As Time Goes By: Children's Early Understanding of Growth in Animals

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ROSENGREN, KARL S.; GELMAN, SUSAN A.; KALISH, CHARLES W.; AND MCCORMICK, MICHAEL. As Time Goes By: Children's Early Understanding of Growth in Animals. CHILD DEVELOPMENT, 1991, 62, 1302-1320. Beliefs about naturally occurring transformations were examined in children aged 3 to 6 years in 4 experiments. Experiment 1 tested children's understanding that animals (but not artifacts) predictably get larger over time. Experiment 1a examined whether the results obtained in the first experiment could be attributed to an added memory component on the artifact task. Experiment 2 further examined beliefs about the aging of artifacts. In Experiment 3, color and shape (metamorphosis) changes of animals were investigated. At all ages, children appeared to understand that animals get larger and not smaller with age. While older children and adults allowed for rather dramatic changes in the size and shape of animals over the life span if the alternative involved decreasing in size with age, preschool children were less willing to accept these changes. Taken together, the results of these studies suggest that even young preschool children have 2 conceptual insights about natural transformations: that they are lawful and nonrandom, and that they are domain and mechanism specific. Further, children as young as age 3 are able to go beyond the perceptual appearance of animals in making judgments about transformations caused by growth. Implications for children's understanding of personal and species identity are discussed.

In nature there are many striking changes that occur as part of the normal life span of plants and animals. A seed sprouts, develops roots, and grows into a giant oak. Tadpoles hatch from eggs and grow into frogs. These transformations involve dramatic changes in appearance, yet are fully natural and possible. In contrast, the transformation of a zebra into a horse, or a bird into an egg, although no more dramatic perceptually, are neither natural nor possible.

Part of a mature understanding of biological concepts entails understanding which transformations are possible and which are not. This is a critical conceptual development in part because it is a component of a developing theory of biology. But equally important, understanding the nature of transformations is eventually part of reasoning about identity. Personal identity is invoked to explain what is constant in the face of change. If children hold different beliefs from adults about what changes are possible, then their concept of identity may differ correspondingly. For example, if children believe that a tadpole cannot change into a frog, then they probably will not believe that identity is maintained as a tadpole matures into a frog.

Specifically, there are three important conceptual insights that children must come to appreciate in this area. First, real-life transformations are not random. They are lawful and predictable. For example, with development to adulthood, animals can get larger but not smaller. Second, the kinds of transformations that are possible are domain specific and mechanism specific (Aristotle, cited in Wiggins, 1980; Keil, 1989; Schwartz, 1978). For example, growth applies consistently to animals and plants but not artifacts (e.g., chairs do not grow). Third, even with dramatic changes in appearance, both personal identity and species identity are main-

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tained across natural transformations of living kinds. For example, a redwood tree continues to belong to the same species throughout its growth from sapling to towering maturity. Moreover, we consider it to be the same individual tree across the years.

The present studies examine children's expectations concerning the first two concepts outlined above: the lawfulness of transformations, and their domain-specific nature. Our primary question is as follows: Do children believe that any change is possible, or do they expect lawful regularities that vary with domain? We do not directly test whether children believe that identity is retained across transformations, but this will be an important implication that we address in the general discussion.

As background to the studies reported below, we first review what children know about transformations. Based on previous research, it seems that children might believe either that any transformation is possible, or that few transformations are possible (conservatism).

In one study of children's understanding of transformations, DeVries (1969) presented children between 3 and 9 years of age with a live cat and asked them to identify and pet the animal. The cat was then placed partially behind a screen so that its head was occluded and a very realistic dog or rabbit mask was placed on it. The children were again asked to identify the animal and interact with it. The youngest children (3-year-olds) responded that the transformed animal was a dog or rabbit, and behavioral measures supported their statements (e.g., children seemed fearful of the ferocious dog). Even when these children witnessed the mask being placed on the cat they still responded as if the cat had been changed into a dog or rabbit. Slightly older children (4-year-olds) would not accept the change once they witnessed the masking of the cat. By 5 years, the children did not believe that the mask changed the identity of the cat even when the mask was placed on the cat behind the screen. These results may be interpreted in two ways: on the one hand, children accepted a transformation that adults would not accept. Thus, their beliefs seem relatively unconstrained. On the other hand, children were reluctant to accept the possibility of a cat retaining its species identity after a radical change. In that sense children seem highly conservative in what changes they believe can take place while an animal still maintains its identity.

Keil (1989) has recently investigated this issue more fully in a number of experiments designed to examine children's knowledge of the consequences of transformations for natural kinds and artifacts. In these studies, Keil and his colleagues presented children with pictures of various natural kinds and artifacts. The children heard stories that involved changing certain perceptual characteristics of the items, and then they were asked to identify the resulting object. For example, in one story a raccoon was made to look like a skunk, and in another story a coffee pot was made to look like a birdfeeder. Keil found that while 5-year-olds say that natural kinds can be transformed into other natural kinds and artifacts can be transformed into other artifacts, older children accept only the artifact transformations. In further investigations, Keil has shown that while 5-year-olds are quite willing to accept changes within ontological categories (e.g., one living thing into another living thing), they are less willing to accept changes that cross ontological boundaries (e.g., inanimate thing into living thing). Thus 5-year-olds are willing to accept that a raccoon can be turned into a skunk but are unwilling to accept that a toy dog can be turned into a real dog. Again, as with the study by DeVries, these results could be interpreted as showing either unconstrained or conservative judgments of transformations, depending on how the result is framed.

The results of the work by Keil and DeVries suggest that young children's judgments of the consequences of transformations are strongly influenced by the perceptual appearance of things in the world. If an animal looks like a dog or skunk, then it is a dog or skunk regardless of what it was a few minutes ago. These results also suggest that children might believe any kind of transformation is possible within an ontological category. This result has profound implications for children's concept of identity over time, since changes that lead to modifications of the outward appearance of things in the world would lead children to believe that the identity had been altered. This suggests that young children's concept of identity may be quite different from that of older children and adults.

To date the research that has examined children's understanding of various transformations has involved changes that do not occur in nature (e.g., raccoon to skunk, cat to dog), rather than changes that actually do
Children may, however, be sensitive to the mechanisms that underlie various transformations. For example, children may be sensitive to whether the mechanism that causes the change is a natural biological transformation or one that defies biological laws. The implication is that even though children report that some transformations do lead to identity change, they may realize that natural transformations (such as growth) do not. We argue that children may have trouble understanding the mechanisms involved in transformations used by past researchers.

