Developmental Psychology
1988, Vol. 24, No. 3, 307–317

0012-1649/88/$00.75

Preschooler's Ability To Decide Whether a Photographed Unfamiliar Object Can Move Itself

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Does the preschooler's use of the animate–inanimate distinction reflect knowledge about which category types engage in self-initiated movements? Three- and 4-year-olds viewed photographs of unfamiliar objects, including mammalian animals, nonmammalian animals, statues with animal-like forms and parts, wheeled vehicles, and multipart rigid objects, and decided whether each item could go up and down a hill by itself. Four-year-olds were reliably accurate about the movement potentials for each of the five classes of items; 3-year-olds' scores were significantly above chance in all but one category. Analyses of rule use and verbalization data showed that children were concerned about cause of movement and used an animate–inanimate hierarchy. Explanations from both age groups varied, in a consistent manner, the kind of information and criteria used to make inferences as function of the type of item. We discuss how these data bear on a theory of concepts.

Without reflecting on it, adults constantly make use of their implicit knowledge about the difference between animate and inanimate objects. When we fold up our umbrellas and put them in the closet, we fully expect them to be there the next time we need them. We do not expect them to have changed size or position, to have grown, eaten, fallen asleep, and so forth, in the interim. Similarly, things that look like rocks are not supposed to move on their own. If they do, we assume that they must be animate and are not surprised when they turn out to be turtles. A pattern of movement that is inexplicable for a rock is taken as commonplace for a turtle. There is a growing body of evidence that young children also use an animate–inanimate distinction (e.g., Bullock, 1985; Carey, 1985; Gelman, Spelke, & Meck, 1983; Keil, 1979, 1983; Richards & Siegler, 1984, 1986). For example, they are able to indicate whether predicates like "is hungry," "sleeps," and "needs to be fixed" render statements about animate and inanimate objects sensible or anomalous.

All analyses of the differences between animate and inanimate objects make the general assumption that changes that are self-initiated or self-generated are controlled by animate agents. For adults, even if inanimate objects look much like animate ones (and vice versa), comparable changes in them are seen as surprising and are attributed to tricks performed by an agent that can initiate change, to some spiritual source, and the like.

Support for this research came from a National Science Foundation Graduate Fellowship to Christine Massey and National Science Foundation Grants BNS 81-04881 and BNS 85-19575 to Rochel Gelman.

We thank the children, staff, and parents of Children's Garden, St. Davids, Pennsylvania, the Wayne Presbyterian Nursery School, Wayne, Pennsylvania, and the Community Friends School, Millville, Pennsylvania, for participating in the project. We also thank Jason Macario for serving as a coder.

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In this article, we test the hypothesis that preschool children's early sensitivity to the animate–inanimate distinction reflects an early concern for whether objects can engage in self-initiated movements and changes of place, despite wide variations in the surface characteristics of the objects within each class. In order to do this, we asked children to look at photographs of unfamiliar objects and to decide whether each could move up and down a hill on its own. The photographs represented two animate categories—mammals and nonmammals—and three inanimate categories—statues, wheeled objects, and complex rigid objects. By requiring children to answer both uphill and downhill questions about an object, we could determine whether they distinguished among inanimate objects that neither initiate nor support their own movement, inanimate objects that, once pushed, move on their own downhill but not uphill (e.g., wheeled objects), and animate beings that both initiate their own movement and continue to move on their own.

Those familiar with Piaget's (1979) accounts of both animism and causality might think that the outcome of this study would be obvious. Our idea that preschool children might be able to tell us whether a novel object, shown statically in a photograph, can cause itself to move or not goes against two of Piaget's conclusions: (a) Young children do not distinguish between self-generated and externally caused movement and (b) young children assume that any object that can be placed in motion is animate. Despite the reliability of Piaget's methods (Carey, 1985), several recent findings support the plausibility of our hypothesis. Gelman, Spelke, and Meck (1983) interviewed preschoolers about the nature of people, cats, dolls, puppets, and rocks and found that the children had a fundamental concern for whether these objects could cause themselves to initiate action. Similarly, others (Bullock, 1985; Poulin-Dubois & Shultz, 1986; Golinkoff & Harding, 1980; Leslie, 1984; Richards & Siegler, 1986) reported early sensitivities to violations of the rule that inanimate objects must have an external cause of movement. Given the related findings that preschool children can in many situations reason about and use causal mechanisms (see Shultz & Kestenbaum, 1984, for a recent review), we were encouraged to pursue our general hypothesis that young children will use information in pictures of unfamiliar objects to determine whether they are animate and, hence, can cause themselves to move.

A request to determine the conditions under which an object moves (in our case, up and down a hill), is a request to consider the kinds of mechanisms needed to accomplish this goal. In the case of animate and inanimate objects, what matters is whether the "mechanism" is contained within the object or must be external to the object. In order to make a decision about kind of mechanism when given pictures of objects, one must focus on mechanism-relevant information. In the case of inanimate objects, the size and weight of the objects are relevant to considerations about how they might be moved, but the color is not. It also matters whether the object has wheels, is on a flat or elevated plane, and so forth. Such information provides clues about the kind of physical objects and events as well as the contexts that could mediate the movement of the object in question. On the other hand, in the case of animate causality, size is often, although not always, an irrelevant clue. Instead, the focus must be more on those sources of information that could lead to the conclusion that it is an animal. For example, a legged object must have "real legs," that is, ones that are made of that kind of material adults know to be biological. Clues in this regard come from the postures assumed by the pictured animals. Additionally, the surface parts (skin, eyes, hair, mouths) are typically varied in color, brightness, and texture, and seldom uniformly smooth and shiny all over.

