Constraints Children Place on Word Meanings

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This paper views lexical acquisition as a problem of induction: Children must figure out the meaning of a given term, given the large number of possible meanings any term could have. If children had to consider, evaluate, and rule out an unlimited number of hypotheses about each word in order to figure out its meaning, learning word meanings would be hopeless. Children must, therefore, be limited in the kinds of hypotheses they consider as possible word meanings. This paper considers three possible constraints on word meanings: (1) The whole object assumption which leads children to interpret novel terms as labels for objects —not parts, substances, or other properties of objects; (2) The taxonomic assumption which leads children to consider labels as referring to objects of like kind, rather than to objects that are thematically related; and (3) The mutual exclusivity assumption which leads children to expect each object to have only one label. Some of the evidence for these constraints is reviewed.

Children acquire the vocabulary of natural languages at remarkable speed. In a carefully documented study of an individual child's vocabulary acquisition, Dromi (1987) reports a point at which her child began acquiring new vocabulary at the rate of 45 words a week. This fits with calculations reported by Carey (1978): by age six children have learned 9,000–14,000 words which works out to roughly nine new words a day from about 18 months on. It is still largely a mystery as to how children acquire language at this astonishing rate.

A traditional explanation for how children form categories and acquire category terms was to assume a kind of general, all-purpose, inductive mechanism. Inhelder and Piaget (1964) and Bruner, Olver, and Greenfield (1966) implicitly held some form of this model. This view about how categories are acquired contains many implicit assumptions about the nature of categories, about the way in which they are learned, and about how children's abilities to categorize change with development (for a discussion of

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these issues, see Markman, 1989). For example, these theories assume that concept learning begins by the learner encountering a positive exemplar of the category. From that exemplar the learner formulates a tentative hypothesis about what the criteria might be that define the category. This hypothesis must then be evaluated against subsequent information. New instances that are consistent with the hypothesis support it, while inconsistent information requires that it be revised. But reformulating hypotheses in the face of negative evidence is not a trivial problem and children up until the age of six or seven have been shown to have great difficulty in dealing with all but the simplest kinds of hypotheses. In sum, even 6-year-olds have trouble solving these kinds of inductive problems, yet 2-year-olds are very successfully solving the inductive problems involved in acquiring new terms. These young children must, therefore, acquire terms in ways that do not require sophisticated, logical-deductive, hypothesis testing (Markman, 1987; Markman, 1989; Markman & Hutchinson, 1984; Markman & Wachtel, 1988).

Another related problem with the traditional view of concept learning is that it does not face the fundamental problem of induction pointed out by Quine (1960), namely, that for any set of data there will be an infinite number of logically possible hypotheses that are consistent with it. The data are never sufficient logically to eliminate all competing hypotheses. How is it, then, that humans so frequently converge on the same hypotheses? To take a concrete example, suppose a child hears someone label a dog as *dog*. The child could think that the label refers to a specific individual (e.g., Rover), or to one of its parts (e.g., tail), or to its substance, size, shape, color, position in space, and so on. Given that it is not possible for anyone, let alone a young child, to rule out every logically possible hypothesis, how is it that children succeed in figuring out the correct meanings of terms?

The answer is that humans are constrained to consider only some kinds of hypotheses or at least to give them priority over others. This may be especially true for children first trying to learn the concepts that their language encodes. The way children succeed in acquiring these terms so rapidly is that they are limited in the kinds of hypotheses they consider. Children do not always have to reject hypotheses on the basis of negative evidence. They can implicitly reject them by being biased against them in the first place. In this paper, I summarize some of the evidence for specific constraints on hypothesis that young children may use.

THE WHOLE OBJECT AND TAXONOMIC ASSUMPTIONS

When an adult points to an object and labels it, the novel term could refer to the object, but it could also refer to a part of the object, or its substance, or color, or weight, and so on. One way children initially constrain the meanings of terms is to honor the *whole object assumption* and thereby assume

that a novel label is likely to refer to the whole object and not to its parts, substance or other properties (Carey, 1988; Mervis, 1987).

Once children decide a term refers to the whole object, they still need to decide how to extend it to other objects. Markman and Hutchinson (1984) proposed that children honor the *taxonomic assumption* in extending objects labels to other objects. This assumption states that labels refer to objects of the same kind rather than to objects that are thematically related. To see why this constraint is needed it is helpful to consider what young children confront when someone teaches them a word via ostensive definition, that is, when someone points to an object and labels it. Some variant of ostensive definition makes up a large part of the way very young children acquire new words because they do not yet know enough language for one to define a new term for them or contrast with other terms, and so on. Again, suppose someone points to a dog and calls it a dog. *Dog* could be a proper name, or it could mean *furry,* or *brown,* or any of a huge number of other properties. Moreover, dog could also refer to "the dog and his bone," or "Mommy petting the dog" or "the dog under a tree." In other words, objects are often found in spatial, causal, temporal or other relations with other objects, so what prevents the child from thinking that the label refers to the objects that are related? These last examples of thematic relations pose a particular problem because children are very interested in such relations and often find them more salient than categorical or taxonomic relations.

