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ABSTRACT

A study investigated how young children understand natural kind terms by examining how 3- and 4-year-olds rely on category membership to draw inductive inferences about objects. One hundred four children (53 girls and 51 boys) from six preschools in California and Michigan participated in the study. The children were shown 10 sets of pictures of natural objects or creatures, told something about the items shown, and asked to draw inferences about other natural kind pictures. Two conditions were added: word only condition and picture only condition. Results suggest that even the youngest children assume that objects with the same name share underlying similarities. When given just labels, the children used them as a base for making inductions, and when labels and appearances conflicted, they relied more on labels than appearances. Even when no labels were given, the children sometimes figured out what categories the pictures belonged to and used this inference to decide about other properties. It is concluded that children are clearly sensitive to the power of language for organizing and extending language, and that words that refer, even common nouns, serve to identify objects as well as foster inductions. (MSE)

Understanding Natural Kinds: A Developmental Comparison

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Categories named by language often capture more than the obvious properties that people already know; they also capture a richer basis of similarity that is not likely to be known by casual inspection. For example, in addition to more superficial features, such as shaggy fur and four legs, most dogs share a particular diet, life expectancy, and DNA structure. Many of the features in common to dogs may not even be known by the average person. In fact, with some objects known or obvious properties are a poor guide to internal structure, and may actually result in a misleading classification. Whales, for example, used to be classified as fish because of their behavior and appearance, but were later reclassed as mammals on the basis of more subtle clues.

Many words in English name categories with a rich, correlated structure, especially words for natural kinds. "Natural kinds" are naturally occurring phenomena such as animals, plants, and minerals. Often what is behind our uses of natural kind terms are scientific theories. For example, we have a theory of biology that considers internal parts to be more important than outer appearances, so we classify whales as mammals rather than as fish. Not all words capture such rich similarities. For example, red things have just a single property in common, and mittens have little in common beyond the obvious. Nonetheless, this quality of capturing deep underlying similarity is pervasive in language (see Kripke, 1971, 1972; Putnam, 1970, 1973; Quine, 1969; Schwartz, 1977, 1979 for further discussion).

There is an interesting developmental problem underlying children's use of natural kind terms. Children start to learn natural kind terms at a very young age, beginning with their first few words (e.g., duck, flower; see Nelson, 1973). Yet at that age children simply do not have the scientific knowledge to understand why these categories extend beyond appearances. Moreover, young children are often misled by appearances. On a wide range of cognitive tasks: memory, quantitative reasoning, perspective-taking, children have a strong perceptual bias (cf. Flavell, 1985). How, then, do children understand natural kind terms? Do children expect these words to share underlying similarities? Or is there a developmental shift in how such terms function over time?

We explored these questions in previous research with 4-year-old children (Gelman & Markman, in press), and began with the question of whether children believe that members of a category share non-obvious features. In other words, to what extent do children rely on natural kind categories to guide their inductions? We presented children with a series of problems of the following sort. Children saw three pictures at a time, for example, a flamingo, a bat, and a blackbird. Two of the pictures were from the same category (e.g., the blackbird and the flamingo). Two of the pictures look alike (the blackbird and the bat). The experimenter first labeled the pictures. Then children heard a new fact about two of the pictures, and a question about the third, for example, "This bird [pointing to the flamingo] gives its baby mashed-up food; this bat gives its baby milk. [Pointing to the blackbird:] Does this bird give its baby mashed-up food, like this bird, or milk, like this bat?"

The issue was whether children base their inductions on the category or on the appearances. There were at least two plausible patterns of results. On the one hand, children could draw inferences based on perceptual similarity. For example, they could decide that the blackbird and the bat feed their young the same kind of food. This would be consistent with their lack of scientific knowledge and with their usual perceptual biases. A second possibility is that even preschoolers recognize the importance of category names for induction. Young children may have a primitive understanding of how categories are organized, even before they can back up their beliefs with solid scientific evidence.

We found that category labels in fact exerted a powerful effect. Sixty-eight percent of the time, 4-year-olds preferred to draw inferences on the basis of category membership even though it was pitted against striking perceptual similarity. For example, they claimed that the blackbird gives its baby mashed-up food, like the flamingo. We replicated the study with a second group of 4-year-olds; they based their inferences on category membership 73% of the time. Performance in both studies was well above chance. So, despite their known perceptual biases and their rudimentary scientific knowledge, 4-year-olds realize that members of a kind share underlying similarities.

