Cultural and Experiential Differences in the Development of Folk Biological Induction

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Abstract. Carey's (1985) book on conceptual change and the accompanying argument that children's biology initially is organized in terms of naïve psychology has sparked a great detail of research and debate. This body of research on children's biology has, however, been almost exclusively been based on urban, majority culture children in the US or in other industrialized nations. The thesis of this paper is that the folkbiology of urban children may be highly atypical of development because neither the culture nor everyday experience involve as an important component, plants and animals. Two experiments are reported where the participants are urban majority culture children, rural majority culture children, and rural Native American (Menominee) children. The tasks involved category-based induction and judgments about the concept of "alive." Each group produced a unique profile of development. Only urban children showed evidence for early anthropocentrism, suggesting that the co-mingling of psychology and biology may be a product of an impoverished experience with and exposure to nature. Even the youngest rural children generalized in terms of biological affinity. In addition, all ages of Native American children and the older rural majority culture children (unlike urban children) gave clear evidence of ecological reasoning. These results showing that both culture and expertise (exposure to nature) play a role in the development of folkbiological thought among children underline the precariousness of basing theories of conceptual development solely on studies of urban, majority culture children.

Current views of cognition portray concepts as being embedded in theory-like explanatory frameworks (Carey, 1985, Murphy & Medin, 1985; Medin, Lynch, and Solomon, 2000). These framework theories differ in different domains of experience; a framework theory for understanding and predicting the behavior of physical objects necessarily differs from one, which allows us to predict the behavior of sentient beings. Correspondingly, theorists have begun to conceive of conceptual development as a domain-specific process, and have investigated development in core domains such as naïve physics and naïve psychology (Wellman & Gelman, 1999; Wellman & Inagaki, 1997). Another important conceptual domain is that of folkbiology (Medin and Atran, 1999). Folkbiology encompasses how people understand, categorize, and reason about plants and animals. The natural world of plants and animals is pervasive; further, extensive knowledge about living things was critically important in our distant and recent past, and remains so for many people today.

A good deal of research has been conducted in the last 15 years on the acquisition of folkbiology, both because of the intrinsic importance of the domain and as a test case for more general ideas about conceptual development. An important idea to emerge from this body of work is that children's understanding of the biological world undergoes a profound shift between ages 4 and 10. Carey (1985, 1995) argues that children's early understanding of plants and animals is anthropocentric. That is, children's understanding of other living things is largely in reference to, or by analogy to, human beings. As a consequence, prototypicality of humans is central to children's conceptions of the biological world.

One source of evidence that young children possess an anthropocentric folkbiology comes from a property projection task where children are taught a new fact about a given biological kind (e.g., a dog "has an omentum") and asked whether other kinds (a bird, a fish, a plant) share that property. The rationale is that projection of a novel internal property is an index of the biological affinity between base and target species. By examining patterns of projection, and comparing those patterns to predictions derived from competing theories, we can diagnose which theories children are using to understand the world around them. Carey (1985) taught children properties about one basic-level animal category, then examined projections to other categories differing in similarity to the target category. Participants of ages 4, 6, 10, and adult were taught, that either people, dogs, or bees had a spleen / omentum (e.g., "a green round thing") inside of them (each subject was only taught on one of the three exemplars). One or two days later participants were asked which of a series of items (human, dog, aardvark, dodo, stinkbug, bee, worm, flower, and some inanimate objects) exhibit each of a series of properties (breathes, has bones, grows, dies), as well as which had the novel property (spleen / omentum).

This task relies on the idea that inductive inferences from prototypical members of a category are perceived as stronger than inferences from less central, typical members (Rips, 1975; Osherson et al, 1990). Therefore, an anthropocentric folkbiology makes several predictions: First, if humans are central, prototypical exemplars of living things, then on average projections from humans should be stronger than projections from other living things. Second, an anthropocentric folkbiology might lead to asymmetries in projection. For example, inferences from human to dog might be stronger than from dog to human because of the prototypicality of human (see Osherson, Smith, Wilkie, and Shafir, 1990 for a formal model that predicts asymmetries of inferences between typical and atypical category members).

Carey (1985) found that 4-and 6-year-olds exhibited reasoning patterns consistent with an anthropocentric view. Her 4-yr olds readily generalized from humans as a base but they showed little generalization from dogs and almost none from bees as a base. For 6-yr-olds, humans were somewhat privileged bases, as children were more likely to project from humans to other animals (69%) than from dogs to other animals (54%). Asymmetries were evident in comparing human => dog (76%) to dog => human (41%), and human => bee (59%) to bee => human (12%). Thus, 6-year-olds also showed clear evidence of anthropocentric reasoning, particularly in terms of using humans as a privileged inferential base and showing asymmetries in projection from humans versus non-humans. For 10-year-olds and adults, humans are no longer uniquely central, though some effects suggestive of anthropocentrism are still evident in the 10-yr old responses.

Carey interpreted these results as supporting a comparison-to-exemplar model of biological reasoning in which the folkbiological gold standard is people. Preschool children use this model for almost all instances of biological inferences. Carey (1985) argues that, “The prototypicality of people plays a much larger role in determining 4-year-olds’ projection of having a spleen than does similarity among animals” (p. 128). Thus, early folkbiology is essentially anthropocentric (See also Johnson & Carey, 1998). More generally, Carey interprets this pattern of reasoning, along with other evidence, as demonstrating that young children possess a qualitatively different understanding of biological phenomena, incommensurate with that of adults. As a consequence, pervasive conceptual change is necessary for children to acquire the adult model in which humans are seen as one animal among many (e.g., Carey, 1999). This anthropocentric view also makes predictions about how children will decide what kinds of things are alive: Similarity to humans rather than a more universal biological criterion should predict live-attributions.

A crucial component of any biological understanding is the ability to differentiate living from nonliving things. Although early evidence suggested that young children held beliefs that inanimate objects such as the sun are alive (e.g., Piaget, 1929; Laurendeau and Pinard 1962), more recent evidence suggests that early studies overestimated animistic reasoning. For example, Richards and Siegler (1984) systematically asked children ages 4-11 whether a range of objects (people, animals, plants, vehicles, other inanimate objects) that were described as either being still, being moved, or (where plausible) moving themselves, were alive. Of interest was whether over the entire set of questions, children's responses corresponded to systematic rules. Results showed that children rarely attributed life to vehicles and objects, and never did so systematically. Most younger children systematically attributed life to people and animals, and by around age 8, most children had added plants to the category of living things. Thus the largest developmental shift was not in learning that inanimates are not alive, but rather learning that plants are (see also Carey, 1985; Dolgin & Behrend, 1984; Richards, 1989).

Other evidence suggests cultural and experiential differences in patterns of life judgements. Hatano, Siegler, Richards, Inagaki, Stavy & Wax (1993) present data showing that Japanese children may be more liberal in granting life status to objects such as mountains than are US children, and that Israeli children (even older children) are more conservative, often denying even that plants are alive. These findings appear to be tied to cultural beliefs.

In some respects the claim that for young children humans are prototypical living things represents a puzzle if not a paradox. Most human cultures draw a sharp distinction between human beings and other animals and one might expect people to be very atypical animals. Johnson, Mervis and Boster (1992) found just that (se also Anglin, 1977). They showed seven- and ten-year-olds, and undergraduates a series of 200 sets of three pictures of mammals and asked them to “point to the two in each set that they thought were most like the same kind of thing.” In general, children and adults showed converging patterns of similarity relationships among mammals. However, adults considered humans more like other mammals than children did. Indeed, when presented with human-nonhuman-nonhuman triads, children almost never paired a human with another animal. This suggests that children do not see humans as especially typical of living things; rather, children may see humans as much more peripheral mammals than adults do. So why the apparent difference between the Johnson et al findings and the Carey results? In the present study we evaluate the idea that the amount and intimacy of children's contact with plants and animals as well as their cultural background has a critical influence on the development of folkbiological reasoning. Both dimensions are important in explaining adult reasoning patterns (López et al. 1997; Atran, Medin, Ross et al. 1999) and both may be relevant to children's reasoning as well.

Carey's study participants were from a highly urbanized population. There is evidence that industrialization has led to biological kinds being less psychologically salient than they were a few centuries ago (Wolff, Medin, and Pankratz, 1998). The extent of this "devolution" or loss of contact with nature may vary as a function of culture and setting (Ross 2001). For example, plants and animals are likely to be much less salient to urban folk than they are for rural folk. Considerations such as these lead to the hypothesis that the young children in Carey's (1985) study generalized more from humans than other animals not because humans are prototypical, but because humans are the only animal about which the children had very much knowledge. In our study we examine the degree to which children with different cultural beliefs and levels of regular exposure to plants and animals reflect anthropocentric folkbiological reasoning.