Few investigators have examined children's understanding of natural changes, such as those that occur as part of the growth process (Carey, 1985). Physical growth is one type of naturally occurring transformation that can radically alter the outward appearance of living things. In one of the earliest investigations, Voyat (cited in Piaget, 1968) studied young children's understanding of the stability of personal identity through growth by having them draw pictures of themselves and the experimenter as a baby, at their present age, as an adult, and then as an old person. Children readily understood that the drawings captured the same individual over time. In contrast, children performed quite poorly when tested about a different domain about which they had little knowledge. In a contrasting task, children witnessed a rapid chemical reaction (potassium ferrocyanide seeded in a copper sulphate solution) that gave the appearance of rapidly growing seaweed. The children were asked to draw pictures of the “plant” at successive stages of its development. They reported that the pictures that were close in size were the same plant, but those that differed greatly in size were not the same plant. Thus, in this study, children appeared to understand that identity could be maintained over time and physical changes for the familiar domain of animal growth, but not for the rapidly occurring chemical reaction. One explanation for these contrasting results may be that children have some understanding of the growth process as it applies to humans, whereas they are unsure of the mechanism that underlies unnatural or unfamiliar transformations, such as the chemical reaction. In such cases, children rely more on similarity.

More recently, Inagaki and her colleagues (Inagaki & Hatano, 1987; Inagaki & Sugiyama, 1988) have examined children's understanding of various properties of living things, including growth. They presented children between 4 and 9 years of age with a series of questions of the form: “Does X grow bigger and bigger?” (Inagaki & Sugiyama, 1988), and “Suppose someone is given a baby X and wants to keep it forever the same size because it is so small and cute, can he or she do that?” (Inagaki & Hatano, 1987). Various animate and inanimate objects were substituted for the “X” in these sentences. These researchers found that by age 6, children distinguish between living things and artifacts and understand that growth for living things is inevitable. Younger children in these studies appeared to make judgments about whether or not an animal or artifact has some attribute (such as the ability to grow) on the basis of how similar that object is to humans. Since these researchers were most interested in examining the pattern of attributions made by children and adults, and not with understanding of growth per se, it is difficult to determine just what preschool children think about growth from these studies. Do children have a specific expectation that animals grow over time, or is there a more general expectation of some type of change over time?

The research described above on children's understanding of transformations and growth is open to two interpretations. On the one hand, it suggests that children under the age of 5 use perceptual appearance to make judgments about category membership and to infer properties of certain category members. A change in an animal’s appearance causes young children to infer that many other important properties of the animal have also changed. This demonstrates an extreme conservatism with regard to the transformations members of animal categories may undergo. Even the smallest change results in a change of category membership. On the other hand, one could interpret these same findings as reflecting an extreme liberalism about the possible transformations. Children seem willing to accept the possibility of a cat being transformed into a dog. Thus, any change could be possible. In either case, these findings indicate that young children fail to appreciate the characteristic kinds of changes that animals naturally undergo.

1 It is not clear from Piaget (1968) the exact ages of children studied by Voyat, although they were younger than 7 years old.
The thesis that children treat the appearance of an animal as crucial to its category identity is consistent with a general view of development that characterizes young children as confined to reasoning about appearances and unable to look beyond the obvious (Wellman & Gelman, 1988). Young children's categories are often thought to be based on superficial perceptual and functional properties (Flavell, 1985; Mansfield, 1977). On this view, the understanding that an object might change appearance yet otherwise stay the same, or further, that there might be characteristic patterns of change that objects would be expected to undergo, would require cognitive sophistication beyond the capacities of a young child. All changes in an individual's appearance would imply radical changes in that individual.

In contrast to the similarity-based approach, there exists a recent body of work suggesting that even 3-year-olds are able to look beyond the obvious in making inferences about categories (Wellman & Gelman, 1988). This view suggests young children recognize that objects may be defined by "deeper" or hidden features, such as internal parts, rather than by evident "surface" features, such as appearance. On this view, children should be willing to accept that an individual could undergo radical appearance changes and yet still remain, somehow, fundamentally the same. The ability to recognize underlying attributes would also allow that some appearance changes be expected, and even characteristic, of certain kinds of things. Children's judgments about when two objects are the same could be much more complex in this conception.

The goal of the current research is to map out more clearly what young children understand about naturally occurring transformations and how this understanding might change with age and experience. The present study is restricted to an investigation of children's knowledge of the characteristic changes that occur in animals over time. More specifically, we are interested in whether children under the age of 5 have any beliefs about the kinds of changes that can be expected as animals grow. We investigate whether these beliefs reflect an appearance-based conception of animals and, as a control, whether these beliefs differ for animals and for nonanimals (i.e., artifacts).

In Study 1 we examined children's understanding of one kind of appearance change, changes in size, associated with growth. This study was designed to investigate whether 3- and 5-year-olds understand that animals undergo a characteristic change, namely, increase in size over time. Children were asked whether they thought animals' appearances could change during growth. Identical questions were asked with regard to the changes undergone by artifacts. Children's responses in this study, and all that follow, were analyzed to examine whether perceptual similarity was used to identify an individual over time.

Experiment 1

Experiment 1 was designed to examine whether children understand that animals may change in appearance by increasing in size over time. Children were presented with pictures of baby animals and brand new artifacts and then were asked to choose which of two other pictures was the animal as an adult or the artifact after it had been around for a very long time. By presenting children with alternatives of various sizes we could determine if children are capable of understanding that animals but not artifacts typically undergo a change in appearance with age. In this study, the artifacts serve as a control to make certain that when children answer correctly it is not due to a response bias to select the larger object on each trial. A similarity-based account should predict that children would choose based on how closely the pictures of adults resembled the babies, and how closely the old artifacts resembled the new ones. If children are, in contrast, extremely liberal in their acceptance of transformations and believe that any change is possible, we might expect them to answer randomly when asked to choose a possible adult/older object. An appreciation of the underlying features and biological mechanisms of animals would lead subjects to choose pictures of adults that differed in appearance from babies (i.e., were larger) but use perceptual similarity in the case of artifacts.

