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Attentional Biases in Artificial Noun Learning Tasks: Generalizations Across the Structure of Already-Learned Nouns

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Abstract

Even though learning noun meanings in a first language should be a difficult task young children learn nouns quickly and often with little effort. Previous research suggests that the task of learning words in made easier by constraints or biases that reduce the problem of finding the correct word-referent mapping to a solvable size. The research presented here examines the relation between the attentional biases young children demonstrate in laboratory noun learning tasks and the pattern of word learning seen outside the laboratory. The comparison suggests that attentional biases in laboratory noun learning tasks are a generalization across the nouns young children have already learned. Further, changing the nouns young children know changes not only the attentional biases they demonstrate in the laboratory, but also their vocabulary development outside the laboratory.

Introduction

Young children typically say their first word at 1-year-of-age. However, conservative estimates suggest that by 5-years-of-age children have as many as 10,000 words in their productive vocabulary. How do children learn so many words so fast? One suggestion is that the task of learning words is made easier by biases or constraints which reduce the problem of finding the correct word-referent mapping to a solvable size (e.g. Landau, Smith, & Jones, 1988; Markman, 1992; Soja, Carey, & Spelke, 1991). There is strong experimental evidence for the existence of a number of these word learning biases. The research presented here concentrates on two: the shape bias for learning names of solid objects and the material bias for learning names of non solid substances.

Evidence for these two attentional biases comes from artificial noun learning experiments. In these experiments, a young child is presented with a novel object. This exemplar object is then named, i.e. “this is a dax”. The child is then presented with novel test objects that match the exemplar in one perceptual dimension, for example in shape only, color only, or material only. The child is then asked which of these test objects can be called by the same name as the exemplar.

Numerous studies have shown that when the exemplar object is made of a solid, rigid material such as wood or hardened clay, children 24-months-of-age and older generalize novel names to other objects that match the exemplar in shape. This “shape-bias” has been demonstrated in numerous laboratories, with stimuli ranging from real, 3-dimensional objects specially constructed for the experiment (Imai & Gentner, 1997; Landau, et al., 1988), to pictures of familiar objects (Imai, Gentner, & Uchida, 1994). However, when the exemplar object is made from a non solid substance such as hair gel or face cream, children generalize the novel name to test objects made from the same material as the exemplar (Dickinson, 1988; Soja, 1992; Soja, et al., 1991). This “material-bias” has also been demonstrated in numerous studies and laboratories, however this bias does not appear to be robust until after 30-months-of-age (Samuelson & Smith, 1999).

In a series of recent studies, I have examined the relation between these attentional biases, demonstrated in laboratory tasks, and the pattern of noun vocabulary growth seen outside the laboratory (Samuelson & Smith, 1999). These experiments suggest that the attentional biases seen in laboratory word learning tasks may be generalizations across the category structure of already learned nouns. This paper reviews these findings and the suggested hypothesis. Two experiments testing this hypothesis are then presented. The results show that changing the nouns young children know changes the development of attentional biases seen in laboratory word learning tasks, and that this change further alters the trajectory of vocabulary development outside the laboratory

Attentional Biases and the Nouns Children Know

If the shape and material biases are to help children learn nouns, then these biases need to match the kinds of nouns that young children learn early. That is, if the shape bias helps children learn names for solid objects by directing their attention to with-in category similarity in shape, then many of the nouns young children learn early should refer to solid things in categories well organized by shape. Likewise, if the material bias helps children learn names for non solid things by directing their attention to similarity in material substance, then there should also be many names for non solid things in categories well organized by material substance among the nouns children learn early. An important question, then, is what kind of nouns do young children learn early?

