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Abstract

Prior research reports that children up to 3-years-old map novel adjectives to object properties only in very limited situations (Gelman & Markman, 1985; Taylor & Gelman, 1988; Hall, Waxman, & Hurwitz, 1993; Klibanoff & Waxman, 1997; Waxman & Markow, 1997). Yet we know by 24-months children use adjectives. In two experiments we provide 36-month-olds (Experiment 1) and 24-month-olds (Experiment 2) with rich *cross-situational* and *syntactic* information. We show that 24- & 36-month-olds learn adjective-to-property mappings when given multiple examples of the mapping, and when object names are used. We claim that previous experiments failed to find robust adjective acquisition because at least one of these sources of information (multiple exemplars) was excluded. We also suggest that children's initial learning about the meanings of adjectives is affected by syntactic properties of the noun phrase in which they appear.

Introduction

By 24-months of age, children already use a number of adjectives in their everyday speech. However, previous research seems to show that when a novel adjective is used to describe a single object, children up to 3-years old only map the adjective to a property of the object in very limited situations, and otherwise tend to interpret it as a noun (Gelman & Markman, 1985; Taylor & Gelman, 1988; Hall, Waxman, & Hurwitz, 1993; Klibanoff & Waxman, 1997; Waxman & Markow, 1997). In particular, younger children were shown to map novel adjectives to object-to-properties only when the adjectives were first taught and tested with respect to members of the same category (e.g., only dogs) (Klibanoff & Waxman, 1997; Waxman & Markow, 1997). The puzzle is that these laboratory findings underestimate what we know of th real-world performance of children in this age range; namely, they use adjectives to describe many different kinds of objects. This paper presents two experiments in which 36-month olds (Experiment 1) and 24-month olds (Experiment 2) were given multiple objects which shared a salient property (e.g., all had yellow stripes). Each object was described to the subjects using the same novel adjective, and using a count-noun to label the objects (e.g., "This is a *zav* doggie! This car is *zav* too! And here's a *zav* monkey!"). Thus our presentation circumstances are both referentially (multiple exemplars) and syntactically (full noun phrase) more informative than the stripped-down presentation conditions of prior studies. We show that with this rich contextual and syntactic information, both subject groups mapped the novel adjective to the object-to-property, and were able to perform this mapping across object categories.

Previous Research

In most of the previous work on adjective learning, two groups of subjects would be taught a novel word by using the word to describe a single training object that had an interesting property (e.g., a salient texture). For one group, the object would be described with a novel adjective, (e.g., "This is a *zav* one"), and for the other another group with a novel noun (e.g., "This is a *zav*"). Subjects would then be asked to chose between two test objects, one of which shared a property with the training object (e.g., material, texture, color). Subjects who heard an adjective with the training object were asked, "Can you find another *zav* one," and subjects who heard a novel noun were asked, "Can you find another *zav*."

Using such a design, Hall et al. (1993) found that novel adjectives did not cause 2-year olds to chose test objects which shared properties with the training objects. However, Waxman & Markow (1997) found that if the training and test objects were all the same basic-level kind (e.g., all snakes), then 21-month olds would be more likely to chose test objects that shared training object properties when they heard novel adjectives than when they heard novel nouns. However, they found that this was only the case after subjects had experience with the adjective-to-property mapping in a prior trials.[1] Klibanoff & Waxman (1997) used a similar design with 3-year olds. They found that 3-year olds learned novel adjective-to-property mappings in one trial, if the test and training objects were all of the same basic-level kind. However, only after first making the correct mapping within basic-level category were 3-year-olds able to to extend the mapping to situations where the named property was carried by another kind of object.

Thus, in the experiments described above, young children demonstrated only a limited ability to learn novel adjectives. However, they were given only fairly limited information from which to compute the adjectives' meaning. In particular, their training sets did not provide tight correlations between adjectives and properties across different exemplars. These are arguably present in real-world learning situations. Nor did they (with the exception of Klibanoff & Waxman, 1997) provide the syntactic information—a known count noun—that clearly designates the novel adjective as something other than a name for an object.

