brain signaling impending collision *J. Neurophysiol.* 75, 986–995

60 Cliff, D. (1991) Computational neuroethology: a provisional manifesto, in *From Animals to Animats* (Meyer, J-A. and Wilson, S.W., eds), pp. 29–39, MIT Press

61 Chiel, H.J. and Beer, R.D. (1997) The brain has a body: adaptive behavior emerges from interactions of nervous system, body and environment *Trends Neurosci.* 20, 553–557

62 Dean, J. (1990) Coding proprioceptive information to control movement to a target: simulation with a simple neural network *Biol. Cybern.* 63, 115–120

63 Brunn, D.E. and Dean, J. (1994) Intersegmental and local interneurons in the metathorax of the stick insect *Carausius morosus* which monitor middle leg position *J. Neurophysiol.* 72, 1208–1219

64 Kristan, W.B., Jr, Lockery, S.R. and Lewis, J.E. (1995) Using reflexive behaviors of the medicinal leech to study information processing *J. Neurobiol.* 27, 380–389

65 Franceschini, N., Pichon, J.M. and Blanes, C. (1992) From insect vision to robot vision *Philos. Trans. R. Soc. London Ser. B* 337, 283–294

66 Harvey, I., Husbands, P. and Cliff, D. (1993) Issues in evolutionary robotics, in *From Animals to Animats 2* (Meyer, J-A., Roitblat, H.L. and Wilson, S.W., eds), pp. 364–373, MIT Press

67 Zaera, N., Cliff, D. and Bruten, J. (1996) (Not) evolving collective behaviors in synthetic fish, in *From Animals to Animats 4* (Maes, P. *et al.*, eds), pp. 635–644, MIT Press

68 Heiligenberg, W.F. (1991) *Neural Nets in Electric Fish*, MIT Press

69 Gray, R.D. (1987) Faith and foraging: a critique of the 'paradigm argument from design', in *Foraging Behavior* (Kamil, A.C., Krebs, J.R. and Pulliam, H.R., eds), pp. 69–140, Plenum Press

70 von Eckardt, B. (1993) *What is Cognitive Science?*, MIT Press

71 Maes, P. (1991) A bottom-up mechanism for behavior selection in an artificial creature, in *From Animals to Animats* (Meyer, J-A. and Wilson, S.W., eds), pp. 238–246, MIT Press

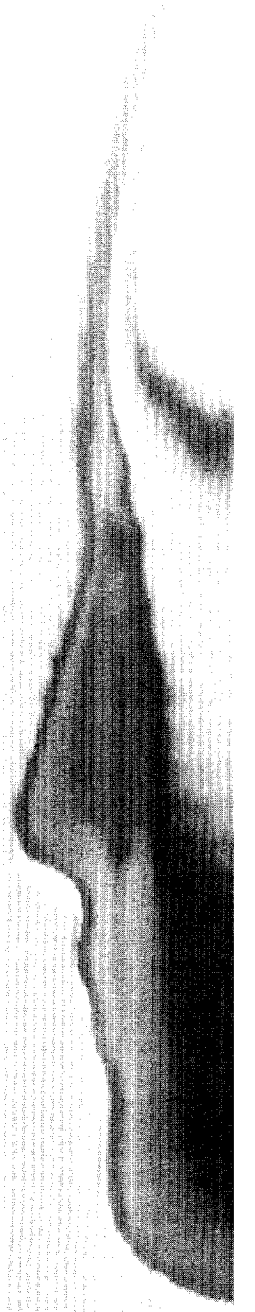
Capacities underlying word learning

Paul Bloom and Lori Markson

Children are strikingly good at learning the meanings of words. Current controversy focuses on the relative importance of different capacities in this learning process including principles of association, low-level attentional mechanisms, special word learning constraints, syntactic cues and theory of mind. We argue that children succeed at word learning because they possess certain conceptual biases about the external world, the ability to infer the referential intentions of others and an appreciation of syntactic cues to word meaning. Support for this view comes from studies exploring the phenomena of fast mapping, the whole object bias, the acquisition of names for entities belonging to different ontological kinds and the effect of lexical contrast. Word learning is not the result of a general associative learning process, nor does it involve specialized constraints. The ability to learn the meanings of words depends on a number of capacities, some of which are specific to language and unique to humans, others of which are potentially shared with other species.