Method

Subjects

Forty-one children participated in the experiment. There were 22 children in a younger age group ($M = 3-10$, range = 3-5 to 4-3; 11 males, 11 females) and 19 children in an older age group ($M = 5-9$, range = 5-1 to 6-6; 9 males, 10 females). In addition, 14 adults ($M = 22$; eight males, six females) participated in the actual experiment, and another 10 adults ($M = 22$; four males, six
females) performed the similarity ratings. The children were from a university preschool, and the adults were recruited from undergraduate psychology classes.

**Materials**

The stimulus materials in Experiment 1 consisted of 36 animal cards and 24 artifact cards. These cards consisted of artists' renderings of 12 animals and eight artifacts that were photographed from varying distances resulting in scaled small, medium, and large reproductions of each animal or artifact. These photographs were mounted on index cards and laminated. Animal stimuli for the study were drawn from a wide range on the phylogenetic scale (e.g., mammals, reptiles, fish, birds). A list of animals and artifacts and the various set types used in this experiment may be found in Table 1. Both familiar and unfamiliar animals were used in order to rule out the possibility that answers were merely reflecting subjects' specific experiences.

The 12 animals were divided into three sets of four animals each. The Bigger-Smaller set consisted of four animal triads containing a medium-size reproduction, a larger reproduction, and a smaller reproduction of each animal. The Same Size–Bigger set consisted of four triads containing two

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<th>TABLE 1</th>
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<td><strong>ITEMS USED IN THE EXPERIMENTS</strong></td>
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<td>Animal Stimuli</td>
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<td>Experiment 1:</td>
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<td>Skink</td>
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<td>Alligator</td>
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<td>Experiment 2:</td>
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<td>Mug</td>
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<td>Television</td>
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<td>Experiment 3:</td>
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<td>Anole</td>
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<td>Mink</td>
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<td>Kangaroo mouse</td>
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<td>Salamander</td>
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medium-size reproductions and a larger one, and the Same Size–Smaller set contained two medium-size reproductions and a smaller one. Examples of each of the three animal sets are shown across the top of Figure 1.

The eight artifacts were divided into two sets similar to the animal cards. The Same Size–Bigger set contained four triads of two medium-size pictures and a larger one of each artifact. The Same Size–Smaller set had four triads that consisted of two medium-size reproductions and a smaller one for each artifact. Examples of these sets are shown across the top of Figure 2. An artifact set equivalent to the animal Bigger–Smaller set was not used since we were interested in examining children's understanding of naturally occurring transformations and did not want to include any sets where only an impossible choice could be made.

Predictions

**Animal sets.**—All of the figures display the predictions, according to three hypothetical principles: growth, similarity (as assessed by adult ratings), and preference for the smaller item. To illustrate, consider the hypothetical results at the far left of Figures 1a, 1b, and 1c. On the far left of each part of this figure is the predicted pattern for subjects responding on the basis of size increase (growth). Next to this is the pattern of results obtained from the adult similarity judgments. Finally, the predicted pattern of results associated with choosing the smaller item is shown.

**Artifact sets.**—At the extreme left of Figures 2a and 2b are the predicted results for subjects choosing the same-sized item. Next to this are the results of adults' similarity judgments. Finally, in Figure 2a, the predicted results for subjects choosing the smaller item are shown, while in Figure 2b, the predicted results for choosing the larger item are shown.

**Procedure**

Half of the children were tested first with the animal cards and, after approximately a week delay, were tested with the artifact cards. The remainder of the children viewed the artifact cards first. The adults also were presented with one of these two orders, but received the two sets in a single session.

Each subject was tested individually in a private room. In order to familiarize the subjects with the task, they were first shown a picture of a young infant and told that it was a picture of "my friend Sharon when
she was a baby.” They were then shown a picture of an adult and told, “This is a picture of Sharon now when she is an adult.” To avoid presenting any cues to subjects, the two pictures used, adult and baby, were of the same size. The children were then shown another example of a baby and adult human and were asked to point to the two babies and point to the two adults. All of the subjects were able to perform this task. The children were then presented with the animal or artifact test stimuli. Within each block of items (animal or artifact), the order of the presentation of each triad was randomly determined for each child.

For the animal sets, the experimenter placed a medium-sized picture directly in front of the child and said, “This is a picture of [proper name] when [proper name] was a baby. Now [proper name] is an adult.” Since we were interested in children’s understanding of how individuals change over time, we used proper names rather than the names of the species. Following the presentation of the initial picture, the next two cards of the triad were placed, in a random order, below the original one (as depicted in Fig. 1) and the child was asked to identify the picture of the animal as an adult: “Which of these pictures is a picture of [proper name] as an adult?”

For the artifact sets, a similar but slightly modified procedure was used. The child was presented with a medium-size photograph of an artifact and told that “This is a picture of my [artifact] when it was brand new.” In order to emphasize the time lapse, the photograph was then placed in a small plastic “toy box” by the experimenter or the child. The top of the box was left open so that the child could still see the picture. The child was then asked, “If I kept my [arti-

2 The labels “baby” and “adult” were used rather than using “older” or “grown-up” since there is some evidence that preschool children rely on the size of objects rather than chronological age when asked to choose the older or younger object (Kratochwill & Goldman, 1973; Kuczaj & Lederberg, 1977; Looft, 1971; and Piaget, 1927). Also, pilot testing with an additional group of preschoolers suggested that children in the age range used in this study understand the words “baby” and “adult.”
fact] in the toy box for a very, very long time, which of these pictures would it look like?"

The two pictures of the triad were then presented and the child was asked to pick one.

