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**COGNITIVE
DEVELOPMENT**

3 **Cultural and experiential differences in the**
 4 **development of folkbiological induction**

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11 **Abstract**

12 Carey's (1985) book on conceptual change and the accompanying argument that
 13 children's biology initially is organized in terms of naïve psychology has sparked a great
 14 detail of research and debate. This body of research on children's biology has, however,
 15 been almost exclusively been based on urban, majority culture children in the US or in
 16 other industrialized nations. The development of folkbiological knowledge may depend
 17 on cultural and experiential background. If this is the case, then urban majority culture
 18 children may prove to be the exception rather than the rule, because plants and animals
 19 do not play a significant role in their everyday life. Urban majority culture children,
 20 rural majority culture children, and rural Native American (Menominee) children were
 21 given a property projection task based on Carey's original paradigm. Each group pro-
 22 duced a unique profile of development. Only urban children showed evidence for early
 23 anthropocentrism, suggesting that the co-mingling of psychology and biology may be a
 24 product of an impoverished experience with nature. In comparison to urban majority cul-
 25 ture children even the youngest rural children generalized in terms of biological affinity.
 26 In addition, all ages of Native American children and the older rural majority culture chil-
 27 dren (unlike urban children) gave clear evidence of ecological reasoning. These results
 28 show that both culture and expertise (exposure to nature) play a role in the development
 29 of folkbiological thought.

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31 1. Introduction

32 Current views of cognition portray concepts as being embedded in theory-like
33 explanatory frameworks (Carey, 1985, 1995; Keil, 1989; Medin, Lynch, & Solomon,
34 2000; Murphy & Medin, 1985). These framework theories differ in different do-
35 mains of experience; a framework theory for understanding and predicting the
36 behavior of physical objects necessarily differs from one, which allows us to pre-
37 dict the behavior of sentient beings. Correspondingly, theorists have begun to
38 conceive of conceptual development as a domain-specific process, and have investi-
39 gated development in core domains such as naïve physics and naïve psychology
40 (Gelman & Hirschfeld, 1999; Wellman & Gelman, 1992; Wellman & Inagaki,
41 1997). However, recent research with adults indicates that framework theories,
42 as well as domain-specific knowledge and reasoning strategies, differ across adult
43 populations varying in expertise and cultural background (see Medin, Ross, Atran,
44 Burnett, & Blok, 2002 for an overview). Most of these advances have been reported
45 within the domain of folkbiology, encompassing how people understand, catego-
46 rize and reason about plants and animals (Medin & Atran, 1999).

47 A good deal of research has been conducted in the last 15 years on the acquisition
48 of folkbiology, both because of the intrinsic importance of the domain and as a
49 test case for more general ideas about conceptual development. However, most
50 of this research has ignored potentially important differences with respect to the
51 experiential base and the cultural background of the children. Studies have focused
52 on urban majority culture children in either the US or other industrialized cultures.
53 Given the findings with adults on the role of culture and experience (see for example
54 López, Atran, Coley, Medin, & Smith, 1997; Medin, Lynch, Coley, & Atran, 1997)
55 the focus on such a restricted participant pool seems surprising.

56 An influential idea to emerge from this body of work is that children's under-
57 standing of the biological world undergoes a profound shift between ages 4 and
58 10. Carey (1985, 1995) argues that children's early understanding of plants and
59 animals is anthropocentric. That is, children's understanding of other living things
60 is largely in reference to, or by analogy to, human beings. As a consequence,
61 prototypicality of humans is central to children's conceptions of the biological
62 world.

63 One source of evidence that young children possess an anthropocentric folkbi-
64 ology comes from a property projection task where children are taught a new fact
65 about a given biological kind (e.g., a dog "has an omentum") and asked whether
66 other kinds (a bird, a fish, a plant) share that property. The rationale is that projec-
67 tion of a novel internal property is an index of the biological affinity between base
68 and target species (Carey, 1985). By examining patterns of projection, and com-
69 paring those patterns to predictions derived from competing conceptual schemes,
70 we may be able to diagnose which theories children are using to understand the
71 world around them. Carey (1985) used this task to explore how children's projec-
72 tions from one basic-level animal category to other categories differed based on
73 the similarity of the base and target categories.

