Linguistic Cues Enhance the Learning of Perceptual Cues

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Abstract

Past research on children's categorizations has centered on the mechanism of children's use of multiple cues in categorization. This paper examines correlations between perceptual cues and linguistic cues. The question asked is a classic one in learning theory: given two redundant cues, does the learner learn more about each than when one cue independently predicts the category? This question has special cogency in the context of children's language learning. We show that when linguistic cues correlated with perceptual cues, children learn more about perceptual cues.

Introduction

Two- and 3-year-old children learn new object names rapidly, often correctly determining the range of instances to which the name applies from just one experience hearing the word used in a single context. Children do this by exploiting multiple cues to meaning. Past research indicates they use both linguistic cues and perceptual cues to figure out the likely meaning of a novel noun. Much of the relevant evidence in this literature concerns the count-mass distinction in English. Count nouns refer to entities conceptualized as discrete objects and as countable. Count nouns obligatorily take the plural (e.g., cups, hopes). Mass nouns refer to entities conceptualized as continuous substances and do not take the plural, but rather mass quantifiers (e.g., some water, a lot of sand). Children use linguistic cues to the count/mass status of a noun to figure out the category to which a novel noun refers. For example, if an entity named with a novel name is presented in a frame that indicates it is a count noun (e.g., "This is a mel"), English-speaking children interpret the word as referring to a discrete entity and typically extend the object name to a class of similarly shaped things (Soja, Carey & Spelke, 1991; Soja, 1992; Landau, Smith and Jones, 1988; Landau, Smith and Jones, 1998; Imai & Gentner, 1997). When the same noun is presented in a frame indicating it is a mass noun (e.g., "This is some mel"), English-speaking children interpret the word as referring to a substance and extend its meaning to entities of the same material (Soja, Carey & Spelke, 1991; Soja, 1992).

Children also use perceptual cues. For example, children extend novel names to new instances by shape when the named entity is solid and rigid (e.g., made from wood) but extend the name to new instances by material when the named entity is nonsolid and non-rigidly shaped. Much previous research has explored which of these kinds of cues dominate by putting them in conflict. In this paper, we ask whether and how they might interact and support children's learning of object names. This is a relevant question for two reasons.

First, linguistic and perceptual cues are highly correlated. This was documented by Samuelson and Smith (1999) who studied the structure of the first 300 nouns commonly learned by English-speaking children. Among these 300 names for common categories, solid things tend to be named by count nouns that refer to things of the same shape, whereas nonsolid things tend to be named by mass nouns that refer to entities of the same material. For learners of English, then, there is a tight correlation between linguistic cues associated with count/mass distinction and perceptual cues that indicates the solidity or non-solidity of an entity.

Second, the evidence suggests that children learn the correlations among perceptual cues, linguistic cues, and category structure as they learn names for common object and substance categories. Specifically, the influence of perceptual cues on children's noun extensions emerges and grows stronger as vocabulary grows. Samuelson and Smith's (1999) data indicate that children learning English do not extend names for solid and nonsolid things differently until children have over 150 nouns. Similarly, English-speaking children's sensitivity to count/mass syntax in the novel noun extension task emerges during this same time period (Soja, 1992).

Two hypotheses

What is the relation between learning about perceptual cues to category organization and linguistic cues to category organization? One possibility is that they are completely independent. Cross-linguistic comparisons of English and Japanese speakers are consistent with this view. Japanese differs from English in that it has no obligatory plural and no counterpart to the count-mass distinction in English. Yet, several studies suggest that

Japanese-speaking children extend names for novel solids and non-solids in pretty much the same way as English-speaking children (e.g., Imai & Gentner, 1997). Thus, children's learning about perceptual correlations and their learning about syntactic cues to category structure (so-called syntactic bootstrapping) may proceed from different learning mechanisms. At the very least, learning about perceptual correlations does not require support from linguistic correlations.

The second contrasting possibility is that learning about perceptual and linguistic cues to category structure are mutually reinforcing. Imai & Gentner's (1997) comparisons of Japanese-speaking and English-speaking children's extensions of names for novel solids and non-solids suggest some subtle differences in the range of items treated as objects and substances, and also some differences in the developmental trend (see, also Yoshida & Smith, 2001.) Further, a number of learning models (Billman & Knutson, 1996; Medin, Altom, Edelson and Freko, 1982; Goldstone, 1998) suggest that the addition of correlated cues bolsters learning about each cue.

Rationale for the experiment

In the present experiment, we examine the role of syntax in children's learning about perceptual cues to category structure through a training study. We attempted to train the solid-nonsolid distinction in Japanese-speaking children who were too young to robustly make the distinction in their novel noun extensions (Shirai, 2000). The design of the four training conditions is shown in Table 1. The linguistic cues are *hitotsu* and *sukoshi*. In the specification of quantitative constructions, (e.g., There is one cup) *hitotsu* is used with objects and *sukoshi* is used with substances. This is thus a natural and salient lexical contrast in Japanese, yet it is one that is neither mandatory nor particularly common. This is in contrast to the count-mass distinction in English, which is mandatory and pervasive. In control conditions, we show that Japanese-speaking children are not sensitive to this contrast, and do not know its implications concerning objects and substances, prior to training.

During the test phase, half of the children in each condition were tested with the linguistic cues and half were not. Here, then, is the question: Will Japanese speaking children show a stronger distinction in their novel noun generalizations between solids and non-solids if trained with these correlated linguistic cues than if trained without them? Is this so even when the linguistic cues are not present during testing? Because our design involves using natural and thus potentially meaningful lexical cues, and because we attempted to accelerate the emergence of a distinction that children eventually learn, we also included two control conditions. Neither involved any training but tested children's sensitivity to the linguistic and perceptual cues.

