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# Thought before language

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**To learn language infants must develop a conceptual base onto which language can be mapped. Recent research in infant cognitive development shows that at least by 9 months of age infants have developed a conceptual system sufficiently rich to allow language to begin. Evidence for this system is shown by categorization of objects above and beyond their perceptual appearance, problem-solving, long-term recall of events, and inductive inferences. During the next year, early concepts gradually become refined. However, at the time when language takes off they are often still less specific than many words in daily use, accounting for the phenomenon of overextension of word meaning.**

This review outlines the extensive evidence now available for conceptual thought before language, and discusses the varied uses to which preverbal concepts are put: problem-solving, recall, inferential thought, and, of course, language acquisition itself. Until recently, it was considered established that babies are purely sensorimotor creatures who have not yet created a conceptual system and so cannot think. According to Piaget [1], infants learn many motor and perceptual skills in the first year, but not until midway in the second year do they begin to acquire the conceptual system that will enable them to recall the past, learn language, and engage in mental problem-solving. Motor and perceptual skills, including perceptual categorization, are classic examples of procedural knowledge (sometimes termed implicit knowledge), whereas recall and mental problem-solving are classic examples of declarative (sometimes termed explicit knowledge) [2,3]. The latter kind of knowledge requires an accessible conceptual system.

The aim of this article is to summarize some of the literature indicating that infants are building an accessible conceptual system from an earlier age than traditionally thought. To bring the topic into manageable bounds, it omits the extensive work on infants' learning about basic physical principles, such as that objects are solid and continue to exist when they disappear from sight [4]. Instead it concentrates on concepts more closely related to early language learning: object kinds, simple actions, and spatial relations. For the same reason the brief conclusions about mapping language onto the conceptual base concentrate on early word learning rather than the acquisition of syntax, which follows after the first words.

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## Perceptual categories versus concept formation

Although concept formation might begin at birth, it is difficult to differentiate perceptual learning from concept formation in the earliest months of life. One of the main techniques for studying perceptual learning in the first 6 months is the familiarization/preferential-looking technique in which infants are shown a series of pictures of instances of one category (e.g. cats) and then shown a picture from another category (e.g. a dog) [5]. Longer looking at the dog indicates that a perceptual category of cats (or pictures of cats?) has been formed. The findings with this method have been that by 3 months infants can form 'basic-level' categories of animals, such as dogs and cats, as well as furniture, such as tables and chairs, on the basis of faces or common shapes. There is some evidence that 3-month-olds can form a more global category of mammals as well [6], perhaps also by generalizing across faces.

This use of the preferential-looking technique tells us the sorts of perceptual categories infants can learn, but does not test for concept formation. This difference is important, because much perceptual learning is an automatic procedure (as Piaget understood) that does not require conceptual thought [7–9]. Perceptual categories or schemas are necessary for recognizing instances of a category, but do not in themselves specify what concept the category represents, for example, animate or inanimate things. Some possible ways to get from perceptual schemas to concepts are discussed in Box 1. Nevertheless, some infancy researchers believe that separate perceptual and conceptual processes are not required [10]. In this 'one-process' view, until language teaches unseen characteristics, concepts consist simply of perceptual categories, such as dogs, plus associated perceptions.

In addition to asking how infants learn to recognize dogs or cups, we want to know what they think a dog or a cup is. Some of the methods used to study this kind of conceptual knowledge and its use in preverbal thinking are the object-examination test, which can uncover non-perceptually-based categorization, deferred imitation, which measures recall of the past, generalized imitation, which measures inductive inference (see Box 2), and mental problem-solving (problem-solving without overt trial and error).

## Preverbal problem-solving

Little work has been done on mental problem-solving, but there is some research on means–end analyses in which

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**Box 1. What kind of mechanism can create a preverbal concept?**

Unless concepts are innate, there must be some way to convert perceptual experience into a form that makes thinking possible. One proposal is Karmiloff-Smith's **representational redescription**, in which procedural information is redescribed into a declarative format independent of perception [50]. A related proposal is **perceptual meaning analysis**, a mechanism well suited for preverbal redescription [51]. I proposed this as a mechanism that extracts and summarizes incoming perceptual information, from which it creates a store of primitive meanings that can be combined to form accessible concepts such as *animal*. These meanings are abstract descriptions of what is happening in the scenes infants observe; for example, an object might be described as 'starts to move by itself' and 'interacts contingently with another object.' Such meanings arise from attentive analysis of spatial information and differ in format from perceptual or motor schemas, in that they allow conscious thought.