Given the preceding observations, it is not obvious that children will succeed on our task. For to do so, they must use pictorial cues that need not correlate with the size, color, overall shape, or shape of the parts of the objects. To illustrate, consider the statue of a quadruped shown in Figure 1. Its overall shape, as well as the shape of its parts, are clearly animal-like. Yet adults surely can tell that the object shown is not animate, perhaps because it is shiny all over, has a regular repeating pattern, and "looks" rigid.[1] Whether young children will ignore overall shape, size, color, and so forth, is not clear. For these are the kinds of information that are known to be salient to young children—so much so, that the developmental literature points to two hypotheses about the way young children will respond to our stimuli. First, they might focus on the shape of the whole object and its parts. The salient role such perceptual information plays in the young child's classification activities is well-documented (e.g., Bruner, Olver, & Greenfield, 1966; Melkman, Tversky, & Baratz, 1981; Tversky, 1985; see Markman & Callanan, 1984 for a review). Tversky and Hemenway (1984) showed that even adults represent basic categories on the basis of the overall shape of an object or the shape of its parts. Thus, one proposed rule that children might use is that things with animal parts and shapes can move themselves.

Carey's (1985) finding that young children are more likely to attribute animate characteristics to objects that look like a person, presumably in terms of size, shape, parts, and so forth, predicts that children will respond to the set of stimuli on the basis of a more restricted perceptual rule. Instead of saying that all depicted objects with animal shapes or animal parts can move themselves up and down a hill (Rule 1), they might say that only those objects that resemble the prototypes with which they are most familiar can move themselves up and down a hill, but that no other object types can (Rule 2).

In order to determine whether children used Rule 1 or Rule 2, we selected stimuli that could yield distinctive across-trials patterns of responding (Siegler, 1976). Included in the stimuli sets were two groups of animal pictures and one group of statues. Animals shown were either mammals, which have faces, torsos, and appendages resembling those of people and typical animals, or nonmammals, which have parts and shapes quite unlike those of people and familiar animals. The statues were animal-like and were chosen because they had typical animal parts and shapes, even though they did not represent any specific familiar animals. If children were to respond by using Rule 2 (prototypical animal shapes and parts), they would treat the statues as mammals and would say that the items in both sets of objects could go up and down a hill on their own. The nonmammals, like the inanimate objects, would be denied these abilities. If children were to use Rule 1 (general animal shapes and parts), they would treat all statues, nonmammals, and mammals alike, allowing that they could all go up and down a hill by themselves.

In Piaget's view, initially, any sort of movement and, later, apparently autonomous movement are the hallmark criteria for young children's judgments of life. Therefore, children could use a third rule: Any object that has moveable parts (be the parts animate or inanimate) can move under any circumstances. If they were to apply this thinking, they would fail to discriminate between self-generated uphill movement and gravity-induced downhill movement and would say that the wheeled objects could move by themselves. Because the statues have limbs, these too would elicit affirmative answers for both the uphill and downhill questions, yielding the overall predicted pattern of yes answers for Rule 3 (visible movement-enabling parts) shown in Table 1. Note that, in the table, Rule 3 generates less than 100% yes response predictions for the mammal and nonmammal categories. This is because the pictures used failed to show obvious limbs for one or two objects in each category (see, for example, the echidna in Figure 1).[2] In contrast, all of the statues depicted parts that resemble those that could enable animal movement.

Given that young children know something about the different kinds of movement patterns that characterize different objects (Richards & Siegler, 1986), we thought it unlikely that Rule 3 would be the organizing principle for many subjects' answers. Indeed, such findings suggest that some children will answer on the basis of a fourth rule: whether the depicted object affords animate as opposed to inanimate movement. In order to use this rule, children have to consider a coordinate cluster of information that informs them about the kind of movement that an object will engage in as well as the material kind of that object. For example, to reject statues as examples of objects that

[1] It is difficult to be more specific about the information in pictures used for making these decisions, because very little is known about the extraction of information about animacy from pictures of real world objects.

[2] Echidnas, also known as spiny anteaters, are considered very primitive mammals, combining both mammalian and reptilian features.