Two- and three-year-old children have poor motor control and bad manners; they are unreflective artists and inept dance partners. However, they are strikingly good at learning the meanings of words. Children learn their first words by 12 months of age, are relatively proficient at word learning by 16–18 months, and eventually come to learn new words at a rate of over ten new words per day (see Box 1). Their early vocabularies include personal pronouns (me, you), proper names (Fido, Mommy), prepositions (in, on), adjectives (good, big), verbs (bite, want) and many classes of nouns including those referring to whole objects (dog, cup), substances (milk, water), parts (eye, finger), habitual activities (bath, nap), periods of time (minute, day) and abstract notions (story, game)[1,2]. While children sometimes get the precise meaning of a word wrong – for instance, sometimes calling a cat 'a dog' – serious mistakes are rare: children never call a chair 'a dog' or confuse proper names with common nouns, object names with substance names or adjectives with verbs[3].

One perspective on word learning is that parents do much of the work, carefully tailoring their speech to make the connection between words and what they describe particularly clear to their children. Such tutelage does occasionally occur in many cultures, including the middle-class Western culture that is the focus of most language acquisition research. But it is not universal; there are societies in which parents make no effort to teach words to children, leaving them to learn words on the basis of overheard speech[4]. Nevertheless, such children have no problem in developing a rich vocabulary. Furthermore, children raised in Western cultures learn at least some words, such as the personal pronouns[5], by overhearing them in the conversations of others, and even the most pampered child will learn many words that are used when the relevant object or event



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Box 1. The rate of word learning

It is often said that children start off learning words very slowly, about one or two a week, and then, after learning somewhere between 20 and 100 words, there is a sudden acceleration in the rate of word learning – sometimes called a vocabulary spurt, naming explosion, or word burst – that propels children to learn words at the rate of five, ten or even twenty new words a day. But vocabulary growth is actually less dramatic than this. While some children might show a sudden increase in the rate at which they learn words[a,b], many do not, exhibiting instead a series of small bursts, a slow monotonic rise or a smoothly increasing exponential function[c,d]. Moreover, a vocabulary spurt will at most bring a child to the point where she learns five to ten words a week, not a day.

To see how the rate of word learning changes, consider the estimates (see Table) from Fenson *et al.*[d], based on parental reports of the vocabularies of children from 12 to 30 months, and from Anglin[e], based on comprehension studies with six-, eight- and ten-year-old children. (Anglin included only those words whose meanings could not be worked out using 'problem solving' strategies and hence must be learned.) Estimating vocabulary size is tricky for several reasons[f], so these numbers should be taken only as very rough estimates.

Age	Average number of words per day
12–16 months	0.3
16–23 months	0.8
23–30 months	1.6
30 months–6 years	3.6
6–8 years	6.6
8–10 years	12.1

Why do children gradually improve at word learning? There are several explanations, including the maturation of memory and attentional capacities, a growing sensitivity to different cues to a word's meaning (such as its syntactic category and the discourse context in which it is used) and an increasing awareness of different entities that can be named. Another factor is access to new words: in particular, literacy exposes children to many more words than they would encounter through social interaction or watching television, and it is likely that the gargantuan vocabularies of some English speakers (well over 100 000 words)[f] could not occur without the ability to read.

Most adults do not learn several new words a day. This might be because we are not as good at word learning as we once were, but a simpler possibility is that we already know most of the words that our immediate environment has to offer. Unless we learn a new language, our only opportunities for word learning are proper names, archaic or technical terms, or new words that enter the language, such as 'internet', 'dissing' and 'karaoke'.

References

a Dromi, E. (1987) *Early Lexical Development*, Cambridge University Press

b Nelson, K. (1973) Structure and strategy in learning to talk *Monogr. Soc. Res. Child Dev.* 38, Serial No. 149

c Goldfield, B.A. and Reznick, J.S. (1990) Early lexical acquisition: rate, content, and the vocabulary spurt *J. Child Lang.* 17, 171–183

d Fenson, L. *et al.* (1994) Variability in early communicative development *Monogr. Soc. Res. Child Dev.* 59, Serial No. 242

e Anglin, J. (1993) Vocabulary development: a morphological analysis *Monogr. Soc. Res. Child Dev.* 58, Serial No. 238

f Miller, G.A. (1996) *The Science of Words* (2nd edn), W.H. Freeman

is not being attended to[6,7]. These considerations suggest that word learning is a robust process, requiring rich inferential capacities on the part of the child.