On a number of tasks designed to assess children's ability to categorize objects, younger children have been found to prefer to organize objects according to thematic relations (cf. Gelman & Baillargeon, 1983; Markman & Callanan, 1983; for reviews). For example, on sorting tasks 6- and 7-year-olds often sort objects on the basis of their taxonomic category such as vehicles, buildings, animals and people. In contrast, younger children often sort objects in groups that represent causal, temporal, spatial or other relations among the objects. These relations emphasize events rather than taxonomic similarity. For example, children might put a boy and a dog together because the boy is taking the dog for a walk. This interest in thematic relations has been found in object sorting, oddity tasks, and studies of memory and word association (see Markman, 1981). From these studies, we can conclude that children are often more interested in the thematic relations among objects than among taxonomic relations, or that thematic relations can sometimes be easier for children to notice than taxonomic ones. Even though children may find thematic relations more salient, single nouns rarely encode thematic relations. For example, English does not have a single word for thematically related objects such as a boy and his dog, or a spider and its web, or a baby and its bottle. In fact, in a recent linguistic attempt to define the notion "word," Di Sciullo and Williams (1987) suggest that one way to distinguish words from phrases is that "words are generic in meaning in a way that

phrases are not." They suggest that this generic quality of words may result from the fact that words do not have tense markings while phrases do. To take their example, "compare the word *robber* and the phrase *man who is robbing the bank*. One cannot say *John is a bank robber* to mean 'John is robbing a bank at this very moment.' *Robber* seems to denote a permanent property, whereas *is robbing a bank* is completely timely." The taxonomic constraint might be one consequence of words being generic in Di Sciullo and William's sense.

To return to Quine's problem of induction, on the one hand children readily learn labels for object categories, concrete nouns such as *ball* or *dog*. On the other hand, children often notice thematic relations between objects. How is it that children readily learn labels for categories of objects if they are attending to these relations between objects instead? Hutchinson and I (Markman & Hutchinson, 1984) proposed that the solution is that children expect labels to refer to objects of the same kind or same taxonomic category. This assumption would allow them to rule out many potential meanings of a novel term, in particular, many thematic meanings. Even though children consider thematic relations good ways of organizing objects themselves, they do not consider thematic relations as possible meanings for words. Thus, when children believe that they are learning a new *word,* they shift their attention from thematic to categorical organization.

To narrow the hypotheses down to object categories still, of course, leaves open the question of to which of the numerous possible categories the label refers. Objects can be categorized in many different ways and at many different levels, for example, basic, subordinate, or superordinate levels within a hierarchy. Which category children map the label onto is itself an interesting question, one that has been addressed by Markman (1989), Mervis (1987) and Waxman (in press).

The studies of Markman and Hutchinson tested both the taxonomic assumption and the whole object assumption: Children should interpret novel labels as labels for objects of the same type rather than objects that are thematically related. To test this, we conducted a series of studies each of which compared how children would organize objects when they were not provided with an object label versus when the objects were given a novel label.

One set of studies was conducted with 4- and 5-year-olds to test the hypothesis that hearing a new word will lead them to look for taxonomic relations rather than thematic relations at roughly the superordinate level of categorization. Children were assigned to one of two conditions. In one of the conditions, children were asked to find a picture that was the same as the target. The other condition was the same except that a nonsense syllable was used to label the target picture. In both conditions, children were first shown the target picture. They were then shown two other pictures and had

TABLE 1
Triads Used in Markman & Hutchinson's Study

Standard Object	Taxonomic Choice	Thematic Choice
Cow	Pig	Milk
Ring	Necklace	Hand
Door	Window	Key
Crib	Adult bed	Baby
Bee	Ant	Flower
Hanger	Hook	Dress
Cup	Glass	Kettle
Car	Bicycle	Car tire
Sprinkler	Watering can	Grass
Paintbrush	Crayons	Easel
Train	Bus	Tracks
Dog	Cat	Bone

to select one of them as being the same as the target. One of the choice pictures was related in a thematic way to the target, for example, as milk is to cow. The other choice picture was a member of the same superordinate category as the target, for example, as pig is to cow. Examples of the materials used are shown in Table 1.

On each trial in the *No Word Condition,* the experimenter, using a hand puppet, said, "I'm going to show you something. Then I want you to think carefully and find another one." The experimenter then placed the target picture face up on the table directly in front of the child, and said, "See this?" She placed the two choice pictures to the left and right of the target, then said, "Can you find another one?"

Everything about the procedure for the *Novel Word Condition* was identical to that of the No Word Condition, except that the target picture was now labeled with a novel word. Children were told that the puppet could talk in puppet talk, and that they were to listen carefully to what he said. The instructions now included an unfamiliar label for the target: "I'm going to show you a dax. Then I want you to think carefully and find another dax." "See this dax. Can you find another dax?"