74 The task relies on two related ideas: first, inductive inferences from prototypical
75 members of a category are perceived as stronger than inferences from less central,
76 typical members of that category (Osherson, Smith, Wilkie, & Shafir, 1990; Rips,
77 1975). Second, inductive inferences are guided by the similarity between the base
78 and target items. Within this paradigm an anthropocentric folkbiology makes two
79 straightforward predictions: first, if humans are central, prototypical exemplars
80 of living things, then on average projections from humans should be stronger
81 than projections from other living things. Second, an anthropocentric folkbiology
82 should lead to asymmetries in projection. For example, inferences from human to
83 dog should be stronger than from dog to human (see Osherson et al., 1990 for a
84 formal model that predicts asymmetries of inferences between typical and atypical
85 category members).

86 The 4- and 6-year-olds studied by Carey (1985) generalized as would be pre-
87 dicted by an anthropocentric view. Four-year-olds readily generalized from hu-
88 mans as a base but showed little generalization from dogs and almost none from
89 bees as a base. For 6-year-olds, humans were still somewhat privileged, as chil-
90 dren were more likely to project from humans to other animals (69%) than from
91 dogs to other animals (54%). Furthermore, asymmetries were evident in compar-
92 ing human \geq dog (76%) to dog \geq human (41%), and human \geq bee (59%) to
93 bee \geq human (12%). For 10-year-olds and adults, humans are no longer uniquely
94 central, though some effects suggestive of anthropocentrism are still evident in the
95 10-year-old responses.

96 Carey interpreted these results as supporting a comparison-to-exemplar model
97 of biological reasoning in which the folkbiological gold standard is people. Carey
98 (1985) argues that, “The prototypicality of people plays a much larger role in de-
99 termining 4-year-olds’ projection of having a spleen than does similarity among
100 animals” (p. 128). Thus, according to Carey, early folkbiology is essentially an-
101 thropocentric (see also Johnson & Carey, 1998). More generally, Carey interprets
102 this pattern of reasoning, along with other evidence, as demonstrating that young
103 children possess a qualitatively different understanding of biological phenom-
104 ena, incommensurate with that of adults. As a consequence, pervasive conceptual
105 change is necessary for children to acquire the adult model in which humans are
106 seen as one animal among many (e.g., Carey, 1999).

107 Carey’s original findings stimulated a great deal of research on children’s biol-
108 ogy. Much of this debate has centered on the question of whether children’s biology
109 is distinct from children’s psychology. By now there are a number of studies that
110 suggest that urban children have distinct notions of biology (e.g., Coley, 1995;
111 Gelman & Wellman, 1991; Hatano & Inagaki, 1994, 1999; Hickling & Gelman,
112 1995; Keil, 1989, 1995 but see also Au & Romo, 1999; Johnson & Carey, 1998;
113 Solomon, Johnson, Zaitchik, & Carey, 1996) and that contextual factors may affect
114 the likelihood of children using a biological framework for explanation (Gutheil,
115 Vera, & Keil, 1998). Although our study bears on the separation of folkbiology
116 from folkpsychology, our focus is on the role of cultural and experiential factors
117 in children’s inductive reasoning, especially with respect to anthropocentrism.

118 In some respects the claim that for young children humans are prototypical
119 living things represents a puzzle if not a paradox. Most human cultures draw a
120 sharp distinction between human beings and other animals and one might expect
121 people to be very atypical animals. Johnson, Mervis, and Boster (1992) found just
122 that (see also Anglin, 1977). In their study (based on a triad similarity compar-
123 ison) children and adults showed converging patterns of similarity relationships
124 among mammals. However, adults considered humans more like other mammals
125 than children did. Indeed, when presented with human–nonhuman–nonhuman tri-
126 ads, children almost never paired a human with another animal. This suggests
127 that children see humans as much more distinctive and peripheral mammals than
128 adults do.