The degree to which a shift from an anthropocentric to a biocentric folkbiology is a universal aspect of conceptual development has not been addressed by previous research. To do so requires looking at conceptual development among children that differ in relevant ways from Carey's population (Coley, 2000). It is important to examine the generality of this anthropocentric pattern of reasoning, on at least two grounds. First, as we have just noted anthropocentric folkbiology may reflect a lack of knowledge about the biological world. More precisely, urban children may not know much about living things other than humans; they may be relative folkbiological novices. Indeed, there is evidence suggesting that knowledge has an impact on young children's reliance on humans as a base for reasoning.

Inagaki & Hatano (1987, 1991) find that humans serve as a privileged base for property projection, but that this process is constrained by knowledge. For example, properties are not projected from humans to nonhuman organisms when such an inference would contradict children's knowledge of the non-human in question. This account differs from other models of analogy in that (1) rather than searching for most appropriate analogical base, a decision is made on whether humans are appropriate or not, and (2) object-specific knowledge is used, not to choose an appropriate analogical base, but rather to (a) judge the feasibility of the already-predicted behavior, and (b) compute the organism's similarity to humans. Moreover, this account differs from Carey's in that humans constitute a privileged analogical base because of children's relatively rich knowledge about humans, not because of the centrality of humans in children's biological theories.

Inagaki (1990) presented evidence that knowledge does influence children's use of biological analogy. She compared kindergartners who raised goldfish with their counterparts who did not raise goldfish. All children were asked questions about observable and non-observable properties of goldfish, asked to reason about goldfish in novel situations, and asked to reason about a novel aquatic animal (a frog) in similar situations. Children who were raising goldfish possessed more knowledge about both observable and unobservable attributes of goldfish. They were also more likely to make reasonable predictions about the behavior of goldfish in novel situations. Although there were no differences in number of reasonable predictions about frogs between the goldfish-raising and non-goldfish-raising groups, the goldfish-raisers were more likely to make reasonable predictions about the behavior of frogs accompanied by comprehensible justifications. Most importantly, while both groups tended to analogize from humans to frogs when answering questions about frogs, the goldfish-raisers were more likely to analogize from goldfish to frogs when answering the same questions. This suggests that knowledge of goldfish enabled children who were raising goldfish to use goldfish as an analogical base in a way that children who were not goldfish raisers could not.

A second possibility is that an anthropocentric folkbiology may reflect cultural assumptions about relations between humans and nature. Popular films (e.g. Disney productions) and children's books often anthropomorphize animals by giving them distinctly human characteristics such as speech, driving vehicles and the like. Religions differ in the extent to which they emphasize the uniqueness of humans versus the rest of nature. In a culture where humans are perceived as an integral part of nature, such as traditional Native American culture, children might be less likely to make anthropocentric construals.

In this study, we examine how differences in experience and/or culture might lead to differences in reasoning about plants and animals. Following Carey, we teach children novel properties about humans, wolves, bees, goldenrod, and water, and then see whether they are willing to project these new properties to an array of animals, plants, and nonliving objects. We also ask children whether each member of this array is alive, and why. Of central importance is the question of comparative development; how do experience and cultural beliefs about nature impact conceptual development?

To address this question we examine children from three distinct populations; Native American children from the Menominee Indian Tribe of Wisconsin, Rural Majority Culture children from the neighboring town of Shawano, Wisconsin, and Urban children from East Boston, Massachusetts. For a number of reasons, the Menonimee population is of particular interest for this study. First, on the traditional Native American view, humans are an integral part of the natural world (Bierhorst, 1994; Suzuki & Knudtson, 1992). This contrasts sharply with the Western view in which humans are seen as distinctly apart from nature. Second, traditional folkbiological knowledge is especially salient to the Menominee. Unlike most woodland tribes, the Menominee reservation occupies (a small fraction of) their traditional range; thus, traditional knowledge of local plant and animal species is still very relevant today. Overall, sustainable coexistence with nature is a strong value among members of this population (Hall & Pecore 1995). Children are introduced to fishing & hunting at a very early age and in general have a very high degree of contact with plants and animals. The Shawano population is a useful comparison because the town is immediately adjacent to the Menominee Reservation. Children in Shawano grow up in the more or less the same physical environment, are introduced to fishing & hunting at an early age and also have a great deal of first hand experience with the natural world. They differ from the Menominee in terms of the cultural and religious significance of their natural surroundings. Finally, the urban population can be said to share some basic cultural beliefs about the relation between humans and the natural world with the Shawano population, but differs from both Wisconsin populations in that Boston kids have very little firsthand interaction with nature in their daily lives.

Examining these populations allows us to examine the pervasiveness of anthropocentric origins of folkbiology, and to begin to "triangulate" with respect to possible causes of conceptual differences (Bailenson, Shum, Atran, Medin, and Coley, in press; see also Coley, 2000). To the degree that the two Wisconsin populations are similar, experience is implicated in shaping folkbiological beliefs. To the degree that the Shawano children resemble the Boston children rather than the Menominee children, a role of cultural beliefs about nature is suggested. Distinct patterns among the three populations might suggest a combination of these factors in shaping conceptual development. Commonalities among the groups would suggest candidates for universals in development. Although these comparisons are by necessity imperfect, they allow us to begin to address the crucial question of how cultural and experiential context act to influence conceptual development.

In parallel with the present studies our research team has also examined inductive reasoning about biological kinds in Yukatek Maya children in southcentral Quintana Roo, Mexico (Atran, Medin, Lynch, Vapnarsky, Ucan Ek', and Sousa, 2001). There we found that even the youngest children tested (4-5 yr.-olds) showed no evidence of anthropocentrism; they generalized readily from both humans and other animals as a function of biological relatedness. Young girls showed less differentiation than boys when the peccary was the base for induction, a pattern consistent with an effect of experience or familiarity. Boys go with their fathers into the forest at an early age and, therefore, are much more familiar with the peccary than are girls. Children generalize more from humans to the sun than from any other base to the sun. This may reflect the special role of the sun in Maya cosmology, though Yukatek adults do not show this pattern. The Atran et al, 2001 studies support the idea that some combination of culture and experience affects children's biological inductions. The present study will help tease apart the contributions of these two variables.

Our study differed from Carey's in that we included two different kinds of inductive bases, goldenrod and water. We added goldenrod so that we could examine generalization both from animals to plants and from plants to animals. We had reason to believe that Menominee children would have a broad view of living kinds that includes not only plants but also natural entities such a rocks. Our original motivation for including water as a base was to see if ecological relations might play some role in children's inductions. Previously we had found that adults knowledgeable about biology often rely on ecological reasoning strategies (Lopez, et al, 1997, Proffitt, Coley, and Medin, 2000) and we were interested in whether and when it might appear in children's reasoning. As it turned out, however, when water is a base children use a wide variety of strategies and it is difficult to draw any clear conclusions. To reduce the complexity of an already complex design, we do not present the results for water as a base in this paper. Nonetheless, we were able to educe evidence for ecological reasoning from other bases.

Method

Participants

A total of 242 children from three distinct populations participated in the study. Native American children attended Keshena Elementary in Keshena, Wisconsin, a newly-built school located on the Menominee Reservation. Rural children attended Lincoln Elementary school in neighboring Shawano, Wisconsin. A 1990 census indicated that the median family income was $33,000 in Shawano county compared with $20,000 in Menominee County. Urban children attended the Guild School in Boston, Massachusetts. The guild school is located in an urban area of East Boston.

Participants in each locale were divided into three age groups: Kindergartners and first-graders ("young"), second- and third-graders ("middle"), and fourth-graders ("old"). Details on mean ages and ranges for each population are presented in Table 1. All children were monolingual English speakers, and were interviewed individually by research assistants from their community.

Materials

Detailed color drawings of five different inferential bases (human, wolf, bee, goldernrod, water) and 16 target objects (human, bear, raccoon, eagle, bluejay, turtle, gartersnake, sturgeon, trout, fly, worm, maple, milkweed, rock, pencil, bicycle) were used to present the questions. Categories were chosen to cover a large range of plants, animals, and nonliving objects. Bases were chosen to correspond to Carey's items (human, dog and bee), as well as to examine the extent to which children were willing to project properties of plants (from goldenrod). Target objects fell into higher order classes (nonhuman mammals, birds, reptiles, fish, invertebrates, plants, nonliving natural objects, and human-made artifacts).

Design

Children were asked to project unfamiliar properties from all 5 bases to all 16 targets. Properties were the names of substances (sacra, <u>andro</u>, hema, <u>estro</u>, <u>hema</u>, and <u>gluco</u>) said to be found inside the base. A different property was used with each base, and bases and targets were presented in a different random order for each child. Most children took more than one session to finish the task. After all of the property projection questions had been asked, children were shown each picture a last time, and asked whether the object was "alive" or not.