I suggested that the meanings created by perceptual meaning analysis are represented in the form of image-schemas [51], although there are other formats that could serve the same functions – for example, Barsalou's **perceptual symbols** [52]. Image-schemas are the abstract spatial representations used by cognitive linguists to represent the primitive meanings underlying language [53]. Serendipitously, they also provide a good description of a number of infants' early concepts, in that they emphasize, as do infants, what objects *do* – how they move and interact – rather than their physical appearance. Some common image-schemas are PATH, UP–DOWN, and LINK, and spatial relations such as CONTAINMENT. For example, PATH is the simplest representation of any object moving through space, omitting all details of the object or the trajectory itself. Further analysis will highlight different kind of paths, such as up and down, and animate or inanimate. Herein lie the early conceptions that enable verb learning. Similarly, LINK represents contingencies between events, another aspect of the world that infants learn from an early age. Differences in paths and their links define animals as different from inanimate objects. From such simple beginnings the concepts arise that underpin the learning of the linguistic distinction between agents and patients.

infants create a sub-goal in the service of a main goal. Willatts [11] used a novel two-step problem in which infants had to retrieve a hidden object from under a cover that was beyond their reach at the far end of a pullable cloth. He found that the ability to construct a plan to solve this means–end problem becomes possible between 8 and 9 months of age. Before that time, he suggested, infants learn various sensorimotor routines about how to uncover objects and how to obtain out-of-reach objects by pulling, but have not yet developed the conceptual processes required to work out a complex goal path by thought alone.

**Box 2. Generalized imitation: a method to test preverbal inductive inference**

Inductive inference sounds like a sophisticated accomplishment, but it is basically just a process of generalization. In the generalized imitation technique an event is modeled but instead of providing the same props used for modeling, different objects are provided and infants must choose between them for their imitations. (As in other imitation methods, a baseline period is given first to see what infants spontaneously do with the various test items). A typical example consists of modeling a dog being given a drink from a cup. Then the infant is given the cup, but instead of the same dog, a different dog, or a cat or bird, is provided, along with an exemplar from another category, such as an airplane. Which of these items infants choose (if any) for their imitations gives an indication of the breadth of the concept under study – that is, how far infants have generalized their observations. Imitating a complex event (as opposed to echoing a sound or perhaps mimicking clapping hands) requires conceptual understanding, as amply shown by Piaget [54].

It was recently suggested that imitation does not require conceptual understanding because toddlers do not understand models as symbols for real objects [55]. However, understanding symbols is not necessary for imitation; just as for pretend play, which occurs throughout the second year, all that is required is for the modeled event to bring to mind the relevant concepts. That this happens is shown by toddlers' scale errors, such as trying to sit in a little model chair [56]. Being reminded of what a model represents is only the first part of symbolic understanding; it also requires representational insight (i.e. understanding reference), a process that is still incomplete in the second year [57]. Imitation occurs somewhat earlier than pretend play, presumably because the modeling provides reminder cues and relieves the infant of the need to plan an event.

## Preverbal recall of the past

The first major body of evidence for an accessible conceptual system in the first year of life was obtained from deferred imitation studies [12]. In this technique an event is modeled while infants watch, and after a delay they are given the objects used in the modeling and encouraged to imitate what they observed. Before modeling, as a baseline condition against which to compare post-modeling performance, the objects are given to the infants to see what they spontaneously do with them. The rationale behind the technique is that to reenact an event requires the same kind of conceptualization and retrieval as to retell it [13].

The technique has uncovered the rudiments of declarative memory in infants as young as 6 months, showing that they can reproduce actions demonstrated for them after a delay of 24 h [14]. By 9 months recall memory is robust, and infants can reproduce not just single actions but event sequences after delays of a month [15]. An example from Bauer *et al.* [16] of a 9-month-old reproducing a novel two-step sequence after a delay of a month is shown in Figure 1. By 10 or 11 months, infants can recall sequences after a delay of several months [15,17] and single actions even up to a year later [18]. Recall after weeks or months indicates that memory consolidation processes are at work [19], which is essential to the development of an accessible conceptual system.

That deferred imitation requires declarative knowledge and cannot be accomplished on procedural grounds alone (as happens, for example, in motor learning or in repetition priming) is shown by the fact that it can occur after a delay following single-trial observational learning without any opportunity to practise the response [12]. Older children can also verbalize the events they acted out before they learned to talk [20]. A final piece of evidence is that whereas infants can act out events they have observed in the past, adult amnesic patients, who are capable of being primed by previous experience but incapable of recall, cannot [21].