To answer this question, I examined the category structures of a corpus of early-learned nouns. The corpus of 312 nouns studied was taken from the Mac Arthur Communicative Development Inventory (MCDI), a parental checklist of 680 words and phrases commonly found in the productive vocabulary of children between 16- and 30-months-of-age. In a series of yes/no judgments, thirteen adult native speakers of English were asked to think of examples of each noun in the studied corpus and say whether the examples were solid, non solid, similar in shape, and similar in material. An 85% agreement criterion was then used to determine the structure of the category referred to by each noun. For example, 85% of the adults agreed that crayons were solid, similar in shape, and similar in material. Thus, CRAYON was classified as referring to a category of solid things similar in both shape and material.

A summary of the findings across the entire corpus can be seen in Figure 1. In the figure, each square represents the 312 nouns studied. The area of each circle represents the proportion of those nouns that fell in each classification. And, the overlapping area of the circles represents the proportion of nouns that fell in the intersection of the classifications. As can be seen in the figure, many of the nouns children learn early name solid things and things in categories well organized by shape. And, there is a large amount of overlap between these classifications; many of the nouns children learn early name solid things in shape-based categories. In contrast, few of the nouns children learn early name non solid substances or things in categories well organized by similarity in material substance. And, there is not much overlap between these classifications; young children do not learn many names for non solid substances in material-based categories (Samuelson & Smith, 1999).

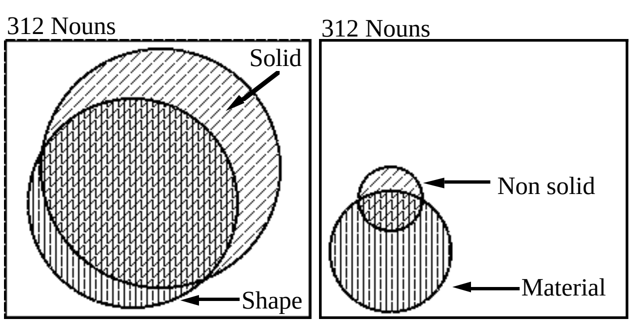

Figure 1: Summary of the category structure of the corpus of 312 early-learned nouns.

Thus, many of the nouns children commonly learn by 30-months-of-age fit the shape-bias. And, by 30-months-of-age children have not learned many nouns that fit the material-bias. These facts fit with previous findings that children demonstrate a shape-bias in artificial noun learning tasks by 24-months-of-age, but do not reliably demonstrate a material bias until 36-months-of-age. However, this study does not address the developmental relation between these findings. That is, do children demonstrate a shape bias because they know many names for solid things in shape-based categories. Or, do children learn many names for solid things in shape based categories because they have a shape bias? To address this question, I compared artificial noun learning with solid and non solid stimuli in children with a range of vocabulary sizes. Specifically, fifty-eight children between 17- and 31-months of age completed a forced choice artificial noun learning task in which half the exemplars and choice stimuli were made from solid materials such as wood and Styrofoam, and the other half were made of non solid materials such as hair gel and face cream. I also measured each child's productive noun vocabulary via parental report on the MCDI.

Figure 2 presents the key results. As can be seen in the figure, I found that children did not generalize novel names for solid objects to other solid objects by shape at levels reliably above chance until they already had 150 nouns in their productive vocabulary. And, children in the vocabulary range I studied did not generalize novel names for non solid stimuli to other non solid stimuli at levels reliably above chance. Thus, it appears that the shape-bias emerges only after children have already learned many names for shape-based categories. And, the material-bias does not emerge within the vocabulary range I studied (Samuelson and Smith, 1999).

These results suggest that the attentional biases young children demonstrate in artificial noun learning tasks might be the product of their previous noun learning. More