129 So why the apparent difference between the Johnson et al. findings and the Carey
130 results? In the present study we evaluate the idea that the amount and intimacy of
131 children’s contact with plants and animals as well as their cultural background has a
132 critical influence on the development of folkbiological reasoning. Both dimensions
133 are important in explaining adult reasoning patterns (Atran et al., 1999; López et al.,
134 1997) and both may be relevant to children’s reasoning as well. Furthermore, there
135 is evidence that industrialization and urbanization has led to biological kinds being
136 less psychologically salient than they were a few centuries ago (Wolff, Medin, &
137 Pankratz, 1999). The extent of this “devolution” or loss of contact with nature may
138 vary as a function of culture and setting (Ross, 2002a). For example, plants and
139 animals may be less salient to urban folk than they are for rural folk (e.g., compare
140 Stross, 1973 with Dougherty, 1978). Obviously, urban children visit zoos, watch
141 animals and plants on television, own pets, observe squirrels, robins and pigeons in
142 parks and walk past trees on a daily basis. However, these sorts of experiences may
143 not be especially “intimate.” The most specific level that Northwestern University
144 undergraduates can name trees, on average, is just “tree” (Coley, Medin, Proffitt,
145 Lynch, & Atran, 1999).

146 In rural Wisconsin, home to two of our study populations, children are intro-
147 duced to hunting and fishing at an early age. Parents may call the attention to
148 the fact that deer prefer the acorns of white oaks to those of other oaks or note
149 that beavers love poplars. Even owning pets might be associated with different
150 meanings in urban and rural contexts. In an urban setting dogs are often treated as
151 family-members and live in the home. In contrast, in our Wisconsin study area the
152 value of a dog is often judged by its abilities as a hunting dog and most dogs do
153 not live in the home. These differences in treatment and respect may affect how
154 children reason about living kinds in relation to human beings. If these considera-
155 tions are correct, the anthropocentrism displayed by the young children in Carey’s
156 (1985) study may not be caused by the fact that humans represent the prototypical
157 animal, but, instead, may be attributable to humans being the only animal about
158 which they have extensive knowledge.

159 If anthropocentrism is indeed a consequence of the lack of knowledge devolu-
160 tion among urban children, then we should find clear differences among children
161 of different cultural and experiential backgrounds. In our study we examine the

162 degree to which children with different cultural beliefs and a rural versus an urban
163 background reflect anthropocentric folkbiological reasoning.

164 The degree to which a shift from an anthropocentric to a biocentric folkbiology
165 is a universal aspect of conceptual development has not been addressed by previous
166 research. To do so requires looking at conceptual development among children that
167 differ in relevant ways from Carey's population (Coley, 2000). It is important to
168 examine the generality of this anthropocentric pattern of reasoning, on at least two
169 grounds. First, as we have just noted, anthropocentric folkbiology may reflect a
170 lack of close experience with the biological world. More precisely, urban children
171 may be relative folkbiological novices. Indeed, there is evidence suggesting that
172 knowledge has an impact on young children's reliance on humans as a base for
173 reasoning. Inagaki and Hatano (1987, 1991) find that humans serve as a privileged
174 base for property projection, but that this process is constrained by knowledge.
175 For example, properties are not projected from humans to nonhuman organisms
176 when such an inference would contradict children's knowledge of the nonhuman
177 in question. This account differs from other models of analogy in that (1) rather
178 than searching for most appropriate analogical base, a decision is made on whether
179 humans are appropriate or not, and (2) object-specific knowledge is used, not to
180 choose an appropriate analogical base, but rather to (a) judge the feasibility of the
181 already-predicted behavior, and (b) compute the organism's similarity to humans.
182 Moreover, this account differs from Carey's in that humans constitute a privileged
183 analogical base because of children's relatively rich knowledge about humans, not
184 because of the centrality of humans in children's biological theories.

185 Furthermore, Inagaki (1990) presented evidence that knowledge influences
186 children's use of biological analogy. In her study all children were asked questions
187 about observable and nonobservable properties of goldfish, asked to reason about
188 goldfish in novel situations, and asked to reason about a novel aquatic animal (a
189 frog) in similar situations. Children who were actively raising goldfish possessed
190 more knowledge about both observable and unobservable attributes of goldfish.
191 They were also more likely to make reasonable predictions about the behavior of
192 goldfish in novel situations. Most importantly, while both groups tended to analogize
193 from humans to frogs when answering questions about frogs, the goldfish
194 raisers were more likely to analogize from goldfish to frogs when answering the
195 same questions. This suggests that knowledge of goldfish enabled children who
196 were actively raising goldfish to employ goldfish as an analogical base in a way
197 that children who were not goldfish raisers could not.