The experiments described in this paper were designed to

[1] Using a different design, Taylor & Gelman (1988) found a weak effect of a novel adjective on object choice in 2-year olds. However, their results did not allow them to conclude that their subjects had correctly learned adjective-to-property mappings.

ascertain whether both 36- and 24-month olds can learn novel adjectives when they are given rich syntactic and contextual information. We test this by 1) providing multiple examples of adjective-to-property mappings, and 2) always using the novel adjective with a known count noun, not a pro-form, when describing objects.

Experiment 1

We tested 3-year olds' ability to map novel adjectives to object properties when they are given multiple examples of word-to-property matches across different known objects. We predicted that, given the covariance of the adjective with the property over multiple objects, and given that known nouns were used to name the objects, 36-month olds would succeed in assigning property interpretations to novel adjectives.

Method

Subjects Subjects were 24 children approximately 36 months old (M=36.3, SD=2.5). Three more children were tested but were not included due to failure to respond in at least three trials. Subjects were tested individually in Philadelphia area daycares or at the University of Pennsylvania.

Materials Each subject received six test trials in which they were presented three *training* objects which were common toys (e.g., horse, ball, car, etc.). For a given trial, all three training objects shared one salient property from the following set of six properties: covered in felt, striped yellow, covered in velcro, wrapped in thin wire, drilled with holes, covered with blue stars. Subjects were also shown two *test* objects on each trial: a Kind-Matched object and a Property-Matched object. The Kind-Matched object was from the same category as one of the three training objects (e.g., another ball), but with a different salient property. The Property-Matched object was a common toy of a different category from all of the training objects of that trial, but with the same salient property as the three training objects. Trials were designed so that no test object would appear more than once as the Property-Matched object in the experiment, and likewise so that no test object would appear more than once as the Kind-Matched object in the experiment. The training and test objects for each trial, and the order of presentation within trial are shown in Table 1.

Procedure Subjects were tested individually and were randomly assigned to one of two conditions: Adjective and Deictic. For each trial in both conditions, the experimenter used a Tweety Bird puppet to remove the three training objects one at a time from a closed container and give them to the subject to examine. In the Adjective condition, each training object was paired with a set of descriptive sentences, spoken by the puppet, which contained a nonsense adjective. The adjectives were: *zav, stoof, rup, bisk, drin*, and *prall*; the examples below use *zav*. The training sentences were of the form, "Look at this *zav* horsie! This horsie is very *zav*." After the three training objects were presented to the subject, the puppet would say, "See, these things are all *zav*," while indicating the three training objects. The experimenter would then show the subject the two test objects side by side, and ask, "Look at these two things. Can you give Tweety Bird the *zav* one? Can you show Tweety Bird which of these two things is *zav*?" The left-right order of the test objects (Property- vs. Kind-Matched) was random. A response was recorded if the subject picked up or pointed to one of the two test objects. If the subject chose the object that had the same property as the training objects, a Property-Matched response was recorded. If the subject chose the object that was of the same basic-level kind of the last training object, a Kind-Matched response was recorded. If subjects failed to respond, the questions were repeated for up to a total of three times. If no response was obtained after the third attempt, a non-response was recorded. A Both response was recorded if the subject selected both objects. The sentences in each trial used a different nonsense adjective.

In the Deictic condition the three training objects were paired with sentences that did not contain an adjective or the name of the object and were of the form, "Look at this!", or, "Wow! Here's something else!" After the three training objects were presented to the subject, the puppet would say, "Look at all these things!", while indicating the three training objects. The experimenter would then show the subject the two test objects, side by side, and ask, "Now you give Tweety Bird something." Responses were recorded in the same way as in the Adjective condition. This condition was included to ascertain if any effects found in the Adjective condition could be ascribed to response biases. We expected that subjects would respond at chance in this condition, or perhaps show a predominance of Kind-Matched responses.

There were four different trial order lists for each condition. For the Adjective condition, each of the four trial order lists varied which adjective was paired with each property. Trials were designed so that the last training object which was presented to the subject matched the category of one of the test objects: specifically, the one that did not share the salient property with the three training objects.