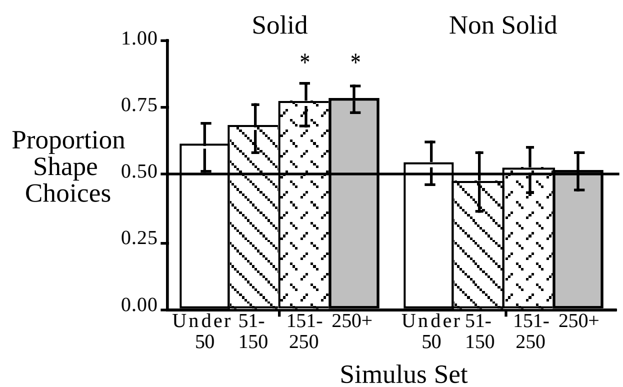

Figure 2: Proportion shape choices by noun vocabulary size for the solid and non solid stimulus sets. Chance responding is .50, * = p < .05 difference from chance.

specifically, what children do in artificial noun learning tasks is attend to whatever perceptual property has mattered most in learning the nouns they already know. Attentional biases thus appear to be a generalization across the structure of already learned nouns. This hypothesis is tested in the following experiment.

Experiment 1

Previous results suggest that children's performance in artificial noun learning tasks is a generalization across the structure of already learned nouns. The specific question addressed in this experiment is whether changing the nouns children know changes their attentional biases in artificial noun learning tasks. The idea was to intensively teach nouns to young children who do not have many nouns in their vocabulary and do not yet demonstrate systematic attentional biases in artificial noun learning tasks. If children's attentional biases in noun learning are a product of the nouns they already know, then changing the nouns they know should change their attentional biases.

To this end, two groups of children participated in a nine week longitudinal study. Children in one group were taught twelve names for categories of solid objects well organized by similarity in shape. Another group of children were taught twelve names for categories of non solid substances well organized by similarity in material substance. Two dependent measures were examined: artificial noun learning with both solid and non solid stimuli, and productive vocabulary via parental report. Both measures were taken early in training and, again, later in training. In addition, a follow-up report of productive vocabulary was obtained one month after the experiment was complete.

Methods

Participants. Twenty children between 15- and 21-months-of-age participated (mean 18m 28d, range 15m 20d to 21m 3d). Children were recruited from the child participants file at Indiana University and contacted by phone. All children were learning English as their first language. Children were randomly assigned to either the Shape Nouns or Material Nouns condition such that the mean age and vocabulary across conditions did not differ. Four additional children began but did not complete the experiment. All children received a small prize at each experimental visit and copies of experimental videotapes and T-shirts at the completion of the study.

Materials. Conditions differed only in the twelve nouns taught to the children over the course of the longitudinal study. All twenty-four nouns are nouns not usually learned until after 26 months of age. The noun category training sets for each condition consisted of three examples of each of the twelve nouns.

In the Shape Nouns condition, children were taught twelve names for solid things in categories well organized by shape, for example, bucket, pear, and ladder. In this condition, example items for each category were the same in shape but differed in size, color, and the material they were made from. For example, one ladder was wide and made of red wood, one was taller and made of white plastic and one was short and wide and made of pink metal.

In the Material Nouns condition, children were taught twelve names for non solid things in categories well organized by material, for example, glitter, lotion, and Jell-O. In this condition, example items for each category were made from the same material but differed in amount, color, and shape. For example, the Jell-O was either red, orange or blue and was either presented as a large pile, a couple small piles, or in the shape of a teddy-bear, and these shapes and amounts changed as the child ate the Jell-O.

Eight sets of artificial noun learning stimuli were also constructed–four made from solid materials such as wood and Styrofoam and four made from non solid materials such as hair gel and face cream. Each set consisted of an exemplar object and four test objects. In each set, two test objects were the same shape as the exemplar but were different colors and made from different materials, and two test objects were made from the same material as the exemplar but were different in shape and color. Eight unique nonsense words were created for use in the artificial noun learning task. The pairing of names to stimulus sets was counterbalanced across children.

Twenty unique sets of practice stimuli were also assembled for use in practice artificial noun learning trials. These sets consisted of small toys familiar to most 15-month-olds such as balls, toy cars, and cups. Each set consisted of two identical toys and a third toy that differed in color, shape and size (for example, two purple plastic eggs and a red wooden block).

