Anthropocentrism is not the first step in children's reasoning about the natural world

Patricia Herrmann, Sandra R. Waxman, and Douglas L. Medin[1]

Department of Psychology, Northwestern University, Evanston, IL 60208

Contributed by Douglas L. Medin, April 13, 2010 (sent for review January 5, 2010)

What is the relation between human and nonhuman animals? As adults, we construe this relation flexibly, depending in part on the situation at hand. From a biological perspective, we acknowledge the status of humans as one species among many (as in Western science), but at the same time may adopt other perspectives, including an anthropocentric perspective in which human characteristics are attributed to nonhuman animals (as in fables and popular media). How do these perspectives develop? The predominant view in developmental cognitive science is that young children universally possess only one markedly anthropocentric vantage point, and must undergo fundamental conceptual change, overturning their initially human-centered framework before they can acquire a distinctly biological framework. Evidence from two experiments challenges this view. By developing a task that allows us to test children as young as 3 years of age, we are able to demonstrate that anthropocentrism is not the first developmental step in children's reasoning about the biological world. Although urban 5-year-olds adopt an anthropocentric perspective, replicating previous reports, 3-year-olds show no hint of anthropocentrism. This suggests a previously unexplored model of development: Anthropocentrism is not an initial step in conceptual development, but is instead an acquired perspective, one that emerges between 3 and 5 years of age in children raised in urban environments.

conceptual development | biological reasoning | culture and cognition

What is the place of humans within the biological world? Answers to this question will undoubtedly vary, depending upon the intellectual proclivities and cultural background of the responder, and depending upon the question at hand. Within the Western scientific tradition, humans are viewed as one among the many species of the animal kingdom. Within many Western religious traditions, however, humans are viewed differently: set apart from the other animal species, and in some cases having dominion over them. Yet within other cultural and spiritual traditions, including those of Native Americans, humans are viewed from still another perspective: as one species among many in an intricate and expansive system, in which not only plants and animals but also natural kinds, such as rocks and water, are considered to be alive and possessing a spirit (1).

These distinct perspectives on the place of humans illustrate not only diversity of opinion, but also the conceptual flexibility of the human mind. For example, it is safe to assume that most, if not all, Western-trained scientists readily adopt a biological perspective, construing humans as one among the many species of animal. However, it is also clear that we simultaneously hold a different construal in which we set humans apart from the other animal species, as evidenced by the fact that institutional review boards and federal funding agencies require that any research involving exclusively human participants be designated as research that does not include animal subjects. A third perspective is pervasive in popular media, especially the media designed for young children, where nonhuman animals are represented in a strongly anthropocentric perspective (for example, Disney films and Aesop's fables).

How do these distinct perspectives develop? Which perspectives are available to young children before formal scientific instruction begins? And how are children's perspectives shaped and elaborated by their experiences? Interestingly, decades of developmental research have suggested that when young children consider the natural world, they adopt one markedly anthropocentric vantage point.

The strongest evidence for this early and single-mindedly anthropocentric stance comes from young urban children's performance in an inductive reasoning task, pioneered by Carey (2). In this task, participants are introduced to a novel biological property (e.g., "has an omentum"), told that this property is true of one biological kind (e.g., either a human or a dog), and then asked to decide which other entities might share this property. Carey reported a dramatic developmental progression. Adults and school-aged children (older than 6 or 7 years of age) projected a novel biological property broadly from one animal to another, whether the property had been introduced as true of a human or nonhuman animal (e.g., a dog). This result was taken as evidence that for these participants, reasoning about the biological world is organized around a concept of "animal" that includes both human and nonhuman animals. However, younger children showed a different pattern: if the novel property was introduced as true of a human, they projected the property broadly to other animals; yet if the same property was attributed to a nonhuman animal (e.g., a dog), they made few generalizations to other animals. These results were taken as evidence that as young children begin to reason about the biological world, they adopt an anthropocentric stance, favoring humans over nonhuman animals as an inductive base (but see ref. 3). Indeed, Carey (2) identified two distinct signatures of early anthropocentric reasoning: (*i*) young children are more willing to draw inferences from a human to a nonhuman animal (e.g., dog) than from a nonhuman animal (e.g., dog) to a human; and (*ii*) young children are more willing to extend a novel biological property to other animals if that property had been introduced in conjunction with a human rather than a nonhuman animal.

What does this human-centered reasoning pattern reveal about young children's understanding of the biological world? The predominant interpretation has been that the perspectives available for reasoning change radically with development. Carey has proposed that young children hold a qualitatively different (and incommensurate) understanding of biological phenomena than do older children and adults, and that development within the domain of biological knowledge entails radical conceptual change (2, 4, 5). In this view, young children begin reasoning about the biological world from an exclusively anthropocentric stance, comparing animals with a single prototype or standard (i.e., human beings) and development within the biological domain requires a fundamental conceptual change as children move from the human-centered model of naive psychology (in which humans serve as the paragon) to the more mature, Western science-

Author contributions: P.H., S.R.W., and D.L.M. designed research; P.H. performed research; P.H., S.R.W., and D.L.M. analyzed data; and P.H., S.R.W., and D.L.M. wrote the paper.