The major purpose of the present study is to examine natural kind concepts in even younger children. Even within the narrow age range from 3 to 4 years of age, children are learning a great deal about language and about categories of objects. If knowledge and experience are responsible for children's performance, then younger children should rely less on category membership than older children for drawing inductive inferences. On the other hand, children may assume from a very early age that categories are structured like natural kinds. If so, then 3-year-olds should already favor categories over outer appearances to support inductions.

Method

Subjects. 104 children (53 girls and 51 boys) from six preschools in California and Michigan participated: 50 3-year-olds (range: 3-0 to 3-11; mean age 3-6) and 54 4-year-olds (range: 4-1 to 4-11; mean age 4-7). The three conditions were roughly balanced for age and sex. Four additional 3-year-olds were tested but did not complete the session and so were dropped from the study.

Procedure. Previous studies (Gelman & Markman, in press) were too demanding for those below age 4. Children were asked to consider three pictures at a time and learn two new facts. In pilot-testing, 3-year-olds simply could not remember all of that information. Therefore, a simpler task was devised that 3-year-olds would understand. Instead of seeing three pictures at a time, children saw just two. Instead of learning two new facts, they learned just one. For each set of pictures the experimenter first presented the target picture, labeled it, and taught the child a new fact about it. For example, if the target was a snake, the experimenter said, "See this snake? This snake lays eggs." Then the child saw four test pictures, one at a time and in random order. (1) One was of the same category and appearance as the target (e.g., another small, brown snake). (2) One was of the same category but of different appearance (e.g., a large gray cobra). (3) One was of a different category but similar in appearance to the target (e.g., a small brown worm). (4) Finally, one was of a different category and a different appearance (e.g., a cow). Children saw only one of the test pictures at a time, in conjunction with the target.

For each new picture, children were asked whether the animal lays eggs like the target snake. The critical comparison is between the second and third test pictures. If children draw more inferences to the cobra, then category membership is more powerful. If they draw more inferences to the worm, then appearances are more powerful. Or, children could draw inferences equally to the two pictures.

Each child saw 10 sets of pictures. All of the categories were natural kinds. For the sake of generality, half of the items were animals (such as cats and bugs) and half were inanimate (such as sugar and gold). Children were taught "deep" properties -- that is, ones that are enduring and true of the entire category. Also, the new facts were designed to be interesting to children, but not ones that they already knew.

We also included two other conditions, to provide a basis of comparison. Children in those conditions were given only names or only pictures. In the <u>Word Only Condition</u>, exactly the same set of pictures were used as in the previous condition. The only difference was that children did not see the first picture. The experimenter held the target card so only she could see the front. The child saw only the back. All other pictures were visible, and all were named. Thus, the only explicit basis for making inferences was the name. In the <u>Picture Only Condition</u>, again the same set of pictures were used as in the other conditions. Here, the only difference was that children did not hear any names. Children saw all pictures; the only explicit basis for making inferences was the appearance.

<u>Results</u>

A 5-way ANOVA was conducted including age, condition, domain (animal versus inanimate), category (same or different from target), and appearance (same or different from target). A 5-way item-by-item ANOVA was also conducted, to determine whether the results generalize across items as well as subjects. The two analyses were then combined using the min-F' statistic (Clark, 1973). The results are presented in Figures 1 through 3. Overall, children drew more inferences to members of the same category than to members of different categories, min-$F'(1,25) = 105.07$, $p < .0001$, and to objects of similar appearance than to objects of different appearance, min-$F'(1,21) = 45.09$, $p < .0001$. However, the main question of interest concerns how these effects were mediated by the condition and the age of the child. As expected, many of the relevant interactions were significant. Children's patterns of inferences varied with condition: category x condition interaction, min-$F'(2,73) = 3.25$, $p < .05$; appearance x condition interaction, min-$F'(2,40) = 18.51$, $p < .0001$; category x appearance x condition interaction, min-$F'(2,57) = 3.70$, $p < .05$. Children based more inferences on category membership when only the label was provided, and more on appearances when only pictorial information was provided. Interestingly, there were no developmental changes in the patterns of children's inferences, on a min-F' analysis. It is easiest to understand these interactions by considering each condition separately.