Adults gave similarity ratings for each set of pictures. For these ratings the pictures were placed in a photo album. Each page of the album consisted of pictures of one of the 12 animal or eight artifact sets. In each case, the medium-sized card was placed in the middle of the top of the page and the two remaining cards were placed underneath this card, as shown in Figures 1 and 2. The adults were tested individually. For each set, adults were asked to rate on a seven-point Likert scale how similar the medium-sized picture (shown in the top line of each figure) was to each of the other two pictures (shown in the lower line of each figure). Thus for each set adults performed two similarity ratings. For each adult, the picture that received the highest similarity rating (i.e., the one that was rated as more similar to the "standard" picture) was recorded. The percentages for "similarity" shown in the figures reflect the percentage of adult subjects (out of 10) for whom the difference in similarity ratings was in the "correct" direction.\(^3\)

RESULTS

The percent of correct responses for each of the three age groups is graphed for the three animal sets and the two artifact sets in Figures 1 and 2, respectively. The subjects' percent of correct responses was entered into a 3 (age: 3, 5, adult) x 2 (domain: animal, artifact) x 2 (order: animals first, artifacts first) ANOVA with domain as a repeated-measures variable. Main effects were obtained for age, \(F(2,49) = 8.7, p < .01\), and domain, \(F(1,49) = 8.3, p < .01\), but not for order. Post-hoc analyses revealed that the adults' performance was significantly better than that of the younger children, and that performance in general was better on the animal sets than the artifacts.\(^4\) A significant age \(\times\) domain interaction was also found, \(F(2,49) = 5.2, p < .01\). Post-hoc tests revealed that this was primarily due to the 3-year-olds' performing significantly worse on the artifacts than on the animals. For the older children and adults, performance did not differ significantly across the domains.

Additional analyses were performed to examine performance as a function of set type. Since the animal pictures included three different sets, while the artifact pictures included only two sets, these analyses were performed separately for each of the domains. For the animals, the percent of correct responses was entered into a 3 (age: 3, 5, adult) x 3 (set: Bigger-Smaller, Same Size-Bigger, Same Size-Smaller) ANOVA, while for the artifact set the percent of correct responses was entered into a 3 (age: 3, 5, adult) x 2 (set: Same Size-Bigger, Same Size-Smaller) ANOVA. In both of these analyses set type was a repeated-measures variable.

As can be seen in Figure 1, the results for the animal sets most closely match the predictions of the growth model. A significant main effect for set type was obtained, \(F(2,98) = 6.1, p < .01\). Follow-up tests revealed that performance on the Same Size-Smaller set was significantly worse than on the other two sets. No significant main effect was obtained for age, \(F(2,49) = 2.5\), N.S., though a significant interaction between age and set was found, \(F(4,98) = 2.6, p < .05\). The post-hoc analyses showed that while 5-year-olds performed equally well on the three sets (Msame size-smaller = 100%, M_{bigger-smaller} = 99%, M_{same size-bigger} = 97%, N = 19), the younger children's and adults' performance was significantly worse on the Same Size-Smaller set than 5-year-olds' performance on any of the sets. Note that this was the one set in which it could be argued that neither answer conforms to a growth model. Thus, subjects who were attempting to apply a growth model may have found this

\(^3\) In Figure 1b, the Similarity bar indicates that the adults gave the bigger and smaller items the same similarity ratings in almost every case. This was true for 95% of the responses (38 out of 40, \(p < .05\)). Since these items were given equivalent similarity ratings, we can assume that individuals using strictly similarity to make their judgments would be equally likely to respond with either item, resulting in a 50% rate of correct responses.

\(^4\) The most commonly used a posteriori tests for evaluating pairwise comparisons among means (e.g., Tukey's HSD test or Neuman-Keuls test) require equal sample size in each of the cells to be compared. When the sample N's are approximately equal, as is the case in the current data, the Spjotvoll-Stoline procedure is recommended (Kirk, 1982, p. 120). This procedure is a generalization of Tukey's test and is considered to be more conservative than other tests for comparing means with unequal N's. Unless otherwise noted, it is this procedure that was used for the post-hoc analyses.
set confusing. In addition, the adults’ performance on the Same Size–Smaller set (M = 84%) was significantly worse than their performance on the other two sets (M_{Bigger,Smaller} = 96%, M_{Same Size,Bigger} = 96%, N = 14). This was also true for the 3-year-olds (M_{Same Size,Smaller} = 78%, M_{Bigger,Smaller} = 90%, M_{Same Size,Bigger} = 89%, N = 22).

Single-sample t tests were performed comparing the means obtained for each set with an expected chance value of 50%. These analyses were performed for each age group separately. Performance on all of the animal sets was significantly greater than chance, t_{5,year-olds}(21) > 3.9, p < .01; t_{5,year-olds}(18) > 26, p < .001; t_{adult}(13) > 4.6, p < .01.

Figures 2a and 2b show the percent of correct responses for each of the three age groups for each of the artifact sets. As can be seen in the figures, the results for these sets most closely match the responses predicted by a model based on either similarity of size or similarity of appearance.

For the artifact sets, a 3 (age: 3, 5, adult) x 2 (set: Same Size–Smaller, Same Size–Bigger) x 2 (order: animals first, artifacts first) ANOVA was conducted, yielding a significant main effect for age, F(2,49) = 13.2, p < .001. Post-hoc tests revealed that adults (M_{Same Size,Smaller} = 98%, M_{Same Size,Bigger} = 98%) performed significantly better than the 3-year-olds (M_{Same Size,Smaller} = 82%, M_{Same Size,Bigger} = 56%). The 5-year-olds’ performance was midway between the other two age groups, but did not differ significantly from either of them (M_{Same Size,Smaller} = 86%, M_{Same Size,Bigger} = 80%). A significant age x order interaction was also obtained, F(2,49) = 4.3, p < .05. Follow-up tests revealed that while order of presentation (animals or artifacts first) did not influence performance of the older two age groups, the 3-year-olds performed significantly worse on the artifacts when they were presented following the animals. We return to this unexpected finding in the Discussion.

When subjects’ performance on the artifacts was compared to chance responding (50%), all but one comparison was significantly greater than chance, t_{3,year-olds}(21) = 4.5, p < .01; t_{5,year-olds}(18) > 4.6, p < .001; t_{adult}(13) > 27, p < .001. The exception was the 3-year-olds on the Same Size–Bigger set, who did not perform above chance, M = 56%, t(21) = 0.63, N.S. Thus, at least by age 5, children consistently answer correctly, selecting the same-sized item as the aged artifact.

The final set of analyses examines whether children consistently distinguish between animals and artifacts in their responses. This is particularly an issue with the 3-year-olds on the Same Size–Bigger set items (i.e., were these children performing poorly on artifacts because they failed to differentiate between animals and artifacts?). But also more generally, it is of interest to see whether children appreciate that the two domains are distinctly different. If children do treat the two domains differently, then we are more justified in saying that their understanding of growth is truly based on an understanding of the properties of animals (rather than a general response bias to choose the larger item).