The authors declare no conflict of interest.

[1]To whom correspondence should be addressed. E-mail: medin@northwestern.edu.

inspired model of naive biology (in which humans are viewed as one biological kind among many).

This claim has stimulated a great deal of research and spirited debate (6–13). Several researchers have argued against the notion of radical conceptual change in the biological domain, suggesting instead that humans may be privileged in young children's reasoning because urban children (who constitute the vast majority of research participants) simply know more about humans than nonhuman animals (11, 14, 15).

Recent evidence from young children raised in rural communities, children whose direct experience with nonhuman animals is considerably richer than that of urban-raised children, lends support to this interpretation. Unlike their urban counterparts, rural 5-year-olds do not privilege humans over nonhuman animals when reasoning about biological phenomena (e.g., refs. 3, 16, 17). This evidence is important because it raises the possibility that anthropocentrism is not a universal first step in children's construal of the biological world, but is instead a perspective that is acquired in some, but perhaps not all, cultural contexts. This possibility carries powerful theoretical and educational implications.

However, notice that evidence from rural 5-year-olds, although intriguing, cannot directly address the developmental proposal for radical conceptual change: It leaves open the possibility that young children universally begin reasoning from an anthropocentric stance, but that rural children, by dint of their relatively enriched experience with the biological world, leave this obligatory anthropocentric perspective behind sooner than their urban counterparts.

In the two experiments reported here, we adopt a different strategy. Taking the evidence of anthropocentric reasoning in urban 5-year-olds as our starting point, we ask how younger urban children reason about the biological world. This is a critical question, but, for methodological reasons, answers have been elusive: it has been difficult to engage preschool-aged children in the induction task in a way that generates systematic responding. In the current experiments, we redress this limitation, designing a modified version of Carey's induction task (2) that makes it possible to tap into the inductive reasoning of children as young as 3 years of age.

If anthropocentrism is an obligatory first step in reasoning about the biological world, then urban 3-year-olds should perform like their 5-year-old counterparts, exhibiting robust human-centered patterns of reasoning. However, if the anthropocentric perspective that characterizes urban 5-year-olds is not an obligatory initial step, but rather is an acquired perspective, then urban 3-year-olds should be less likely than their 5-year-old counterparts to privilege humans when reasoning about biological phenomena. This prediction assumes that 3-year-olds produce systematic data: random responses bear on the appropriateness of the task, not the theories.

Results

Experiment 1. Sixty-four urban children (32 3-year-olds and 32 5-year-olds) participated in a modified version of the inductive reasoning task. As in the standard version, children were introduced to one biological entity (either a human or a dog), were taught about a novel biological property that characterized it [e.g., "People (or dogs) have *andro* inside"], and were then asked whether this novel property could be found inside a series of different objects, including humans, nonhuman animals, plants, and artifacts. To engage young children in the task, this protocol was embedded within the context of a guessing game involving "silly" puppets who needed the child's help. For every question the experimenter posed (e.g., "What do you think? Do bees have *andro* inside?"), one puppet answered in the affirmative (e.g., "Yes! Bees do have *andro* inside") and the other countered in the negative (e.g., "No! Bees do not have *andro* inside"). The child's task was to decide which puppet was right.

If this modified version of the induction task taps into the same underlying construal as the standard version, then 5-year-old children should adopt an anthropocentric stance, privileging the human over the nonhuman animal (here, a dog) as an inductive base. If the modified version successfully engages 3-year-old children, then their performance will reveal whether the anthropocentrism evinced by urban 5-year-olds represents their first step in reasoning about the biological world or is instead an acquired perspective.

Results. The results, depicted in Fig. 1, indicate that the anthropocentric pattern of reasoning is an acquired perspective. Human-centered patterns of reasoning were indeed evident in urban 5-year-olds, but were absent in younger urban children.

We focused our data analysis on the two patterns of inductive reasoning that have been taken as signatures of the anthropocentric perspective (2, 3). For all analyses, $P < 0.05$ was set as the threshold for statistical significance, and the patterns exhibited by individual children converged well with the mean patterns observed at each age.