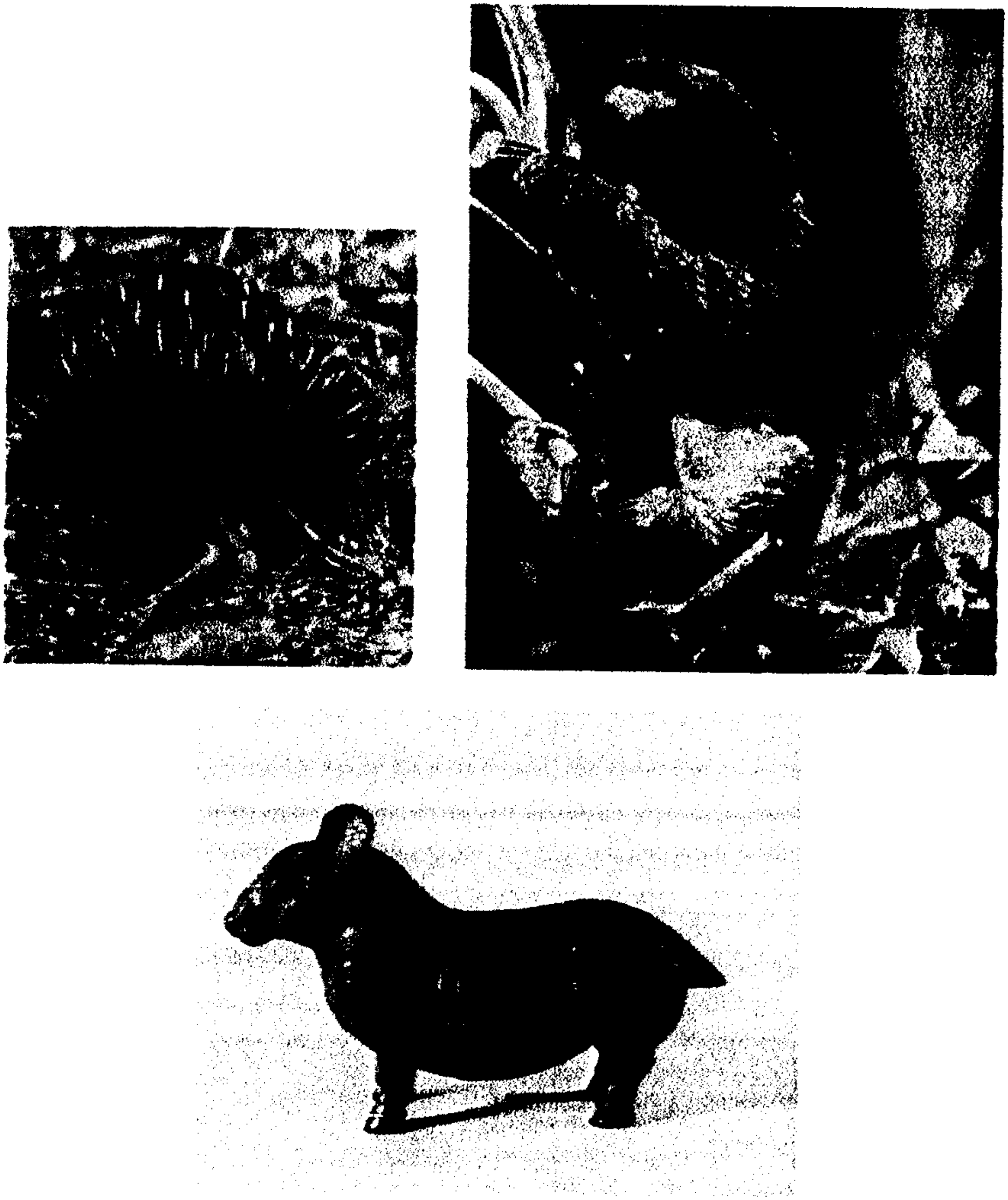

Figure 1. Examples of photographs used in the experiment: echidna (top left), sloth (top, right), and statue of quadruped (bottom). The echidna photograph by J. A. L. Cooke is reprinted with the permission of Oxford Scientific Films, Ltd. (Picture No. 33691). It and the photograph of the sloth are from *Life on Earth* (p. 206 and p. 250, respectively) by David Attenborough (1979), Boston, Massachusetts, Little Brown. The quadruped statue photograph is reprinted courtesy of the Freer Gallery of Art, Smithsonian Institution, Washington, DC (Acc. No. 40.23).

Table 1
Predicted Percentage of Yes Responses to Up and Down Questions as a Function of Item Category and Possible Rule Use

Category/question	Rule 1: General animal shapes and parts	Rule 2: Prototypical animal shapes and parts	Rule 3: Visible movement-enabling parts	Rule 4: Animate–Inanimate
Mammalian animals				
Up	100	100	100 – X[a]	100
Down	100	100	100 – X[a]	100
Nonmammalian animals				
Up	100	0	100 – X[a]	100
Down	100	0	100 – X[a]	100
Animal-like statues				
Up	100	100	100	0
Down	100	100	100	0
Wheeled vehicles				
Up	0	0	100	0
Down	0	0	100	100 – Y[b]
Rigid objects				
Up	0	0	0	0
Down	0	0	0	0

[a] X represents tendency to give *no* answers to items for which a child cannot identify obvious legs or paws. [b] Y represents tendency to give *no* answers that were based on the assumption that the wheeled object was not yet in motion.

move themselves, one must note that the limbs on such objects are made of the wrong material, that the objects have the wrong surface characteristics, and so forth. Because children brought up such considerations when talking about dolls and puppets in Gelman, Spelke, and Meck's (1983) interviews, we thought it possible that at least some of our subjects would do the same when confronted with pictures of unfamiliar objects and, therefore, would respond on the basis of what is shown as Rule 4 in Table 1. Use of this rule predicts correct performance on all items.

Method

Subjects

Ten 3-year-olds (*M* age = 3 years, 4 months) and ten 4-year-olds (*M* age = 4 years, 4 months) participated in this study. An additional 3-year-old was excluded because she was unable to complete the practice items correctly after two attempts. All children had written parental permission to participate. Approximately 80% of the permission requests that were sent out were returned, all with permission granted.

Materials

Materials for this study consisted of (a) a 19 × 25 in. (48 × 63 cm) drawing of a hill with a park bench at the bottom and a swingset at the top, a path going from one to the other, and some trees in the background, and (b) a set of 25 color photographs mounted on 10 × 10 ½ in. (25.5 × 27 cm) pieces of off-white matte board. The large drawing was used to introduce children to the task and to keep them focused on questions about going up and down the hill. It was on display in front of the child throughout the session. Four of the mounted photographs were practice items, including photos of a man, a little girl, a fork, and a chair. These items were used to introduce the format of the task to the children and also as a minimal check to see that they understood and were following instructions. Each child had to be able to identify correctly and predict whether each of the four practice items could go up and down a hill "all by itself." If a child made an error on one of these items, the experimenter gave the instructions again and repeated the questions. If the child was still unable to get these familiar items right, he or she was not included in the study.

The remaining 21 mounted photographs were divided evenly into five groups of items for analysis, with the additional item, a robot, not counted in any group. The five groups of items included four *mammals*, four *nonmammalian animals* (mostly invertebrates), four *statues*, four *wheeled vehicles*, and four *rigid objects*. (For ease of reference, the nonmammalian animals will be referred to as nonmammals hereafter.) The robot was included as a pilot item to assess the kinds of inferences that children make about a case in which the object's appearance and behavior are seemingly animate and the underlying causal mechanisms are obscure or unknown to the child. (The Appendix lists the items, and Figure 1 shows several examples of the photographs.)