Results

The number of Property-Matched responses was tallied for each subject and averaged across subjects. (Of course, on trials in which subjects chose both test objects, the response was not counted as a Property-Matched response.) If subjects behaved at chance in chosing the test object, the mean number of Property-Matched responses should be 3. Figure 1 shows mean Property-Matched response for subjects in the Adjective and the Deictic conditions. Mean Property-Matched responses was 4.4 (SD=1.8) and 2.9 (SD=1.4) for subjects in the Adjective and Deictic conditions, respectively.[2] Subjects in the Adjective condition were better than chance at choosing the test object with the property which matched the training items ($t(11)$=2.76, $p<.05$. Subjects in the Adjective condition were also significantly more likely to pick Property-Matched test objects than subjects in the Deictic condition ($t(22)$=2.27, $p<.05$. Subjects in the Deictic condition performed at chance ($t(11)$=.2, ns.).

An analysis by item was also performed in which each

[2]One subject, whose chose no Property-Matched objects, scored less than two standard deviations from the Adjective mean. If this subject is removed from the analysis as an outlier, mean Property-Matched responses in the Adjective condition is 4.8 (SD=*1*.2).

Table 1: Stimulus Sets, Experiments 1 & 2

Training	Property	Test
elephant block ball	FELT	car-FELT ball-VELCRO
car cup rabbit	STARS	fish-STARS rabbit-STRIPES
block cup horse	WIRE	elephant-WIRE horse-HOLES
elephant car fish	VELCRO	rabbit-VELCRO fish-STRIPES
ball horse boat	HOLES	block-HOLES boat-WIRE
block horse cup	STRIPES	boat-STRIPES cup-STARS

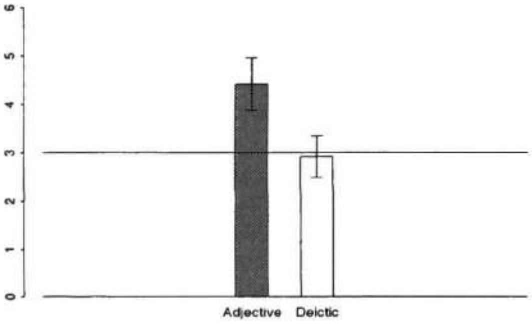

Figure 1: Average # of Property Responses (36-Month-Olds)

training-test set was treated as an item and Property-Matched responses were averaged across the six items. Chance Property-Matched responses for items is 6. Items were shown to have elicited a significantly greater number of Property-Matched responses than would be expected by chance in the Adjective condition (M=8.8, SD=1.5, $t(5)$=4.72, p<.01). Property-Matched responses elicited by items in the Deictic condition were at chance level (M=5.8, SD=1.7, $t(5)$=.24, ns.). Items in the Adjective also elicited significantly more Property-Matched responses than items in the Deictic condition ($t(10)$=3.24, p<.01).

These results suggest that children of about 36-months can learn the meanings of novel adjectives from very few exposures. It appears that experience with multiple examples of consistent adjective-to-property pairings over objects from different categories, when the adjective modifies a count nouns, is sufficient to allow 3-year olds to learn the meanings of adjectives.

We then applied this method to 24-month old children, to see if supplying word-to-property invariance across multiple exemplars would help younger children learn novel adjectives as well.

Experiment 2

In Experiment 2 we use the same method as in Experiment 1, but with 24-month old children. Experiment 2 was designed to test whether 24-month olds could learn mappings from novel adjectives to properties when the same mapping is present across different exemplars.

Method

Subjects Subjects were 24 children approximately 24 months of age (M=24.1, SD=1.4). Five more children were tested but were not included due to failure to respond in at least three of the trials. Subjects were tested individually in Philadelphia area daycares or at the University of Pennsylvania.

Materials The materials were identical to those used in Experiment 1, except that three object types were replaced with new objects. All rabbits were replaced with pigs, all boats were replaced with monkeys, and all fish were replaced with kangaroos. The objects which were replaced were poorly featured plastic sand molds, which pilot studies with 24-month olds showed were somewhat difficult to identify. The objects which replaced them did not have this problem. The within-trial presentation order of the objects is identical to that of Experiment 1 (see Table 1), but with the rabbits, boats, and fish, replaced with pigs, monkeys, and kangaroos, respectively.