We first considered children's projections of the novel biological property from human to dog and from dog to human, asking whether their projections were stronger when the property was introduced in conjunction with the human rather than the dog. An ANOVA using Age (3 vs. 5 years) and Condition (human-base vs. dog-base) as between-participants factors and Target (human vs. dog) as the dependent measure revealed an effect for Condition, $F(1, 60) = 3.898$, $P = 0.05$, $\eta^2 = 0.07$, mediated by an Age-by-Condition interaction, $F(1, 60) = 9.625$, $P = 0.003$, $\eta^2 = 0.18$. The 5-year-olds made more projections from the human to the dog (M = 0.87, SD = 0.35) than from the dog to the human (M = 0.27, SD = 0.46), $P < 0.001$. This result replicates precisely the pattern reported by Carey (2). However,

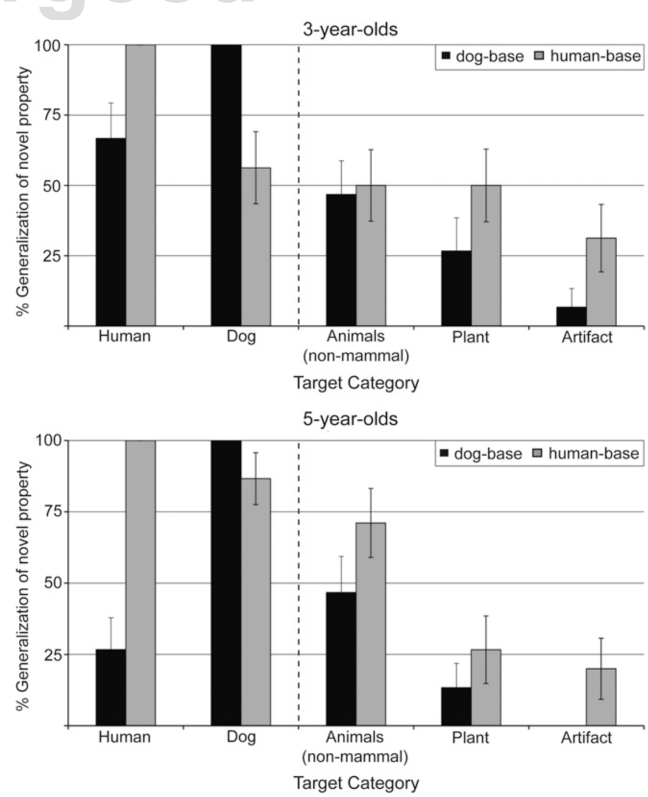

Fig. 1. Experiment 1. Generalization to each target category as a function of age and condition. Error bars depict SEM.

3-year-olds revealed no such asymmetry: they were at least as likely to generalize from a dog to a human (M = 0.67, SD = 0.48) as from a human to a dog (M = 0.53, SD = 0.51), $P = 0.47$.

We next considered children's responses to the remaining targets, asking whether they were more willing to project the novel property when it had been introduced in conjunction with a human than a dog. For this analysis, the human and dog targets, considered in the previous analysis, were excluded. An ANOVA with Age (3 vs. 5 years) and Condition (human-base vs. dog-base) as between-participants factors and Target category [animal (nonmammal), plant, artifact] as a within-participants factor indicated a main effect for Condition, $F(1, 56) = 4.282$, $P = 0.04$, $\eta^2 = 0.07$, as well as a main effect for Target category, $F(2, 56) = 24.37$, $P < 0.001$, $\eta^2 = 0.30$. These effects were mediated by a suggestive Age-by-Target category interaction that fell short of reliability, $F(2, 56) = 2.39$, $P = 0.09$, $\eta^2 = 0.04$.

To pursue our focus on developmental change, we went on to examine performance at each age. Consider first the 5-year-olds. A main effect for Condition, $F(1, 28) = 42.41$, $P = 0.04$, $\eta^2 = 0.60$, echoed the results reported by Carey (2): 5-year-olds were more likely to project the novel biological property if it had been introduced in conjunction with a human (M = 0.52, SD = 0.46) than a dog (M = 0.31, SD = 0.37). There was also a main effect for Target category, $F(2, 28) = 21.53$, $P < 0.001$, $\eta^2 = 0.44$: 5-year-olds were more likely to project the property to the animal targets (M = 0.59, SD = 0.36) than to either of the nonanimal targets (M_{plant} = 0.20, SD_{plant} = 0.41; $M_{artifact}$ = 0.10, $SD_{artifact}$ = 0.31), $P < 0.001$ for all. There were no differences in 5-year-olds' projections to plant and artifact, $P = 0.20$. This finding is consistent with the view that by 5 years of age, children appreciate a category "animal" and can use it as a basis for projecting a novel biological property (3, 7, 18).