## Some preverbal concepts

Given that by the middle of the first year infants have begun to form accessible conceptual representations that

**Figure 1.** Recall without words. A 9-month-old recalling a novel two-step event sequence seen several times (but not practised) a month before. To turn on the light, the infant had to drop the car down the L-shaped chute, then push it with the rod so it rolled against the far wall, which turned on the light. Reproduced from [16] with permission of Blackwell Publishing.

they use for recall and problem-solving, the question becomes what these early concepts are like. How do infants characterize the world surrounding them? One test that has been used to investigate early concepts is object-examination. In this test a few small-scale models of a category, such as animals, are given to the infant to examine one at a time. Then a model from a new category, such as vehicles, is given to the infant. Longer examination of the new instance indicates that the infant differentiates the two categories. Although in many ways similar to categorization studies using preferential-looking, the object-examination test frequently gives different results, perhaps because examination requires focused attention, which constitutes only a portion of looking time [22].

The object-examination test has shown that by 7 months, infants differentiate models of animals, vehicles and furniture from each other [23,24]. Because of the within-class similarities in appearance of exemplars from each of these three domains, this finding might be due solely to perceptual categorization. However, 9-month-olds also differentiate birds from airplanes (see Figure 2), which are perceptually highly similar, but at the same age fail to differentiate dogs from fish, which differ considerably in appearance. It has been suggested that the models of birds and planes might have been correctly categorized because all the birds had eyes and all the planes had wheels [10], but this does not explain why infants also found it easy to categorize different kinds of wheeled vehicles whilst failing to differentiate dogs from fish [23]. Furthermore, although 3-month-olds can perceptually differentiate tables and chairs [6], 7–11-month-old infants fail to categorize them on the object-examination test, and only at 11 months are kitchen utensils categorized as different from furniture [24]. No perceptual explanation has been forthcoming for this pattern of successes and failures. (One can, however, use the object-examination task to form perceptual categories in real time if enough trials are given [25]).

Pauen [26] systematically varied the between-category similarity of small-scale models of animals and furniture. In high-similarity conditions, each item had legs, curved as well as rectilinear parts, and black-and-white dots that could be interpreted as eyes in the animals and knobs or decorations in the furniture. Even when there was high between-category similarity among the items, 10- and 11-month-olds categorized the items appropriately on the object-examination test and did so as much as when between-category similarity was low. As before, such data patterns are difficult to explain on perceptual grounds alone, again indicating that non-perceptual knowledge was controlling performance.

## Preverbal inductive inference

The generalized imitation test (Box 2) has been used to study the inferences infants make, by asking how far infants generalize properties associated with a concept. Infants (like adults) must rely on inductive inference to

**Figure 2.** Categorizing animate and inanimate things. 9-month-olds categorize these model birds and airplanes as different kinds of things, despite their perceptual similarity.

extend their knowledge beyond their particular experiences. So, an infant might only have observed people and perhaps a dog or a cat eat, but will infer from these observations that other animals eat too. A series of studies showed that after seeing modeled behavior with one animal, 9- to 14-month-olds would use any other animal to imitate animal-specific behaviors, such as drinking or sleeping, but not a non-animal [27–29]. Similarly, they would use any vehicle to imitate keying or giving a ride. By contrast, they typically refused to imitate modeled actions that were inappropriate to a kind, such as putting a vehicle to bed or giving it a drink [27]. (Giving the infants a choice might be crucial for this result; if an inappropriate action only is modeled, they might be induced to copy it). These results confirm not only that infants have developed global concepts, such as *animal* and *vehicle*, but also that they use these broad concepts to limit their generalizations (some of which might later need correction, such as that fish drink or that airplanes are opened with keys). At the same time, infants are sensitive to the difference between domain-specific properties, such as eating and sleeping, and domain-general properties, such as going indoors or being washed. In the domain-general case they are willing to generalize *across* domain boundaries, and thus exhibit quite different behavior than in the domain-specific case [28].