Procedure

Children who had received parental permission were interviewed individually at their school. Each child was first given two warm-up tasks. In the first, they were asked to name all the plants and animals that they knew. In the second, they were shown a shape and asked two questions about it. For instance, they might be shown a red triangle and asked, "Is this red? Is it a square?" The object was to get the child to answer both "yes" and "no" in the experimental context, and hopefully minimize response biases.

Children were then shown a picture of one of the bases and asked to name it. If they named it correctly, they were given positive feedback. If not, they were gently corrected. Next, they were taught a new property about the base. For example, the experimenter might show the wolf picture, and say, "Now, there's this stuff called andro. Andro is found inside some kinds of things. One kind of thing that has andro inside is wolves. Now, I'm going to show you some pictures of other kinds of things, and I want you to tell me if you think they have andro inside like wolves do, OK?" Children were then shown each target individually, asked to name them (the first time through, with feedback given as above), and then asked whether they "have andro inside, like the [base]." Questions were asked generically, about the kinds in question ("Do trouts have andro inside, like wolves do?") rather than about the individuals pictured ("Does this trout have andro inside, like this wolf does?").

Results

Each of the three study populations produced a unique profile. Although there were a number of similarities, the clear differences undermine the idea that anthropocentrism is a universal feature of folkbiological development. Below we detail these results in three sections. In the first we describe analyses of children's judgements of which base and target objects are "alive." In the second section we take a detailed look at the patterns of projections as developed within each population. Within this section we will frequently address some of the hypotheses forwarded by Carey and collaborators. Finally, in the third section we compare the different pattern found among the three populations and across the two tasks.

Alive Judgments

Children were shown each picture in the set, and asked whether or not members of the depicted kind were alive. For purposes of analysis, responses were scored as 1 for "yes" and 0 for "no." We are aware of the fact that the simple yes / no answer probably does not reflect all aspects that go into children's concept of alive. For example, a number of distinct components (e.g. having offspring, growing, needing food etc) may be involved in the children's notion of living kind and children may be uncertain about which are necessary versus only typical. Consequently, one might get a better idea of children's understanding of alive by probing these constituent components. Still, our data allow us to identify some important patterns in the development of a general concept of alive across age and culture.

Within this task we are concerned with several questions: First, do children make their alive judgment for animals based on the similarity of an animal to humans? This question relates to the anthropocentric theory forwarded by Carey. Second, to what extent do children believe that plants are alive? Third, do children systematically exclude inanimates from the class of living things and if so, do they distinguish between natural inanimates and artifacts? Our data allow us to look at these questions from a cross-cultural, developmental perspective. First, we follow the individual developmental paths of each group.

Urban Majority Culture Children's Attributions of Life. Table 2 represents the summary table of alive judgments for the urban children across the three age groups. Note, there were two items called "human," one represented by the picture of a girl and the other by the picture of a boy but the data are collapsed over gender.

Insert Table 2 about here

A first glance at the table reveals three general points: (1) urban children of all ages attribute life to humans. (2) middle and older urban children show ceiling effects on animals being alive and (3) young children show a relative high and fairly indiscriminate overall attribution of being alive, even with respect to natural inanimates and artifacts.

In our first analysis we tested whether young urban children's alive judgments of alive for animals could be predicted by the similarity of an item to human beings. This would support an anthropocentric view of biology. For the purpose of this analysis we grouped the animals in higher order categories: 1 mammals; 2 birds; 3 reptiles and fish and 4. invertebrates. If similarity to humans predicts the likelihood with which the children judge an item as alive, we would expect a monotonic trend (by regression analysis), indicating a decrease in alive attributions from mammals to invertebrates. (The two older groups responses to all animals show a ceiling effect.) Although the trend is in the direction of a decrease (from .83 for mammals to .64 for invertebrates), it fell short of statistical reliability. In general, however, young Boston children are more likely to see humans as alive than animals. This difference is only marginally significant (F=3.23; MSe=0.168; p=0.084) and is driven by the unfamiliarity of these children with fish (differences fish and humans: F=4.27; MSe=0.571; p=0.039).

The data also suggest that the youngest urban children are no more likely to attribute liveness to plants than to natural inanimates and artifacts, but that all three groups of items are less likely to be categorized as alive than animals. Nonetheless, the difference between plants and animals proves not to be significant, perhaps because of the low power associated with our sample size. It also appears that there are effects of familiarity on judgments. Young children are more likely judge the maple tree as alive than the other two plants.

In general young urban children see animals as alive, but seem to be less sure about plants and inanimate natural objects. If we compare how often animals, plants, artifacts and inanimate natural objects are attributed with life, only the difference between animals and artifacts is significant (F=4.682; MSe=0.671; p=0.04). This indicates that young children have not yet gained a clear concept of plants and inanimate natural objects with respect to being alive.

Older urban majority culture children show a more differentiated understanding of “alive”. The middle and old group of children see all animals as alive. With respect to plants, both middle-aged and older children show a mixed response pattern. Both groups of children are clearly more likely to attribute life to plants than to inanimate objects (middle children: F=11.46; MSe=1.64; p=0.002; older children: F=29.28; MSe=3.76; p=0.000). However, children of both age groups are also more likely to attribute life to animals than to plants (middle children: F=7.63; MSe=0.834; p=0.01; older children: F=10.37; MSe=0.942; p=0.002).

Summary. The limited sample size limits the conclusions that can be drawn concerning young urban children. Their attributions of alive are broader and somewhat undifferentiated and only the animals versus artifacts distinction proved to be reliable. There was a trend for attributions of living to be greater for humans than for other animals and greater for mammals than for invertebrates but this fell short of statistical significance. Middle and older children attributed life to essentially all animals but even the oldest group was less likely to attribute life to plants than to animals.

Rural Majority Culture Children's Attributions of Life.

As can be seen from the Table 3, rural majority culture children of all ages appreciate humans and animals as alive. Even children of the youngest group the judgments are at ceiling and show no differences between the different classes of animals.

Insert Table 3 about here

Majority culture children of all ages are much more likely to describe animals as alive than plants (young children: F=71.9; MSe=5.74; p=0.000; middle group: F=37.73; MSe=4.41; p=0.000; old group children: F=5.95; MSe=0.338; p=0.018). They are also more likely to see plants as alive than inanimates (young children: F=10.62; MSe=1.12; p=0.002; middle group: F=23.9; MSe=3.90; p=0.000; older children: F=143.9; Mse=9.2; p=0.000). Clearly, inanimates (both artifacts and natural inanimates) are seen as not alive but majority culture children are uncertain as to where plants fit in the scheme of living kinds. Looking more closely at Table 3, we see a developmental trend in attributing life to plants. Older children are more likely to attribute life to plants than children from the middle group (F=8.42; MSe=1.41; p=0.005), who are more likely to see plants as alive than the youngest children (F=3.85; MSe=0.761; p=0.053).

Summary. All groups of rural majority culture children see all animals as alive and clearly distinguish between plants and inanimates. Like the Boston children, they are more likely to see animals as alive than plants. The only clear developmental trend is a systematic increase in attributing living status to plants.

Menominee Children's Attributions of Life. As Table 4 indicates, Menominee children of all ages, like rural majority culture children, consistently judge animals to be alive (ceiling effect). They are also more likely to attribute life to animals than to plants (youngest group: F=6.15; MSe=0.388; p=0.017; middle group: F=8.0; MSe=0.445; p=0.006; older children: F=11.8; MSe=0.972; p=0.001), and more likely to assign life status to plants than natural inanimates or artifacts (youngest children: F=13.4; MSe=1.89; p=0.001 (inanimates); F=58.8; MSe=5.11; p=0.000 (artifacts); middle group: F=23.11; MSe=3.0; p=0.000 (inanimates); F=105.2; MSe=9.5; p=0.000 (artifacts); older children: F=17.9; MSe=2.6; p=0.000 (inanimates) and F=28.55; MSe=3.8; p=0.000).

Insert Table 4 about here

So far it appears that all groups are less sure that plants are alive than that animals are. But the qualitative trends can obscure important quantitative differences, differences which we presage now and take up systematically shortly. Comparing Tables 3 and 4 one can see that young Menominee children are considerably more likely to attribute living status to plants than are rural majority culture children (means= .75 and .35, respectively). This difference is also evident for the middle groups (means= .81 and .56 respectively) but is absent or even reversed in the older groups (means= .67 and .84, respectively). We suspect that the drop between middle and older Menominee children is a sampling error and we would not be inclined to take it seriously unless it were replicated. We have no other explanation for it.

Young Menominee children are also more likely than majority culture children to attributes life to natural inanimates (means= .36 versus .08). This difference is also seen in the middle and older children Menominee children of the youngest and middle group distinguish between artifacts and natural inanimate in that they are less likely to attribute life to artifacts (youngest children: F=6.82; MSe=0.783; p=0.012; middle group: F=18.4; MSe=2.11; p=0.000). Menominee children grow up in a cultural context tends to see all of nature as alive. “Spirit rock,” is an important landmark on the Menominee reservation. At the same time one should note that the majority of Menominee children do not attribute life to rocks and water. The decrease in this judgment among the older children likely indicates that Menominee children learn the notion of alive that is appropriate for the school context.