In order to address these issues, a final analysis was performed using the percent of bigger responses (rather than the percent of correct responses, as used earlier) for the two set types used in both domains. Our reasoning was as follows: If children fail to differentiate between the aging of items across the two domains, then their pattern of responses should be identical—that is, the number of choices of the bigger item should not vary by domain. However, if children realize that animals and artifacts are subject to different aging processes, then on this measure a significant domain effect should emerge. Note that the previous analyses could not address this question, since they focused only on percent correct responses.

We employed a 3 (age: 3, 5, adult) x 2 (domain: animal, artifact) x 2 (set: Same Size–Bigger, Same Size–Smaller) ANOVA with domain and set as repeated-measures variables. Overall, subjects appropriately chose the bigger item more often in the animal sets than in the artifact sets, F(1,52) = 98, p < .001. A significant domain x set interaction was obtained, F(1,52) = 205, p < .001. Post-hoc tests revealed that this result was due to subjects showing the domain difference primarily on the Same Size–Bigger sets rather than on the Same Size–Smaller sets. This is exactly as expected, given that the correct answer on the Same Size–Smaller sets does not vary with domain. Finally, a significant effect was found for the age x domain x set interaction, F(2,52) = 11.9, p < .001. Post-hoc tests revealed that with increasing age subjects tended increasingly to differentiate the two domains, but particularly on the Same Size–Bigger sets.
(for the reason given above). However, the post-hoc tests showed that even 3-year-olds distinguish between the animals and artifacts on the Same Size–Bigger set. Overall, since subjects’ choice of the bigger item is shifting across the two domains, these results suggest that subjects clearly differentiate between animals and artifacts.

**Discussion**

The high level of performance on the animal sets suggests that by 3 years of age children realize that growth in animals entails a change in size. Children do not expect animals to be unchanging over time. They are able to go beyond strict perceptual similarity, using knowledge of the growth process to make judgments about natural transformations. The result that children show a clear and consistent pattern in predicting how animals grow suggests that they do expect some transformations (and not others) as a natural consequence of aging.

The results from the artifact sets suggest that subjects were not merely choosing the largest item in each array. Subjects chose the bigger items more often on the animal sets than the artifact sets. In addition, subjects chose the bigger item more often when choosing between a similar-sized artifact and a smaller one than when choosing between a similar-sized item and a bigger one. However, older subjects performed better than younger children on the artifact task and appeared to differentiate more clearly between the two domains. The fact that the youngest children were performing at chance levels on the Same Size–Bigger set of the artifacts, and that the order of presentation influenced the performance of the youngest children on the artifact sets, suggests that the youngest children may not have a complete understanding of the types of changes artifacts can undergo. It appears that when the youngest children are primed with a task involving biological growth, they are more likely to use a biological model in making choices about artifacts. It is interesting to note that the reverse does not hold (i.e., priming with artifacts does not influence choices about animals). This asymmetry implies that biological changes may be salient, even by age 3. This suggestion is also consistent with the anecdotal report that children often label items of decreasing size in a three-item array as the “Daddy, Mommy, and Baby” (see also Smith, 1989).

**Experiment 1A**

In Experiment 1, it was not clear whether the difference obtained between the animal and artifact sets was due to a difference in children’s understanding of animals and artifacts or rather to variations in the procedures used for each set. For the artifact sets in Experiment 1, the original item was placed in a box and subjects were asked to pick which of two other items the item in the box would look like after a very long time. Even though the top of the box remained open when the pictures of artifacts were placed in it, many of the children did not look back to the original picture before making their judgments. Thus some of the children may have forgotten what the original item looked like during the choice period and perhaps were merely showing a preference for the larger item. Experiment 1A was designed to examine if the difference in results obtained for the youngest children between the two sets could be due to an added memory component in the artifact task. In this experiment the subjects were presented with an analogous task for the animals.

**Method**

**Subjects**

The subjects were 10 preschool children (five males, five females) obtained from the same university preschool as in Experiment 1 and ranging in age from 3-4 to 4-0; \( M = 3-9 \).

**Procedure**

The materials were the same as those used in Experiment 1, except that only the animal sets were used. On each trial, each child was presented with the initial medium-sized picture and told that “This is a picture of [proper name] as a baby.” The picture was then placed in a cage that enabled the child to see the picture still if he or she so desired. The child was then presented with the two additional pictures of the triad and asked, “If [proper name] was
RESULTS AND DISCUSSION

A repeated-measures ANOVA was performed on the number of correct responses for each of the three sets of pictures used in this experiment. The children's performance for each of the three set types was not significantly different, $F(2,18) = 1.9$, N.S. Performance for each of the three sets ($M_{Bigger\ Smaller}$ = 80%, SE = 11%; $M_{Same\ Size-Bigger}$ = 85%, SE = 10%; $M_{Same\ Size-Smaller}$ = 78%, SE = 10%; $N = 10$) was significantly greater than chance (50%, $p < .05$). These results were not significantly different from those obtained in the animal sets of Experiment 1 for 3-year-olds (90%, 89%, 78%, respectively, $F[1,30] < .77$, N.S.).

This experiment used a similar procedure for the animal sets to that used in Experiment 1 for the artifact sets. Altering the procedure used for the animal sets did not cause the younger children to perform more poorly in this experiment. Thus, the differences between the animals and artifacts in Experiment 1 probably reflect differences in reasoning about the two domains, rather than procedural differences between the two tasks.

Experiment 2

Experiment 2 was designed to examine more closely children's understanding of changes that occur over time with artifacts. In Experiment 1 we assumed that an old artifact should look identical to a new one. It is not, however, strictly the case that exact perceptual similarity is needed to identify a picture of an old artifact with a picture of a new one. The similarity-based conception is no more appropriate for artifacts than it is for animals. Artifacts, too, typically show appearance changes as they age. Inanimate objects become dirty, chipped, cracked, etc. It may be the case that subjects expect some difference in appearance between old and new artifacts. In Experiment 1, the only appearance differences were ones of size. Thus we could not distinguish between an expectation that appearances should change with age and an expectation that things should vary in size with age. In this experiment, some of the artifacts were visibly aged so that these two response patterns could be distinguished.

Children and adults were presented with a drawing of a medium-sized object (the "brand new" object) and then were given a choice between objects that were the same size as the original but differed in surface appearance (the "aged" object) or objects that looked very similar but varied in size from the original (either smaller or larger). Based on the results of adult similarity ratings, we hypothesized that if children were choosing solely on the basis of overall perceptual similarity, then they would tend to select the picture that differed in size from the original. However, if children do understand that artifacts maintain their size over time but can change in appearance (e.g., get dirty, broken, or miscolored), then they should consistently choose the "aged" object.