In order to assure that these items were indeed unfamiliar to the children, we tested a larger set of items with a different group of 7 children of the same age from the same school. Any items that were recognized or named accurately (or both) by more than 1 child in the stimulus selection study were not included in the current experiment. The final set of items, then, consisted of animals and objects for which preschool children were highly unlikely to have had opportunities for direct contact, observation, or instruction.

Procedure

Most of the children completed the task in one session. For a few of the younger children, the items were divided into two sessions. All children were tested individually, and all the sessions were taped and transcribed for scoring. The experimenter began the sessions by asking the children to look at the large drawing of the hill. In order to make sure that they were clear on the words *top* and *bottom* and *up* and *down*, she asked them to identify what was at the top and bottom of the hill (swingset and bench, respectively) and to tell or show her where they would start and finish if they were going up and then down the hill. All the children were able to do this easily. The experimenter then told them that they would be looking at pictures of all kinds of things and that she would be asking them to help her figure out which ones could go up or down the hill by themselves and which ones needed help. The experimenter then placed the first practice item, a photograph of a man, in front of the child and asked her to say what it was a picture of. The child was then asked whether the man could go up the hill by himself and whether he could go down the hill by himself. The same procedure was followed for the other three practice items. Practice items were always presented in the same order (man, chair, fork, and girl).

After the practice items were completed, the experimenter introduced the experiment by saying, "Now we're going to look at some pictures of things that you've probably never seen before. I don't even know what all these things are called. But we're going to try to figure out which ones can go up the hill all by themselves and which ones can go down the hill all by themselves and which need some help to go from one place to the other. Let's take a look at this one.". She then placed the first item in front of the child and asked, "What do you think about that one. Do you think it could go down (up) the hill all by itself?". After answering, the child was asked to explain why or why not. In addition to their inferences about movement, the children were also asked in reference to a sample of items whether each was an animal, whether it was alive, and how the child could tell one way or the other.

Test items were presented in a different random order for each child, with the restriction that no more than two items from the same subgroup could occur in a row. Half of the children were always asked the downhill question before the uphill question for each item, whereas the other half were always asked the questions in the reverse order. We did not expect children to have accurate labels for the items, and the experimenter did not request or encourage children to produce labels.

Results

Uphill–Downhill Responses

Scoring. For each item, the children were asked whether it could go up the hill by itself (up questions) and down the hill by itself (down questions). Because children occasionally changed their minds during a trial, their first yes–no and last yes–no answers were scored and analyzed separately. In addition, yes–no answers that were modified by explanations were analyzed in separate analyses. Explanations were considered in these additional analyses because children from time to time answered a yes–no question incorrectly but offered a sensible explanation of their answer (for example, denying that an animal could go up the hill because it was a baby and needed help from its mother). Thus, in all, the scoring of the up–down questions led to four analyses of the data: (a) first yes–no answers only, (b) first yes–no answers with explanations, (c) last yes–no answers only, and (d) last yes–no answers with explanations.

For mammals and nonmammals, correct yes–no answers involved saying *yes* to both the up and down questions. Answers for statues and rigid objects were correct if the children said that they could not go up or down the hill by themselves. Children who said that wheeled vehicles could not go up the hill by themselves were obviously correct. Because the experimenter's question did not specify whether the vehicles were started on the slope or not, both answers saying that an agent was required and those saying the vehicles could roll down without an agent were considered correct answers to the downhill question for these items. Answers to the uphill and downhill questions for the robot were simply recorded and not coded as correct or incorrect, because the correct answers are ambiguous even for adults. Responses to the robot item were not included in these or subsequent analyses and are summarized informally when they are discussed.

Results. Overall, children did well. For example, they were correct on 83.5% of their first yes–no answers. Four-year-olds were correct on this analysis on 90.1% of their trials; 3 year-olds, on 77.7% of theirs.

A three way analysis of variance (ANOVA), using age as a between-subjects variable and Item Type (mammals, nonmammals, etc.) and Question Type (uphill vs. downhill) as within-subjects factors, was performed on each of the four data sets. The ANOVA that was based on initial yes/no answers alone yielded no significant effects. For the first three analyses, the main effect of age and item type and their interaction approached significance; for the ANOVA on last answers with explanations counted, the effect of item type and the Age × Item Type interaction were significant beyond the .05 level, $F(4, 72) = 2.62$, and $F(4, 72) = 4.01$, respectively). Table 2 gives the means and standard deviations for each of the four ways of scoring the data.

An examination of the standard deviations for each of the analyses in Table 2 suggests that the primary effect of scoring last answers and taking into account explanations is to decrease variability. The patterns of results remain substantially the same across the four analyses. The pattern of results for the final analysis, where the effects reach significance, can be seen in the last two rows of Table 2, which show the number of correct answers (out of eight) possible for each group in each item category. It can be seen that the significant effects reflect the 3-year-olds' lower scores on animate items. Both 3- and 4-year-olds' scores were nearly perfect on the statues, wheeled vehicles, and rigid objects.

Given the 3-year-olds' lower scores on animate items, we considered whether a reliable number of children responded correctly to the mammal and nonmammal pictures. A binomial test (where $p < .05$) of whether the yes–no responses to the up-down pair of questions were above chance required 6 of 10 children to get three of the four items in each category correct. Figure 2, which is based on just the initial yes–no responses (i.e., before children had a chance to offer explanations), shows that the 3-year-olds met this criterion on the mammal but not the nonmammal categories. Nevertheless, the conclusion that the younger children were therefore responding randomly to the nonmammalian stimuli is not warranted. This is because these younger children seemed much more concerned than the 4-year-olds about the particular context in which the nonmammals had to move themselves. Thus, for example, *bugs* (some children's spontaneously generated label for various nonmammalian animals) were said to be too little to negotiate so big a hill. As the next analysis reveals, even those children who started out with a no answer to the yes–no questions regarding animals' self-generated movement were often using an animate–inanimate rule to judge all stimuli in the experiment.

