit-patterns alike. When parents start naming dogs and rabbits, however, the language they use provides a stimulus for acquiring new meanings. They are telling children that these perceptual categories differ in other ways than their appearance. The differential labels direct their attention to analysing dogs and rabbits for further meaning, thus stimulating concept formation at the so-called basic level.

This kind of parental labelling is of little use, however, for the acquisition of grammatical morphemes and sentential structure. Here, as I discussed earlier, is where sensorimotor schemas begin to fail as a basis for language acquisition. Sentences describe situations and events that put objects in relation to each other. Now meaning becomes essential. I suggested that, in the course of analysing objects, babies have extracted meanings such as animate and inanimate thing, self-motion, and caused-motion. A combination of these analyses forms an image-schema of AGENT as a self-moving object that causes another object to move. For example, Leslie (1984) showed that babies as young as four months are surprised when a hand moves an object without making contact with it. Thus, the simple spatial analyses that result in the concept of animal are also used to attain the meanings that underlie one of the most basic structures of natural language, namely, the simple declarative sentence in which an agent acts on a patient. These same analyses also underlie the distinction between verbs of self-motion and causative verbs.

Indeed, it is surprising how many of the relational structures of language have an underlying spatial basis of the sort readily described by image-schemas. I have already mentioned the spatial basis of verbs of self-motion and caused-motion. (These are not necessarily distinguished in English, but are differentially marked in many languages.) These are the types of verbs that prototypically differentiate intransitive and transitive verb phrases. Slobin (1985) has shown

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that marking this distinction is one of the earliest grammatical forms that children acquire in various languages of the world. For example, Choi & Bowerman (1992) note that Korean children differentiate causative verbs from verbs of self-motion from their first appearance in their vocabularies and do not make category errors in their usage. Similarly, they learn the obligatory distinction between animate and inanimate nouns equally early and also without error (Choi 1992).

Although the distinction between transitive and intransitive verb phrases is abstract it depends on concepts of animacy, inanimacy, self-motion, and caused-motion. It is interesting that even though children learn these verb frames in their language very easily, they often underextend their marking of them. Slobin (1985) has pointed out that whether the language marks transitive verb phrases by accusative inflections, direct object markers, or ergative inflections, the marking occurs at first only when children are talking about an animate agent physically acting on an inanimate object. Only later do they learn to apply transitive verb frame markings to the full range that the language uses.

We can also see the role of spatial meaning in verb forms such as those that refer to ongoing action (as in the progressive '-ing' in English) or completed action (as in the morpheme 'le' in Chinese). These forms emphasize different aspects of PATH. In addition, the verb stems themselves that are typically learned first describe paths rather than states. Image-schemas provide an overall sketch of the paths of motion described by these verbs, leaving out the details. This initial emphasis on the overall shape of a path (as in the downward motion that 'fall' implies) allows young children to extend their usage of a verb beyond the particulars of its initial encounter to new situations (Golinkoff *et al.* 1994).

Then there are prepositions, the vast majority of which express spatial meanings (Landau & Jackendoff 1993). Even prepositions that do not at first glance have to do with space have often been given a spatial interpretation, either in their historical derivation or in the meanings given to them by young language learners. For example, most prepositions expressing temporal relations were borrowed from terms that were initially spatial in meaning (such as 'before', 'after', and 'ago'). Children apparently initially interpret prepositions indicating possession (such as 'belongs to') as spatial, in the sense that they interpret the meaning as having to do with the endpoint of a trajectory of an object (Mandler 1992; Mills 1985). Both time and possession are abstract meanings, not easily analysed. Giving them a spatial interpretation may be the first step on the difficult road toward understanding them.

Because there have been so few studies of prelinguistic primitives, we do not at this point know how many spatial analyses have been carried out at the time that language begins. Spatial relational terms, such as the prepositions in English, are a case in point. The two earliest prepositions English-speaking children learn are 'in' and 'on' (Brown 1973). In fact, with the exception of the progressive '-ing', these are the earliest grammatical morphemes that English children learn. These prepositions are not only learned early, children also tend to use them from the beginning without error. On the one hand, the ease with which they are learned suggests that they can be mapped directly onto image-schemas of CONTAINMENT, CONTACT, and SUPPORT. On the other hand, there are other ways of expressing these relations in other languages that are learned equally effortlessly and also without error. For example, German makes a two-way distinction in support relations, depending on whether a horizontal or vertical surface is involved. Spanish, on the other hand, combines containment and support into a single all-purpose preposition 'en'. Other languages, such as the example in Korean I discussed earlier, emphasize either containment or support but supersede them both when the containing, contacting, supporting relation is a tight-fitting one.