The 3-year-olds showed a different pattern. At this age, there was no evidence that humans serve as a privileged inductive base for reasoning about biological phenomena. There was no main effect for Condition, $F(1, 28) = 0.87$, $P = 0.39$, $\eta^2 = 0.03$: 3-year-olds' tendency to project the novel biological property was comparable, whether it had been introduced in conjunction with the human (M = 0.41, SD = 0.50) or the dog (M = 0.35, SD = 0.42). There was a main effect for Target category, $F(2, 28) = 6.53$, $P = 0.003$, $\eta^2 = 0.19$: 3-year-olds were more likely to project the property to the animal targets (M = 0.48, SD = 0.35) than the artifact target (M = 0.17, SD = 0.38), $P < 0.001$. Projections to the plant target (M = 0.33, SD = 0.48) did not differ from those to either the animal targets, $P = 0.15$, or the artifact target, $P = 0.06$. This finding is consistent with previous research that suggests that 3-year-old children are not certain about the biological status of plants (6, 12, 18–20).

The goal of Experiment 1 was to develop a version of the category-based induction task that would yield the classic anthropocentric pattern of reasoning among urban 5-year-olds, but that would also accommodate children as young as 3 years old. The modified version presented here was successful in both respects. Urban 5-year-olds favored humans over nonhuman animals as an inductive base, replicating previous reports (2). Importantly, however, although 3-year-old children were successfully engaged in the task and systematic in their responses, they did not display anthropocentric reasoning. In Experiment 2 we sought to replicate this intriguing developmental pattern and to extend the evidence of 3-year-olds responding systematically by examining their responses to a broader range of target objects, including mammals.

Experiment 2. The design of Experiment 2 was identical to that of Experiment 1, except that several additional target objects were included: two mammals (bear and squirrel), two nonmammals (eagle and turtle), and two nonanimals (plant and pencil). Again, 5-year-old children revealed an anthropocentric pattern of reasoning [replicating Experiment 1 and Carey (2)], but 3-year-olds revealed no hint of anthropocentrism (replicating Experiment 1) (Fig. 2).

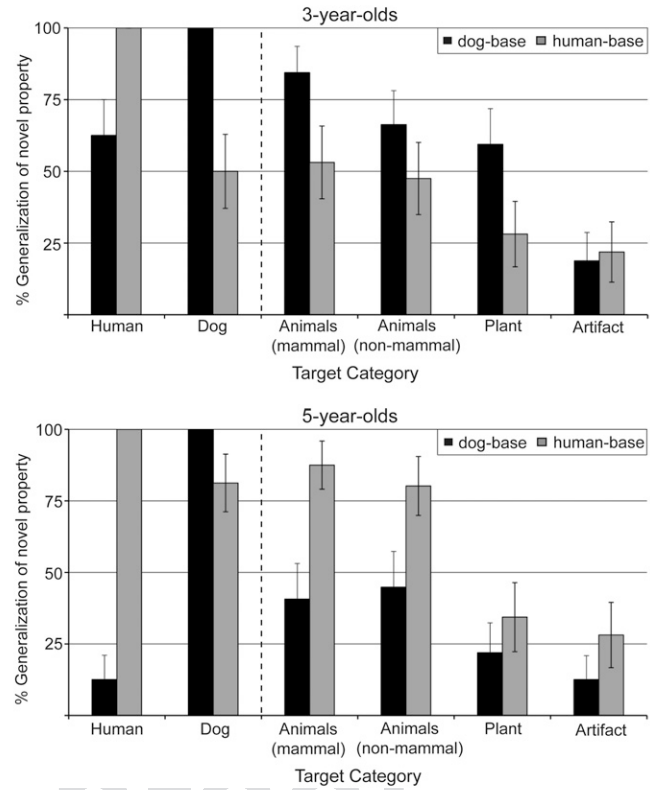

Fig. 2. Experiment 2. Generalization to each target category as a function of age and condition. Error bars depict SEM.

We first examined human-dog reasoning asymmetries. An ANOVA using Age (3 vs. 5 years) and Condition (human-base vs. dog-base) as between-participants factors and Target (human vs. dog) as the dependent measure demonstrated a reliable main effect for Condition, $F(1, 60) = 6.36$, $P = 0.01$, $\eta^2 = 0.10$. This was mediated by an Age-by-Condition interaction, $F(1, 60) = 13.272$, $P = 0.001$, $\eta^2 = 0.18$. As in Experiment 1, 5-year-olds were more likely to project the novel biological property from a human to a dog (M = 0.81, SD = 0.40) than from a dog to a human (M = 0.12, SD = 0.34), $P < 0.001$, but 3-year-olds showed no difference in their tendency to project the property from a human to a dog (M = 0.50, SD = 0.52) vs. from a dog to a human (M = 0.62, SD = 0.50), $P = 0.43$.

We next considered children's projections from each base to the remaining targets. As in Experiment 1, this analysis excluded the targets used in the previous analysis (human, dog). An ANOVA with Age (3 vs. 5 years) and Condition (human-base vs. dog-base) as between-participants factors and Target category (mammal, nonmammal animal, plant, artifact) as a within-participants factor showed a reliable main effect for Target category, $F(3, 180) = 39.147$, $P < 0.001$, $\eta^2 = 0.40$, and an Age-by-Condition interaction, $F(1, 60) = 9.176$, $P < 0.005$, $\eta^2 = 0.13$, both of which were mediated by an Age-by-Condition by Target category interaction, $F(3, 180) = 3.97$, $P < 0.01$, $\eta^2 = 0.06$.