Procedure. Children and their parents visited the lab once a week for nine consecutive weeks. These nine weeks were broken into three blocks of three weeks each. Each block consisted of two weeks of noun category training. On the third week children were tested in artificial noun learning. Productive vocabulary was measured via parent report on the Mac Arthur Communicative Development Inventory at the beginning and end of the experiment and at a follow-up appointment one month after the final experimental session.

During all experimental sessions, the child sat across a large table from the experimenter with his or her parent. Experimental sessions began with two practice trials of the artificial noun learning task. These practice trials were used both to engage the child in the experimental session, and to encourage their participation in the artificial noun learning task. In these practice trials, the experimenter gave the child one set of practice stimuli to examine. After the child had examined the items the experimenter retrieved the toys, put one of the matching pair and the non-matching item on a tray, held up the other matching item and said, "See this,

this is my (name of toy)." She then pushed the tray towards the child saying "Can you get your (name of toy)". If the child picked-up or gestured towards the matching toy she was praised heavily. If she picked the incorrect toy the experimenter said "Is that the (name of toy)? No! Get the (name of toy)" until the child picked the correct toy.

On noun category training weeks, noun training followed the practice trials. During noun training, the child, experimenter, and parent played with and named the examples of four noun categories. The three examples of each category were played with as a set for approximately three minutes each. The experimenter then put these items away and brought out the examples of the next noun category. The experimenter named each noun category at least 20 times for each child, and encouraged the child to say each noun at least once.

On artificial noun learning weeks, the artificial noun learning task followed the practice trials. This task was identical to the procedure used during the practice trials. The child was given the exemplar, one shape-match test object, and one material-match test object to examine. The experimenter then placed the test objects on the tray, held up the exemplar and said, "See this, this is my bing", (for example). The experimenter then pushed the tray towards the child and said "Can you get your bing?". If the child did not respond she was prompted again. The experimenter then proceeded to the next trial for that stimulus set. The parent was asked not to refer to the stimuli during this task but to encourage the child to respond. There were four trials for each stimulus set (each shape-match test object with each material-match test object) and one solid and one non solid stimulus set at each artificial noun learning task. Children never saw the same stimulus set twice. Order of solid and non solid sets was counterbalanced across artificial noun learning tests and order of stimulus sets was counterbalanced across children.

All experimental sessions were video taped for later coding of naming instances and artificial noun learning responses. Three coders blind to the experimental hypothesis coded all artificial noun learning sessions. Coders indicated which test object the child picked on each trial. Twenty percent of the trials were coded by two coders and reliability was greater than 90%.

Results and Discussion

Figure 3 shows the mean proportion of shape choices in the artificial noun learning task with solid and non solid stimuli for children in the Shape Nouns and Material Nouns conditions at weeks three and nine. A Condition (Shape Nouns v. Material Nouns) X Stimulus Set (Solid v. Non Solid) X Week (3 v. 9) ANOVA revealed a significant main effect of Condition, F = 6.854, p < .02, and significant Week by Condition and Stimulus Set by Week interactions, F = 4.695, p < .05, F = 10.436, p < .01 respectively. As can be seen in the figure, at week three there were no

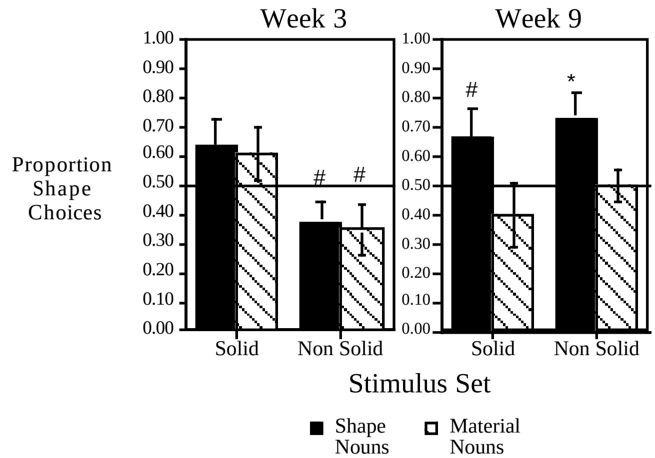

Figure 3. Results of Experiment 1. Chance responding equals .50. * = p <.05, # = p =.06 difference from chance.