But which capacities? The proposal that we will explore here is that children succeed at word learning because they possess a rich understanding of the external world, the ability to infer the referential intentions of others ('theory of mind') and, by the time the child is about two years of age, an appreciation of syntactic cues to word meaning. This position contrasts with the theory that word learning is accomplished through an associationist learning mechanism that is sensitive to statistical properties of the input[8,9], perhaps assisted by 'dumb attentional mechanisms'[10]. It is also different from the proposal that children possess special constraints dedicated to the process of word learning[11,12]. We suggest that children's conceptual biases, intentional understanding and syntactic knowledge are not only necessary for word learning (nothing simpler would suffice) but that they are also sufficient (nothing else is needed).

Fast mapping

Given the high number of words that children come to understand (about 10 000 by the age of six; about 60 000 for the average high school graduate)[13,14], one would expect them to be proficient at learning and storing word meanings on the basis of minimal experience. They are. In a classic study, young children who were involved in an unrelated activity were asked to walk over to two trays, a blue one and an olive one, and to: 'Bring me the chromium tray, not the blue one, the chromium one'[15]. All of the children retrieved the olive tray, correctly inferring that the experimenter intended 'chromium' to refer to this new color. Furthermore, most of the children still remembered some of the meaning of this word when tested six weeks later.

This finding raises the question of whether this rapid learning – sometimes called fast mapping – only happens for words. To test this, three- and four-year-old children were given ten objects to play with as part of a measuring game and were casually introduced to a novel name for one of the objects: 'Let's use the koba to measure which is longer. We can put the koba away now'. For a different object, the children were told: 'We can use the thing my uncle gave to me to measure which is longer. We can put the thing my uncle gave to me away now'. During the test phase, participants were shown the same objects and asked to: 'Find the koba' and 'Find the one my uncle gave to me'[16].

Even after a month, the children remembered the new word, providing further evidence for the robustness of fast mapping. A group of adults did just as well at the same task, which suggests that word learning differs in an interesting way from other aspects of language learning, such as

morphology and syntax, in which children are clearly superior[17]. Children and adults were equally good, however, at remembering the arbitrary linguistically presented fact that they had learned about a novel object – that it was given to the experimenter by her uncle. A further experiment found that fast mapping has its limits. When taught the location of a sticker: 'This goes here...' as a small sticker was placed on to one of the novel objects, both children and adults did relatively poorly when asked a month later to place a small sticker on the appropriate object (see Fig. 1). The question of what can and cannot be fast mapped is as yet unresolved, but it is now clear that fast mapping is not restricted to language learning.

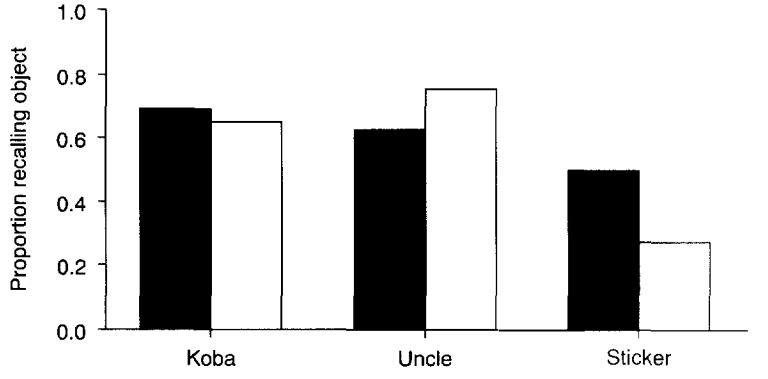


Fig. 1 Fast mapping is not limited to word learning. The proportion of three- and four-year-old children (open bars) and adults (filled bars) who, after a one-month-delay, recalled the object to which the novel word referred (Koba), the object that had the property of being given to the experimenter by her uncle (Uncle), and the object that had a sticker affixed to it (Sticker). There was no difference in performance between children and adults in both the 'Koba' and 'Uncle' conditions, suggesting that there is no critical period for word learning. In addition, there was no difference in performance between these two conditions, suggesting that fast mapping is not restricted to language learning. Finally, both age groups did worse in the 'Sticker' condition. This was especially so for the children, who were not better than chance.

Object names

When confronted with the unfamiliar word 'koba' in the above study, children immediately understood it as a name for one of the objects in front of them. This leads to a rather vexing puzzle. Suppose a child hears a new word and determines that it describes a certain object in the world, for instance, a rabbit. Most likely, children learn this through attending to the referential focus of the speaker, as indicated by cues such as direction of gaze[3,6]. But the problem now arises that there are an infinite number of logically possible meanings for the word. It could refer to the color of the rabbit, its shape, its surface, the tail, the ears, the rabbit and the ground it is standing on, its motion, even 'undetached rabbit parts'[18]. Children do not entertain such possibilities, however. In this situation, they will immediately take the word as naming the whole rabbit. More generally, there is a wealth of evidence showing that children and adults tend to interpret new words as referring to whole objects, not to parts of objects, properties of objects or the stuff that objects are made of[3,19,20].