198 Similar differences in knowledge and associated reasoning patterns are docu-
199 mented in another study of our research team. Atran et al. (2001) found that among
200 Yukatek Maya (southern Mexico) young girls showed less differentiation than boys
201 when the peccary was the base for induction, a pattern consistent with an effect of
202 experience or familiarity. Boys go with their fathers into the forest at an early age
203 and, therefore, are much more familiar with the peccary than are girls. In general,
204 for this rural population even the youngest children tested (4–5-year-olds) showed
205 no evidence of anthropocentrism; they generalized readily from both humans and

206 other animals as a function of biological relatedness. Note that the experiential
207 differences documented in both [Atran et al. \(2001\)](#) and [Inagaki \(1990\)](#) undermine
208 arguments about urban children being heavily exposed to and knowledgeable about
209 animals (bugs, squirrels, etc.).

210 In this study, we take the issue a step further by examining how differences
211 in experience and/or culture might lead to differences in reasoning about plants
212 and animals. Following Carey, we teach children novel properties about humans,
213 wolves, bees, goldenrod, and water, and then see whether they are willing to project
214 these new properties to an array of animals, plants, and nonliving objects. Of central
215 importance is the question of comparative development: how do experience and
216 cultural beliefs about nature affect inferences in the biological domain?

217 To address this question we examine children from three distinct populations:
218 Native American children from the Menominee Indian Tribe of Wisconsin, rural
219 majority culture children from the neighboring town of Shawano, Wisconsin, and
220 Urban children from East Boston, MA. For a number of reasons, the Menominee
221 population is of particular interest for this study. First, traditional folkbiological
222 knowledge may be especially salient to the Menominee. Unlike most woodland
223 tribes, the Menominee reservation occupies (a small fraction of) their traditional
224 range; hence, traditional knowledge of local plant and animal species is still current
225 and pertinent. Menominee harvest a wide array of forest products (such as timber,
226 firewood, ginseng, wild berries, roots, and mushrooms) and children participate
227 from an early age on in these activities. Hunting and fishing is common for children
228 of both sexes and one can frequently observe groups of children (of different ages)
229 pursuing these activities along the rivers and lakes of the reservation. Although
230 this does not preclude them from owning pets and watching television (which they
231 also do), it casts their relation with the environment in a different perspective.
232 Even the notion of “pet” likely varies across urban and rural contexts — in rural
233 Wisconsin dogs are often used in hunting and they rarely live indoors with families.
234 The Menominee tribe is well known for its record of sustainable forestry ([Hall &
235 Pecore, 1995](#)). In part, this seems to reflect a consensual folkecological model (see
236 [Medin et al., in press](#)) that stresses the importance of living kinds interacting in
237 the local environment, including interacting with humans.

238 The nearby majority culture town of Shawano provides a useful comparison
239 population. Children in Shawano grow up in a very similar physical environment,
240 also are introduced to fishing and hunting at an early age and also have a great
241 deal of first hand experience with the natural world. However, with respect to
242 the predominant adult models (the potential end product of the developmental
243 process) we still find clear cultural differences. Ecological relations are much
244 more salient and important for Menominee fishermen than for majority culture
245 fishermen ([Medin et al., 2002](#)).

246 Examining these populations allows us to examine the pervasiveness of an-
247 thropocentric origins of folkbiology, and to begin to “triangulate” with respect
248 to possible causes of conceptual differences ([Bailenson, Shum, Atran, Medin, &
249 Coley, in press; Medin et al., 2002](#)). To the degree that the two Wisconsin popu-

250 lations are similar, experience is implicated in shaping folkbiological beliefs. To
251 the degree that the rural majority culture children resemble the urban children
252 rather than the Menominee children, a role of cultural beliefs, practices and goals
253 about nature may be implicated. Distinct patterns among the three populations
254 might suggest a combination of these factors in shaping conceptual development,
255 whereas commonalities among all the groups would suggest candidates for universals
256 in development. Obviously, whatever the results are (other than universals),
257 much work remains to be done to understand the causes of these differences. How
258 are distinct cultural models learned and transmitted? What are the channels of
259 learning, and what kind of experience has what kind of effects? To tackle these
260 issues is beyond the scope of this paper. To address them we need first a clear
261 understanding of the differences and commonalities in children's development of
262 folkbiology. This issue is the main focus of what follows.