differences between children in the two conditions in their responding to the solid or non solid stimuli. However, by week nine, children in the Shape Nouns condition picked shape matching test objects more than children in the Material Nouns condition for both the solid and non solid sets, Tukey's HSD p < .05. Further, only children in the Shape Nouns condition at week nine picked shape matching test objects at levels significantly above chance. Thus, children who were taught twelve names for solid objects in categories well organized by shape also learned a shape-bias but children who were taught twelve names for non solid substances in categories well organized by material substance did not learn a material-bias.

Importantly, this learned shape-bias demonstrated in the laboratory also influenced children's vocabulary development outside of the laboratory. Figure 4 presents the mean number of words in the total productive vocabulary of children in each condition at the first experimental session, at the last experimental session, and at the follow-up appointment one month after the experiment had ended. As can be seen in the figure, during the course of the experiment children in both conditions learned new words outside the laboratory at rates that did not differ. However, after the experiment ended, children in the Shape Nouns condition acquired significantly more words by the follow-up appointment. It appears that the twelve shape-biased nouns they were taught in the laboratory somehow accelerated their learning of other words outside the laboratory. It is also possible, however, that the difference in the vocabularies of children in the two conditions at the follow-up appointment was actually due to a suppression of the vocabulary development of children in the Material Nouns condition. Perhaps teaching these children twelve names for non solid things in categories well organized by material substance–categories that even 30-month-old children do not know many of–actually harmed their vocabulary development.This possibility was tested in Experiment 2.

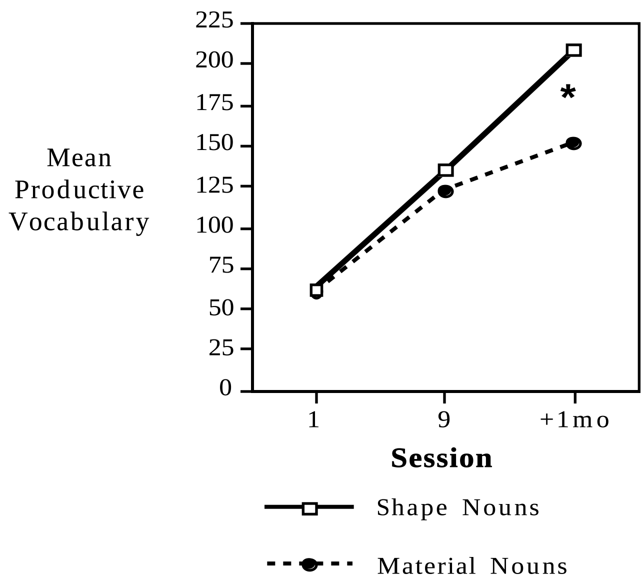

Figure 4. Mean productive vocabulary of children in experiment 1.

Experiment 2

This experiment provides a control for the possibility that the vocabulary development of children in the Material Nouns condition of Experiment 1 was harmed by the unusual kind of noun categories they were taught. Ten children visited the laboratory nine consecutive weeks but did not receive any noun category training. Children participated in weekly artificial noun learning task practice trials as well as the full artificial noun learning task every third week. As in Experiment 1, the children's vocabulary was measured at the beginning, end, and one month follow-up appointments. Thus, this experiment provides a measure of the typical vocabulary development of a matched set of children who repeatedly visit the laboratory and participate in the artificial noun learning task.

Methods

Participants. Ten children between 15- and 21- months-of-age participated (mean 18m 2d, range 15m 9d to 21m 7d). Children were recruited from the child participants file at Indiana University and contacted by phone. All children were learning English as their first language. Children were matched to children from Experiment 1 such that the mean age and vocabulary across experiments did not differ. All children received a small prize each experimental visit and copies of experimental videotapes and T-shirts at the completion of the study.