We predicted that children in the Novel Word Condition, because they were given a label, should choose the taxonomically related choice picture more often than children in the No Word Condition. As is typical for children this age, when no word was present they did not often make categorical choices. When children in the No Word Condition had to select between another member of the same superordinate category and a thematically related object, they chose the categorical relation only 25% of the time. As predicted, the presence of a new word caused children to seek taxonomic relations. When the target picture was labeled with an unfamiliar word,

Figure 1. A taxonomically related pair of objects from Markman & Hutchinson (1984).

children were much more likely than children hearing no label to select categorically. They now chose the other category member 65% of the time.

The proposal is that children focused on categorical relationships because of the sheer presence of the word, and not because of any particular knowledge about the meaning of the word. One possible alternative explanation is that children translated the novel puppet words into known words which already refer to objects of the same kind. The next study was designed to provide evidence that children use abstract knowledge about words rather than specific known meanings to facilitate taxonomic responding (see Markman & Hutchinson, 1984 for other arguments against this alternative hypothesis). In this study, pictures of artificial objects were used instead of real objects. Children are not likely to translate unfamiliar names for these pictures into known words, because they do not know real word names for them. If the presence of an unfamiliar word still causes children to shift from thematic to taxonomic responding when the materials are also unfamiliar, then this would rule out translation as an explanation for the effect.

Four- and 5-year-old children participated in the study. The design and procedure for this study are essentially the same as that of the previous study. The main difference is that the experimenter first taught children the taxonomic and thematic relations for the artificial objects before asking them to select the picture that was like the target.

Before children saw the target picture and the two choices, they were shown two training pictures that illustrated how the target picture related to each of the choice pictures. One picture showed the target object and the taxonomic choice, side by side. For these pairs, children were told a common function that the two objects shared. An example taxonomic training picture is shown in Figure 1.

For this example, the experimenter said, "This swims in the water" (pointing to the left hand object). "This swims in the water" (pointing to the right hand object).

A second training picture showed the target and the thematic choice in an interactive relationship. The experimenter told the children how the two objects interacted. The thematic training picture for the set just given is
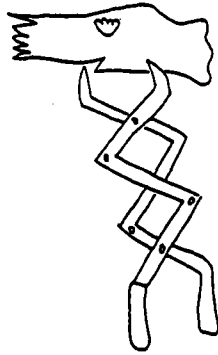
Figure 2. A thematically related pair of objects from Markman & Hutchinson (1984).
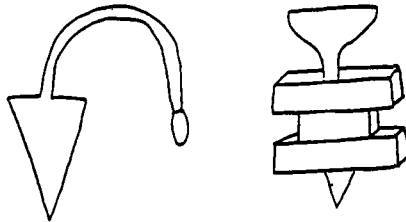

Figure 3. A taxonomically related pair of objects from Markman & Hutchinson (1984).

shown in Figure 2. For this example, the experimenter said, "This catches this" (pointing to the objects she was referring to as she said the sentence).

A second example taxonomic training picture is shown in Figure 3. For this example, the experimenter said, "This pokes holes in thing" (pointing to the left hand object). "This pokes holes in things" (pointing to the right hand object). The thematic training picture for the same set is shown in Figure 4. For this picture, the spoken information was "You keep this in here."

After children saw the two training pictures in a set, the pictures were removed from the table. The remainder of the procedure was identical to that of the previous study. In the No Word Condition, the experimenter said, "I'm going to show you something. Then I want you to think carefully, and find another one." The experimenter then placed the target picture face up on the table directly in front of the child, and said, "See this?" She placed the two choice pictures to the left and right of the target, and then said, "Can you find another one?"

As before, everything in the Novel Word Condition was the same except that a novel word was used to label the target picture. After children saw the
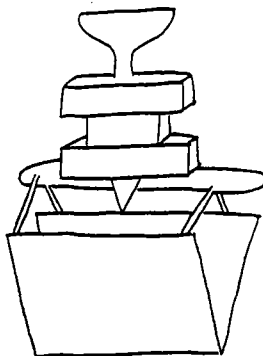
Figure 4. A thematically related pair of objects from Markman & Hutchinson (1984).

training pictures, the experimenter said, "I'm going to show you a dax. Then I want you to think carefully, and find another dax. See this dax? Can you say dax? Can you find another dax?" A different unfamiliar word was used for each set.

The results for the choices were parallel to those of the previous studies. As usual, when children in the No Word Condition had to select between another member of the same superordinate category and a thematically related object, they often chose the thematic relation. They selected the other category member a mean of only 37% of the time. When the target picture was labeled with an unfamiliar word children were more likely to select categorically. They now chose the other category member a mean of 63% of the time. Children hearing a novel word were significantly more likely to select an object from the same category than children not hearing a label. Thus, children place an abstract constraint on what single nouns might mean. Children limit count nouns to refer mainly to objects of the same kind rather than allowing them to refer to objects that are united by thematic relations.

In addition to the word reported here, several other findings support this conclusion. Even children as young as 2- and 3-years place constraints on what unfamiliar words might mean. When presented with two basic level objects, such as two different kinds of dogs, and a third object that was thematically related, such as dog food, very young children showed some tendency to select a dog and dog food. If however, one of the dogs was labeled with an unfamiliar term, children were now more likely to select two dogs (Markman & Hutchinson, 1984).