Rule Analysis

Given how well the children did, no matter what the scoring, it was not surprising that few of their patterns of responses revealed the use of perceptual rules that are based on the shape of known animate objects (be these shapes just of mammals or of animals in general). Of the 20 subjects, only one 4-year-old's data fit the Rule-2 pattern of responses outlined in Table 2. This

Table 2
Mean Number Correct and Standard Deviations for Four Scorings of Up and Down Data by Item Category and Age Group

Scoring	Mammals		Nonmammals		Statues		Wheels		Rigid objects	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
First answers without explanations										
3-year-olds	5.7	2.3	5.3	2.6	7.0	1.1	7.2	1.0	7.3	0.8
4-year-olds	7.1	1.7	7.3	1.2	7.4	1.9	6.9	1.9	7.5	1.1
First answers with explanations										
3-year-olds	5.9	2.2	5.6	2.7	7.2	1.0	7.3	1.1	7.6	0.5
4-year-olds	7.4	1.3	7.8	0.6	7.4	1.9	7.1	1.9	7.8	0.6
Last answers without explanations										
3-year-olds	6.8	1.9	6.0	1.9	7.1	1.0	7.9	0.3	7.7	0.7
4-year-olds	7.8	0.6	7.7	0.7	7.3	1.9	7.7	0.7	7.3	1.1
Last answers with explanations										
3-year-olds	6.9	1.8	6.1	1.7	7.3	0.9	7.9	0.3	7.9	0.3
4-year-olds	8.0	0.0	8.0	0.0	7.4	1.9	7.9	0.3	7.8	0.6

child said that three of the four statues could move themselves and do so because they were animals, looked like animals, and behaved like animals—no matter what they were made from. His concept of animal was a well-informed one, including both mammals and nonmammals; thus, he did not appear to be basing his answers on a narrow prototype.

Another 2 subjects, both 3 years and 1 month of age, made consistent errors on mammal and nonmammal items for which they could not identify obvious legs or paws. Thus, their answers for the animate items were similar to those predicted by Rule 3 (visible movement-enabling parts). Both children, however, correctly denied that the statues could move themselves, even though they had legs, or that wheeled vehicles could go uphill by themselves on their wheels. Thus, their responses to the inanimate item groups did not fit the Rule-3 predictions.

Of the remaining 17 children, 12 (*M* age = 4 years) used Rule 4 systematically and therefore were virtually always correct. Inspection of the explanations of the remaining 5 children (*M* age = 3 years, 9 months) made it clear that they used a variant of Rule 4. These children correctly stated that the inanimate items could not move themselves, but they sometimes denied that an animate object could go up and down a hill by itself,

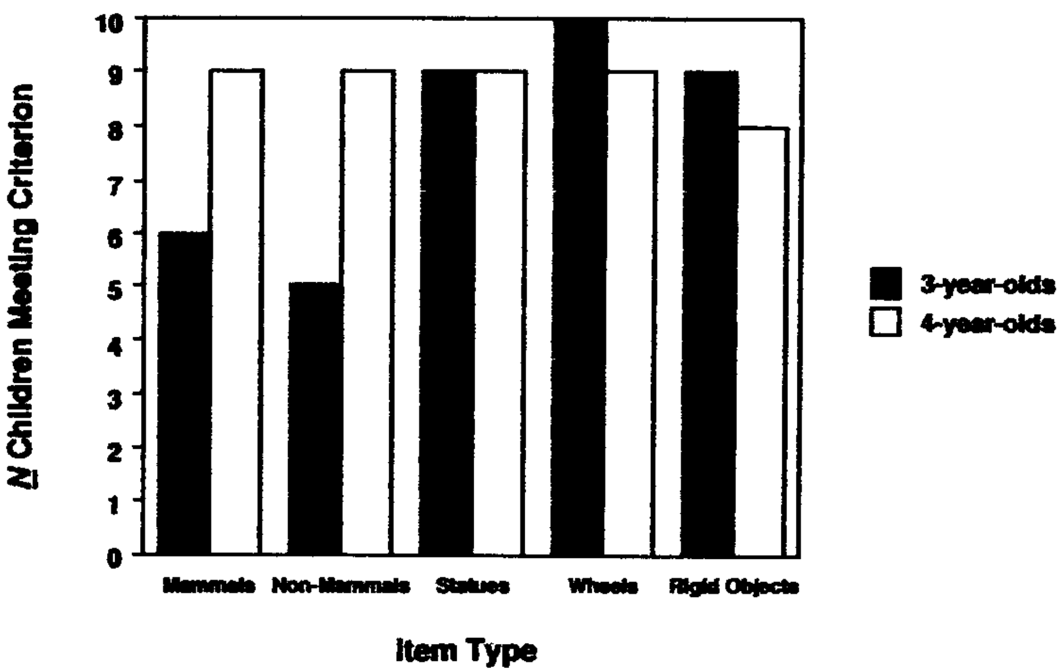

Figure 2. The number of children in each age group meeting the criterion of three out of four correct first answers to the pair of up and down questions in each item category.

offering, for example, the explanation that the animal in question was too little or the hill was too big. Given that they said the animal could do other less strenuous things by itself, they clearly were using an animate–inanimate rule but were worried more about the particular details of the context. As already indicated, these children tended to be younger, accounting, in part, for the 3-year-olds' lower first-answer scores on the animal items. Their scores improved when criteria were relaxed. In fact, the mean scores for these 5 children's last answers with explanations were at least seven out of eight correct answers in each item category. In order to be scored as fitting Rule 4, each child had to give correct answers for at least three of the four items in each category once their justifications were taken into account. Our suggestion that the vast majority of children classified objects as animate or inanimate and related their answers to this classification is buttressed by an analysis of their explanations and their spontaneous labeling.