Summary. Menominee children uniformly see animals as alive and the vast majority of them also see plants as alive. They are also more likely to attribute life to natural inanimates than to artifacts, though this trend decreases with age.

Comparison Across Groups. So far we have described individual patterns for the three groups. Only our urban, majority culture children show a developmental change in terms of seeing animals as alive. Both of our rural groups are at ceiling in attributing life to animals. Young urban children do not show a reliable difference between inanimates and plants, though this difference becomes salient for the two older groups of urban children. In contrast, the youngest group of rural, majority culture children is more likely to attribute life to plants than to inanimates. Both groups eventually converge on a model that sees humans and animals as alive, and that does not attribute life to both natural inanimates and artifacts. Plants are located in an intermediate position. Although in general natural inanimates and artifacts are not seen as alive, young and middle aged Menominee children make a distinction between both, in attributing life more often to the former than to the latter. All three groups are more confident that animals are alive than that plants are alive. At the same time young and Menominee children are more likely to say that plants are alive than either groups of majority culture children.

To compare children across cultures on a given task has the inherent problem that we often do not know if the results are due to a general response bias or to different concepts (see Cole, 1996). We believe, however, that response bias cannot account for the main trends in the present data. All groups (across age and culture) uniformly attribute life to humans but not to artifacts. Still, Menominee children are more than twice as likely to see plants as alive than as the rural majority culture children ($F=14.62$; $MSe=2.0$; $p=0.000$) and they are also more likely to see natural inanimates as alive than rural majority culture children ($F=8.35$; $MSe=0.878$; $p=0.006$). Young Menominee children are also more likely to attribute life to either animals or plants than are urban children of the same age (animals: $F=19.4$; $MSe=0.52$; $p=0.000$; $p=0.000$; plants: $F=3.09$; $MSe=0.369$; $p=0.088$). The difference for plants is only marginally significant, perhaps because the young urban children have a broad and less-well differentiated pattern of aliveness attributions. This may represent a response bias. Young urban children are significantly more likely to see artifacts as alive than Menominee children ($F=6.45$; $MSe=0.814$; $p=0.016$). No difference was found for natural inanimates. These data are consistent with the generalization that young urban children have not yet developed a clear understanding of which items are alive and which are not, while Menominee children embrace an extended notion of alive that includes natural inanimates.

The same trends are found if we compare young urban and rural majority culture children. Rural children have a better understanding of animals being alive ($F=47.6$; $MSe=0.812$; $p=0.000$). The groups do not differ with respect to their responses for plants. Urban children are more likely than rural majority culture children to attribute life to both natural inanimates and artifacts (inanimates: F=18.3; MSe=1.90; p=0.000; artifacts: F=8.2; MSe=0.991; p=0.007). Again this may reflect a response bias on the part of the young urban children.

These urban-rural differences are no longer evident in middle and older children. However, the middle group of Menominee children is much more likely to see plants as alive than either rural (F=6.85; MSe=1.24; p=0.011) or urban majority culture children though the latter difference is not reliable. Furthermore, the middle group of Menominee children is more likely to see natural inanimates as alive than children of their age in the two other groups (Menominee vs rural: F=4.4; MSe=0.677; p=0.039; Menominee vs urban: F=3.8; MSe=0.51; p=0.057, marginally significant). All these differences disappear for the groups of oldest children.

Summary. Children in all three groups eventually converge on a common model of alive, though their trajectories are distinct. Young urban children have a relatively broad and relatively undifferentiated pattern of aliveness judgment. There was some evidence that young urban children judge aliveness in an anthropocentric manner though the trend fell short of reliability. The youngest rural children know that animals are alive. Menominee children appear to start out with a broader view of nature and are much more likely than rural majority culture children to judge that plants are alive (and that natural inanimates are alive). This part of Menominee development involves narrowing their cultural conception that all nature is alive to bring it into correspondence with western science views of living. The developmental trend for rural majority culture is to broaden their concept of living to include plants. Thus we see both effects of experience (rural vs. urban) and culture.

We now turn to the second property projection task. We will, however, return to these findings to see to what extent the differences in alive judgments can be related to inductive reasoning.

<u>Property Projection</u>

In this task children were asked whether a novel substance found inside each base would also be found inside each target. Responses were scored 1 for “yes” (making the projection from base to target) and 0 for “no” (declining to make the projection). We take property projection as a measure of perceived biological affinity. The fact that associations may be made on the basis of either taxonomic similarity or ecological relatedness poses something of an interpretative challenge. As we shall see, however, each population yields a unique profile and often we are in the position to discern which of the two strategies were used (biological affinity versus ecological relatedness).

There are several different ways of organizing the results, each emphasizing different aspects of them. However, as for the previous experiment we first address the developmental pattern for each cultural group separately and conclude with a section on cross-group comparisons. Finally, we will address the question of how the results of the two tasks relate to each other and discuss the importance of our findings with respect to Carey's theory.

Urban Majority Culture sample. Table 5 gives a summary table of the responses of the urban, majority culture children. First note that young urban children appear to show no systematic differences between the different bases and targets. That is, they tended to generalize broadly and indiscriminately. For example, human to raccoon generalization was at the same level as human to trout, worm, maple, milkweed and pencil. This indiscriminate projection pattern is supported by two separate trend analyses (regression) exploring generalization as a function of the similarity of the targets to humans and wolves. If children have a clear notion of biological affinity, the likelihood of them projecting to targets should be predicted by the similarity between target and base. In order to test this, we combined our targets (only animal and plants) into higher order categories: (1) mammals, (2) birds, (3) reptiles & fish (4) invertebrates and (5) plants. For the group of younger children no significant trend was found, consistent with undifferentiated generalization.

Insert Table 5 about here

There are two exceptions to the otherwise flat generalizations of the young urban children. Projections from one human figure to another are quite high as are projections from goldenrod to milkweed. This suggests that the young children generalize more for the few instances of very high similarity. In short, young urban children give no evidence of having a clear concept of biological affinity among animals, at least with respect to extending properties from base to targets. The only significant effect we could find in their pattern of projection was that goldenrod forms a stronger base for projections to other plants than to animals (including humans) (F=7.87; MSe=0.652; p=0.009). This effect is largely driven by the two instances of high generalization mentioned above. Finally, the young children seem to generalize more from water to animals that are found in the water such as turtle, sturgeon and trout.

The middle and old group of urban children show much more differentiation. The same regression analysis was conducted for these to groups looking at biological affinity and projection from humans and wolves as a base. For both the middle and older children a significant linear trend was observed both for humans (F=8.87; Rsq = 0.47; p=0.014 for middle and F=33.48; Rsq =0.77; p=0.000 for the older children) and for wolves as a base (F=95.22; Rsq=0.90; p=0.000 for middle age and F=67.84; Rsq=0.87; p=0.000 for the set of older children). This indicates that the middle and older group of Boston kids use underlying biological affinity of the targets for their projections from a base. With respect to bee as a base, the two groups of older Boston children clearly see a biological affinity that links bees more strongly with flies than vertebrates (F=34.3; MSe=1.64; p=0.000 for middle group and F=37.2; MSe=1.82; p=0.000 for the older children). Also goldenrod forms a stronger base for projections to other plants than to animals (including humans) for the two groups of older children (F=22,79; MSe=1.88; p=0.000 for the middle children and F=85.76; MSe=4.17; p=0.000 for the old children). Not surprisingly, older children also generalize more from water to animals that live in the water.

These findings have some bearing on the average projection strength of the individual bases. Note that an anthropocentric theory of the development of folkbiological knowledge predicts that on average projections from humans should be stronger than projections from other living things. Our two older Boston populations do not show such an effect. In fact, comparing wolf and human as a base for the mammals within the set of targets, shows the opposite pattern. Both groups of children are (marginally significant) more likely to project from wolf to mammals than from human to mammals (F=3.8; MSe=0.329; p=0.061 for the middle children and F=3.46; MSe=0.38; p=0.069 for the old children).

According to Carey's theory, anthropocentric folkbiology should lead to asymmetries in projection. To measure asymmetries in projection, for each child the average projection from human to each of the following categories of targets was calculated: 1. mammals, 2. insects, and 3. plants. If asymmetries exist, then, for example, humans to mammals should form a stronger projection than wolf to human. Both the middle and old urban children show clear asymmetries in their projection, with humans to mammals being a stronger inference than wolf to humans (middle group: F=6.96; MSe=1.16; p=0.013; older group: F=10.12; MSe=1.92; p=0.003). Only the middle group shows the same effect for humans to plants and plants to humans (F=8.41; MSe=1.08; p=0.007). For the old group of children we find an asymmetry for humans and insects (F=6.09; MSe=0.942; p=0.017), again human to flies being a stronger inference than bee to human. These observations match Carey's predictions but note that the asymmetries are no smaller in the old group than in the middle group.