How is this bias best explained? One theory is that children possess a special constraint that guides them to view new words as names for objects[19,20]. An alternative is that this bias towards objects is the result of a more general fact about how people reason about the world. We are prone to think about the world in terms of whole objects and hence, when searching for the meaning of a word, are driven to favor the object interpretation[21,22] (see Box 2).

The claim here is not merely that children parse the world into objects and, therefore, tend to take new words as object names. After all, children are also sensitive to motion and color but show no bias to interpret new words as naming motion and color. The proposal is instead that objects are highly salient, both linguistically and non-linguistically. In support of this, note that the very same focus on objects shows up in domains other than word learning. When preschoolers are shown an array of objects and asked to count, they show a strong tendency to count the objects, even

Box 2. What is an object?

What precisely do we mean when we say that children have an object bias? We have an intuitive sense of what we mean by the term, so that a rabbit is an object, but the rabbit's foot is not (at least, not if it is attached to the rabbit), nor is the rabbit and the tree that it is next to. But what are the precise criteria that guide children to view some things as objects and others as not?

One promising theory has been elaborated by Elizabeth Spelke on the basis of infant research[a,b]. The most important criterion is that objects follow the principle of cohesion; an object is a connected and bounded region of matter that maintains its connectedness and boundaries when in motion. If young infants see a portion of matter obey the principle of cohesion, they treat it as an object and expect other object principles to apply. (These other principles state that objects are solid and do not pass through each other, they follow continuous paths through space and they move if and only if they touch.)

Of course, it is not necessary actually to observe cohesive and bounded movement before concluding that something is an object; it is enough to infer that there could be such movement. Hence, we can parse stationary scenes into distinct objects when the gaps between entities imply that they will move independently, when the scenes contain entities that we know from previous experience exist as separate objects (as with a rabbit that is in contact with a tree) or when Gestalt cues, such as good continuity and sameness of color and texture, suggest that different entities have the potential for independent movement (as when we see a shiny red object resting on a flat green surface). Pre-linguistic infants are sensitive to all of these cues, but only sometime after they are able to parse objects on the basis of motion[c].

References

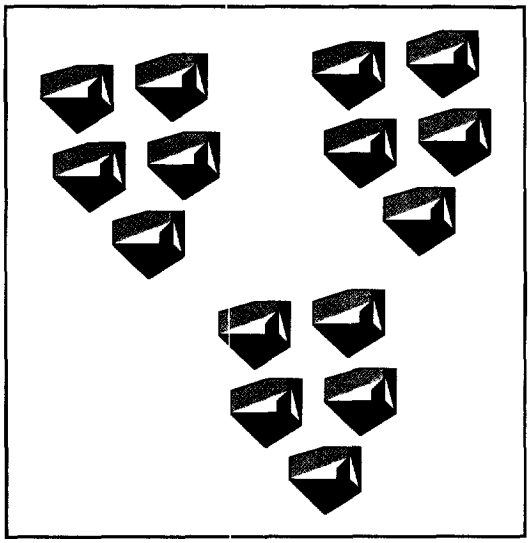
a Spelke, E.S. (1994) Initial knowledge: six suggestions *Cognition* 50, 431–445

b Spelke, E.S. *et al.* (1992) Origins of knowledge *Psychol. Rev.* 99, 605–632

c Needham, A. and Baillargeon, R. (1997) Object segregation in 8-month-old infants *Cognition* 62, 121–149

Box 3. Natural collections

These are fendles.



What do you think 'fendle' means? Does it refer to each of the individual objects (so that there are 15 'fendles' here) or does it refer to the individual groups (so that there are three 'fendles' here)?

Some individuals are psychologically natural in the sense that they are readily taken as the meaning of a new count noun. Whole objects are the paradigm case of this. But we also learn words that refer to non-object individuals, such as collections. The example above suggests that grouping is not enough to motivate treating a group of objects as a nameable individual. If you think that 'fendle' refers to the collections in the example above, you are part of a small minority; most people take the word as an object name.

There are at least three cues that motivate people to focus on the collection interpretation. The first is syntactic. If each of three stationary groups is described with a singular count noun (as in: 'This is a fendle...this is a fendle...and this is a fendle', while pointing to each group in turn), adults and five-year-old children treat the word as denoting the collections, not the individual objects[a].