By narrowing the available choices to a single domain, the technique can also be used to specify more exactly how infants conceive of various animals and vehicles. When 14-month-olds were shown events such as giving a dog a drink from a cup and then given the cup along with a different dog and either a cat, an unfamiliar mammal, or a bird, they were indiscriminate in their generalizations when mammals were substituted – they chose a cat or unfamiliar mammal for their imitations as often as the other dog [28]. They were less likely to choose a bird. It is as if they were saying, 'I saw you give a land animal a drink'. However, they often used the bird as a second choice, as if they were saying, 'I saw you give a land animal a drink, but birds drink too'. By contrast, the infants were more selective in their imitations with vehicles. They were more likely to match the 'basic-level' category of the modeled item (car or motorcycle) and less likely to generalize from land vehicles to airplanes. It appears that infants (in the urban culture under study) categorize animals mainly on the basis of their behavior but are somewhat more advanced in their categorization of vehicles, using both function (or location?) and appearance.

Even for vehicles, however, the data suggest that conceptualizing objects initially depends on conceptualizing what they do. This phenomenon might depend on infants' attention to motion. One study found that infants at five-and-a-half months were more likely to process and remember information about what people around them were doing than what they or the objects being used looked like [30]. In these experiments infants watched videos that showed actions such as brushing teeth or hair. Neither the objects nor the faces of the actors were encoded as well as the activities. Young infants are also sensitive to the difference between caused motion and self-motion [31,32], between contingent and non-contingent interaction among objects [33], and between biological and non-biological motion [34]. These global conceptualizations of actions are sufficient to form robust concepts of animate and inanimate things (Box 1), but we still have relatively little information about when understanding of action becomes functional understanding, as opposed to mere motion understanding.

Between 6 and 12 months infants discriminate goal-directed behavior from non-purposeful behavior whether carried out by computer-generated shapes or by real people [35–38]. They also parse continuous actions into units organized around goals [39]. This understanding of actions, however, can still fairly be said to be more primitive than functional understanding. The latter requires coordinating knowledge of specific object kinds with specific actions. However, at least some detailed understanding begins in this period, as shown by the preverbal problem-solving abilities discussed earlier [11].

## Differentiation of preverbal global concepts

The results described above show that infants have global concepts of animals, vehicles, and furniture (and also plants [28]). The question arises of whether they have any concepts that will more-or-less match the first nouns they learn. We know that 1-year-old infants see the difference between dogs and cats and between tables and chairs, but do they have any knowledge of the behavioral or functional differences that make these items conceptually different? This issue has had little exploration, but one series of studies using generalized imitation [28,40] found little evidence for 'basic-level' concepts (i.e. those that match commonly used nouns) before the middle of the second year. For example, at 14 months infants chose a pan as often as a cup to imitate giving a doll a drink, a bird as often as a dog to imitate a dog chewing on a bone, and a wrench as often as a hammer to imitate hammering (Figure 3). By 19–20 months imitation was largely correct

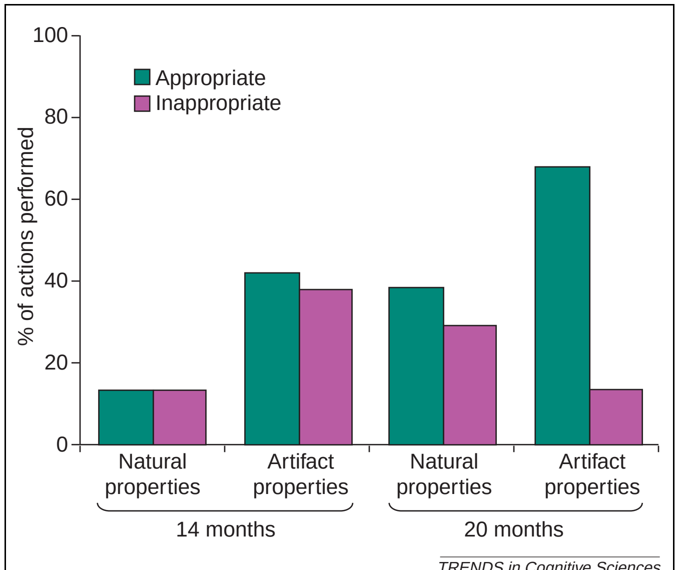


**Figure 3.** Generalizing 'basic-level' properties by 14- and 20-month olds. Household artifacts are differentiated before animals and plants. Figure adapted from [28], with permission of Elsevier.

for a variety of household artifacts and for vehicles, but not until 24 months for animals and plants. Thus, we see a narrowing of global concepts to something more refined at about the time that the noun explosion in language takes place. At 20 months, concepts of natural kinds lag behind artifacts (Figure 3). A likely reason for the different rate of differentiation between the animal and artifact domains is the difference in daily experience and opportunities to observe crucial differences between what objects do, or is done to them.