We examined this interaction by analyzing performance at each age. For the 5-year-olds, there was a reliable main effect for Condition, $F(1, 30) = 6.13$, $P = 0.02$, $\eta^2 = 0.17$. As in previous reports with urban children, 5-year-olds treated humans as a privileged inductive base, projecting the novel biological property more strongly if it had been introduced in conjunction with a human (M = 0.57, SD = 0.42) than a dog (M = 0.30, SD = 0.44). There was also a main effect for Target category, $F(3, 90) = 17.208$, $P < 0.001$, $\eta^2 = 0.37$. As in Experiment 1, 5-year-olds were more likely to extend the novel property to the remaining animal target categories [mammals (M = 0.64, SD =

0.42) and nonmammals (M = 0.62, SD = 0.46)] than to the plant (M = 0.28, SD = 0.45) or artifact (M = 0.20, SD = 0.40) categories, $P < 0.001$ for all. There was no difference in 5-year-olds' projections to the two animal categories, $P = 0.70$, and no difference in their projections to the two nonanimal categories, $P = 0.14$. This finding converges well with the results of Experiment 1, suggesting again that 5-year-old urban children appreciate the category "animal" and use it as a basis for their inductive inferences of novel biological properties.

Once again, the 3-year-old children demonstrated a very different pattern. First, there was no evidence of human-centered reasoning. The effect of Condition was not reliable: $F(1, 30) = 3.25$, $P = 0.08$, $\eta^2 = 0.10$. Indeed, there was a modest tendency for 3-year-olds to project more strongly from the dog (M = 0.57, SD = 0.44) than from the human (M = 0.38, SD = 0.47) base. The 3-year-olds did show a main effect for Target category, $F(3, 90) = 26.207$, $P < 0.001$, $\eta^2 = 0.47$, mediated by a Condition-by-Target category interaction, $F(3, 90) = 3.997$, $P = 0.01$, $\eta^2 = 0.12$. Although 3-year-olds' tendency to project the novel property to the artifact targets was comparable in the two conditions, $P = 0.79$, there were differences in their projections to the remaining animal targets. The 3-year-olds were more likely to project the novel property to the other mammal targets if it had been introduced in conjunction with the dog (M = 0.85, SD = 0.24) than in conjunction with the human (M = 0.53, SD = 0.46), $P = 0.02$. The same pattern was observed with the nonmammal animals. The 3-year-olds were also more likely to project the novel biological property to plant targets if it had been taught on a dog (M = 0.59, SD = 0.38) than on a human (M = 0.28, SD = 0.41), $P = 0.03$. In short, for 3-year-old urban children, "dog" constitutes a stronger inductive base for reasoning about biological phenomena than does "human."

It is worth noting, however, that 3-year-olds' generalization from the "dog" to the mammal and nonmammal animal targets is higher in Experiment 2 than in Experiment 1. We suspect that the additional animal targets included in Experiment 2 promoted greater focus on the category *animal*, which for 3-year-olds tends to include specifically *nonhuman animals* (17, 18). The variability in 3-year-olds' responses to the plant targets in the two experiments likely reflects their uncertainty about the life-status of plants.

Discussion

The current results offer unambiguous evidence that the anthropocentric pattern of reasoning observed in urban 5-year-old children is not an obligatory initial step in reasoning about the biological world. Instead, the results show that anthropocentrism is an acquired perspective, one that emerges between 3 and 5 years of age in American children raised in urban environments.

This interpretation is consistent with evidence from two independent sources. First, beginning in the first year of life, children distinguish animate objects (including human as well as nonhuman animals) from inanimate objects, and invoke this distinction when making predictions about the behavior of objects (21–27). We suggest that the 3-year-olds in our experiments also invoked this concept of animacy in their reasoning about biological phenomena. Second, the current results, coupled with those from 5-year-old rural children (3), underscore the view that in every domain of human development, the path of acquisition is importantly shaped by the input that learners receive.