263 Our study differed from Carey's in that we included two different kinds of
264 inductive bases, goldenrod and water. We added goldenrod so that we could ex-
265 amine generalization both from animals to plants and from plants to animals. We
266 had reason to believe that Menominee children would have a broad view of living
267 kinds that includes not only plants but also natural entities such as rocks. In tra-
268 ditional Menominee culture all natural entities like rocks and water are alive (in
269 related work in progress we are systematically examining cultural differences in
270 children's conception of alive by a series of detailed probes). Our original motiva-
271 tion for including water as a base was to see if ecological relations might play some
272 role in children's inductions. Previously we had found that adults knowledgeable
273 about biology often rely on ecological reasoning strategies (López et al., 1997,
274 Proffitt, Coley, & Medin, 2000) and we were interested in whether and when such
275 strategies might appear in children's reasoning. As it turned out, however, when
276 water is a base children use a wide variety of strategies and it is difficult to draw
277 any clear conclusions. To reduce the complexity of an already complex design, we
278 do not present the results for water as a base in this paper. Nonetheless, we were
279 able to educe evidence for ecological reasoning from other bases.

280 2. Method

281 2.1. Participants

282 A total of 242 children from three distinct populations participated in the study.
283 Native American children attended Keshena Elementary in Keshena, WI, a recently
284 built school located on the Menominee Reservation. Rural children attended Lin-
285 coln Elementary School in neighboring Shawano, WI. Urban children attended the
286 Guild School located in an urban area of East Boston, MA.

287 Participants in each locale were divided into three age groups: Kindergart-
288 ners and first-graders ("young"), second- and third-graders ("middle"), and fourth-
289 graders ("old"). Details on mean ages and ranges for each population are presented

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

290 in Table 1. All children were monolingual English speakers (though Menominee
291 children typically know Menominee terms for clan animals), and were interviewed
292 individually by research assistants from their community.

293 2.2. Materials

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

303 2.3. Design

304 Children were asked about projecting unfamiliar properties from all five bases
305 to all 16 targets. Properties were the names of substances (*sacra*, *andro*, *estro*,
306 *hema*, and *gluco*) said to be found inside the base. A different property was used
307 with each base, and bases and targets were presented in a different random order
308 for each child. Most children took more than one session to finish the task.

309 2.4. Procedure

310 Children who had received parental permission were interviewed individually
311 at their school. Each child was first given two warm-up tasks. In the first, they
312 were asked to name all the plants and animals that they knew. In the second, they
313 were shown a shape and asked two questions about it. For instance, they might

314 be shown a red triangle and asked, “Is this red? Is it a square?” The object was
315 to get the child to answer both “yes” and “no” in the experimental context and to
316 minimize response biases.

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

330 Responses were scored 1 for “yes” (making the projection from base to target)
331 and 0 for “no” (declining to make the projection). Like Carey, we took property
332 projection as a measure of perceived biological affinity. The fact that we found that
333 associations may be made on the basis of either taxonomic similarity or ecological
334 relatedness poses something of an interpretative challenge.

335 3. Results

336 Each of the three study populations produced a unique profile. (Mean projec-
337 tions by base, target and age for the three groups presented in [Tables 2–4](#).) Although
338 there were a number of similarities, the clear differences undermine the idea that
339 anthropocentrism is a universal feature of folkbiological development. Below we
340 detail these results organized to address three questions: the extent to which bio-
341 logical similarity guided projections, evidence for anthropocentric reasoning, and
342 evidence for causal/ecological reasoning.