Hutchinson (1984) replicated the Markman and Hutchinson (1984) findings using a procedure whereby children were taught a novel word for the target object as before, but when asked for others, they were free to select none, one, or two additional objects, one of which was related taxonomi-

cally to the target and one of which was related thematically. With the exception of the 3-year-old boys, Hutchinson replicated the Markman and Hutchinson (1984) results with this procedure. That is, children spontaneously extended a term to label taxonomically related objects, even when they were free not to.

Waxman and Gelman (1986) have found that a label will induce 3-year-olds to classify taxonomically at the superordinate level, at least for superordinate categories for which the children do have a label. Moreover, they found that a novel label, actually a Japanese term, helped children organize objects taxonomically in a free classification task, where children were to sort pictures of objects into groups.

Waxman and Gelman (1986) compared the effectiveness of hearing a novel label with other means of highlighting the salience of categories. In some cases, children were shown typical instances of the category and told to think about them as a group. In other cases, children were given the common English superordinate term for the categories. Four-year-olds benefited from all of these manipulations. Three-year-olds, however, were helped by the use of labels, but not by seeing typical instances. Moreover, 3-year-olds did just as well when Japanese labels were provided for these familiar superordinate categories as when the known English labels were provided.

Other studies using different kinds of competing hypotheses (e.g., color or substance) have also found evidence for the whole object assumption (Baldwin, in press; Landau, Smith, & Jones, 1988; Soja, Carey, & Spelke, 1985).

In order for the taxonomic assumption to play a role in early language acquisition, it needs to be available to children younger than 2 and 3 years old. Although children's early language use suggests they honor the whole object and taxonomic assumptions (Huttenlocher & Smiley, 1987), one recent experimental study of very young children's usage of these assumptions was inconclusive (Bauer & Mandler, 1989). Bauer and Mandler (1989) set out to determine whether the labeling effect would hold up for even younger children. In a series of studies, they looked at 16 31-month-old children's tendency to sort thematically and whether labeling would increase the children's tendency to sort taxonomically. Unexpectedly, even the youngest children were sorting taxonomically from the start. That is, even with no labels children were sorting taxonomically around 75% of the time. Labeling did not increase this already high level of performance. Bauer and Mandler (1989) have thus convincingly demonstrated that quite young children are capable of sorting taxonomically. However, because of the already high rate of sorting taxonomically, they were unable to test whether children of this age adhere to the taxonomic assumption. That is, it is still important to know whether in those cases where children do show a thematic preference, whether hearing a label causes them to shift to taxonomic sorting. This question was addressed by Backscheider and Markman (1990).

One reason why Bauer and Mandler (1989) achieved such a high rate of taxonomic responding in their young children, is that they used a rein-forcement procedure whereby they briefly pretrained children to select taxo-nomically and where this selective reinforcement of taxonomic choices was maintained throughout the testing procedure. This selective reinforcement clearly mattered because, in a control study, Bauer and Mandler achieved an equally high rate of thematic responding by selectively reinforcing the-matic rather than taxonomic choices. Since they demonstrated that selective reinforcement is a powerful way to influence children's responses, Bach-scheider and I eliminated selective reinforcement from our procedure. Our results replicated the original Markman and Hutchinson (1984) findings, even with 18- to 24-month-olds. In the absence of labels, very young chil-dren selected taxonomically only 32% of the time. That is, they showed the thematic bias seen in older children. In marked contrast, when an object was given a novel label children interpreted the novel label as referring to objects of the same taxonomic category 77% of the time. Thus, the taxo-nomic assumption is used by children by 18 months of age.

To summarize, there are now a number of studies using several different methodologies which together demonstrate that children from 18 months on honor the taxonomic assumption. We do not yet know whether younger babies honor the constraint (Nelson, 1988). However, if the taxonomic con-straint is already in place by 18 months, that suggests that it could play a fundamental role in acquiring word meanings even early on in language learn-ing. In particular, it is at roughly 18 months of age that children undergo the vocabulary spurt where they become capable of acquiring words at very fast rates (Bloom, Lifter, & Broughton, 1985; Corrigan, 1983; Dromi, 1987; Halliday, 1975; McShane, 1979; Nelson, 1973). This very fast form of learn-ing must be a highly constrained form of learning. To speculate, then, the emergence of the whole object and taxonomic constraints may be what ac-counts for the very young child's sudden ability to acquire words rapidly.

THE MUTUAL EXCLUSIVITY ASSUMPTION

The whole object assumption leads children to treat novel terms as labels for whole objects—not for parts or substances of objects or for other proper-ties. But children must of course learn terms that refer to parts, substances and other properties. The *mutual exclusivity* assumption, to be discussed next, helps children override the whole object assumption, thereby enabling them to acquire terms other than object labels.