Procedure The procedure was the same as the one used in Experiment 1, with the following exceptions. For each trial, before the subject was presented the training objects, they were shown, and allowed to play with, all five training and test objects for that trial. Pilot studies suggested that subjects' initial encounter with the objects attracts their attention away from the puppet's description of the objects during training and the experimenter's requests during testing, resulting in high rates of non-responses. The brief pre-training exposure period familiarizes the subject to all the objects in the trial.

In addition, subjects who were tested in daycares during pilot studies often did not respond to the puppet or the experimenter. Therefore, one or two days before the experiment was carried out, the experimenter would play with the subjects in a group with their peers. This interaction allowed the subjects to become comfortable with the experimenter, and they were much more responsive during the experiment. Subjects who came into the lab did not receive this pre-experiment play, but at least one parent was in the testing room with them.

Results

Because there were many non-responses in Experiment 2, the mean number of Property-Matched responses per subjects was not an appropriate measure, as it was in Experiment 1. Instead, difference scores were computed for each subject by scoring Property-Matched responses as 1, Kind-Matched responses as -1, and summing these scores; non-responses and Both responses were scored as 0. Chance performance should thus yield a mean difference score of 0. Positive difference scores indicate subjects preferred Property-Matched responses, negative scores indicate they preferred Kind-Matched responses. Mean difference scores were 1.7 (SD=1.9) and -.5 (SD=2.6) for subjects in the Adjective and Deictic condition, respectively. Figure 2 shows the difference scores for subjects in Experiment 2 as well as the data for subjects in Experiment 1 replotted as difference scores for comparison.[3]

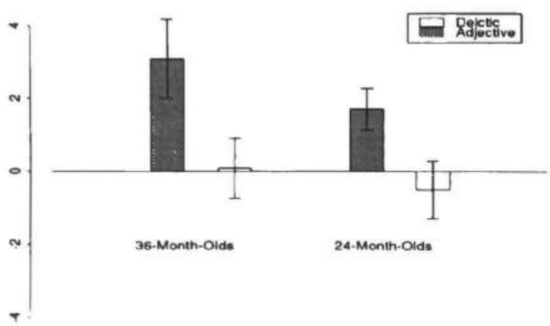

Figure 2: Difference scores; Expts. 1 & 2

Subjects in the Adjective condition were significantly more likely to make Property- vs. Kind-Matched responses than would be predicted by chance ($t(11)=3.08$, $p<.05$). Subjects in the adjective condition also made more Property- vs. Kind-Matched responses than subjects in the Deictic condition ($t(22)=2.34$, $p<.05$. Subjects in the Deictic condition were at chance in their choice of test objects ($t(11)=.66$, ns.). However, one subject in the Deictic condition produced a difference score of 6, which is beyond two standard deviations from the mean. If this subject is treated as an outlier and removed, then subjects in the Deictic condition show a trend towards a *Kind*-Matched preference (M=-1.09, SD=1.7, $t(10)=2.13$, $p=.059$).

An analysis by items showed that mean difference scores for items in the Adjective condition was 3.3 (SD=4.4), and in the Deictic condition was -1 (SD=2.19). The items analysis showed that there was a trend towards items eliciting a greater number of Property-Matched responses in the Adjective condition than would be predicted by chance ($t(5)=1.87$, $p=.06$, one-tailed). The item effect is not as strong as it was in Experiment 1, however, all items but one elicited more Property-Matched responses than Object-Matched responses: the set of objects covered in velcro was the only set to elicit more Object-Matched responses than Property-Matched responses. The velcro set was also the set in Experiment 1 that elicited the fewest number of Property-Matched responses in the Adjective condition. When the item analysis was performed with this item removed, the item effect was significant ($t(4)=3.87$, $p<.05$). Items also tended to elicited more Property- vs. Kind-Matched responses in the Adjective condition than in the Deictic condition ($t(10)=2.17$, $p<.05$, one-tailed). Finally, items elicited chance performance in the Deictic condition ($t(5)=1.18$, ns.).