Considered in this light, what is the most straightforward interpretation of our studies? We propose that anthropocentrism does not represent the young child's initial entry point for reasoning about the biological world, but that it is a learned perspective, and one that is likely supported more strongly in some cultures and some contexts than in others. As we have pointed out, there are differences among communities in the construals favored when considering the relation between human and nonhuman animals (28, 29). In addition, even within a given community, people are able to appreciate more than a single construal of this relation, and different perspectives will become highlighted in certain contexts (e.g., school vs. home) and even under certain priming conditions (10). This observation is directly relevant to the issue of conceptual development within the biological domain. We expect that adults, like children, retain an appreciation of an anthropocentric view (which means, of course, that this view is not cast aside during development). We also expect that in urban technologically saturated communities, where direct contact with nonhuman animals is relatively limited (30) and where images of nonhuman animals in children's books, discourse, and media often take an anthropocentric cast (31), young children encounter considerable support (intended or not) for an anthropocentric perspective as they seek to understand the relation between human and nonhuman animals. Moreover, there is evidence that 5-year-old children are especially attuned to cultural discourse about essentially biological phenomena (32). We suggest that the anthropocentrism exhibited by urban 5-year-old children is not only a by-product of their more limited exposure to the natural world, but may also be passed on to them by adults in their community.

Anthropocentric images are not confined within city limits, but the consequences of this style of input may be attenuated in rural communities, where alternative perspectives may be more readily available and more explicitly encouraged. Where children's direct and engaged contact with the natural world is more extensive, an anthropocentric perspective may be less salient. In ongoing work we are attempting to see if rural children will adopt a human-centered perspective when exposed to anthropocentric primes.

We do not assume that a proclivity toward anthropocentrism is universal. For example, in Native American communities (including the Menominee Nation and the Tzotzil Maya), humans' place within the natural world is construed quite differently. In these communities, where humans are seen as participants in an intricately connected circle of living things, anthropocentric construals are likely to be less prevalent not only in parent-child discourse, but also in the media designed by native adults for young children (33).

Additional research is required if we are to deepen our appreciation of how young children come to reason about the biological world. Developing converging measures and recruiting them to identify the perspectives adopted by young children from diverse communities will be important, as will broadening the question, asking not only how children come to understand the place of humans, but also the place of plants and nonhuman animals in the natural world (18, 19, 34). Cross-linguistic evidence may be essential for honing in on the ways in which language reflects, as well as influences, our perspectives on biological kinds (18, 35, 36). Finally, it will be important to analyze more fully the various cultural models and framework theories about the natural world. For example, within any cultural community, the input to young children will range from clearly anthropomorphized representations of animals to subtle patterns of perspective-taking (1, 37). An important goal for the future will be to capture more precisely these sources of input and to identify their impact on children's and adults' reasoning.

In closing, if our fundamental perspectives on the natural world—and the place of humans within it—are shaped by experience, cultural beliefs, and practices, then children from different backgrounds may harbor different perspectives, even by the time they enter school. It is therefore important to identify which perspectives children acquire earliest or with least effort, and how these are shaped over development. Addressing this issue and adopting a cross-cultural developmental approach is central not only to theories of conceptual development but also to science education (38–40). If we are to design effective science curricula, it is important to understand the diverse perspectives children bring to their classrooms, and how these are elaborated within formal and informal learning contexts.

Materials and Methods

Participants. Sixty-four normally developing 3-year-old children (28 girls; mean age 3.45 years) and 64 normally developing 5-year-old children (30 girls; mean age 5.15 years) whose first language was English were recruited from the Chicago area. Parents or guardians filled out consent forms approving their children's participation. An additional 20 children (17 3-year-olds; 3 5-year-olds) were excluded for (*i*) failure to respond correctly during training (seven 3-year-olds: three in Experiment 1 and four in Experiment 2), (*ii*) failure to extend the novel property from the base object (e.g., a human) to the target object that matched that base (e.g., another human) (nine 3-year-olds, including four in Experiment 1 and five in Experiment 2; three 5-year-olds, including one in Experiment 1 and two in Experiment 2), or (*iii*) failure to complete the test phase (one 3-year-old in Experiment 2).

Materials. Materials included (*i*) simple outline drawings of a human and a dog (used in the teaching phase), (*ii*) six different finger-puppets (presented as pairs in the training and test phases), and (*iii*) a series of 6-inch by 4-inch laminated, color photographs of humans, animals, plants, and artifacts presented against natural backgrounds (9 in Experiment 1; 15 in Experiment 2; presented in the test phase). Two photographs served as bases (human; dog) in both Experiments 1 and 2. The remaining photographs (human, dog, robin, bee, fish, tree, and watch in Experiment 1; the addition of bear, squirrel, eagle, turtle, plant, and pencil in Experiment 2) served as targets.

Experiment 1 was primarily designed to investigate asymmetries in children's projection of the novel biology property between human and dog. Experiment 2 was designed not only to replicate the findings of Experiment 1, but also to assess 3- and 5-year-olds' projection of the novel biological property to a larger range of targets, including mammals and additional non-mammal animals.

Procedure. Children sat across from the experimenter in a quiet area of our laboratory or their preschool. Half of the children at each age were randomly assigned to either the human-base or dog-base condition. We use the dog-base to illustrate below. The procedure involved three phases, patterned closely after Carey's (2) original procedure.