METHOD

Subjects

Eleven children in a younger group ($M = 3-9$, range = 3-3 to 4-3; six males, five females) and nine children in an older group ($M = 5-6$, range = 5-0 to 6-0, six males, three females) participated. Ten adults ($M = 22$; three males, seven females) also participated in the experiment. In addition, the same 10 adults who made the similarity judgments in Experiment 1 made similarity judgments.

Materials

Ten new sets of artifact drawings were constructed for this experiment. Each set consisted of three drawings of an artifact on laminated cards. The artifacts used in this experiment are listed in the middle portion of Table 1. Five of the sets consisted of a medium-sized object, a larger copy of that object, and a medium-sized but "aged" version of the original object. The other five sets contained a smaller version of the original, rather than a larger version of the original. The "aged" drawings contained marks that simulated effects of aging that artifacts undergo over time (cracks, scuff marks, dirt, etc.). Thus in this experiment one of the drawings (the larger or smaller one) was identical to the original drawing, except for the size variation. The "aged" drawings preserved size but varied in appearance from the original item. Examples of the artifact drawings used in this experiment are presented at the top of Figure 3.

Procedure

The procedure was the same as that used in Experiment 1 for the artifact cards.
RESULTS

For each set type, the subjects' percent of correct responses was entered into a 3 (age: 3, 5, adult) x 2 (set type: Same Size—Bigger, Same Size—Smaller) ANOVA with set as a repeated-measures variable. A significant main effect of age was obtained, $F(1,29) = 8.9, p < .01$. The adults' and older children's performance was significantly better than that of the younger children. There was no significant main effect for set, nor was there a significant age x set interaction.

The percent of correct responses for each of the three age groups is graphed for each of the two artifact set types in Figure 3. Consider first the hypothetical results that are displayed at the far left of Figures 3a and 3b. On the far left of each part of this figure is the predicted pattern for subjects responding on the basis of same size. Next to this is the pattern of results obtained from the adult similarity ratings.

All three age groups responded above chance (50%) to the Same Size—Smaller set, $M_3 = 78\%, t(10) = 3.0, p < .05, M_5 = 100\%, M_{adult} = 100\%, \text{binomial probability, } p < .01$. As in Experiment 1, while the adults and older children performed significantly above chance on the Same Size—Bigger set, $M_{adult} = 100\%, \text{binomial probability, } p < .01, M_5 = 98\%, t = 21.5, p < .001$, the youngest children did not, $M_3 = 64\%, t(10) = 1.1, \text{N.S.}$

DISCUSSION

This experiment demonstrates that 5–6-year-old children and adults understand that inanimate objects typically do not change in size over time, although the appearance of these objects may change in other ways due to the aging process. There is tentative support for the notion that even younger children (3–4-year-olds) have some understanding that inanimate objects may change in appearance but not change in size. The comparison of predicted and observed results in Figure 3 suggests that children do not assume that objects retain unchanging appearances over time. While this is especially clear with the Same Size—Smaller set, it is also true with the Same Size—Bigger set. However, it is also clear from the results obtained with the Same Size—Bigger set that the youngest children do not consistently
choose the same-sized item when presented with a choice between a same-sized aged item and a larger version of the original. In this study, only six of the youngest children (out of 11) consistently (i.e., on all trials) chose the same-sized item across set types. The remaining children in this age group either consistently chose the larger item \((N = 2)\) or did not show a consistent pattern of responding \((N = 3)\). However, the pattern of results obtained for the 3-year-olds in this study does differ from the pattern of responses found for animal sets in Experiment 1. Thus this study further suggests that young children may have at least a partial or fragile understanding of how artifacts age.

**Experiment 3**

Size is not the only dimension on which adults vary from children. Over the aging process in animals, facial and bodily proportions typically change. While many of these changes are subtle (e.g., in humans the deepening of wrinkles or gradual graying of hair), there are many species in which adults look quite different from their young. For example, tadpoles and frogs differ dramatically from one another, as do caterpillars and butterflies. In this experiment, we were interested in whether children and adults would accept shape and color variations actually found in nature. Although changes in color alone are not associated with the growth process per se, they are part of the natural transformations of many animals (e.g., chameleons, snowshoe hares). Thus it is of interest to see if young children will accept the fact that two pictures can be of the same animal despite a difference in color or shape.

There are two reasons why this is an important issue. First it allows us to see if children would be willing to accept rather dramatic changes in appearance brought about during the growth process. In Experiment 1, physical size was the only aspect of the animals that was varied. Thus the babies and adults looked quite similar. However, most living things change in a variety of ways over the life span. This experiment allows us to examine if children would accept more dramatic change. The second reason this experiment is of interest is that it allows us to test further children’s understanding of the unidirectionality of growth. If children believe that growth is inevitable, they should be willing to accept a dramatic change in appearance that occurs as part of the growth process when the alternative is a decrease in size over time. Finally, the changes of color and shape allow us to examine if the degree of change influences children’s judgments. That is, a metamorphosis of a tadpole into a frog seems to be more dramatic than a chameleon changing color. Do children find it easier to accept changes of color than metamorphosis when the alternative is a decrease in size?

We presented children and adults with the same procedure as in the previous studies. However, in every case, one of the choices was markedly different from the “baby” in either color or shape, while the other item differed only in physical size. On half of the trials both the markedly different item and the other item were larger in size than the “baby.” On the remaining trials the markedly different item was larger and the other item smaller than the “baby.” The most dissimilar looking picture was the actual adult version of the animal in each case.

This task allowed us to test children’s beliefs about the relative importance of size and appearance changes. Experiment 1 showed that children share the adult belief that changes in size due to aging are unidirectional; animals grow but they do not shrink. Would children continue to maintain that an adult must be larger than a baby even in a forced-choice paradigm where the only other option involved a radical difference in appearance on the part of the (larger sized) adult? It is our adult intuition that the principle of the unidirectionality of growth should outweigh concerns that the adult form of an animal resemble the infant.