Let us briefly turn to a related topic. If the property projection task serves as a method to understand underlying concepts of biological affinity, than it should be correlated with patterns already noted in the alive judgment task. This is indeed the case. On the alive task young urban children did not show a clear understanding of which elements are alive. Therefore, perhaps it is not surprising that this group did not show strong differences in projections between living versus non-living objects.

Although children of the middle urban group are no more likely to project from goldenrod to animals than to rock or artifacts, they are much more likely to project from bee to animals than either to rock or artifacts (F=34.12; MSe=2.1; p=0.000; F=62.0; MSe=2.36; p=0.000). These data and the alive judgments indicate that by the age of 8 urban children see animals as alive, but they have not yet developed a clear understanding of plants as alive. The older urban children are also more likely to project from bee to animals than to either rock or artifacts (F=59.3; MSe=3.7; p=0.000; F=67.7; MSe=2.36; p=0.000). They still do not differ in their projections from either goldenrod to animals versus rocks or from goldenrod to animals versus artifacts. However, they are also more likely to project from goldenrod to rock than from goldenrod to artifacts (F=7.0; MSe=0.942; p=0.011). This suggests that the older urban children see plants as part of nature but may not have clearly worked out the idea that plants are closer to animals than to natural animates.

Summary. Young urban, majority culture children did not show a pattern of projection based on similarity of bases to targets. Their only evidence of differentiation was high generalization for a few cases of high similarity (human to human, goldenrod to milkweed). The middle and old urban children did produce coherent generalization patterns. Interestingly, for both these groups humans were a worse base for induction than wolves, a pattern opposite of what one would expect from anthropocentrism. Both groups did show human-animal asymmetries in projection consistent with Carey's observations. Finally, the two older groups give some evidence of differentiating plants from natural inanimates.

Rural majority culture population. The results for the three age groups of rural majority culture children are shown in Table 6. Again we tested the children's notion of biological affinity using the similarity between base and targets to predict the likelihood of the children projecting to the targets. For the young rural children we found a significant linear trend for both human (F=28.53; Rsq=0.74; p=0.000) and wolf as a base (F=28.28; Rsq=0.739; p=0.000). This indicates that even young rural children use knowledge of biological affinity for inductive reasoning. Both the middle and older group of children show the same significant trend, again for both bases (middle: F=93.92; Rsq=0.903; p=0.000 for humans as a base and F=80.76; Rsq=0.890; p=0.000 for wolves; old children: F=62.04; Rsq=0.861; p=0.000 for humans and F=56.86; Rsq=0.85; p=0.000 for wolves as a base).

Insert Table 6 about here

Young rural children are also more likely to project from bees to flies than from bees to vertebrates (F=37.45; MSe=4.07; p=0.000) and more likely to project from bees to flies than from bees to humans (F=36.87; MSe=5.58; p=0.000) or to plants (F=55.0; MSe=5.9; p=0.000). Not surprisingly, the same pattern can be observed for both the middle children (bee to flies > bee to vertebrate: F=94.0; MSe=9.61; p=0.000; bee to fly > bee to human: F=76.1; MSe=10.89; p=0.000 and bee to fly > bee to plant: F=56.8; MSe=7.84; p=0.000) and the older group (bee to fly > bee to vertebrate: F=46.4; MSe=3.56; p=0.000; bee to fly > bee to human: F=22.95; MSe=3.07; p=0.000; bee to fly > bee to plant: F=15.42; Mse=1.83; p=0.000).

If we look at goldenrod as a base, the data indicate that rural majority culture children of all ages draw a clear distinction between plants and animals. They are more likely to project from goldenrod to other plants than to animals (young: F=45.51; MSe=3.67; p=0.000; middle:

F=80.41; MSe=7.344; p=0.000; old: F=31.38; MSe2.71; p=0.000). This analysis was done over all animals (excluding humans) but the patterns are equally significant for humans and the different categories of animals individually.

Next we will consider projection of the individual bases. The inductive power of human beings as a base is not different from either wolf or bee for any of the age groups with animals as the target. In every case, however, projection from wolf to other mammals is stronger than projection from projection from humans to other mammals. For the two younger groups but not the old group this difference is reliable (young: F=4.09; MSe=0.712; p=0.048; middle: F=6.71; MSe=1.1; p=0.11). This is the pattern we also saw with urban majority culture children.

The projection from both humans and wolves to animals is significantly stronger than from goldenrod to animals (young children: F=7.00; MSe=0.074; p=0.016 for humans and F=14.17; MSe=0.241; p=0.001 for wolves; middle group: F=9.75; MSe=0.099; p=0.006 for humans and F=8.32; MSe=0.214; p=0.01 for wolves; for the old group: F=24.11; MSe=0.323; p=0.000 for humans and F=5.56; MSe=0.173; p=0.03 for wolves). For bees versus goldenrod as a base and animals as targets, there is a trend for bee to be a stronger base but only for the young children is this difference significant (F=9.71; MSe=0.186; p=0.006). We believe that this developmental shift reflects the fact that the old group of rural children is starting to use ecological knowledge for their reasoning. For example, they sometimes mentioned that bear like honey (note that bee to bear projections have a .73 proportion versus .40 for bee to raccoon) or that a bee might sting various animals. Note also that this projection from bees to animals is not strong for animals that live in the water, again consistent ecological reasoning.

Rural majority culture children of all ages show significant human-animal asymmetries in their projections. These asymmetries only occur with respect to humans and mammals. Projections from human to mammals are more likely than from wolf to human (young: F=5.67; MSe=1.08; p=0.021; middle: F=24.62; MSe=4.2; p=0.000; old: F=9.41; MSe=1.67; p=0.003). These data provide some evidence for anthropocentric bias as was previously observed for urban majority culture children. A common justification for not generalizing from animals to humans was that “people aren’t animals.”

Relation to alive judgments. Again, the projection data show some parallels to the findings in the alive judgments. Young rural children are not reliably more likely to project from goldenrod to animals versus rock or artifacts, consistent with some uncertainty about whether plants are alive. However, they are more likely to project from animals to plants than from animals to artifacts (F=5.40; MSe=0.211; p=0.024 for wolf and F=8.72; MSe=0.621; p=0.005 for bee as bases). The middle group of rural children is more likely to project from goldenrod to animals than to either rocks or artifacts (F=9.11; MSe=0.706; p=0.003; F=21.9; MSe=1.08; p=0.000). This suggests that young rural children have some notion about plants being alive and that this notion is solidified by the time the children around 8 years old. Not surprisingly, the same pattern is found for the old group of rural children (goldenrod to animal > goldenrod to rock: F=9.11; MSe=1.00; p=0.002; goldenrod to animal > goldenrod to artifacts: F=21.96; MSe=0.75). Overall, these results show a general pattern of consistency between notions of alive and property projection.

Summary. The rural majority culture children are quite advanced relative to their urban counterparts. Even the youngest children show generalization based on biological affinity and give evidence of distinguishing between plants and nonliving things. Rural children do parallel urban children in showing a human-animal asymmetry in reasoning, consistent with at least one aspect of Carey's anthropocentrism hypothesis. Finally, the oldest group of children gave evidence of ecologically-based reasoning. For example, they were likely to generalize from bees to bears (noting that bears eat honey) and from bees to milkweed and maples (both flowering plants).

Rural Native American children. The projection data for the Menominee children are summarized in Table 7. As with the rural majority culture children, Menominee children of all ages show clear conceptions of biological affinity with respect to their projections from humans and wolf to animals. A linear trend describes this pattern for all three age groups (young: F=11.75; Rsq=0.540; p=0.006 for humans as a base and F=17.49; Rsq=0.636; p=0.002 for wolf as a base; middle: F=18.38; Rsq=0.648; p=0.002 for human and F=99.79; Rsq=0.909; p=0.000 for wolf; older: F=41.51; Rsq=0.806; p=0.000 for humans and F=65.38; Msq=0.867; p=0.000 for wolf.)

Insert Table 7 about here

Children of the young and the middle group are no more likely to project from bee to fly than they are to project from bee to vertebrates. This difference is only significant for the group of older children (F=7.29; MSe=1.12; p=0.01). Although the justifications were very limited, we believe that ecological reasoning is involved in producing these patterns. For the young Menominee children bees seem to be more affiliated with things that fly (eagle, bluejay, fly), though some of the justifications mentioned that a bee might sting various animals. The middle group favors the bear over the raccoon as a projection target (almost as high as fly). Again, eating honey and/or being stung were sometimes given as justifications.