Verbalization Data

We did not map out a priori analyses for possible answers to requests for explanations, because we did not expect much in the way of verbalizations from such young children. Our plan was to perform qualitative analyses of any such data in order to determine whether they were orderly. We were caught by surprise when it became clear that the stimuli were eliciting a great deal of talk and even spontaneous labeling—despite the fact that we avoided asking children to name the items. As will be seen, although the children did not use the correct names for the novel objects, their labeling was orderly. So were their explanations.

Explanation data. Our first concern regarding the explanation data was to determine whether we could classify them reliably. Inspection of the protocols yielded the coding categories described and illustrated in Table 3. Two independent raters coded half of the transcripts and achieved an overall reliability of 92%. All disagreements were resolved by discussion between the raters, and one of the raters coded the remaining protocols.

Our next questions about the explanations were (a) whether some were more prevalent than others and (b) whether they clustered as a function of item types. Overall, *category membership* was the explanation type most frequently used, accounting for fully one-quarter of the explanations offered. That is, children used the item's membership in a category, such as *animal, furniture* or *toy,* to justify their inferences about it. In addition to using category membership to justify their inferences to the experimenter, children often seemed to use it to arrive at their answers. That is, often their first response to an item, before answering any questions about it, was to announce what kind of thing that they thought it was and then to infer what it could do. The next most frequently used codes were *parts enabling movement* and *general appearance,* each accounting for approximately 15% of the explanations given. Children frequently discussed the presence or absence of movement-enabling parts like legs, wheels, or paws in explaining their answers to questions about moving up and down the hill. More general references to the objects' appearance included having a face, eyes, or a particular overall shape. Other common kinds of reasons included an object's need for an agent, whether it was alive or real, whether it had a capacity for movement or activity, and what it was made of.

The types of explanations offered by the children were not evenly distributed across the various item categories. That is, the children based their explanations on different information, depending on the kind of item under consideration. Post hoc analyses suggested three major patterns of explanations. In all cases, children talked about the category membership of the object. However, the remaining kinds of explanations varied across object type. Thus, when talking about animals (in either the mammalian or nonmammalian stimulus sets), children also focused on their enabling parts, general appearance, and the fact that the depicted items were alive or active. When discussing the statues, children also talked about whether the item was alive, real, or just pretend, and what the object was made out of. Finally, when discussing the wheeled vehicles or rigid objects, the children also referred to whether the objects had movement-enabling parts or needed an agent to move them.[3]

The fact that children systematically varied the kind of explanation that they gave depending on the type of item supports the evidence (discussed above) that most of the children in this study were not relying on single features or simple prototypes. Their yes–no answers and explanation patterns suggested that

[3] In order to satisfy ourselves that the high levels of performance and rich verbal explanations were not the result of an unusually advantaged or gifted sample of children, we gave the unfamiliar objects task to a small sample of rural children ($N = 5$, M age = 4 years, 5 months) attending a summer day camp program in northeastern Pennsylvania. The scores on the yes–no data for these children were quite comparable to the scores of the 4-year-olds in the original sample. The rural children were correct on 93% of their first answers, without explanations considered, for the up and down questions. When their explanations are taken into account, their scores go to 100% correct. They made no errors at all on the animal questions and answered 90% of the alive questions correctly. Initial errors on the up–down questions occurred predominantly on statue items. In almost all of these cases the children first said the object could move by itself and then added "if it were a real one." Errors on the alive questions fell in the statue and nonmammal categories. All of the rural children were judged as using a strict animate–inanimate rule.

The high levels of spontaneous labeling and categorization were also replicated with the rural sample. Like the suburban children, the rural children used category membership as the most frequent type of justification for their answers to the up and down questions. However, there were some differences in the explanations offered by the two samples. The rural children were more likely to give explanations centering on whether the object was alive or real (as opposed to pretend or fake). This coding category was the second most frequently used category for the rural children, and they used it for items of every kind. The suburban children, on the other hand, were more likely to focus on the objects' parts. There is also some indication in the rural children's explanations of their answers to the alive and animal questions that they may be more likely to use biological criteria, such as "growing," "having babies," or "hatching from eggs." Finally, two of the rural children offered a type of explanation not given by any of the suburban children: These children distinguished between animals and artifacts by saying that animals were made by God, whereas the rest of the items in the set were made by "workers."

Table 3
Coding Categories for Explanations

Coding category	Description	Examples of explanations
Category membership (25%)	Child uses target's membership in a category to justify inference.	"It can go by itself because it's an animal." "It can't do anything 'cause it's just a toy."
Parts enabling movement (15%)	Inference is justified by reference to parts that enable the target to move (e.g., legs, feet, wheels). (This category is only relevant for justifications of responses to the uphill and downhill question.)	"It can't move. It doesn't have feet." "It can roll down on its wheels."
General appearance (15%)	Child justifies response by reference to some general feature of the target's appearance.	"It's an animal because it has a face."
Agent (10%)	Child bases response on claim that the target does or does not need help to do something.	"You have to carry it down."
Alive, real, pretend (8%)	Child justifies response by reference to target's status as real or not, alive or not, pretend or not.	"It's not a real piggy; it's just a furniture one."
Movement, activity (8%)	Child justifies response by target's ability to engage in movement or activity of any sort. (Note that the child must infer this ability, because targets are presented only as still photographs.)	"It can go up the hill because it's climbing up the grass."
Substance, composition (5%)	References to what a thing is made of or to properties that derive from what is made of are coded here. This can include inferences about nonvisible composition (e.g., that a target has blood and bones inside).	"It's not alive because it doesn't have real fur; it's just plastic."
Other (14%)	The categories listed above capture most of the content in children's answers. This category codes reasons that appeared less than 2% of the time and a few highly idiosyncratic or uninterpretable statements. (Coding categories used for less than 2% of the responses coded function, mechanism, psychological, and biological statements.)	"I don't know." "'Cause my mommy told me."

the various groups of items used in this study were seen by the children as members of various animate and inanimate categories. The nature of their spontaneous labeling tendencies further indicated that these categories were hierarchically organized.