Materials. The same eight sets of artificial noun learning stimuli and 20 sets of practice stimuli used in Experiment 1 were used.

Procedure. The procedure was the same as Experiment 1 with the exception that children were not taught any noun categories.

Results and Discussion

The key result is pictured in Figure 5. There were no significant differences in the productive vocabularies of children from this experiment and children from the Material Nouns condition of Experiment 1. Thus, teaching children twelve names for non solid substances in categories well organized by material substance did not harm the vocabulary development of children in the Material Nouns condition of Experiment 1. And, thus, teaching children twelve names for solid objects in categories well organized by shape in Shape Nouns condition of Experiment 1 did accelerate their vocabulary growth.

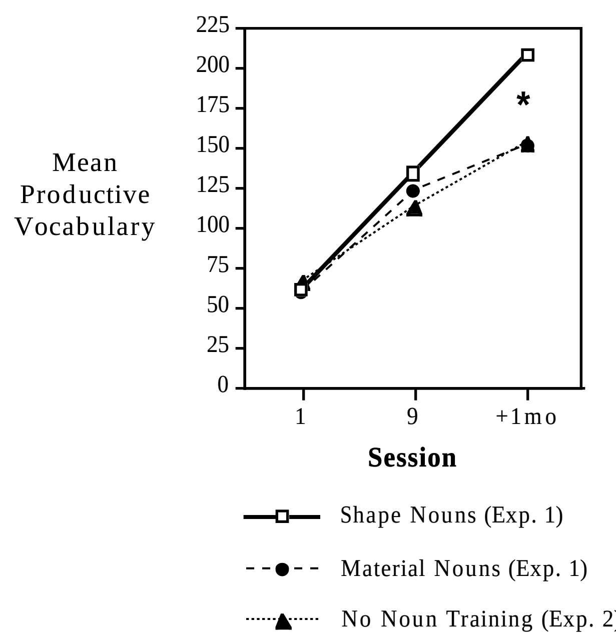

Figure 5. Mean productive vocabulary of children in Experiment 2 (no noun training). Data from Experiment 1 are included for comparison

Conclusions

Results from the present experiments comparing early vocabulary growth and the attentional biases seen in laboratory artificial noun learning tasks suggest a clear and sensible developmental story. Early in vocabulary development, children learn many names for solid objects in categories well organized by shape. This learning changes children: they begin to attend to shape when learning novel names in the context of novel solid objects. Thus, it appears that the attentional biases young children demonstrate in artificial noun learning tasks are a generalization across the nouns that they have already learned. In fact, teaching very young children, children who do not yet demonstrate systematic attentional biases in artificial noun learning tasks, names for solid objects in shape-based categories teaches them a generalizable shape bias. This in turn, promotes the more rapid learning of other words.

There are two important questions that remain unanswered by these results. First, why is there such an advantage for solid-shape-based categories over non solid-material-based categories? One possibility is that this a reflection of the structure of the language children hear (but see Sandhofer, Smith, & Luo, 1999).

The second unanswered question is how do children ever get a material-bias? We know that by three-years-of-age children reliably demonstrate a bias to attend to material substance when generalizing a novel name for a novel non solid substance. However, this bias is not reliable before 30-months-of-age (Samuelson & Smith, 1999). The developmental story for the material-bias may be the same as that for the shape-bias, just more protracted in time. That is, while children are rapidly learning names for solid things, they are also encountering a smaller number of non sold substances and their names. Each of these few substances may have to be individually learned, as an exception, without the boost from past learning given to names for solid objects. But, as vocabulary grows, children may learn enough names for non solid substances that the correlation between the perceptual cues of non solidity and naming by substance cohere to form a generalizable expectation about how substances are named.

Acknowledgments

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