Figure 1.

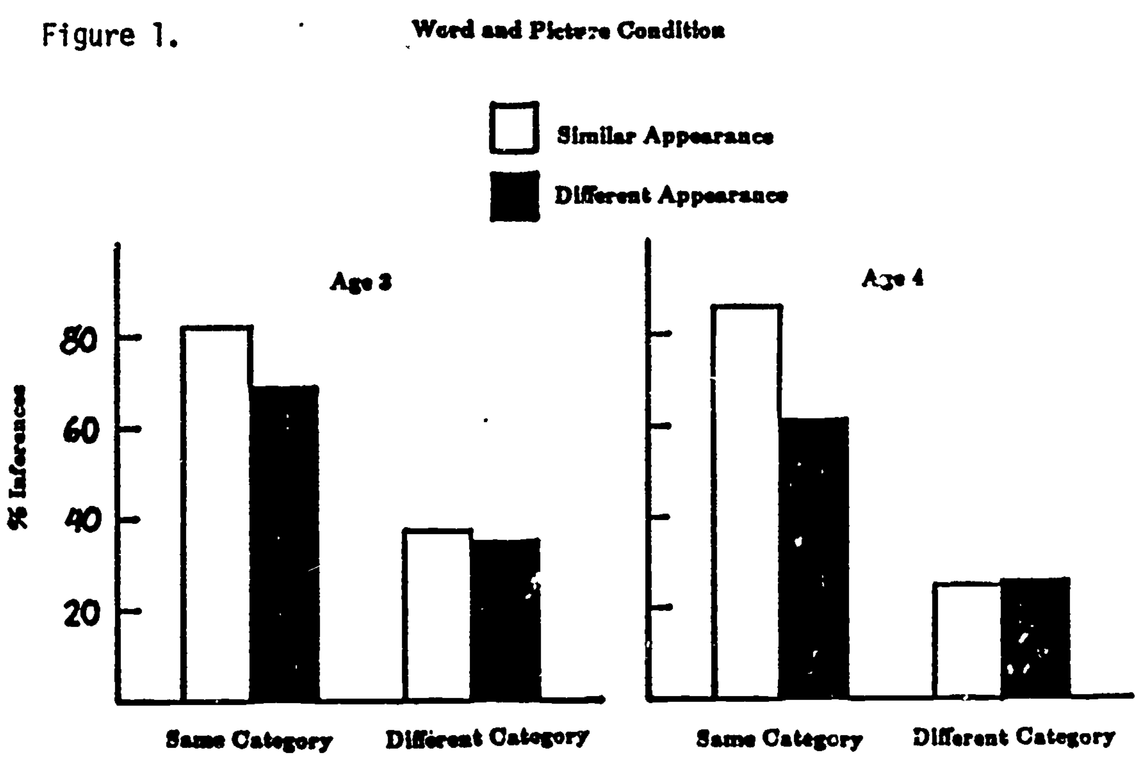


Figure 2.