343 3.1. *Within-group differences*

344 We conducted factor analyses for each age group for each population to see
345 if we could find distinct patterns of responding within a group. The rationale for
346 this analysis is to test if one underlying model (factor) explains a large amount of
347 the variance. If this is the case, we can readily assume a general consensus among
348 the participants (see [Romney, Weller, & Batchelder, 1986](#) for the original model
349 and [Atran et al., 1999](#) for its application as a tool to explore existing consensus).
350 In almost every case a single factor solution gave a good account of the data
351 and there were no obvious subgroups. For the young urban children there was no
352 clear consensus and the second factor accounted for 12% of the variance. When we

Table 2
Summary responses of urban majority culture children

	Human	Bear	Raccoon	Eagle	Bluejay	Turtle	Gartersnake	Sturgeon	Trout	Fly	Worm	Maple	Milkweed	Rock	Pencil	Bicycle
Young																
Hum	.93	.50	.43	.57	.64	.57	.57	.36	.43	.29	.43	.43	.43	.36	.50	.43
Wolf	.21	.43	.43	.43	.50	.57	.64	.64	.36	.57	.36	.50	.43	.07	.21	.36
Bee	.50	.43	.50	.43	.29	.43	.71	.64	.64	.50	.43	.43	.57	.21	.43	.36
Goldenrod	.50	.50	.50	.43	.50	.50	.43	.43	.43	.57	.43	.64	.93	.50	.50	.36
Water	.57	.64	.50	.50	.57	.86	.86	.86	.86	.43	.57	.57	.57	.36	.36	.36
Middle																
Human	1.00	.67	.73	.67	.73	.73	.53	.47	.40	.47	.47	.47	.53	.20	.13	.07
Wolf	.33	.93	1.00	.69	.69	.69	.63	.63	.56	.50	.56	.38	.25	.13	.06	–
Bee	.31	.50	.50	.75	.56	.56	.63	.44	.44	1.00	.38	.25	.56	.06	.06	–
Goldenrod	.13	.44	.19	.38	.31	.50	.38	.31	.13	.31	.19	.81	.75	.19	.13	–
Water	.63	.25	.13	.38	.25	.80	.50	.81	.88	.13	.27	.50	.63	.13	–	.06
Old																
Human	1.00	.81	.65	.73	.77	.62	.65	.46	.62	.35	.20	.31	.23	.12	.12	–
Wolf	.35	.92	.88	.85	.69	.62	.46	.31	.38	.38	.38	.19	.04	–	–	–
Bee	.08	.62	.50	.77	.73	.46	.73	.54	.35	.96	.46	.38	.50	.08	.08	.04
Goldenrod	.12	.38	.38	.27	.38	.19	.58	.27	.35	.62	.38	.88	.96	.35	.15	–
Water	.58	.50	.35	.46	.50	.81	.46	.96	.92	.31	.42	.69	.77	.46	–	.12

Rows represent the average projection for each base according to the three age groups.

Table 3
Summary responses of rural majority culture children

	Human	Bear	Raccoon	Eagle	Bluejay	Turtle	Gartersnake	Sturgeon	Trout	Fly	Worm	Maple	Milkweed	Rock	Pencil	Bicycle
Young																
Hum	.96	.57	.46	.36	.46	.29	.25	.29	.32	.07	.29	.25	.07	.04	.04	.14
Wolf	.24	.76	.75	.45	.41	.31	.31	.28	.28	.38	.41	.17	.10	.14	.03	–
Bee	.28	.45	.31	.48	.45	.31	.34	.31	.28	.90	.24	.28	.24	.07	.03	.07
Goldenrod	.10	.24	.24	.21	.21	.14	.28	.17	.17	.24	.24	.59	.83	.10	–	.03
Water	.52	.48	.31	.31	.34	.66	.24	.66	.66	.21	.24	.17	.31	.17	.07	–
Middle																
Hum	.98	.60	.55	.40	.40	.34	.36	.34	.32	.34	.24	.14	.20	.02	.04	.02
Wolf	.16	.84	.73	.58	.52	.30	.44	.32	.28	.28	.26	.10	.18	.02	.02	–
Bee	.20	.28	.22	.36	.32	.16	.28	.14	.16	.86	.32	.22	.38	.02	.02	.02
Goldenrod	.12	.28	.22	.12	.24	.22	.40	.12	.20	.34	.34	.68	.90	.08	.06	.02
Water	.54	.50	.43	.35	.45	.67	.45	.86	.76	.22	.36	.56	.53	.29	.10	.02
Old																
Hum	1.00	.77	.83	.70	.73	.63	.53	.60	.63	.63	.40	.30	.30	.03	–	.03
Wolf	.47	.93	.90	.73	.60	.60	.53	.40	.37	.47	.24	.30	.13	.07	.03	.03
Bee	.53	.73	.40	.53	.70	.27	.50	.23	.20	.93	.33	.50	.67	–	.13	.07
Goldenrod	.30	.53	.30	.23	.41	.47	.57	.37	.30	.33	.40	.73	.90	.13	.27	.07
Water	.93	.96	.86	.75	.68	.93	.61	.89	.89	.41	.54	.79	.69	.24	.25	.07