A second cue is the perceived goal of the experimenter. In one study, the experimenter carefully arranged three groups of objects in front of the subjects, with a picture frame around each group, giving the impression that the groups were independent artistic creations. If the frames are then removed, and the display is described as: 'These are fendles', children will tend to treat 'fendle' as a collective noun, suggesting that they can construe the groups as individuals solely because they infer that they are thought of as individuals in the mind of the experimenter[b].

A third cue is movement. When adults were shown three groups on a computer screen, each moving as a single unit, tracing paths across the screen, avoiding each other, and so on, they construed that the groups were individuals and interpreted 'fendle' as a collective noun. To test whether this is due to experience with real-world collections, like flocks of birds, Karen Wynn and I tested five-month-old infants in a similar experiment. We showed half of the infants two collections of three objects each and half of them four collections of three objects each. Each collection traced a vertical path up and down on a computer screen and each object moved independently within its collection, while also following the trajectory traced by the collection as a whole. Once infants were habituated to this display, they were presented alternately with two collections of four objects, and four collections of two objects, each moving horizontally back and forth on the screen. Infants looked reliably longer at the new number of collections, showing that they were sensitive to the number of collections of entities presented to them.

What do these cues have in common? It is interesting that they are all ways in which a collection is like an object – both are described with singular count nouns, treated as a single entity by others and move as bounded units. This is consistent with the view that principles of object parsing may extend to other non-object domains. Alternatively, humans may possess some set of more general principles that parse the world into relevant units, including not only objects and collections, but also shadows, holes, parts, sounds and actions[b,c]. Further research into how children and adults learn words for non-object individuals will bear on this issue.

References

a Bloom, P. and Kelemen, D. (1995) Syntactic cues in the acquisition of collective nouns *Cognition* 56, 1–30

b Bloom, P. (1996) Possible individuals in language and cognition *Curr. Dir. Psychol. Sci.* 5, 90–94

c Wynn, K. (1996) Infants' individuation and enumeration of actions *Psychol. Sci.* 7, 164–169

when explicitly told to count something else. For instance, when shown an array of five forks, one of them broken in half, and asked to count the forks, they will typically answer 'six', counting each of the objects, even though they know perfectly well what a fork is[23]. It is not, however, that children can only count objects; when there are no objects in sight, they have little difficulty counting individuals such as sounds[24].

These considerations put the object bias in a different perspective. It may be that children have a range of ontological categories at their disposal. Objects are just very salient; it is hard for children not to focus on them. This explains why young children find it much easier to learn a name for a non-solid substance such as 'water'[25], than to learn a solid substance name like 'wood'[21]. Children can learn 'water' without the distraction of a salient object, while learning 'wood' requires that children actively focus on a bounded object but think of it, not as an object, but as a portion of solid stuff. The acquisition of collective nouns presents an interesting intermediate case; these are words such as 'family' and 'flock' which refer not to one object, but to individuals that are composed of many objects (see Box 3).

Common nouns, proper names and other ontological categories

Once children know that a word refers to a whole object, they must then determine whether it refers to a kind, as with a common noun such as 'dog', or to a specific individual, as with a proper name like 'Fido'. One important factor is the type of entity: two-year-old children know that words

Box 4. Syntactic cues to word meaning

The fact that the syntactic category of a word can provide cues to its meaning is not a lucky accident, it follows naturally from the way that language works. Rules of syntax allow people to combine words to express a potential infinity of sentence meanings, and this combinatorial power rests in part on the correspondence that exists between syntactic categories and conceptual categories. To take a very simple example, nouns often refer to things and verbs often refer to actions, so one can combine the two to form a sentence that states that certain things tend to perform certain actions, as in: 'Dogs bark'.

Over the last decade, there have been many demonstrations of the role that syntactic knowledge has in word learning. Summing up several studies, young children can use a number of cues to word meaning (see Table).

While there is little doubt that a sensitivity to syntactic cues plays some role in word learning, there remains substantial debate about how children become sensitive to these cues, how early in development they apply and how important they are for the acquisition of certain word meanings[b–k].