Labeling data. Recall that we did not ask or encourage children to label the items. We did not want to defeat the purpose of using novel stimuli. As expected, the children who labeled the objects on their own did not use the "correct" or conventional labels. The very fact that the children did not know these names may be what motivated them to introduce their own labels. Overall, the children produced 330 labels, an average of 16.5 labels per child, with a range of 7 to 32 labels per child. Often children gave more than one label for a single item. And the labels that were used revealed a surprising range of creative labeling strategies. Some of the children's labels would be correct for another object that looked something like the unfamiliar one, for example, *bicycle* for one of the wheeled objects or *monkey* for the tarsier. Often these resemblances led to labels that were rather far afield, as when several children called the tarantula an *owl*. Some of the labels were appropriate superordinates, for example, *animal, insect, machine*, and *furniture*; some were compounds, for example, *furniture-animal*; and some were phrasal descriptions about category membership, for example, *a kind of tool, some kind of bug*, and *a creature that lives in the woods*.

As suggested by these examples, the children's labels typically were "in the ballpark"; that is, they were in the right category either at the superordinate or at another level. In fact, only twice was a child's label drawn from the wrong ontological category. In one case, a 3-year-old called the echidna, which has spines like a porcupine, a *pine cone*. In another case, another 3-year-old said the robot was a *storm*. (This may have been intended as a metaphor or analogy, because she later said it was *scary like a storm*.)

The ways in which they expressed their category assignments also hint at how they may have arrived at some of them. For example, a child might say that one of the mammals was "like

Table 4
Percentage of Correct First Answers to Animal and Alive Questions

	3-year-olds		4-year-olds	
Item category	Animal question	Alive question	Animal question	Alive question
Mammalian animates	91	58	96	79
Nonmammalian animates	73	69	96	100
Statues	[a]	38	[a]	88
Wheeled vehicles	100	54	90	69
Rigid objects	94	82	100	86
Robot	100	71	100	86
All items combined	87	61	96	85

Note. *Yes* answers to the animal and alive questions were correct for the two categories of animates and incorrect for the three inanimate categories, with the exception noted below.
[a] Responses not counted because scoring was ambiguous. Because the statues were statues of animals, it was acceptable to answer either *yes* or *no* to the animal question for these items.

a monkey," suggesting an analogy strategy. Other approaches may have been class inclusion and exclusion at a superordinate level, as suggested by such responses as "It's a kind of tool" or "It's not a person or an animal." The apparent facility with which the children arrived at these judgments leads us to speculate that this may be a domain of knowledge in which children are comfortable enough to use some rather sophisticated inference strategies (Brown, Kane, & Echols, 1986).

Animal and Alive Responses

Scoring. Affirmative answers to the animal and alive questions were considered correct for mammals and nonmammals and incorrect for wheeled vehicles, rigid objects, and the robot. Because the statues were representations of animal-like creatures, both yes and no answers to the animal question were accepted as correct. A number of children spontaneously disambiguated their answers to this question by describing the Statues as "fake" or "pretend" animals or as "just a furniture animal." Only no answers to the alive question were scored as correct for the statues. Negative answers to both the animal and alive questions were considered correct for the robot item.

Results. Because the animal and alive questions were not asked as frequently or as systematically as the up and down questions, they were not analyzed statistically and are summarized here more qualitatively. Table 4 shows the percentage of correct first answers to the animal and alive questions for each age group in each item category. Animal questions were asked on a total of 174 trials, and the alive questions, on 255 trials.

Children of both ages performed better on the animal questions than on the alive questions. Considering first answers only, 3-year-olds answered the animal questions correctly 87.1% of the time, but only 60.6% of the time for the alive questions. Four-year-olds' responses were correct for 96.3% of the animal questions and 85% of the alive questions. The 4-year-olds were uniformly good at judging whether items in each category were animals. Scores for the 3-year-olds' answers to animal questions were above 90% correct in each category except the nonmammal category, where they answered correctly 73.3% of the time. Three-year-olds had the most difficulty judging whether the statues and wheeled vehicles were alive (38.5% and 4.5% correct, respectively). Four-year-olds found it hardest to answer alive questions for the wheeled vehicles (68.8% correct) and mammals (78.6% correct).

Another way to look at the answers to the alive questions is to consider the children's tendency to say *yes* for each category of items. The rank ordering of percentage of yes answers in each category for the 3-year-olds was as follows: nonmammals (69%), statues (62%), mammals (58%), wheeled vehicles (45%), the robot (29%), and rigid objects (18%). The rank ordering of categories for the 4-year-olds was as follows: nonmammals (100%), mammals (79%), wheeled vehicles (31%), rigid objects and the robot (14%), and statues (12%). The most significant difference between the two age groups was in their answers for the statue category: 3-year-olds were much more likely than 4-year-olds to say that the statues were alive. In fact, the younger children were more likely to say that the statues were alive than the mammals.

It is possible that asking the children whether the items were animals or alive caused them to respond differently than they would have otherwise. That is, the experimenter's requests for the children to categorize the items as animals or not or as alive or not could lead to improved performance and response patterns more in line with our hypothesis. Because the experimenter did not ask these probes until the children had had several trials to see if they might have brought up the issues spontaneously, it was possible to do a comparison of children's responses before and after the animal and alive questions were first introduced by the experimenter. A one-tailed sign test was done to evaluate the hypothesis that children's scores on the up and down questions improved on items completed *after* the experimenter began asking the animal and alive questions. The test, which used children's first answers without explanations, showed no significant before or after difference ($p = .395$).