Teaching phase. The child and experimenter each received a line drawing of the base (e.g., a dog). The experimenter introduced a novel biological property (e.g., "Dogs have *andro* inside them. *Andro* is roundish, greenish, and it goes inside!"). She then handed the child a crayon, saying, "Look! I'm drawing *andro* in my picture of a dog! Will you draw *andro* in yours?" After the child finished drawing in the property, we imposed a 2-min delay, during which the child participated in unrelated play (e.g., puzzles).

Training phase. Next, the experimenter engaged the child in two practice trials, designed to clarify the task for the child. The experimenter told the child that she had brought with her some pictures and some "silly puppets." She explained that each puppet sometimes said the right thing, and sometimes was very silly, and that the child's job was to help her (the experimenter) figure out which puppet was right. She then placed one puppet on either side of the child's line drawing (e.g., dog) and initiated a brief puppet show, in which she posed questions and the puppets responded. To begin, she asked, "What do we have here?" One puppet asserted (correctly), "That's a picture of a dog!" The other countered (incorrectly), saying, "No. That's not a picture of a dog!" The experimenter asked the child to decide which puppet was right (the first puppet) and to indicate their choice by pointing. Next, the puppets "spoke" again. This time, the first asserted (incorrectly), "That's a picture of a chair!" and the second countered (correctly), "No! That's not a picture of a chair!" Again, the child was instructed to point to the puppet that was correct (this time, the second puppet). If the child responded incorrectly, the experimenter repeated the puppet dialogue and asked which puppet was right. If a child failed to respond correctly after three repetitions, the child was excluded from further analysis.

Test phase. To begin the test phase, the experimenter showed the child all of the target photographs, asking the child to identify each, and then providing feedback. Next, the experimenter introduced each target sequentially, in random order, with a puppet positioned on either side. For every question the experimenter posed (e.g., "What do you think? Do X's have *andro* inside?"), one puppet answered in the affirmative (e.g., "Yes! X's do have *andro* inside") and the other countered in the negative (e.g., "No! X's do not have *andro* inside"). The child's task was to decide which puppet was right. Response-neutral encouragement was offered after any response (e.g., "Okay! Good for you!"). The experimenter then introduced another target, this time flanked by a different pair of puppets, and so on. The order in which the puppet pairs appeared and the order in which each "spoke" was counterbalanced. The experimenter recorded the child's response to each target.

ACKNOWLEDGMENTS. We thank Erin Leddon, Megan Bang, Susan Gelman, Rochel Gelman, and Renee Baillargeon for comments on previous versions of this manuscript and Jennie Woodring and Heather Norbury for contributions to data collection and analysis. This work was supported by National Science Foundation Grants BCS-0132469 and BCS-0745594 and National Institutes of Health Grant R01 HD41653 (to D.L.M. and S.R.W.).