All three age groups also show a clear distinction between plants and animals, as projections from goldenrod to plants are significantly higher than projections from goldenrod to animals (young: F=12.4; MSe=1.75; p=0.001; middle: F=45.69; MSe=3.68; p=0.000 and old: F=13.0; MSe=1.76; p=0.001). In addition, for all groups of Menominee children projections from humans and other animals to plants are lower than from goldenrod to plants (young: F= 23.52; MSe=3.2; p=0.000 for humans; F=8.58; MSe=1.33; p= 0.005 for wolf and F=8.2; MSe=1.5; p=0.006 for bee; middle: F=95.0; MSe=7.2; p=0.000 for humans; F=42.2; MSe=5.06; p=0.000 for wolf and F=33.3; MSe=4.0; p=0.000 for bee; old: F=16.1; MSe=2.38; p=0.000 for humans; F=30.1; MSe=3.42; p=0.000 for wolf and F=8.85; MSe=1.52; p=0.005 for bee).

Next, we looked again at the projection strength for the individual bases. For the young group no difference is found between human and wolf as a base to animals in general or to any of the superordinate groups (mammals, birds, reptiles, fish and invertebrates) individually. There is a slight trend for wolves provide a stronger base than humans, with the exception projections from humans to fish. (Here again, ecological reasoning may be involved in that fish are an important component in the Menominee diet.) Humans do not provide a better base for projections to animals than bees (again, analyses were done across all animals and for the individual groups). Interestingly, they do not provide a better base than goldenrod either, with one exception: children of this age group are more likely to project a property from humans to fish than from goldenrod to fish (F=4.71; MSe=1.02; p=0.035). Again, we take this as an indication that ecological relations play a role in these projections.

For the middle group of children no difference was found with respect to humans and wolves as a base to animals; if anything, wolf tended to provide a better base for projection to animals than humans. In general the middle group of Menominee children is more likely to project a property from humans to animals than from bees to animals. However, this difference is only (marginally) significant for fish as targets (F=3.53; MSe=0.681; p=0.065). Bees, on the other side, provide a better base for plants (again only marginally significant: F=3.0; MSe=0.473; p=0.085). Ecologically, these differences seem to make sense as humans are closer to fish (based on their activities) and bees are in closer interaction with plants. Finally, if we compare humans and plants as bases, we find that humans provide a better base to project to animals (although this difference is only significant for mammals and birds; F=6.4; MSe=1.12; p=0.014 and F=7.0; MSe=1.2; p=0.01).

The older group of Menominee children also shows no reliable differences between wolf versus human as a base for generalizing to animals. In general human provides a better base to other animals than does bee (though again, not reliably so) with the exception of fly as a target where this pattern is reversed (F= 7.4; MSe=1.3; p=0.009). Bees also provide a somewhat better base to plants as targets, again suggesting some ecological reasoning. Finally, humans provide a stronger base than plants for animals as targets (though this difference is only significant for mammals; (F=3.9; MSe=0.72; p=0.053).

The young Menominee children show no significant human-animal asymmetries. The middle group appears to show a larger asymmetry at least for humans and mammals (marginally significant; F=3.69; 0.766; p=0.059 Finally for the group of old group we find some indications of asymmetries between humans and mammals (means: human to mammals 0.70 versus wolf to human 0.52), but none of the differences proved to be statistically significant.

Relations between Alive Judgements and Patterns of Projection. As stated earlier, traditional Menominee beliefs, and indeed those of many Native American peoples, designate natural objects that are inanimate by scientific standards (e.g., rocks) as being an integral part of nature and therefore “alive.” In fact, young and middle Menominee children are less likely to judge artifacts as alive compared to natural inanimates. Therefore, we would expect that Menominee children should be more willing to project from animals and plants to rock than to the two artifacts in the set of targets. Again, we find this prediction confirmed (although this is not significant for the middle-aged children).

Summary. Like the rural majority culture, the youngest Menominee children manifest a projection pattern related to biological affinity. They also demonstrate a clear distinction between plants and both natural inanimates and artifacts. Responses of even the youngest group suggest an influence of ecological considerations. The Menominee children show none of the markers of anthropocentrism discussed so far.

Cross-population comparisons. The different developmental patterns within the three populations necessarily lead to differences across populations. First of all, experience clearly has an impact on children's understanding of biological affinity. Both rural populations show a clear notion of biological affinity at the youngest age. This is not the case for the group of young urban children. Older urban groups generally show similar effects of affinity as the children of the two rural cultures.

This difference in experience is also shown in the fact that our rural populations show an effect of ecological reasoning within this task. In particular human interaction with fish and the interaction bees have with both plants and bears seem to be salient ecological knowledge for both of our old rural samples. Menominee children show sensitivity to ecological factors at an earlier age than do the rural majority culture children. Fishing is an important outdoor activity for these children (and their parents) in this part of Wisconsin. Bears are also hunted as game in this area and bees are readily available for observation.

Both groups of majority culture children show clear asymmetries in reasoning between human and mammals. Furthermore, the middle and old group of urban children continue to manifest uncertainty concerning the status of plants as living things, in sharp contrast with rural majority culture children and in even sharper contrast with Menominee children. With the possible exception of young urban children, all groups and ages have a clear notion of animals and plants as being different and distinct from natural inanimates and artifacts. Young and older Menominee children are the only groups to be reliably less likely to make a projection from animals and plants to artifacts than to rock (young children: $F=9.18$; $MSe=0.803$; $p=0.003$; older children: $F=4.9$; $MSe=0.43$; $p=0.028$). This is consistent with the Native American notion that all of nature is alive.

General Discussion

Our goal in this investigation was to take a first step in examining potential influences of culture and experience on the development of folkbiological thought. The background for this study was the question of whether an anthropocentric folkbiology would inform reasoning as had been found in previous work with urban populations (e.g. Carey, 1985). However, against the backdrop of studies with adults (Lopez, et al, 1997; Bailenson, et al, in press) and Yukatek Maya children (Atran, et al, 2001), we expected to find both cultural and experiential differences in the development of folkbiological knowledge. Testing urban majority culture children, rural majority culture children, and rural Native American (Menominee) children, we observed three distinct developmental trajectories.

First, consider children's conceptions of "alive." As several researchers have noted it is difficult to assess a child's conception of living kind with a single question. Nonetheless, our findings are quite intriguing and supported by their relation to inductive reasoning. Young urban children attribute life to both humans and animals (though their aliveness judgments show a trend toward being related to how similar a given animal is to humans). Generally, however, they showed a very broad and relatively undifferentiated pattern of responding and often attributed life to both natural inanimates and artifacts.

The youngest children from both rural populations were nearly unanimous in attributing life to all animals and, unlike young urban children, in distinguishing plants from natural inanimates. The young Menominee children are twice as likely as rural majority culture children to attribute life to plants and much more likely to attribute life to natural inanimates. The latter tendency is consistent with Menominee cosmology and teaching. Menominee elders maintain that rocks are alive. One would need to probe the components of the notion of alive to determine whether and how the Menominee *concept* of alive corresponds to the scientific notion of alive. With respect to achieving the scientifically normative concept of which things are alive, young Menominee children are precocious with respect to plants and must learn to eliminate their over-extension to natural inanimates. Rural (and urban) majority culture children begin with an under-extended concept of living kind that must be broadened to include plants.

In short, the youngest children of the three populations seem to be guided by different principles for specifying and extending the concept, "alive. The young urban children lag behind the young rural children in their conception of what is living. Older children in all three groups (more or less) converge on the normative concept of living. The fact that three distinct organizational principles appear to be operating suggests that one may need three distinct teaching strategies to address these early conceptions of living.

Property Projection. The property projection task was also associated with striking quantitative and qualitative differences across populations. First, consider the urban majority culture children. The youngest children responded in a more or less undifferentiated fashion.

They generalized more from humans to humans than to other targets and more from goldenrod to other plants than to other targets. They also generalized less from wolf to humans and from wolf to inanimates than to other targets. Other than that their projections appeared to hover around a chance level of 50 percent. Although we did not replicate Carey's findings that humans were a better base for induction, our results are similar to hers in the sense that we did not find that the young urban children had a clear notion of biological affinity to guide their judgments.

Our procedure differs from Carey's in that she tested children one or two days after introducing the novel property and her tests were conducted in the context of a series of probes concerning more familiar properties such as having a heart, breathing and so on. Generally, Carey found a reluctance to project properties from bases other than humans. It may be that our task demands encouraged guessing in the young urban children rather than a reluctance to generalize at all.

At a specific level we only replicated Carey with respect to the human-mammal versus mammal-human asymmetry. Inferences from humans were stronger than inferences to humans. This asymmetry was observed in both of our majority culture populations and it was reliably present even in the oldest group of children. Menominee children showed no significant asymmetries, though the trend was in the direction of asymmetries for both the middle and old group of children.