In addition to the whole object and taxonomic assumptions, then, chil-dren constrain word meanings by assuming at first that words are mutually exclusive—that each object will have one and only one label. In order for categories to be informative about objects, they will tend to be mutually ex-

clusive, especially at the basic level of categorization. A single object cannot both be a chair and a dresser or a chair and a table. A single object cannot both be a cow and a bird or a cow and a dog. Obviously, however, there are many exceptions: categories overlap, as in "dog" and "pet," and they are included in one another as in "poodle" and "dog." So mutual exclusivity is not an infallible assumption to make. On the other hand, it is a reasonable one and, as I hope to show, by assuming that terms are mutually exclusive, children make progress in acquiring new words, even if it is at the cost of making some mistakes along the way.

In fact, one piece of evidence in favor of the hypothesis that children assume words will be mutually exclusive is that it helps explain some errors children make. It helps explain, for example, why children find class inclusion difficult (because it violates mutual exclusivity) and why the part–whole relation of collections is simpler (because it maintains mutual exclusivity) (Markman, 1987; 1989).

While honoring the mutual exclusivity assumption, children will nevertheless violate mutual exclusivity under some circumstances. To acquire class-inclusion relations, for example, children must override their initial tendency to assume terms are mutually exclusive. With enough evidence to the contrary, or enough information about the referent of a term, children will allow multiple labels for the same object. The mutual exclusivity bias guides children's initial hypotheses about a word's meaning and without evidence to the contrary, children will maintain this hypothesis. But mutual exclusivity can be overriden. Thus, violations of mutual exclusivity in children's lexicons are not necessarily evidence against this principle. Gathercole (1987), Merriman and Bowman (1987), and Nelson (1988) have all pointed out cases in which mutual exclusivity is clearly violated and a complete theory of how these constraints guide children's word learning must account for the counterexamples and violations to the principle. As a working hypothesis, children are presumed to be biased to assume at first that terms are mutually exclusive, but will relinquish that assumption when confronted with clear evidence to the contrary (see Markman, in press; Merriman & Bowman, 1989).

Mutual exclusivity is related to several other principles that have been postulated to account for language acquisition, including Slobin's (1973) principle of one-to-one mapping and Pinker's (1984) Uniqueness Principle (see Markman & Wachtel, 1988 for a discussion). A third principle, Clark's (1983, 1987) Principle of Lexical Contrast is most closely related to mutual exclusivity. Clark argues, following Bolinger (1977), that every word in a dictionary contrasts with every other word and that to acquire words children must assume that word meanings are contrastive. Mutual exclusivity is one kind of contrast, but many terms that contrast in meaning are not mutually exclusive. Terms at different levels of a class-inclusion hierarchy, such as *dog* and *animal,* contrast in meaning in Clark's sense, since obvi-

ously the meaning of *animal* is different from that of *dog.* Yet, these terms violate mutual exclusivity. Mutual exclusivity is a more specific and stronger constraint than the principle of contrast. Some of the evidence that Clark (1987) cites for the principle of contrast, however, is also evidence in support of mutual exclusivity.

One problem with the evidence that Clark (1983, 1987) cites in favor of mutual exclusivity, is that it comes almost entirely from production data. There may be many reasons why beginning language learners would be limited in the amount they can produce which would prevent them from expending valuable resources on redundant information. This limitation on production could be for very different reasons than a constraint on the lexicon. A lexical constraint should be apparent in comprehension as well as in production. In fact, Markman and Wachtel (1988) argued that the best evidence for mutual exclusivity would be from comprehension data not from production. They designed six experimental studies of children's comprehension of terms to investigate whether children honor mutual exclusivity. I will summarize these next.

The simplest situation where the principle of mutual exclusivity could be applied is where two objects are presented, one of which already has a known label and one of which does not. If a new label is then mentioned, the child should:

1. On the whole object assumption, look for an object as a first hypothesis about the meaning of the label;
2. On the mutual exclusivity assumption, reject the already labeled object; and
3. Therefore, assume the other object is being referred to by the novel label.

This was tested in Study 1 of Markman & Wachtel (1988) as well as by Golinkoff, Hirsch-Pasek, Lavallee, & Baduini (1985) and Hutchinson (1986). All three of these studies found that in this simple situation where one could map an unfamiliar word to an unfamiliar object, 3-year-old children use the principle of mutual exclusivity in figuring out the meaning of a new word. Note also that in this situation the child can simultaneously satisfy the taxonomic and mutual exclusivity assumptions. The next study from Markman and Wachtel (1988) examined what happens when this simple mapping strategy is not longer possible, and the taxonomic assumption and mutual exclusivity may conflict.