References

a Bloom, P. and Kelemen, D. (1995) Syntactic cues in the acquisition of collective nouns *Cognition* 56, 1–30

b Katz, N., Baker, E. and Macnamara, J.T. (1974) What's in a name? A study of how children learn common and proper names *Child Dev.* 45, 469–473

c Bloom, P. (1994) Semantic competence as an explanation for some transitions in language development, in *Other Children, Other Languages: Issues in the Theory of Language Acquisition* (Levy, Y., ed.), pp. 41–75, Erlbaum

d Brown, R. (1957) Linguistic determinism and the part of speech *J. Abnorm. Social Psychol.* 55, 1–5

e Naigles, L. (1990) Children use syntax to learn verb meanings *J. Child Lang.* 17, 357–374

f Taylor, M. and Gelman, S. (1988) Adjectives and nouns: children's strategies for learning new words *Child Dev.* 59, 411–419

g Landau, B. and Stecker, D. (1990) Objects and places: syntactic and geometric representations in early lexical learning *Cognit. Dev.* 5, 287–312

h Bloom, P. and Wynn, K. Linguistic cues in the acquisition of number words *J. Child Lang.* (in press)

i Bloom, P. (1996) Controversies in language acquisition: word learning and the part of speech, in *Handbook of Perceptual and Cognitive Development* (Gelman, R. and Au, T., eds), pp. 151–184, Academic Press

j Gleitman, L.R. (1990) The structural sources of word meaning *Lang. Acquis.* 1, 3–55

k Pinker, S. (1994) How could a child use verb syntax to learn verb semantics? *Lingua* 92, 377–410

Syntactic cue	Usual type of meaning	Examples	Refs
This is a *fep*/the *fep*	Individual member of a category	*cat, forest*	a,b
These are *feps*	Multiple members of a category	*cats, forests*	a,c
This is *Fep*/*Fep* is here	Specific individual	*Fido, John*	b
This is much *fep*/some *fep*	Non-individuated stuff	*water, sand*	c,d
John *feps*	Action with one participant	*sleeps, stands*	d,e
John *feps* Bill	Action with two participants	*hits, kisses*	e
This is a *fep* thing	Property	*big, good*	f
The dog is *fep* the table	Spatial relationship	*on, near*	g
There are *fep* big dogs here	Quantifier	*some, five*	h

describing individuals that have an intrinsic specialness, such as people and pets, are more likely to be proper names than words that describe things that are seen as interchangeable members of a kind, such as trucks and bees[26,27]. Another factor is syntax. For example, when exposed to a word that describes a doll, children younger than two can use the syntax of the word to work out its meaning. If a word is used in a context such as: 'This is a...', they take it as naming the individual, as in 'Stella'; if it is used in a context such as: 'This is a...', they take it as naming the kind, as in 'doll'[27].

A sensitivity to syntactic cues may play a more general role in word learning. The original study was carried out by Roger Brown, who showed preschoolers a picture of a strange action being performed on a novel substance with an unfamiliar object[28]. One group of children was told: 'Do you know what a sib is? In this picture, you can see a sib' (count noun syntax); a second group was told: 'Have you seen any sib? In this picture, you can see sib' (mass noun syntax); and a third group was told: 'Have you seen sibbing? In this picture, you can see sibbing' (verb syntax). The preschoolers tended to construe the count noun as referring to the object, the mass noun as referring to the substance, and the verb as referring to the action. Subsequent research has found that syntactic cues can guide young children to learn words belonging to a range of different ontological categories (see Box 4).

Lexical contrast

Eventually, children do learn words that describe objects but which are not object names. One non-syntactic cue that could help children learn the meanings of such words involves lexical contrast. When children already have a name for an object, they tend to assume that another word, presented in the presence of that object, has a different meaning. When three-year-old children are shown a familiar object, such as a cup, and an unfamiliar object, such as a pair of tongs, and asked to: 'Show me the dax', they tend to select the unfamiliar object as the referent of the novel label. If only the cup is present in the above situation, children tend to interpret the word not as naming the object, but as naming the stuff that the cup is made out of (pewter), or a part of the cup (handle)[29].

What is the nature of such a constraint? One possibility is that children hold a specifically linguistic assumption that

Table 1. The scope of the lexical contrast assumption[a]

Condition	What children were told and asked	Which object they tended to choose
Names	This is a *bem* (Object A) Can you show me a *jop*?	Object B
Facts: one speaker	My sister gave this to me (Object A) Can you show me the one that dogs like to play with?	Object B
Facts: two speakers	My sister gave this to me (Object A) Can you show me the one that dogs like to play with?	No preference

[a]*Three-year-olds were presented with two unfamiliar objects in all conditions.*

an object can have only one name. Thus, a novel name must refer to something else, either a different object or a part or property of the object[29,30]. A different possibility is that children's responses are guided by their inferences about the communicative intentions of others, based on theory of mind[31]. Specifically, a child may reason that if the experimenter had wanted her to focus on the familiar object, the experimenter would have asked for that object using its name, as this name is mutual knowledge shared by both the child and the speaker. Instead, the experimenter used a novel name and, therefore, must intend the child to focus on something else. Under this account, children's responses do not derive from assumptions about words *per se*; they derive instead from more general beliefs that children hold about the communicative interactions of other people.