Older urban children reveal coherent, similarity-based patterns of projection, with the older group showing greater differentiation than the middle group. Older urban children generalized more readily from wolf to mammal than from human to mammal. This suggests that the older children do not see humans as the prototypical animal nor do they see humans simply as one animal among many (see also Johnson, Mervis, and Boster, 1992 who report related findings). Some justifications appealed to the claim that humans are not animals and it is also possible that children are drawing a distinction between wild and domestic. Carey's (1985) study which found that asymmetries were reduced or eliminated in older children's judgments used dog rather than wolf as a base.

Property projection by rural majority culture children shows a distinctly different picture. The youngest rural children used a clear notion of biological affinity in their responses, much like the oldest urban children. They showed similarity-based property projection for the four living targets. They showed greater projection from wolf to mammals than from humans to mammals as did older rural children.

Unlike their urban counterparts, older rural majority show a clear influence of ecological relations. Consider, for example, projections from bees to humans , bee to bears and from bee to plants. Between the middle and old group of rural children, the proportions increase from .20, .28 and .30 , respectively to .53, .73 and .58. The corresponding proportions for the urban middle and old groups of children go from .31, .50 and .40 to .08, .62, and .44. A common justification for the rural children is that bees might sting or that bears eat honey. Projections from goldenrod to animals demonstrate a clear increase not seen in urban children. In short, the rural children are not only precocious with respect to similarity based attributions but also they show a developing sensitivity to ecological relations not seen in urban children.

The Menominee children provide yet a third profile. The youngest children show broad, similarity-based projection from the four living bases and both their justifications and their projections give some indication of ecological reasoning. (For example, their projections from bee to birds were quite high. Incidentally, the only other group to show a pattern like this was the oldest group of urban children.) Ecological reasoning is clearer on the middle and old group where, for example, projections from bee to bears are stronger than bee to raccoons. The broad generalization from bases like bee and goldenrod to other living targets and the absence of generalization to artifacts suggests that some combination of ecological reasoning was often the basis for responding.

There was a trend for the human-mammal asymmetry to appear for all age groups, though it typically fell well short of reliability. Unlike the rural majority culture children, the Menominee children do not justify their projections by suggesting that humans are not animals Our results for the Menoninee children may derive, in part, from the different status of bears and wolves as mammals. Wolves are sacred and scarce, which contrasts with bears, which are common and part of the Menominee human origin story. Bears are also hunted and their meat is eaten by Menominee (except by some members of the bear clan for whom eating bear meat is morally prohibited). This and the existence of a bear clan might have influenced the high projection rate from humans to bear.

There were few developmental changes in the Menominee population. Wolf to plant inferences decreased with age. Inferences from bee also diminished modestly with age, except for targets such as bear, fly, and milkweed. The decrease may reflect differentiation. Overall, like the rural, majority culture children, the Menominee children show precocious similarity-based responding and even more precocious ecological responding. It is not entirely clear whether the broad but differentiated projection seen by Menominee children reflects Menominee cosmology or ecological relations and it may prove difficult to disentangle them.

Implications for theory. Carey (1985) argued that young children do not have an autonomous folkbiology. Since her landmark book, there has been a great deal of research using other probes and procedures that has either tends to support or undermine her suggestions (e.g. See relevant chapters in Hirschfeld and Gelman, 1994; Premack and Premack, 1996; Medin and Atran, 2000). The present studies shift the focus from procedures to populations. With our urban population we replicate Carey (1985) in the sense that the young group of children did not appear to have a coherent folkbiology based on biological affinity. Data from our two rural populations, however, suggest an altogether different interpretation of the urban data. The youngest rural children provide clear evidence of generalization based on biological affinity. The Menominee children of all ages and the older rural majority culture children also provide clear evidence of ecological reasoning. This propensity for ecological reasoning is also prominently seen in biological experts (e.g. Proffitt, Coley, and Medin, 2000, Bailenson, et al, in press) but tends not to be seen in college students who know relatively little about plants and animals. The upshot of these observations is that urban children may provide a very poor base for developing general claims about the development of children's folkbiology.

A role for familiarity? There is an obvious sense in which our comparison of the three populations is biased. The plants and animals used were doubtless more familiar to the rural children than to the urban children. Furthermore, there is evidence that familiarity does influence children's willingness to project properties (Atran et al, 2001). Much the same might be said for knowledge of ecological relations. But these realities are part of the target of these studies. In fact, this is part of our argument: urban children lack essential expertise of the domain to develop a folkbiological model that is not driven by what they know about humans. Therefore, Carey's finding does not represent an universal privilege toward humans, but rather the opposite, a lack of knowledge of otherwise privileged information among children of her study population (see Inagaki 1990). We could have selected plants and animals that were unfamiliar to rural children. However, it is not so obvious that we could have selected plants and animals that were highly familiar to urban children. In follow up work we plan to test urban and rural majority culture children as well as Menominee children, directly comparing the effects of native versus exotic species that are seen in zoos, such as African mammals. If only relative specific familiarity drives responding then urban children, who are exposed to zoos, may be precocious relative to rural children. We do not expect to see this pattern of results, however. Instead, we predict that the more intimate experience of rural children with animals and plants will form a base of analogies to support reasoning about unfamiliar animals and plants (e.g. Inagaki 1990; Bailenson, et al, in press).

Our data reinforce the observations of Atran, et al (2001) with Yukatek Maya children in showing that the patterns observed by Carey are not universal. The anthropocentrism she proposed may be, in part, attributable to the unfamiliarity of urban children with the world of nature and in part to culture (see also Wolff, Medin and Pankratz, 1999 for an analysis of the decreasing cultural salience of plants and animals in technological societies).

Another avenue for further work is to see whether and how these group differences carry over and influence learning in the classroom. Depending on one's perspective it is interesting to consider how one might take advantage of the precocity of the rural children (especially the Menominee children), or how one might remedy the relatively impoverished experience of the urban children.

Conclusion

In this paper we analyzed the development of folkbiological induction in children of three distinct cultural groups. Our findings suggest different underlying construals of the biological world among our three populations. The differences between urban and rural majority-culture children seem to reflect their differences both cultural support for an interest in nature and for direct experiences with nature. Both groups of majority culture children may share anthropocentric cultural beliefs, but the richer experience of rural children could support more biocentric thought earlier than is seen among urban children.

One way to capture the difference between the two rural groups is to argue that Menominee children's patterns of folkbiological reasoning reflect a framework where ecological reasoning, the relations between species – including humans – is very salient. Some evidence for such a view comes from studies with Menominee and majority culture fish experts (Medin, Ross, Atran et al. soon to be submitted). Majority culture experts show a clear influence of goal orientation in the ways they perceive local fish while Menominee experts pay more attention to ecological features. Goal orientation, however, is another way to put human beings in the center of the perspective – as different from animals.

Both culture and experience play an important role in the development of folkbiological knowledge. We think that analyzing cognitive development in terms of domain-specificity is a very fruitful strategy. Nonetheless, it may be hazardous to try to develop universal generalizations on the basis of data from children from populations where both cultural support for an direct experience with nature is generally impoverished.

Reference Note

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Table 1: Mean ages and age range for the individual groups.

Group	Age-Group	Count	Mean Age	Age Range
Urban majority	6 year olds	14	6-0	5-4 - 6-8
	8 year olds	16	8-0	7-3 – 9-10
	10 year olds	26	10-0	9-0 – 11-2
Rural majority	6 year olds	29	6-6	6-0 – 6-10
	8 year olds	50	8-1	7-7 – 8-6
	10 year olds	30	9-8	9-8 – 10-9
Rural Menominee	6 year olds	24	6-03	5-06 – 7-06
	8 year olds	32	8-07	7-08 – 9-05
	10 year olds	21	10-03	9-08 – 11-00

Table 2: Urban majority culture children's alive judgments as a function of age. Entries represent the likelihood of kids in a given age group judging a given element as alive.

	Young	Middle	Old
Human	0.86	1.00	1.00
Wolf	0.86	0.94	0.96
Bear	0.79	0.88	0.96
Racoon	0.64	0.94	1.00
Eagle	0.79	1.00	0.92
Bluejay	0.64	1.00	1.00
Turtle	0.79	1.00	1.00
Gartersnake	0.79	1.00	1.00
Sturgeon	0.57	0.88	0.77
Trout	0.57	1.00	1.00
Bee	0.71	1.00	1.00
Fly	0.64	0.81	1.00
Worm	0.64	0.94	0.92
Goldenrod	0.43	0.56	0.69
Maple	0.71	0.69	0.69
Milkweed	0.50	0.63	0.69
Water	0.57	0.33	0.27
Rock	0.50	0.06	0.15
Pencil	0.43	0.13	0.08
Bicycle	0.36	0.19	0.12

Table 3: Rural majority culture children's alive judgments across age. Entries represent the likelihood of kids in a given age group judging a given element as alive.