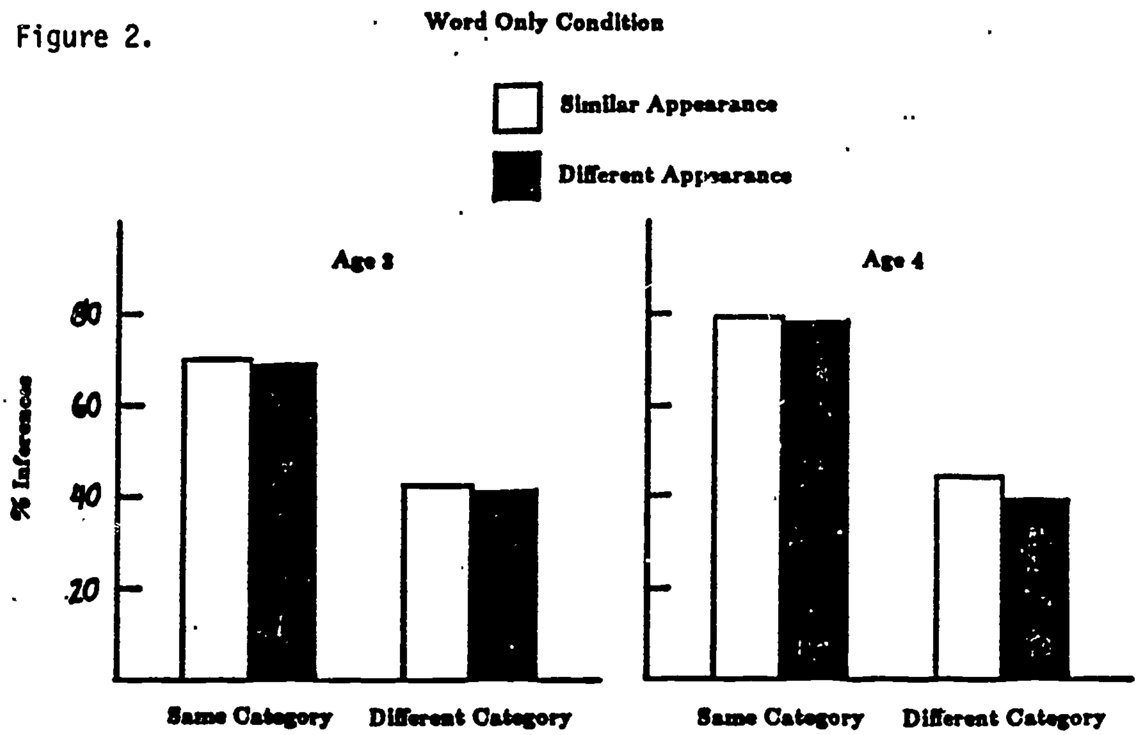
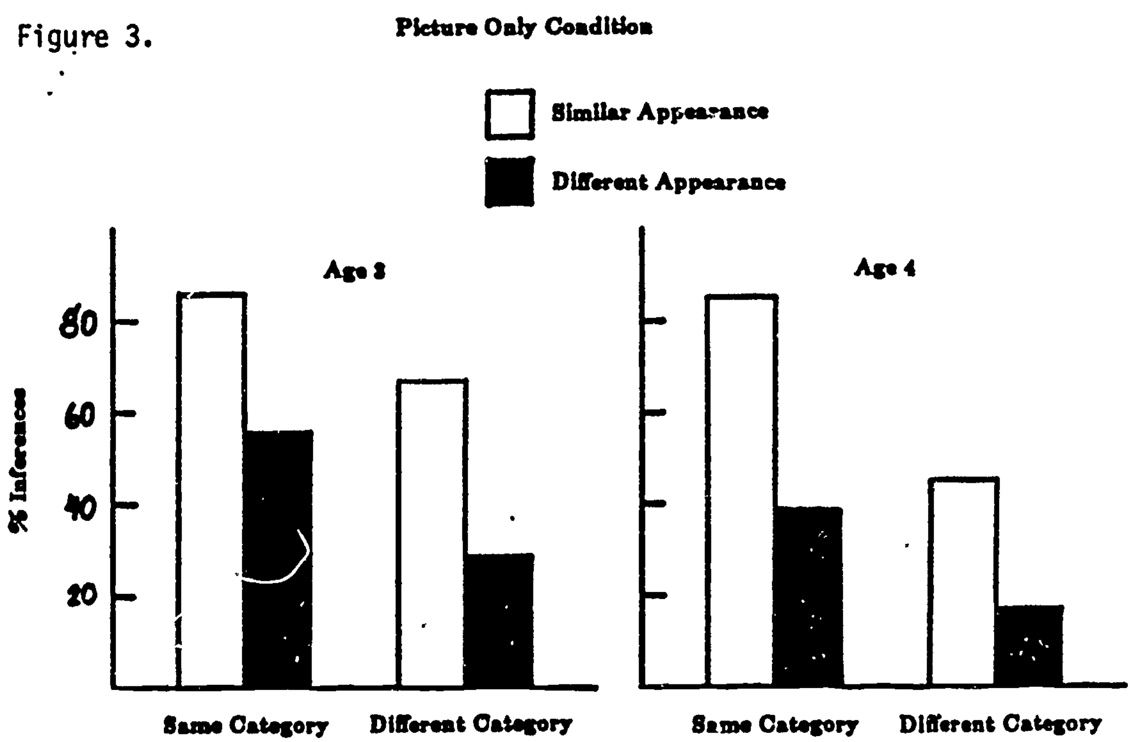


Figure 3.