Suppose a novel word is used to describe a single object. According to the taxonomic and whole object assumptions, a child should first hypothesize that the new word refers to the object as an exemplar of a category of similar objects, and not to the object's part, substance, and so on. Suppose, however, that the object described by the novel term is an object for which the child already has a label. In this case, in order to adhere to the principle of mutual exclusivity, the child would have to reject the novel term as a

TABLE 2
Experimental Items for Study 2 of Markman & Wachtel (1988)

CONDITION			
Familiar		Unfamiliar	
Object	Novel Label for Part	Object	Novel Label for Part
Fish	Dorsal fin	*Current detector	Detector
Fire truck	Boom	Pipe tool	Damper
Hammer	Claw	*Ritual implement	Crescent
Camera	Focusing grip	*Pagoda	Finial
Telephone	Receiver	Microscope	Platform
Race car	Air foil	*Lung	Trachea

* These items were used in Study 3 as well.

label for the object, but then may not have any clear alternative as a possible meaning for the term. That is, since there is no other object around to label, the simple novel label-novel object strategy cannot be used. Under these circumstances, there are several different strategies available. Children could decide to abandon mutual exclusivity in these cases and interpret the novel term as a second label for the object. Another possibility is that they could reject the term as a label for the object without coming up with an alternative meaning. Rejecting one meaning for the term, however, leaves the child with a term that is not yet attached to any referent. This in itself may motivate children to try to find some meaning for the novel term. The mutual exclusivity principle does not speak to how children select among the potential meanings, but children might analyze the object for some interesting part or property and interpret the novel term as applying to it. Such an analysis is considerably more difficult than the simple novel label-novel object matching strategy, and there may be many candidate meanings for the term. The remaining studies examine whether children can use mutual exclusivity, in this more difficult situation, to learn part and substance terms.

Study 2 of Markman and Wachtel (1988) addressed whether children can use mutual exclusivity to reject a novel term as a label for an already labeled object, and whether that would motivate them to search for another salient aspect of the object to label. In this study, we attempted to teach children labels for objects with prominent parts. Children heard a novel noun attributed to either a familiar or an unfamiliar object. The term could thus refer to either the object itself or to a salient part of the object.

Three- and 4-year olds heard either familiar or unfamiliar objects labeled with a novel term and were then tested to see whether they thought the term referred to the object as a whole or to a salient part of the object. The set of familiar and unfamiliar objects along with their relevant parts is presented in Table 2.

Children were assigned to one of two conditions, the Familiar Condition where the object had a known label, or the Unfamiliar Condition where children did not know a label for the object. In both conditions children were taught a label applied to an object with a noticeable part. The labels used were in fact adult labels for the part. In neither condition did children already know a label for the part being taught. For example, children in the Familiar object condition were taught "boom" as the part of a (familiar) fire-truck and "dorsal fin" as the part of a (familiar) fish. Children in the Unfamiliar condition were taught "finial" as the part of an (unfamiliar) pagoda, and "trachea" as a part of an (unfamiliar) lung. The prediction is that children will interpret the label as referring to the object itself for unfamiliar objects, but to a part for familiar objects.

As predicted, children interpreted a novel term quite differently depending on whether the object was familiar or not. Children gave a mean of only 20% part responses in the Unfamiliar condition, compared to a mean of 57% part responses in the Familiar condition. Thus, as expected by the mutual exclusivity hypothesis, children hearing a novel term in the presence of an object with a known label, were less likely to think the novel term referred to the whole object than were children who heard the term in the presence of an object with no known label.

In Study 2 of Markman and Wachtel (1988), the parts and wholes that children were questioned about in the experimental items differed for the Familiar and Unfamiliar conditions. Study 3 was designed to equate the items in the two conditions. Only unfamiliar objects were used in this study, but some of the children were provided with labels for the objects before the experimental labels were taught. In this way, the identical item could be unfamiliar for some children and "familiar" or at least previously labeled for other children.

There were two conditions in the study, the Familiarization condition and the Unfamiliar Condition. The labeling procedure and method of asking children whether the object referred to the part or the whole was virtually identical to that used in Study 2. The main difference is that in the Familiarization condition, children were first taught a label for the object. To do this children were shown a picture of the object, for example the lung, told what it was called, for example, "This is a lung," and given a short description of the function of the object, for example, "We all have two lungs in our chest and use them to breathe." They were given this familiarization with the experimental objects before they were then run in the standard procedure.

In both conditions children were asked about the unfamiliar objects that had been used in Study 2. As before, the experimenter told the children what they were about to see, for example, "Here is a finial," and then presented the picture of the object. She then asked, which one is the finial, this whole thing (the experimenter circled the object with her index finger) or just this part (the experimenter pointed to the part.)?"

The results from Study 3 replicated those of Study 2. As predicted, children interpreted a novel term quite differently in the two conditions. Children who heard the term (e.g., *trachea*) in the presence of an unfamiliar object (e.g., lung) more often interpreted the term as referring to the object (the lung) and not its part. They gave a mean of 32% part responses. In contrast, children in the Familiarization condition interpreted the novel labels as referring to parts of the object. For example, children who had just heard the picture of a lung labeled "lung" interpreted "trachea" as referring to the part (the trachea) and not the object (lung). They gave a mean of 85% part responses.

In summary, Study 3 again provides evidence for the mutual exclusivity hypothesis. When a novel term is used in the presence of an object that already has a label, children tend to reject another label for the object, and, in this case, assume the term refers to a part of the object instead. This was true in this study, even though the label for the (previously unfamiliar) object was provided only a few moments before another novel label was taught.