These results show that, like 36-month olds, 24-month olds can use the invariance of the word-to-property mapping across multiple objects to learn the meanings of novel adjectives. In addition, there is some indication that 24-month-old subjects prefer to chose test-objects that match the the last kind of object they saw during training, in the absence of an adjective and noun.[4] In the following discussion, we develop a proposal of adjective learning that ties together these results with the previous findings in the literature.

General Discussion

As we mentioned in introductory remarks, prior experimental work has not accounted for early adjective learning. In general, children fail to demonstrate in the laboratory whatever capacities are responsible for their success in real life, as manifested in their productive adjectival vocabulary. Some experimental success has been achieved by Waxman & Markow (1997) and Klibanoff & Waxman (1997) by showing toddlers several objects that are all within a single basic kind, e.g., horses, but which vary on a single property dimension, e.g., texture, accompanied by a sentence designed to cue the category ("This is a *zav* one"). However, with 2-year olds generalization has been limited to new targets of the kind first modeled (i.e., to new horses that instantiate the property). In the present studies, we successfully taught two- and three-year olds new adjectives by enriching the input information in two ways. First, taking advantage of these children's broad knowledge of basic level kinds, we instantiated the property across several of these. Second, we improved the linguistic information by explicitly labelling each kind ("This is a zav *horsie*... This is a zav *car*"). Under these presentation conditions, the mapping between property and nonsense adjective generalized across kinds.

It is not surprising to discover that novices are aided by multiple exemplars; that is, by cross-situational observation. Multiple exposures would seem to be especially useful for these youngsters for, as we know (Markman, 1990), in this age range they have to fight off a strong "object bias." This is a tendency to assume that any new word labels the tiger rather than his stripes, his temperment, his growl, or indeed any single trait. It stands to reason that they will be aided if the tigers, the horses, the cows, come and go across successive scenes while some property of each remains constant. Yet in the Deictic condition of the present experiments—which exhibited just such situational constancies— toddlers were not tempted to extract property representations (Figure 2). Cross-situational observation appears to be a *necessary* but not a *sufficient* condition for overcoming the object bias so as to extract a property representation of the passing scene. This finding fits with several collateral studies of word learning (Gleitman and Gillette, 1995; Gillette et al, forthcoming) which demonstrate that *even when the subjects are adults*, learning of words other than nouns via cross-situational information

[3] All the reported results from Experiment 1 hold when the same analyses are performed using difference scores instead of absolute number of Property-Matched responses.

[4] Of course, in this experiment Kind-Matched test-objects are also property *miss*matched objects; thus, an overall Kind-Matched preference could, in fact, be a preference to choose test-objects which *differ* across properties from training-objects, in the Deictic condition.

alone is extremely difficult, inefficient, and error-prone. In striking contrast, cross-situational information is efficiently used when the *linguistic* information is simultaneously enriched: when the new word appears in a known structure (for the original demonstration of such an effect, Brown, 1957).

Consistent with such findings, our young Ss became successful adjective learners just when the problem was posed in the presence of a full noun-phrase: "Here's a zav *horse*" (Figure 2). At first glance, this seems puzzling. After all, this linguistic structure doesn't seem all that different from the structure in "Here's a zav one," as used in many prior adjective-learning studies. The difference becomes more obvious when related to another body of facts about the time course of language learning: Learning to bind pronouns to their referents is one of the most ticklish task infants face, and deficits are seen through the early school years. The crucial innovation in our study was to structurally exhibit, in a lexically full noun phrase, that the required interpretation was some *modifier* (hence property) of the objects, thus excluding the favored nominal interpretations. In recent follow-up work (Mintz and Gleitman, forthcoming) we have found that toddlers *do not* succeed in adjective learning when pronouns are used with novel adjectives instead of object names, even using the rich cross-exemplar training that succeeded in Experiments 1 & 2.