Word and Picture Condition. In this condition, children saw the objects and heard them labeled. Figure 1 shows how often children drew inductions from the target pictures (e.g., how often they said that a particular animal lays eggs). The category labels were especially powerful in directing children's inferences. Children consistently drew more inferences when categories were identical than when they differed. In fact, they drew more inferences to pictures that matched on category alone (mean = 64%) than to pictures that matched on appearances alone (mean = 29%), $p < .002$ at each age. For example, they were much more likely to say that a cobra lays eggs than that a worm lays eggs. In fact, this pattern held up on every one of the 10 items. The most interesting result in this condition is that there are no developmental differences. The category is a powerful source of information for children, even by age 3.

Word Only Condition. Results are shown in Figure 2. In this condition the target picture in each set was labeled, but children never saw it. As expected, children strongly based their inductions here on category labels: they tended to say that the snakes lay eggs, for example, but that the worm and the cow do not. The appearances, which weren't fully available to the children, had no effect. This pattern held up on every item at both ages.

Picture Only Condition. Children saw all of the pictures but never heard names for them. In this condition, children answered quite differently, depending on the item. On some problems, especially the inanimate items, children based their answers on appearances. But on other items, especially the animal items, children based their answers on the categories. Children never heard what the pictures are called; nevertheless they often based their answers on category membership.

Figure 3 presents the results, collapsed across items. In some cases children may have been able to figure out the category labels. For example, when children saw a leaf-insect, they may have realized that it was an animal because it had a head, feet, and antennae. When children then saw the leaf, despite its similarity to the leaf-insect, they would have known it was not an animal because it lacked a face and legs. On other items, though, the category would have been harder to figure out from a picture alone. For example, a reddish mass could be clay, dirt, or sand.

There is some evidence for this interpretation from children's spontaneous comments. Children at both ages frequently named the category after answering the yes/no question. For example, one child said, "Because it's a bird!"; another explained, "They're both shells." One 3-year-old correctly denied that one white-striped furry creature (a skunk) could see in the dark like another white-striped furry creature (a cat), explaining, "It's not a kitty, it's a baby horse." We had not provided any of these labels.

So it seems that children often figured out what categories these pictures belonged to, even in the absence of labels. They then used the categories as the basis of their inductions. To test this idea more directly, we asked a second group of children simply to name each picture used in the study. Children were shown all of the pictures, one at a time, and simply reported what they thought each one was called. We computed a rank-order correlation between children's accuracy in naming each item, and the number of inferences to that item, when no labels were provided. The Spearman rho correlation between naming and inferencing was .77, $p < .05$. It seems that when children see only the appearances, they invoke the category labels, then use them to decide which things share underlying similarities.

Discussion

In this work we have examined how natural kind terms promote inferences above and beyond outer appearances. Children as young as we could test assume that objects with the same name share underlying similarities. This was shown in three ways. First, when given just labels, children as young as age 3 use them as the basis for drawing inductions. Second, when labels and appearances conflict with each other, children rely more on labels than on appearances for drawing inductive inferences. This was true for both the animals and inanimates, so it seems to be a fairly general assumption that children have by age 3.

The third finding is that even when no labels were provided for the pictures, children sometimes figured out what categories they belonged to. They then used the inferred labels to decide about other properties. The categories were never explicitly mentioned, yet they continued to be salient.

Our data clearly indicate that children are sensitive to the power of language for organizing and extending knowledge. Consequently, much knowledge gets passed down implicitly through the system of categories named by language. Furthermore, this work highlights that an especially important function of language is to make reference. Words that refer -- including common nouns -- accomplish at least three things: they identify particu / objects, they imply that objects are grouped into kinds, and they foster inductions. It is a remarkable fact that children grasp all three aspects of this function of language.

In fact, children are drawing inferences at such an early age, they may start out with a general assumption that categories named by common nouns promote inductions. With development, they would then have to refine this assumption and limit it to properties and category types that are appropriate. Other expectations about the structure of natural language categories also appear quite early. For example, children as young as age 1 or 2 assume that proper nouns map onto individual objects, whereas common nouns refer to categories of objects (Gelman & Taylor, 1984). The assumption that common nouns promote rich inductive inferences could be another early expectation, one that helps children acquire category terms rapidly and efficiently.

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