In Study 1 of Markman and Wachtel (1988), children could use a simple strategy of mapping an unfamiliar label to an unfamiliar object to preserve mutual exclusivity. Because there was only one object referred to in Studies 2 and 3, this simple strategy was precluded. Children still adhered to mutual exclusivity in this case, and used it to learn terms for salient parts of objects. However, parts of objects are themselves objects or at least object-like. Thus, learning parts of objects may be as close to the simple mapping strategy as one can get using a single object. The next three studies from Markman and Wachtel (1988) examined whether mutual exclusivity is used by children when the experimenter refers to an object made of a salient substance, using an adjective or mass noun. There are two ways in which this situation differs from that of the studies on learning labels for parts. First, instead of depicting objects with salient parts, we selected objects with a metallic substance we thought would be salient and that young children have not yet labeled. Second, in these studies the object was referred to by an adjective or a mass noun—"See this? It's pewter." This is not the typical way, in English, of designating objects. It therefore provides a strong test of the taxonomic assumption. When an unfamiliar object is labeled, the bias to look for object labels may be strong enough to override grammatical form class information. So even when an adjective or mass noun is used to describe an object, children may interpret it as the label for the object. A commonly heard anecdote, for example, is that young children think that *hot* is the label for stoves because parents refer to stoves by the term *hot* before they label them as "stoves," for example, "Don't touch that, it's hot."

These two issues, then, are examined in Study 4. First, following the taxonomic assumption, will children interpret even a novel adjective as a label for an unfamiliar object? Second, following the mutual exclusivity assump-

tion, will children reject a novel term as a label for a familiar object made from a salient substance.

In Study 4, 3- and 4-year-olds heard a puppet refer to an obect as pewter. Half of the children heard the term attributed to a familiar object—a metal cup. Half of the children heard the term attributed to an unfamiliar object —a pair of metal tongs. To introduce the novel term "pewter," a puppet showed the child the object (either the metal cup or the metal tongs) and said: "See this? It is pewter."

If the tendency to expect an object label is strong enough to override form class cues, then children hearing "pewter" ascribed to the metal tongs should interpret "pewter" as the label for tongs. They should then agree that a different pair of tongs, made from a different substance and of a different color—a pair of wooden tongs—is also pewter. In contrast, when children hear "pewter" ascribed to a familiar object, if they try to adhere to the mutual exclusivity principle, then they should reject "pewter" as the label for the cup. They should, then, deny that a cup made from a different substance and of a different color—a ceramic cup—is pewter. The main prediction, then, is that when the children see an object that is similar in kind to the original object but that is of a different substance, they should agree that it is "pewter" when the object referred to is unfamiliar (the metal tongs) but deny that it is pewter when the object is familiar (the metal cup). Thus children should agree that a pair of wooden tongs is pewter but deny that a ceramic cup is pewter.

This prediction from the mutual exclusivity hypothesis was confirmed. Of the 12 children who were taught that a metal cup was pewter and then asked if a ceramic cup was pewter, only one child thought it was. The other 11 children denied that it was pewter. Thus, even in this more difficult situation, children adhered to the mutual exclusivity principle, denying that a new term could be a label for an object even when it might not be clear what else the term refers to. In contrast, of the 12 children who were taught that metal tongs were pewter, 7 of the 12 thought that wooden tongs were also pewter.

Another question addressed by this study is whether children would interpret even a novel adjective or substance term as a label for unfamiliar object. The results indicate that at least to some extent 3-year-olds are willing to override form class clues in order to interpret the term as a novel label. That is, about half of the children considered "pewter" to be the label for tongs and agreed that wooden tongs were pewter.

Study 5 from Markman and Wachtel (1988) was a modified replication of Study 4 that used a within-subject design. Each child heard one novel substance term applied to a familiar object and a different novel substance term applied to an unfamiliar object. The two substance terms were "chrome" and "rattan." The findings from this study replicated those of Study 4.

First, the bias to assume that a novel term refers to a novel object was again strong enough to override discrepancies in grammatical form class. Seventy-five percent of the children who heard the terms "chrome" or "rattan" attributed to novel objects, treated the terms as labels for the objects. Second, children were less likely to think that the novel terms were labels for the objects when they already knew a label for the object. Only 40% of the children who heard "rattan" and "chrome" attributed to familiar objects treated the terms as labels for the objects; 60% rejected the terms as labels.

In Studies 4 and 5, 3 and 4-year-old children treated a novel term as a label for a novel object, but tended to reject the term as a label for a familiar object. Although we know that children are rejecting the novel term as a term for a familiar object, we do not know whether they have in fact accepted the term as a substance term. Study 6 attempted to get at children's hypotheses about the meanings of the terms more directly by giving children a forced-choice between object labels and substance labels.

In this study, we labeled an object using a novel term, for example, "See this (a metal cup)? It's chrome," as in the previous studies. Children were then shown a similar object but of a different substance (e.g., a ceramic cup). They were also shown a chunk of the substance itself—for example, an unformed piece of chrome. They were then asked "Which is chrome? This thing here or this stuff here?" This procedure is similar to that used by Soja, Carey, and Spelke (1985) in their investigation of children's acquisition of count nouns and mass nouns. The question for the present study is whether children will interpret a term as a substance term in the presence of an object as long as the object has a known label. In other words, will mutual exclusivity help children override their bias for object labels to interpret a novel term as a substance term?