**Method**

**Subjects**

Fifteen younger preschool children \((M = 4-1, \text{ range } = 3-6 \text{ to } 4-5; \text{ seven males, eight females})\), 12 older preschool children \((M = 5-9, \text{ range } = 4-6 \text{ to } 6-3; \text{ eight males, four females})\), and 10 adults \((M = 20; \text{ four males, six females})\) participated in this experiment. The children were from two classrooms at a university preschool and the adults were recruited from an undergraduate psychology class. In addition, the same adults who made similarity ratings in the previous experiments made similarity ratings of the stimuli in this experiment.

**Materials**

The materials consisted of 12 sets of animal cards. A variety of species was included,
ranging from insects to mammals (see Table 1). These sets were divided into two different set types. The first set type contained a medium-sized photograph and two larger photographs. One of the larger photographs was identical in appearance to the "baby" except that it was larger, while the other photograph was larger and either a different color or different shape from the original animal. For example, a medium-sized caterpillar was paired with a larger version of the caterpillar and a larger version of the adult moth. In the second set type, a medium-sized photograph of an animal (the "baby") was paired with a smaller item of the same color and shape or a larger item in which the color or the shape of the object varied in ways that naturally occur. For example, a medium-sized picture of a caterpillar was paired with a smaller version of the caterpillar or a larger version of the adult butterfly.

This set is critical for testing whether radical appearance change is preferred over decrease in size as a possible effect of aging. Half of each set type included changes in color, while the remaining items involved shape changes (metamorphosis). All of the shape and color changes used in this experiment were ones that could actually occur in nature. Some of the color variations, however, were ones that occur due to seasonal changes and are not due to growth per se. The overall procedure for this experiment was identical to that used in Experiment 1 with the animal cards.

Results

The percent of correct responses for each of the subjects was entered into a 3 (age: 4, 5, adult) x 2 (change type: color, shape) x 2 (set: Bigger–Bigger, Bigger–Smaller) ANOVA with change type and set as repeated-measures variables. Performance increased significantly with age, $F(2,34) = 4.4, p < .05$. Post-hoc tests revealed that adults and older children consistently chose the item that had undergone metamorphosis or a color change more often than did the younger children.

For the Color Bigger–Smaller items, the younger children's responses were not significantly different from chance, $M_3 = 62\%$, $t(14) = N.S.$, while both of the older groups were significantly above chance, $M_5 = 83\%$, $t(11) = 2.97, p < .05$, $M_{adult} = 90\%$, $t(9) = 4.0, p < .01$. Thus, while a number of the youngest children chose the smaller, more similar animal when presented with a color change alternative, very few of the older subjects did so. Rather, they consistently preferred the larger and differently colored item. This indicates an understanding of the importance of size cues by age 5 years. Below that age, children appear to be torn be-
between choosing the larger item and choosing the more similar item.

Metamorphosis

Figure 5 shows the percent of correct responses for the items involving metamorphosis. Consider first the hypothetical results displayed at the far left of Figures 5a and 5b. On the left of each part of this figure the predicted pattern is shown for subjects expecting shape changes to occur with growth. Next to this is the observed pattern for subjects responding on the basis of perceptual similarity, based on the adult ratings.

As can be seen in Figure 5a, only the youngest children responded consistently below chance on the Metamorphosis Bigger-Bigger items, $M_3 = 11\%$, $t(14) = 7.3$, $p < .001$. Here, the youngest children consistently chose the more similar animal. Both of the older groups were not significantly different from chance levels on these items ($M_5 = 36\%$, $N = 12$, $M_{adult} = 7\%$, $N = 10$). This result implies that at least some of the time, older children and adults expect shape to change with growth. In fact, eight of the 12 5-year-olds and all of the adults chose the dissimilar item at least once.

For the Metamorphosis Bigger-Smaller items, the younger children’s performance was not significantly different from chance levels, $M_3 = 58\%$, $t(14) = N.S.$, while both of the older groups were significantly above chance, $M_5 = 86\%$, $t(11) = 3.7$, $p < .01$, $M_{adult} = 97\%$, $t(9) = 14$, $p < .01$. Thus, while the youngest children fairly often chose the smaller, more similar animal when presented with an alternative involving metamorphosis, older subjects rarely did so. Older subjects consistently preferred the larger item, even when it differed in shape. This again indicates an understanding of the relative importance of growth as opposed to other aspects of appearance by age 5 years.

Discussion

The results of Experiment 3 suggest that young preschool children (approximately 3 years of age) generally expect that young of various species will maintain a similar appearance as they grow. That is, young preschool children expect color and shape to remain constant throughout the normal growth process. For example, if a baby mink is brown as a baby, young preschool children predict that the mink as an adult will
FIG. 5.—Stimuli sets, predicted results for subjects basing their judgments on metamorphosis or similarity, and the observed percent of correct responses (including standard errors) for the Metamorphosis Bigger–Bigger (a) and Metamorphosis Bigger–Smaller animal sets used in Experiment 3 (*p < .05). The data include results from 15 3-year-olds, 12 5-year-olds, and 10 adults. Ten additional adults performed the similarity ratings.

also be brown. Older children (approximately 5 years of age) and adults responded at chance levels on the Color Bigger-Bigger and Metamorphosis Bigger–Bigger items. In these items, both choices were larger than the “baby,” though one item was clearly more similar to the “baby” in appearance. Thus these results suggest that the older children and adults may expect that some animals can change in appearance with age. Adults also had a stronger tendency to expect changes in shape (metamorphosis) than color changes as part of the normal life cycle of animals. This result may be due to a greater familiarity with animals that undergo metamorphosis (e.g., caterpillars and tadpoles) than with animals that undergo a change of color (e.g., anoles and weasels).

When presented with a choice between a striking change in appearance over the growth process versus a decrease in size with age, older children and adults overwhelmingly chose the change in appearance. Thus for the older children and adults a specific developmental trajectory with respect to size is seen as being an inevitable part of the growth process. Younger preschool children responded at chance levels on this task, suggesting that their understanding of the growth process is less sophisticated. In some instances these children are willing to accept a decrease in size over changes in the outward appearance of animals. However, seven of 15 3-year-olds consistently selected the less similar but larger animal on every trial (i.e., on six out of six trials). We suggest that children may experience a conflict between two principles: that animals do not decrease in size as they mature, and that animals maintain a similar appearance as they mature.