Most generally, then, this work fits into an emerging picture of language acquisition that explains the child's accomplishments in terms of layers of information that become available in sequence as a consequence of solving parts of the learning problem (rather than, for example, as a consequence of conceptual changes in the learners themselves). At the first step of this incremental learning procedure, novices have no information other than their natural ways of organizing the world as these can be mapped against word use. That is, in the initial knowledge state, they can acquire a small stock of concrete nouns based on two coupled facts. The first of these is conceptual (they can conceive, e.g., of elephants) and the second is the plausible conditions for making reference ("elephant" is more likely to be uttered in the presence of elephants than of rhinoceroses). This first learning is limited to *favored representations* (Markman's object bias) of *concrete* (i.e., directly observable) basic level objects (Gillette et al, forthcoming). The early noun learning now serves as a scaffold on which children build a rudimentary representation of the phrase structure of the input language (Fisher, Hall, Rakowitz, and Gleitman, 1994; Fisher, 1996), enabling the learning of words from non-nominal categories. Specifically, in the presence of phrase structure knowledge the learners can work back and forth between their representations of the world and their implicit knowledge of how these are linked to information – selectional and syntactic – that is displayed across the input sentence (Pinker, 1984; Landau and Gleitman, 1985). In the present experiment, we were able to model adjective learning in our young subjects by allowing them to leverage their hard-won knowledge of the noun phrase in the service of this task.

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References

Bates, E. (1993). Comprehension and production in early language development. *Monographs of the Society for Research in Child Development, 58*, 222-242.

Brown, R. (1957). Linguistic determinism and parts of speech. *Journal of Abnormal Psychology 55*, 1-5.

Clark, E. V. (1988). On the logic of contrast. *Journal of Child Language, 15*, 327-335.

Gelman, S. A., & Markman, E. M. (1985). Implicit contrast in adjectives vs. nouns: Implications for word-learning in preschoolers. *Journal of Child Language, 12*, 125-143.

Fisher, C. (1996). Structural limits on verb mapping: The role of analogy in children's interpretations of sentences. *Cognitive Psychology, 31* 41-81.

Fisher, C., Hall, S., Rakowitz & Gleitman, L. (1994). When is it better to give than to receive: Syntactic and conceptual constraints on vocabulary growth. *Lingua 92*, 333-375.

Gentner, D. (1982). Why are nouns learned before verbs: Linguistic relativity versus natural partitioning. In S. Kuczaj (Ed.), *Language Development, Vol. 2: Language, thought, and culture*, 301-334. Hillsdale, NJ: Erlbaum.

Gentner, D. & Markman, E. M. (1994). Structural alignment in comparison: No difference without similarity. *Psychological Science, 5*, 152-158.

Gillette, J., Gleitman, H., Gleitman, L. & Lederer, A. (1998). Human simulations of lexical acquisition.

Gleitman, L. R., & Gillette, J. (1995). The role of syntax in verb learning. In P. Fletcher and B. MacWhinney (Eds.), *The Handbook of Child Language.* Cambridge, Mass.: Blackwell.

Hall, D. G., Waxman, S. R., & Hurwitz, W. M. (1993). How two- and four-year-old children interpret adjectives and count nouns. *Child Development, 64*, 1651-1664.

Klibanoff, R. S., & Waxman, S. R. (1997). Preschoolers' acquisition of novel adjectives and the role of basic-level kind. Paper presented at the 22nd Annual Boston University Conference on Language Acquisition.

Landau, B. & Gleitman, L. R. (1985). *Language and Experience.* Cambridge, MA: Harvard University Press.

Markman, E. M. (1990). Constraints children place on word meanings. *Cognitive Science, 14*, 57-77.

Pinker, S. (1984). *Language learnability and language development.* Cambridge, Mass.: Harvard.

Taylor, M. & Gelman, S. A. (1988). Adjectives and nouns: Children's strategies for learning new words. *Child Development, 59*, 411-419.

Waxman, S. R., & Markow, D. B. (1997). The role of object kind in mapping adjectives to object properties: Soft ice-cream and soft slippers. Paper presented at the biennial meeting of the Society for Research in Child Development. Washington, DC.