As in Studies 4 and 5, children heard a familiar object (a hat) or an unfamiliar object (an odd-shaped container) labeled as rattan. They also heard a familiar object (a cup) or an unfamiliar object (tongs) labeled as chrome. The experimental test for whether children interpreted the term as a label for the object or the substance was to give children a choice between a similar object of a different substance and the substance itself. To illustrate, for the familar rattan condition, children were shown the rattan hat and told "See this? It's rattan." They were then shown a plastic hat and a piece of rattan and asked: "Which one is rattan, this stuff here (pointing to the piece of rattan) or this thing here (pointing to the hat)?".

The predictions were that when children heard a novel term applied to a novel object, they should have chosen the object as the referent of the term, but when they heard the term applied to a familiar object, they should have chosen the substance as the referent of the term. This prediction was supported. The mean number of object responses was .57 out of 1 for the unfamiliar condition compared to only .13 out of 1 for the familiar condition.

Thus, in support of the mutual exclusivity hypothesis, when children heard a novel term applied to a familiar object, they rejected the term as a label for the object and interpreted it as a substance term instead.

In sum, these studies provided evidence that children do, in fact, assume that words tend to be mutually exclusive. The first study, along with Golinkoff et al. (1985) and Hutchinson (1986), demonstrated that when a novel object label is heard, children assume that it refers to a novel object rather than to an object whose label is already known. To use mutual exclusivity in this situation, children can adopt a simple strategy of mapping the novel label onto the novel object (see Merriman & Bowman, 1989 and Gathercole, 1987, for other interpretations. The remaining studies explored whether children adhere to the principle of mutual exclusivity when this simple strategy can no longer be used.

If a novel label is applied to an object for which children already have a label, then they should, by mutual exclusivity, reject the new term as an object label. If that object, however, is the only one around, then children cannot interpret the term as a label for a different object. Instead they must analyze the same object for some property or attribute to label. Studies 2–6 provided evidence that 3- and 4-year-olds try to maintain mutual exclusivity of terms even in this more difficult situation. Children interpreted a novel label as referring to the object itself when the object did not yet have a label. In contrast, as predicted, they interpreted the label as referring to part or substance of the object when the label for the object was already known.

CONCLUSIONS

Together, the studies reported here show how constraints such as the taxonomic and whole object assumptions and the assumption of mutual exclusivity can guide children's initial hypotheses about what words can mean, thereby, helping to solve the problem of induction that word meaning poses. Young children possess the knowledge that single nouns are more likely to refer to objects of the same kind than to objects associated by their participation in a common event or theme. This knowledge helps explain how children acquire new words. By constraining the meaning of a term to categorical relations, children are able to rule out a huge number of other potential meanings for any given term. In particular, relational and thematic meanings would be eliminated from consideration by the constraint that nouns refer to object categories. By limiting the number and kind of hypotheses that children need to consider, this constraint simplifies the problem of language learning.

The whole object assumption leads children to expect terms to refer to objects—not to their parts or substances or other properties. The disadvantage of this constraint is obvious—languages are filled with terms that refer

to parts and substances and other properties of objects. Mutual exclusivity can help remedy this limitation of the whole object assumption. First, it provides children with grounds for rejecting a class of hypotheses about a term's meaning. Namely, the new term should not be another object label. Second, it motivates children to acquire terms other than object labels. Having rejected one meaning of a term, children would be left with a word for which they have not yet figured out a meaning. This should then motivate them to find a potential meaning for the novel term, leading them to analyze the object for some other property to label. In this way, the mutual exclusivity assumption motivates children to learn terms for attributes, substances and parts of objects.

Thus, this function of mutual exclusivity helps overcome a major limitation of the whole object assumption which leads children to look for only object labels. Although the whole object assumption provides a critical first hypothesis about word meanings, children must eventually be able to learn terms for properties of objects and not just terms for objects alone. These two principles complement each other. The taxonomic and whole object assumptions clearly have priority when the object being labeled has no previously known label, since mutual exclusivity is not relevant in those cases. When one object has a known label and another has no known label, then both mutual exclusivity and the whole object assumptions can be met. The whole object and mutual exclusivity assumptions compete when a child hears a term applied to an object for which they already know a label. Here mutual exclusivity can motivate children to learn terms other than object labels.

One can envision how the mutual exclusivity principle can be used to successively constrain the meanings of terms. Suppose a child already has words for apple and for red and now someone refers to the apple as "round." Now, by mutual exclusivity, the child can eliminate apple and red as the meaning of "round" and try to analyze the object for some other property to label. There are still many unanswered questions as to how this analysis would proceed. But at least we can conclude that as each successive word is learned it further constrains the meanings of the yet to be learned words, thereby helping children figure out their meaning.

In sum, children are helped in early language acquisition by the whole object, taxonomic, and mutual exclusivity assumptions. These biases guide children's initial hypotheses and eliminate numerous hypotheses from consideration and thereby help them solve the inductive problem posed by word-learning.

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