1. Bang M, Medin DL, Atran S (2007) Cultural mosaics and mental models of nature. *Proc Natl Acad Sci USA* 104:13868–13874.
2. Carey S (1985) *Conceptual Change in Childhood* (Bradford Books, Cambridge, MA).
3. Ross N, Medin DL, Coley JD, Atran S (2003) Cultural and experiential differences in the development of biological induction. *Cogn Dev* 18:25–47.
4. Carey S (1988) Conceptual differences between children and adults. *Mind Lang* 3: 168–181.
5. Carey S (1995) *Causal Cognition: A Multidisciplinary Debate*, eds Sperber D, Premack D, Premack JA (Clarendon Press, Oxford).
6. Inagaki K, Hatano G (2002) *Young Children's Naive Thinking About the Biological World* (Psychology Press, New York, NY).
7. Coley JD (1995) Emerging differentiation of folkbiology and folkpsychology: Attributions of biological and psychological properties to living things. *Child Dev* 66:1856–1874.
8. Coley JD (2007) The human animal: Developmental changes in judgments of taxonomic and psychological similarity among humans and other animals. *Cognition, Brain, Behavior* 11:733–756.
9. Gelman S, Wellman HM (1991) Insides and essence: Early understandings of the non-obvious. *Cognition* 38:213–244.
10. Gutheil G, Vera A, Keil FC (1998) Do houseflies think?: Patterns of induction and biological beliefs in development. *Cognition* 66:33–49.
11. Heyman GD, Phillips AT, Gelman SA (2003) Children's reasoning about physics within and across ontological kinds. *Cognition* 89:43–61.
12. Keil FC (1992) *Modularity and Constraints in Language and Cognition: The Minnesota Symposia*, eds Gunnar M, Maratsos M (Earlbaum, Hilldale, NJ).
13. Keil FC (2007) Biology and beyond: Domain specificity in a broader developmental context. *Hum Dev* 50:31–38.
14. Hatano G, Inagaki K (1999) A developmental perspective on informal biology. *Folkbiology*, eds Medin DL, Atran S (MIT Press, Cambridge, MA).
15. Inagaki K, Hatano G (2006) Young children's conception of the biological world. *Curr Dir Psychol Sci* 15:177–181.
16. Sousa P, Atran S, Medin DL (2002) Essentialism and folkbiology: Evidence from Brazil. *J Cogn Cult* 2:195–223.
17. Waxman SR, Medin DL (2007) Experience and cultural models matter: Placing firm limits on childhood anthropocentrism. *Hum Dev* 50:23–30.
18. Anggoro FK, Waxman SR, Medin DL (2008) Naming practices and the acquisition of key biological concepts: Evidence from English and Indonesian. *Psychol Sci* 19: 314–319.
19. Leddon EM, Waxman SR, Medin DL (2008) Unmasking "alive:" Children's appreciation of a concept linking all living things. *J Cogn Dev* 9:461–473.
20. Springer K, Keil FC (1989) On the development of biologically specific beliefs: The case of inheritance. *Child Dev* 60:637–648.
21. Gelman SA (2003) *The Essential Child: Origins of Essentialism in Everyday Thought* (Oxford Univ. Press, New York, NY).
22. Kuhlmeier VA, Bloom P, Wynn K (2004) Do 5-month-old infants see humans as material objects? *Cognition* 94:95–103.
23. Luo Y, Baillargeon R (2005) Can a self-propelled box have a goal? Psychological reasoning in 5-month-old infants. *Psychol Sci* 16:601–608.
24. Luo Y, Kaufman L, Baillargeon R (2009) Young infants' reasoning about physical events involving inert and self-propelled objects. *Cogn Pyschol* 58:441–486.
25. Molina M, Van de Walle GA, Condry K, Spelke ES (2004) The animate-inanimate distinction in infancy: Developing sensitivity to constraints on human actions. *J Cogn Dev* 5:399–426.
26. Pauen S, Trauble B (2009) How 7-month-olds interpret ambiguous motion events: Category-based reasoning in infancy. *Cogn Psychol* 59:275–295.
27. Massey CM, Gelman R (1988) Preschooler's ability to decide whether a photographed unfamiliar object can move itself. *Dev Psychol* 24:307–317.
28. Evans EM (2001) Cognitive and contextual factors in the emergence of diverse belief systems: Creation versus evolution. *Cogn Psychol* 42:217–266.
29. Kellert SR (1993) *The Biophilia Hypothesis*, eds Kellert SR, Wilson EO (Island Press, Washington, DC).
30. Rogoff B, Paradise R, Mejía Arauz R, Correa-Chávez M, Angelillo C (2003) Firsthand learning through intent participation. *Rev Psychol* 54:175–203.
31. Marriott S (2002) Red in tooth and claw? Images of nature in modern picture books. *Child Lit Educ* 33:175–183.
32. Waxman SR, Medin DL, Ross N (2007) Folkbiological reasoning from a cross-cultural developmental perspective: Early essentialist notions are shaped by cultural beliefs. *Dev Psychol* 43:294–308.

33. Medin DL, Bang M (2008) Perspective taking, diversity and partnerships. *American Psychological Association*, 22 (2). Available at http://www.apa.org/science/about/psa/2008/02/medin.aspx.
34. Opfer JE, Siegler RS (2004) Revisiting preschoolers' living things concept: A microgenetic analysis of conceptual change in basic biology. *Cogn Psychol* 49:301–332.
35. Waxman SR (2008) *Infant Pathways to Language: Methods, Models, and Research Directions*, eds Colombo J, McCardle P, Freund L (Lawrence Erlbaum Associates, Mahwah, NJ).
36. Waxman SR, Lidz J (2006) *Handbook of Child Psychology*, eds Kuhn D, Siegler R (Wiley, Hoboken, NJ), 6th Ed, Vol 2.
37. Leung AK, Cohen D (2007) The soft embodiment of culture: Camera angles and motion through time and space. *Psychol Sci* 18:824–830.
38. Donovan MS, Bransford JD, eds (2005) *How Students Learn: Science in the Classroom. Committee on How People Learn: A Targeted Report for Teachers* National Research Council (The National Academies Press, Washington, DC).
39. National Research Council (2007) *Taking Science to School: Learning and Teaching Science in Grades K–8*. Committee on Science Learning Kindergarten Through Eighth Grade, eds Duschl R, Schweingruber H, Shouse A, Board on Science Education, Center for Education Division of Behavioral and Social Sciences and Education (The National Academies Press, Washington, DC).
40. Gelman R, Brenneman K, Macdonald G, Roman M (2010) *Preschool Pathways to Science: Facilitating Scientific Ways of Thinking, Talking, Doing and Understanding* (Brookes Pub Co., Baltimore, MD).