General Discussion

Taken together, these studies demonstrate that even 3- and 4-year-olds realize that animals, but not inanimate objects, increase in size over time. All three experiments suggest that young children are neither unconstrained in their beliefs about transformations, nor strictly conservative. Their beliefs are at least partially constrained in that subjects reliably preferred certain transformations over others. They are not wholly conservative, however, because children expect an increase in size, rather than size constancy, with growth.
The youngest children expect that young of a species will closely resemble the adult of that same species in color and shape. Thus, the youngest children make more conservative judgments of transformations than older subjects. Older children and adults were more likely to expect changes in appearance over the life span. When presented with a choice between a bigger item that resembled the "baby" and a bigger item that differed in color or shape, older preschoolers and adults often picked the item that differed in appearance. This was especially true for adults when confronted with animals that undergo metamorphosis as part of their normal life cycle. This result is particularly important because it suggests that for older children and adults, identity can be maintained even over changes in appearance. It is likely that the older children's and adults' acknowledgment of radical transformations is due at least in part to exposure to specific factual information about metamorphosis and what types of organisms undergo metamorphosis as part of their normal life cycle. The specific role of knowledge and experience in children's acceptance of various transformations is in need of further study.

The older preschool children in this study clearly understood that growth has a privileged status relative to other changes. When presented with a choice between a bigger, perceptually different item and a smaller, perceptually similar item, the older children and adults consistently chose the bigger item. Thus by 5 years of age children grasp the principle that animals do not get smaller as they mature, and weight it more heavily than the principle that adults and babies resemble each other.

One ancillary issue is whether children would have performed less well with a more varied set of animal species. For example, Inagaki and Sugiyama (1988) found that when young children are asked directly if an animal can grow, they tend not to attribute the property of growing bigger to animals phylogenetically far from people, such as fish or insects. Nonetheless, in our study we did include examples of both fish and insects, as well as reptiles and mammals, and found using a forced-choice paradigm that children apply the same expectations across this wide range of species.

Our present work also shows that young children reason differently about artifacts and animals. It is clear from the children's responses to the artifacts that they do not have a bias simply to pick the largest item in an array. For the animals they expected an increase in size with age, while for artifacts they generally expected them to remain the same size over time. The youngest children were, however, less systematic in their responses about artifacts than animals. Indeed, the youngest children may not fully grasp what kind of changes artifacts undergo over time. This can be seen in two ways. First, the youngest children were performing at chance levels on the Same Size–Bigger set of the artifacts; second, the order of presentation influenced the performance of the youngest children on the artifact sets. When children were primed with a task involving biological growth, they tended to use a biological model in making choices about artifacts. The reverse was not true (i.e., priming with artifacts did not increase use of an artifact model). In future research, it would be interesting to see why this asymmetry exists. Perhaps children find biological changes easier to understand because, as Schwartz (1978) suggests, they are more predictable among members of a kind. Or it may be that children reason about transformations most readily on analogy with humans, much as they use humans as the reference point for other biological properties (see Carey, 1985; Inagaki & Sugiyama, 1988).

The present results contrast with earlier studies examining young children's understanding of the consequences of transformations. Previous work by DeVries (1969) and Keil (1989) found that children under age 5 often respond on the basis of appearance in making category judgments following transformations. None of the transformations used in such studies could occur naturally, and in most cases were carried out by adults (either the experimenter masking the cat or scientists in many of Keil's stories). In contrast, the present experiments differ by focusing on children's understanding of changes that occur as part of the normal life cycle of animals. We investigated children's knowledge of the consequences of a natural process (i.e., growth) and found that children have some knowledge about natural life cycle changes even by age 3. What this suggests is that children may be sensitive to the mechanism that underlies the transformation. This issue is in need of further investigation.

Although the present studies do not examine children's understanding of identity directly, the work has implications for de-
developing notions of identity. Note that implicitly, identity was maintained across the transformations, in that the same individual name was used for both the baby and adult in a set (e.g., “This is a picture of Jimmy when Jimmy was a baby. Now Jimmy is an adult. Which of these pictures is a picture of Jimmy as an adult?”). If we assume that children, like adults, interpret the task as preserving identity across time within a picture set, then children realize that natural transformations caused by growth do not lead to changes in identity—even when the outward appearance of the individual changes with age. Importantly, however, children may have a different set of beliefs concerning non-natural transformations that involve human intervention. We should also note that Keil’s experiments involved looking at children’s understanding of the maintenance of species identity, while our own work has focused on children’s understanding of the maintenance of individual identity.\(^5\) It may be that subjects in our experiments believe that the same individual can be transformed from a caterpillar to a butterfly, but that it will no longer belong to the same species.

In recent years there have been a growing number of investigations of children’s intuitive knowledge of biology and biological process (e.g., Carey, 1985; Keil, 1989; Springer & Keil, 1989). Carey has suggested that young children have a poor understanding of biology that is best described as based on a social theory of human behavior rather than on biological theory. Carey suggests that children do not develop sophisticated biological theories until age 9 or so. In contrast, Inagaki and her colleagues (Hatano & Inagaki, 1987; Inagaki & Hatano, 1987) have reported that young children hold some biological beliefs distinct from psychology. Similarly, Springer and Keil (1989) found that preschool children appear to have some understanding of biological notions of inheritance. They argue that young children’s biological theories exist, but are less well developed than those of older children and adults. The present data cannot resolve this controversy, but do add further support to the “naïve biology” view, in that children draw a principled distinction between animate and inanimate patterns of transformations (and perhaps identity).

In sum, these data suggest that one cannot consider questions of identity without considering the mechanism of change. When the mechanism is a natural, biological one (in this case, growth), even 3-year-olds expect changes to be highly ordered and constrained. Indeed, our youngest subjects in some sense had the most constrained beliefs about growth, expecting individuals to change as little as possible in shape and color. In contrast, even adults may have highly unconstrained beliefs about identity when the mechanism is either sufficiently powerful (e.g., a plastic surgeon can, in some people’s view, alter one’s sex) or unknowable (e.g., magic or death are in some theories sufficient to transform one’s identity). Thus, rather than suggesting an across-the-board developmental change in how readily children accept changes in identity, we believe the important developmental changes reflect how readily children identify the appropriate mechanism of change, and their knowledge about the mechanism.

References


\(^5\) We have also presented a group of 5-year-olds with the same procedure used in these experiments, but using species names rather than proper names. The results of this pilot study were almost identical to those reported in Experiment 1 for children of the same age.