To my knowledge children in all these languages learn to express the relevant prepositions or verbs equally effortlessly. I assume that is because the prepositions, although packaging spatial relations in somewhat different ways, are none the less making use of preverbal analyses all children have made. It seems odd to English speakers to emphasize tightness as Korean does. The relation itself is not odd, of course. Even young children have had a great deal of experience with it. They play with pop-beads, they see caps going on pens, and experience clothes fitting tightly over their heads. It would be surprising indeed if they did not have available a meaning that would make transparent the import of the relevant Korean expressions. Indeed, this example illustrates how troubles can arise just because of the preverbal meaning of tightness. Young Korean children's use of the verb for tight-fitting to the case of tight clothing is actually an overextension of the preverbal meaning, since Korean uses another word to express clothes going on the body.

The interesting thing about these different ways of combining meanings is that each language picks a small subset of possible combinations. Most of the distinctions are binary or trinary. (One exception is the Mixtec use of body parts to locate objects, a variant of the more frequent contact and support relations used in other languages (Bowerman 1989). Even here, however, the number of options for expressing location is small.) These restrictions are often considered to be a characteristic of language itself. For example, Newport (1982) has pointed out that sign languages have a golden opportunity to express the continuous nature of motion in a way that an aural language cannot. Nevertheless, sign languages do not take advantage of the spatial medium in that way, tending to use discrete components instead. Although this might be considered a restriction that language imposes on itself, in my opinion it occurs because it is a characteristic of the meanings that have been formed before language begins. If motion has already been reduced to sets of binary or trinary distinctions, then language may simply conform to those sets of meanings. A given language has freedom to choose how to package these meanings, but not necessarily to work with meanings that are unrelated to preverbal experience.

Children learn a great many spatial relations preverbally. When it comes time to learn their native tongue, they must learn how their particular language packages these preverbal meanings, but it would be much more difficult for them to learn distinctions that they have never thought of. It is not impossible to learn an utterly new concept by tuition, but it is a painful and typically protracted process compared to the relatively effortless way that young children learn to interpret the language patterns they hear. The ease of learning may be the crucial point; it would be hard to understand how infants could learn without error if they were acquiring totally new meanings. On the other hand, if they are learning how language packages meanings they already know, this should not pose as much of a learning problem.

I have described the conditions under which preverbal children derive meanings. These meanings provide a tertium quid between perceptual and motor knowledge on the one hand and language on the other. It may be that many of the characteristics of language are due to the nature of that middle tier of meanings rather than to the propositional nature of language itself. Looking at the world and moving around in it provide continuous analogue information, but the attentive or aware mind is a great simplifier: it derives meanings that are still analogue but tend to form contrasting pairs or triples. I have discussed a number of these, such as animate vs. inanimate, self-motion vs. caused-motion, going in vs. going out. There are of course many more: up vs. down, part vs. whole, and as I have discussed, tight-fitting vs. loose-fitting. All of these relations are easily represented by image-schemas. The fact that they are combinable units in the form of highly schematized oppositions makes it possible for preverbal children to think about what would otherwise be overwhelmingly complex information. It also means that these meanings are well adapted to be mapped into natural language, or perhaps I should say to which natural language is well adapted. These considerations suggest, as others have also argued (see, for example, Bates *et al.* 1991), that language is not unique in many of its attributes, but is built on a pre-existing cognitive foundation and makes use of many general processing characteristics of the human mind.

This approach lessens the necessity for ascribing to the human mind what sometimes seems to be an ever-increasing list of innate characteristics, whether these be innate meanings or innate aspects of language. In the processing system that I have described, meanings are not inborn but are derived from analysis of the information in perceptual displays. Such analyses continue throughout life and provide an alternative to language for constructing new concepts about the world. In addition, as cognitive linguists have amply documented, the image-schemas that result from analyses of space are applied to the understanding of non-material realms as well. Our vocabulary of terms for thinking and talking about abstract ideas and mental processes seems to be analogically derived from the easier-to-analyse physical world (see, for example, Johnson 1987; Sweetser 1990). Much adult thought is language-saturated, but we must not be misled thereby into assuming that propositional representation is the only format for the mind.

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