Experiment

Method

Participants Forty monolingual 2 _ year-old Japanese-speaking children residing in Niigata, Japan, were randomly assigned to the two training conditions and one control condition. Half of the children in each condition participated in the novel noun generalization test at the end of training, either with linguistic cues or without linguistic cues in the tasks, for a total of 6 conditions.

Stimulus Training stimuli consisted of 4 training pairs, two solids and two non-solids, as shown Figure 1. The items in the solid pairs were the same shape but differed substantially in material and color. The items in each nonsolid pair were the same material but differed substantially in color and shape. Stimuli for the test trials consisted of novel solid items made of wood, clay, or sponge, and novel nonsolid items made of hair gel, hand cream, or toothpaste. During test, children were queried about 6 unique test sets, 3 times each for a total of 18 trials per a participant. Each of these test sets contained one exemplar and 3 choice objects unique to that set. One test choice object matched the exemplar in shape only, one matched in material only, and one matched in color only (See Figure 2.) During test, the exemplars were named with a novel name with and without the lexical cues *hitotsu* and *sukoshi* corresponding to the condition to which the participants were assigned.

Design and procedure Children participated in one of the 6 conditions that resulted from crossing the 3 levels of training (training with correlated linguistic cues, training without correlated linguistic cues, and absence of training), 2 levels of linguistic cues (with/without linguistic cues in the task) with 2 levels of solidity (sold/non-solid) for each condition.

Children in the Training condition participated in 10 training sessions over a period of 4 weeks. During each session, the child was presented with the training stimulus repeatedly with/without correlated linguistic cues depending on the child's condition. Each stimulus was shown and introduced by its own novel name, and then played with and repeatedly named for 5 minutes. Each training session took a place for approximately 30 minutes every other day. Notice, this is an implicit category-learning task. During training, children are not required to discriminate between category instances, but attend to the linguistic cues as predictive of category membership.

All children participated in the same test trials where the child was shown an exemplar of a test stimulus set

and told its unique novel name with and without corresponding linguistic cues; "This is (*hitotu/sukoshi*) kochi" or "This is (*hitotu/sukoshi*) kochi". The child was then presented with 3 test objects and was asked to hand the item that can be considered as the name of the exemplar with and without corresponding linguistic cues; "Where is (*hitotu/sukoshi*) kochi?" or "Where is kochi?" Feedback was not provided on these test trials. Since these are novel objects and novel names, success requires knowledge of some general principle---that solids are named by shape and nonsolids are named by material. Are children more likely to notice this regularity when there are correlated linguistic cues?

Results

Each graph in Figure 3 shows the percentage of children's "correct novel word generalization" for solid and non-solid items where "correct" was considered to be shape based for the solids and material based for the non-solids.

Two graphs in the top row represent the performance of children without training sessions. Children generalized all names the same---by shape---treating solids and non-solids equally. This shows that, prior to training, children are not sensitive to the linguistic distinction, nor given these stimuli, to the solid-nonsolid distinction. The two graphs in the bottom represent the performance of children participated in the training sessions with corresponding syntactic cues. The graph on the left shows children's performance without the corresponding syntactic cues in the test trials and one on the right shows children's performance with the corresponding syntactic cues.

Overall, children who had training sessions with the linguistic cues generalize novel names correctly more often than of children without the training sessions, $F(1, 28)=27.2$, $p< .01$. The results suggest that the presence of correlated linguistic cues enhances learning about perceptual cues;

Discussion

The training study revealed the importance of correlated cues in category learning by demonstrating how correlations between linguistic cues and perceptual cues mutually reinforce attention to relevant perceptual cues in the name extension task. The findings fit the traditional idea of how language influences thought.

Whorf. (1956, p.252) wrote

> *And every language is a vast pattern-system, different from others, in which are culturally ordained the forms and categories by which the personality not only communicates, but also analyzes, notices or neglects types of relationship and phenomena….*

If correlated linguistic cues influence what is learned about perceptual cues, Whorf will be right: the language one learns will influence what one notices or neglects to notice about the world.

Table

Table 1: 4 key conditions

	Test with novel stimuli	
	Syntax	**No-syntax**
Trained with syntax	**Correlated cues**	**No in task correlated cues**
No-Trained	**Only in task correlated cues**	**No correlated cues**

Figures

Figure 1: Stimulus items used for the training sessions.

Figure 2: Stimulus items used for the test trials.

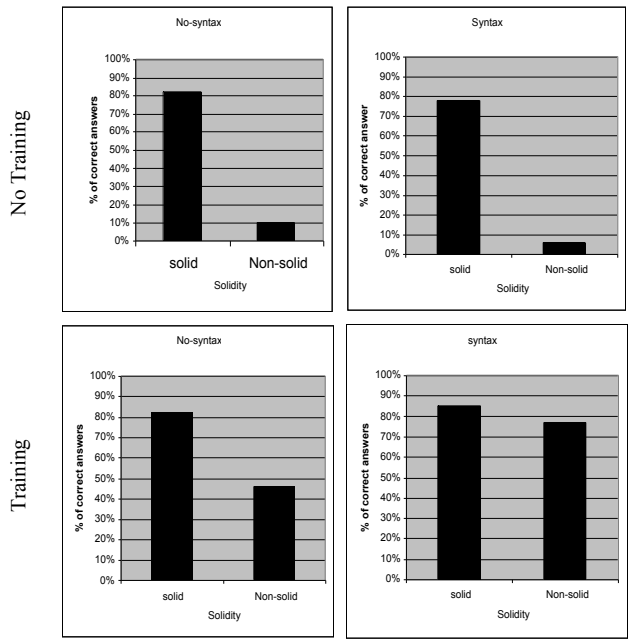

Figure 3: Mean percentage of correct answers.

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