To examine this possibility, the following study was carried out (see Table 1 for summary)[32]. Three-year-old children were presented with two unfamiliar objects and told a novel name for one of them ('This is a bem'). The children tended to infer that a second, different name ('Can you show me a jop?') referred to the other, unlabeled object, replicating previous studies. In another condition, a different group of children were told a novel fact about one of the objects ('My sister gave this to me') and were then asked to select the referent of a different fact ('Can you show me the one that dogs like to play with?'). Again, children in this condition tended to choose the other object, the one that they had not been told the fact about. Presumably, this is because children reasoned that if the experimenter had intended to describe the first object, she would have referred to it by stating the original fact – she would not have introduced a different fact.

This account predicts that children should be less inclined to produce such a response in a two-speaker scenario, where the second speaker does not share mutual knowledge with the child. That is, if one speaker tells the child: 'My sister gave this to me' about one object, and then a different speaker, who is new to the discourse context, enters the room and asks: 'Can you show me the one that dogs like to play with?', children should now choose each of the objects with equal frequency. As predicted, three-year-old children selected among the two objects randomly. This supports the hypothesis that children's interpretation of the referent of a speaker's utterance is based upon their understanding of how people communicate with one another; it is not the product of a special lexical constraint.

Outstanding questions

- Children can learn and retain both word meanings and certain other information after minimal exposure. What distinguishes the sorts of information that can and cannot be fast mapped?
- Is the ability to fast map present in non-linguistic creatures, such as young infants and non-human primates?
- Children have a general bias to focus on objects but, nonetheless, they quickly learn words that refer to the attributes or actions of objects. What cues other than syntax and lexical contrast can help them over-ride this object bias?
- Is the acquisition of new words from overheard speech as effective as word learning when young children are active participants in the communicative interaction?
- Even 15-month-old infants tend not to accept two names for the same object. Is it plausible that this quite precocious understanding is based on an understanding of the communicative intentions of others?
- How does word learning by young children differ from word learning by older children and adults?
- What can developmental disorders such as specific language impairment and autism tell us about the relationship between word learning and other aspects of language development?

Summary and implications

The studies reviewed above support the view that young children's remarkable ability to learn words emerges from more general cognitive capacities: intentional, conceptual and syntactic. Such capacities explain phenomena such as fast mapping, the whole object bias, the acquisition of names for entities belonging to different ontological kinds and assumptions about lexical contrast.

Our claim is that while other aspects of language acquisition, such as the learning of phonology, morphology and syntax, involve dedicated cognitive modules[33], word learning does not. The ability to learn the meanings of words emerges instead from a host of other capacities, some of which are shared by other species (such as object parsing), some of which are parasitic on language learning and hence unique to humans (such as the use of syntactic cues to word meaning), and others for which human uniqueness is an open question (such as the ability to fast map).

We suspect that the central capacity underlying word learning is theory of mind. Here, this was argued to underlie children's intuitions about lexical contrast, and elsewhere it has been proposed to account for various other phenomena in word learning, including how children work out what a new object name refers to[3,6,34]. Word learning can be accomplished, at least to a limited extent, without the ability to fast map and without sensitivity to syntactic cues. But an understanding of the notion of referential intent may be essential. Interestingly, it is exactly this capacity that is lacking in non-human primates[35]. The ability to contemplate the thoughts of others may be the engine that drives word learning, and the emergence of this capacity may be a

catalyst for the ability to learn language, both in normal development and in the evolution of the species.