We also examined the distribution of explanation types on items completed before and after the experimenter introduced the animal and alive questions. When the percentage of times that each explanation type was used before the probes is compared with each type after the probes, 8 of the 12 types varied less than two percentage points. Of the four explanation types that showed more of a change in distribution, category membership and alive/real/pretend explanations—the explanation types that one might expect to be most encouraged by the probes—actually *decreased* from when before the probes were asked to after (33.8% to 21.6% and 10.3% to 7.0%, respectively). The proportions of enabling parts and movement or activity explanations increased somewhat (20.6% to 28.4% and 2.9% to 6.3%, respectively).

Overview and Conclusions

Three- and 4-year-olds in this experiment were shown glossy photographs of unfamiliar mammals, nonmammalian animals, statues of animals, wheeled vehicles, and multipart rigid objects. The children made predictions about whether each item could go up and down a hill by itself, explained their inferences, and occasionally answered questions about whether the target items were alive or were animals. Children of both ages made reliable accurate inferences about the movement potentials for each of the five classes of items tested, except for the 3-year-olds' first answers in the nonmammal category. Furthermore, they correctly judged whether each item was an animal or not 91.4% of the time. They were notably less successful in judging whether each was alive (68.8% accuracy). Their explanations revealed a tendency to vary in a consistent manner the kinds of information on which they were focusing, depending on the type of object under consideration. Finally, their spontaneous labeling suggested that the children were inclined to group and name the unfamiliar objects in sensible and flexible ways, and that their groups were hierarchically organized to some extent.

The labeling and explanation data offer some suggestions for how children were able to succeed in this task. First, they used the knowledge they already had of the animate–inanimate hierarchy in attempting to classify novel items. The comparisons that they made explicit in some of their labels indicate that they used strategies such as analogy to familiar members of a known category or class inclusion and exclusion at a superordinate level in order to make their inferences. Finally, they used a coordinate cluster of information available from the pictures and systematically varied their attention to and use of this information from category to category. Taken together, these patterns give us the impression that the children were "milking" their available knowledge in a problem-solving fashion to make a best guess about the nature of the object and whether it could move itself or not.

We have suggested throughout this article that the children's performance on this task cannot be attributed to simple perceptual prototypes or rules that are based on single perceptual features. Clearly, the children were using perceptual information, because pictures were their only direct source of information about these unfamiliar objects. However, the patterns in their answers are not predicted by the obvious perceptual similarities and dissimilarities among the items. For example, although the mammals and animal-like statues resembled each other in terms of overall form and parts, whereas the nonmammalian animals bore less resemblance to either group, the children gave similar inferences and explanations for the mammals and nonmammals and gave a different pattern for the statues. This finding fits with recent results reported by Gelman and Markman (1986), who showed that, by age 4, children can override perceptual similarity to make inferences on the basis of category membership. In the present study, children's selection and use of perceptual information seemed to be guided by their conceptual knowledge. It seems necessary to invoke some such governing conceptual knowledge to explain the subtle but consistent ways in which children shifted and combined criteria in differentiating the various categories of items presented to them.

We propose that the organizing concept in this case is a concern for the causal mechanisms governing an object's capacity for movement. Several sources of evidence point to the psychological primacy of cause of movement for the animate–inanimate distinction. The developmental literature is filled with reports documenting a strong relation between movement and the attribution of life (e.g., Carey, 1985; Laurendeau & Pinard, 1962; Piaget, 1979). Richards and Siegler (1986) reported that this holds for adults as well: Motion was among the five most frequently named attributes of life for all ages that they tested, including adults. Furthermore, in the absence of other information about an unknown object, adults were just as likely as children to use movement as an indicator of life. They also found that children as young as 5 years discriminated among different types of motion, attributing life only to objects displaying animate-type movement.

Other evidence for the developmental primacy of cause of movement comes from studies with infants, which showed that they are sensitive to anomalous, apparently agentless, movement patterns for inanimate objects (Golinkoff & Harding, 1980; Poulin-Dubois & Shultz, 1986). At the same time, aspects of the animate–inanimate distinction that are further removed from cause of movement are relatively late to develop. Carey (1985) has shown that biological functions—especially those shared by both plants and animals, like reproduction and growth—only begin to play a role in children's thinking during the grade-school years. Related evidence comes from the explanations in the present study, in which children frequently mentioned parts enabling movement, the role of agents, and substance—all of which are relevant to movement mechanisms—but rarely discussed other biological or psychological characteristics. Similarly, although children in our study were fairly good at deciding whether the unfamiliar items were animals or not, they were much less accurate in their application of the description *alive*, whose meaning is less tightly correlated with movement patterns.

We suggest that a concern for internal versus external cause of movement may constrain the concept of *animal*, and that an animal–nonanimal distinction can then serve as the developmental base for the more biological animate–inanimate distinction held by adults. The presence of a principle that is based on cause of movement would provide young children with a powerful tool for induction and would speak to why induction might proceed along one line rather than another.

With a basic structure to operate from and a principle to guide them, children might be expected to acquire and organize knowledge about novel objects and descriptive predicates sooner and more efficiently. Indeed, we believe that the richness of the labels and explanations given by the children in this experiment hints at a more elaborate and coherent knowledge of animals and inanimate objects than was previously expected in preschoolers.

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Appendix

Items Used in Unfamiliar Objects Study

Animates	
Mammals	**Nonmammalian animals**
Sloth	Praying mantis
Pygmy marmoset	Shiny shelled insect
Tarsier	Tarantula
Echidna	Anolis lizard in displaying posture

Inanimates			
Statues	**Wheeled vehicles**	**Rigid objects**	**Robot**
Statue of quadruped	Electronic golf caddy	Valet/pants presser	
Ewer in shape of mythical bird	Antique bicycle without pedals	Panoramic camera	
Statue of Chow puppy	Antique large-wheeled bicycle	Rowing machine	
Figurine with insect-like eyes	Antique carriage	Multipurpose home exercise machine	

Received December 31, 1986
Revision received November 20, 1987
Accepted November 23, 1987 ■