	Young	**Middle**	**Old**
Human	1.00	0.98	1.00
Wolf	0.97	0.98	1.00
Bear	1.00	0.98	0.97
Racoon	1.00	0.98	1.00
Eagle	0.97	1.00	1.00
Bluejay	1.00	0.98	1.00
Turtle	1.00	0.96	1.00
Gartersnake	0.97	0.98	1.00
Sturgeon	0.97	0.96	1.00
Trout	1.00	1.00	1.00
Bee	1.00	0.98	1.00
Fly	1.00	0.98	1.00
Worm	0.97	0.98	0.97
Goldenrod	0.41	0.52	0.87
Maple	0.34	0.58	0.83
Milkweed	0.31	0.58	0.83
Water	0.14	0.26	0.20
Rock	0.03	0.18	0.03
Pencil	0.07	0.12	0.00
Bicylce	0.07	0.10	0.00

Table 4: Menominee children's alive judgment across age. Entries represent the likelihood of kids in a given age group judging an element as alive

	Young	**Middle**	**Old**
Human	1.00	1.00	1.00
Wolf	1.00	0.97	1.00
Bear	1.00	0.97	1.00
Raccoon	1.00	1.00	0.95
Eagle	1.00	1.00	1.00
Bluejay	1.00	1.00	0.95
Turtle	0.96	0.97	0.90
Gartersnake	0.87	1.00	0.95
Sturgeon	0.90	0.94	0.86
Trout	0.96	0.94	0.86
Bee	0.96	1.00	0.95
Fly	0.74	1.00	0.95
Worm	0.87	1.00	1.00
Goldenrod	0.87	0.84	0.62
Maple	0.74	0.81	0.71
Milkweed	0.65	0.78	0.67
Water	0.48	0.53	0.33
Rock	0.23	0.28	0.19
Pencil	0.09	0.09	0.24
Bicycle	0.09	0.09	0.10

Table 5: Summary responses of Urban majority culture Children. Rows represent the average projection for e
three age groups.

	Human	Bear	Raccoon	Eagle	Bluejay	Turtle	Gartersnake	Sturgeon	Trout	Fly	Worm	Maple	M
Young													
Hum	0.93	0.50	0.43	0.57	0.64	0.57	0.57	0.36	0.43	0.29	0.43	0.43	
Wolf	0.21	0.43	0.43	0.43	0.50	0.57	0.64	0.64	0.36	0.57	0.36	0.50	
Bee	0.50	0.43	0.50	0.43	0.29	0.43	0.43	0.71	0.64	0.50	0.43	0.43	
Goldenrod	0.50	0.50	0.50	0.43	0.50	0.50	0.50	0.43	0.43	0.57	0.43	0.64	
Water	0.57	0.64	0.50	0.50	0.57	0.86	0.57	0.86	0.86	0.43	0.57	0.57	
Middle													
Human	1.00	0.67	0.73	0.67	0.73	0.73	0.53	0.47	0.40	0.47	0.47	0.47	
Wolf	0.33	0.93	1.00	0.69	0.69	0.69	0.63	0.63	0.56	0.50	0.56	0.38	
Bee	0.31	0.50	0.50	0.75	0.56	0.56	0.63	0.44	0.44	1.00	0.38	0.25	
Goldenrod	0.13	0.44	0.19	0.38	0.31	0.50	0.38	0.31	0.13	0.31	0.19	0.81	
Water	0.63	0.25	0.13	0.38	0.25	0.80	0.50	0.81	0.88	0.13	0.27	0.50	
Old													
Human	1.00	0.81	0.65	0.73	0.77	0.62	0.65	0.46	0.62	0.35	0.20	0.31	
Wolf	0.35	0.92	0.88	0.85	0.69	0.62	0.46	0.31	0.38	0.38	0.38	0.19	
Bee	0.08	0.62	0.50	0.77	0.73	0.46	0.73	0.54	0.35	0.96	0.46	0.38	
Goldenrod	0.12	0.38	0.38	0.27	0.38	0.19	0.58	0.27	0.35	0.62	0.38	0.88	
Water	0.58	0.50	0.35	0.46	0.50	0.81	0.46	0.96	0.92	0.31	0.42	0.69	

Table 6: Summary responses of rural majority culture children. Rows represent the average projection for ea three age groups.

	Human	Bear	Raccoon	Eagle	Bluejay	Turtle	Gartersnake	Sturgeon	Trout	Fly	Worm	Ma
Young												
Hum	0.96	0.57	0.46	0.36	0.46	0.29	0.25	0.29	0.32	0.07	0.29	0.
Wolf	0.24	0.76	0.75	0.45	0.41	0.31	0.31	0.28	0.28	0.38	0.41	0.
Bee	0.28	0.45	0.31	0.48	0.45	0.31	0.34	0.31	0.28	0.90	0.24	0.
Goldenrod	0.10	0.24	0.24	0.21	0.21	0.14	0.28	0.17	0.17	0.24	0.24	0.
Water	0.52	0.48	0.31	0.31	0.34	0.66	0.24	0.66	0.66	0.21	0.24	0.
Middle												
Hum	0.98	0.60	0.55	0.40	0.40	0.34	0.36	0.34	0.32	0.34	0.24	0
Wolf	0.16	0.84	0.73	0.58	0.52	0.30	0.44	0.32	0.28	0.28	0.26	0
Bee	0.20	0.28	0.22	0.36	0.32	0.16	0.28	0.14	0.16	0.86	0.32	0
Goldenrod	0.12	0.28	0.22	0.12	0.24	0.22	0.40	0.12	0.20	0.34	0.34	0
Water	0.54	0.50	0.43	0.35	0.45	0.67	0.45	0.86	0.76	0.22	0.36	0
Old												
Hum	1.00	0.77	0.83	0.70	0.73	0.63	0.53	0.60	0.63	0.63	0.40	0.
Wolf	0.47	0.93	0.90	0.73	0.60	0.60	0.53	0.40	0.37	0.47	0.24	0.
Bee	0.53	0.73	0.40	0.53	0.70	0.27	0.50	0.23	0.20	0.93	0.33	0.
Goldenrod	0.30	0.53	0.30	0.23	0.41	0.47	0.57	0.37	0.30	0.33	0.40	0.
Water	0.93	0.96	0.86	0.75	0.68	0.93	0.61	0.89	0.89	0.41	0.54	0.

Table 7: Summary responses of Menominee children. Rows represent the average projection for each base ac
groups.

	Human	Bear	Raccoon	Eagle	Bluejay	Turtle	Gartersnake	Sturgeon	Trout	Fly	Worm	Maple	Milkweec
Young													
Hum	0.87	0.58	0.58	0.67	0.54	0.63	0.54	0.63	0.63	0.46	0.46	0.38	0.2
Wolf	0.42	0.75	0.75	0.71	0.58	0.74	0.63	0.50	0.57	0.57	0.57	0.46	0.5
Bee	0.63	0.58	0.54	0.75	0.79	0.63	0.71	0.58	0.58	0.79	0.46	0.46	0.4
Goldenrod	0.42	0.46	0.54	0.46	0.54	0.42	0.48	0.33	0.33	0.29	0.46	0.75	0.8
Water	0.46	0.50	0.29	0.42	0.33	0.52	0.42	0.58	0.67	0.38	0.54	0.50	0.6
Middle													
Hum	0.96	0.71	0.66	0.63	0.74	0.74	0.41	0.55	0.65	0.55	0.47	0.16	0.2
Wolf	0.47	0.84	0.81	0.78	0.72	0.69	0.66	0.69	0.56	0.56	0.47	0.31	0.3
Bee	0.35	0.66	0.45	0.56	0.63	0.45	0.53	0.45	0.32	0.68	0.44	0.35	0.4
Goldenrod	0.41	0.44	0.39	0.31	0.48	0.48	0.45	0.39	0.38	0.41	0.47	0.81	1.0
Water	0.59	0.44	0.38	0.53	0.50	0.68	0.47	0.81	0.88	0.34	0.44	0.59	0.6
Old													
Hum	0.81	0.81	0.62	0.62	0.57	0.57	0.48	0.52	0.62	0.48	0.43	0.29	0.3
Wolf	0.52	0.95	0.81	0.67	0.62	0.48	0.43	0.48	0.62	0.52	0.33	0.19	0.2
Bee	0.38	0.62	0.52	0.48	0.57	0.29	0.52	0.43	0.43	0.81	0.43	0.33	0.5
Goldenrod	0.38	0.43	0.48	0.33	0.43	0.43	0.52	0.33	0.38	0.43	0.24	0.76	0.8
Water	0.67	0.76	0.57	0.67	0.48	0.71	0.33	0.81	0.81	0.48	0.38	0.76	0.7

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