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References

1 Nelson, K., Hampson, J. and Shaw, L.K. (1993) Nouns in early lexicons: evidence, explanations, and extensions *J. Child Lang.* 20, 61–84

2 Bloom, L., Tinker, E. and Margolis, C. (1993) The words children use: evidence against a noun bias in early vocabularies: *Cognit. Dev.* 8, 431–450

3 Macnamara, J. (1982) *Names for Things: a Study of Human Learning*, MIT Press

4 Schieffelin, B.B. (1985) The acquisition of Kaluli, in *The Crosslinguistic Study of Language Acquisition* (Vol. 1) (Slobin, D.I., ed.), pp. 525–593, Erlbaum

5 Oshima-Takane, Y. (1988) Children learn from speech not addressed to them: the case of personal pronouns *J. Child Lang.* 15, 94–108

6 Baldwin, D.A. (1991) Infants' contribution to the achievement of joint reference *Child Dev.* 62, 875–890

7 Gleitman, L.R. (1990) The structural sources of word meaning *Lang. Acquis.* 1, 3–55

8 Locke, J. (1690) *An Essay Concerning Human Understanding* (reprinted 1964, Woozley, A.D., ed.), Meridian Books

9 Plunkett, K. (1997) Theories of early language acquisition *Trends Cognit. Sci.* 1, 146–153

10 Smith, L.B., Jones, S.S. and Landau, B. (1996) Naming in young children: a dumb attentional mechanism? *Cognition* 60, 143–171

11 Markman, E.M. (1990) Constraints children place on word meanings *Cognit. Sci.* 14, 57–77

12 Golinkoff, R.M., Mervis, C.B. and Hirsh-Pasek, K. (1994) Early object labels: the case for a developmental lexical principles framework *J. Child Lang.* 21, 125–155

13 Anglin, J. (1993) Vocabulary development: a morphological analysis *Monogr. Soc. Res. Child Dev.* 58, Serial No. 238

14 Miller, G.A. (1996) *The Science of Words* (2nd edn), W.H. Freeman

15 Carey, S. and Bartlett, E. (1978) Acquiring a single new word *Papers Rep. Child Lang. Dev.* 15, 17–29

16 Markson, L. and Bloom, P. (1997) Evidence against a dedicated system for word learning in children *Nature* 385, 813–815

17 Newport, E. (1990) Maturational constraints on language learning *Cognit. Sci.* 14, 11–28

18 Quine, W.V.O. (1960) *Word and Object*, MIT Press

19 Markman, E.M. and Hutchinson, J.E. (1984) Children's sensitivity to constraints in word meaning: taxonomic versus thematic relations *Cognit. Psychol.* 16, 1–27

20 Waxman, S. and Markow, D. (1996) Words as an invitation to form categories: evidence from 12- to 13-month-olds *Cognit. Psychol.* 29, 257–302

21 Bloom, P. (1994) Possible names: the role of syntax-semantics mappings in the acquisition of nominals *Lingua* 92, 297–329

22 Gentner, D. (1982) Why nouns are learned before verbs: linguistic relativity versus natural partitioning, in *Language Development, Volume II: Language, Thought, and Culture* (Kuczaj, S.A., ed.), pp. 301–334, Erlbaum

23 Shipley, E.F. and Shepperson, B. (1990) Countable entities: developmental changes *Cognition* 34, 109–136

24 Wynn, K. (1990) Children's understanding of counting *Cognition* 36, 155–193

25 Soja, N.N., Carey, S. and Spelke, E.S. (1992) Perception, ontology, and word meaning Cognition 45, 101–107

26 Hall, D.G. (1994) Semantic constraints on word learning: proper names and adjectives *Child Dev.* 65, 1291–1309

27 Katz, N., Baker, E. and Macnamara, J. (1974) What's in a name? A study of how children learn common and proper names *Child Dev.* 45, 469–473

28 Brown, R. (1957) Linguistic determinism and the part of speech *J. Abnorm. Social Psychol.* 55, 1–5

29 Markman, E.M. and Wachtel, G.F. (1988) Children's use of mutual exclusivity to constrain the meaning of words *Cognit. Psychol.* 20, 121–157

30 Woodward, A.L. and Markman, E.M. (1997) Early word learning, in *Handbook of Child Psychology, Volume 2: Cognition, Perception, and Language* (Damon, W., Kuhn, D. and Siegler, R., eds), pp. 371–420, John Wiley & Sons

31 Clark, E.V. (1987) The principle of contrast: a constraint on language acquisition, in *Mechanisms of Language Acquisition* (MacWhinney, B., ed.), pp. 1–33, Erlbaum

32 Diesendruck, G. and Markson, L. (1997) Children's interpretation of word meanings: lexical constraints or pragmatics? Paper presented at the *Boston University Conference on Language Development*, Boston, MA, USA

33 Pinker, S. (1994) *The Language Instinct*, Harper Collins

34 Bloom, P. (1997) Intentionality and word learning *Trends Cognit. Sci.* 1, 9–12

35 Tomasello, M. Uniquely primate, uniquely human *Dev. Sci.* (in press)