The emphasis on actions in differentiating objects does not necessarily mean that the actions themselves are precisely understood. Functional understanding can be quite general for long periods. However, Booth and Waxman [41] showed that 14-month-olds were more likely to categorize novel objects if shown a function for them at the same time. A study presented at the International Conference on Infant Studies (Träuble and Pauen, May 2004) found that 11-month-old infants categorized novel objects on the basis of their overall perceptual similarity, without paying much attention to what their parts look like. But if some parts were shown to produce interesting results, the infants then switched to categorizing the objects on the basis of their parts instead of overall similarity. Even infants as young as 5 months can be primed to attend to surface details if paired with functional information [42].

## Relational concepts

Infants also develop a number of spatial relational concepts over the course of the first year, such as *containment*. Baillargeon and her colleagues have shown that containment starts out as a global, relatively undifferentiated concept that gradually becomes refined [43]. For example, the concept of containment does not initially take into account variables of the height or width of a container with respect to the object being contained, but does so by 7–8 months [44]. In a similar fashion, infants gradually acquire an abstract notion of *above* and *below* [45]. Even 3-month-olds who are habituated to a picture of a figure above a line will dishabituate if the figure is moved to below the line. But they will not dishabituate if a different figure is used in the test until 6–7 months. At first these spatial relations appear to be perceptually bound to the objects instantiating them. To go beyond this and abstract *aboveness* itself from the rest of the display requires further analysis beyond what the perceptual system normally provides, suggesting that it is an achievement of perceptual meaning analysis (see Box 1).

In related work on containment, it has been shown that 5-month-olds are sensitive to change in an object from tight to loose containment (or vice versa) [46]. By 9 months infants categorize containment as tight- or loose-fitting in an abstract fashion. For example, after seeing several very different looking objects put into tight containment (such as a book put into a slipcase and a cork into a bottle), infants from both English-speaking and Korean-speaking homes dishabituated when shown still another object put into loose containment, such as a pencil put into a pencil cup (and vice versa from loose to tight containment) [47]. Infants thus demonstrated concepts of tight and loose fit *per se* (i.e. abstracted away from other information), showing their readiness to learn a language such as Korean, which includes degree of fit as a component of its terms for containment. Interestingly, Korean adults showed the same sensitivity but English-speaking adults did not, indicating one of the ways that language can affect habits of thought [47].

## Conclusions: mapping language onto preverbal concepts

This summary of preverbal thought has shown that the conceptual basis necessary to understand simple language develops over the course of the first year. During this time infants develop extensive concepts of objects such as animals, actions such as drinking, and spatial relations such as containment. They can put these together in a form sufficient to recall the past, solve simple problems, and make inductive inferences. At the same time, their concepts are often more general than the words used in daily speech. This mismatch between concept and word leads to the familiar phenomenon of overextension, in which early words have a broader extension for children than they do for adults. Even at age 2, as many as 30% of common nouns are still understood too broadly, for example, understanding (and using) the word *dog* to include foxes, and the word *cake* to include pies [48]. A similar phenomenon occurs with verbs. For example, young Korean learners use a single verb meaning *un-fit* for any act of separation, whereas Korean adults make several finer distinctions, and young English learners use the prepositions *off* and *out* to convey a similarly wide variety of acts of separation [49].

An interesting question is whether the refinement in conceptualization that is taking place in the first half of the second year leads to the noun explosion or, conversely, whether learning nouns helps the refining process (see also Box 3). Hearing different words consistently used for, say, two animals that the child has interpreted as minor perceptual variants, should lead the child to pay attention to the differences. On the other hand, naming alone does not facilitate categorization of novel objects in 14-month-olds unless accompanied by functional information, whereas by 18 months, labels alone do so [41]. Findings of this kind suggest that before language becomes well-established, conceptual differentiation plays a larger role

### Box 3. Questions for future research

- What other kinds of mental problem-solving do infants engage in towards the end of the first year?
- What is the exact role of functional understanding in infants' differentiation of global concepts?
- Is the lag in conceptual differentiation of animals and plants compared with artifacts due only to the difference in daily experience, or is there some other factor that makes natural kinds more difficult to learn (such as lack of functional information)?
- Is it the usual case that before language becomes well-established concept development plays a larger role in word learning than word learning plays in concept development, and if so, does this change towards the end of the second year?

in word learning than word learning plays in conceptual differentiation.

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