Rows represent the average projection for each base according to the three age groups.

Table 4
Summary responses of Menominee children

	Human	Bear	Raccoon	Eagle	Bluejay	Turtle	Gartersnake	Sturgeon	Trout	Fly	Worm	Maple	Milkweed	Rock	Pencil	Bicycle
Young																
Hum	.87	.58	.58	.67	.54	.63	.54	.63	.63	.46	.46	.38	.21	.13	.04	.04
Wolf	.42	.75	.75	.71	.58	.74	.63	.50	.57	.57	.57	.46	.50	.21	.04	0
Bee	.63	.58	.54	.75	.79	.63	.71	.58	.58	.79	.46	.46	.46	.17	.08	.04
Goldenrod	.42	.46	.54	.46	.54	.42	.48	.33	.33	.29	.46	.75	.88	.21	.04	.08
Water	.46	.50	.29	.42	.33	.52	.42	.58	.67	.38	.54	.50	.63	.33	.17	.17
Middle																
Hum	.96	.71	.66	.63	.74	.74	.41	.55	.65	.55	.47	.16	.28	.10	.13	.03
Wolf	.47	.84	.81	.78	.72	.69	.66	.69	.56	.56	.47	.31	.35	.19	.13	.09
Bee	.35	.66	.45	.56	.63	.45	.53	.45	.32	.68	.44	.35	.45	.13	.16	.10
Goldenrod	.41	.44	.39	.31	.48	.48	.45	.39	.38	.41	.47	.81	1.00	.28	.19	.16
Water	.59	.44	.38	.53	.50	.68	.47	.81	.88	.34	.44	.59	.63	.38	.19	.13
Old																
Hum	.81	.81	.62	.62	.57	.57	.48	.52	.62	.48	.43	.29	.38	.24	0	.05
Wolf	.52	.95	.81	.67	.62	.48	.43	.48	.62	.52	.33	.19	.29	.05	.05	0
Bee	.38	.62	.52	.48	.57	.29	.52	.43	.43	.81	.43	.33	.52	.14	.14	.10
Goldenrod	.38	.43	.48	.33	.43	.43	.52	.33	.38	.43	.24	.76	.86	.24	.14	.05
Water	.67	.76	.57	.67	.48	.71	.33	.81	.81	.48	.38	.76	.76	.24	.05	0

Rows represent the average projection for each base according to the three age groups.

353 separated young urban children based on their second factor scores, the most salient
 354 difference was that one group tended to say yes to most of the projections and the
 355 other group tended to say no to them. Both subgroups had broad, undifferentiated
 356 generalizations. Overall, there were no salient within-group clusters and the group
 357 patterns are not artifacts of averaging over distinct sub-profiles.

358 3.2. Biological similarity as a guide to projections

359 If children have a clear notion of biological affinity, the likelihood of projec-
 360 tion should be predicted by biological similarity between base and target. We
 361 addressed this question in several ways. First, we conducted trend analyses to as-
 362 certain whether projections of properties from *human* and *wolf* showed a linear
 363 decrease in likelihood to bases in the following order: *mammals*, *birds*, *reptiles* and
 364 *fish*, *invertebrates*, and *plants*. A reliable linear trend would indicate projections
 365 based on biological similarity. *R*-squared values for the regressions, by age group
 366 and population, are presented in Table 5. Second, in order further detail the shape
 367 of these linear trends, we combined our targets into higher order categories: (1)
 368 *higher animals* (nonhuman mammals, birds, and reptiles), (2) *lower animals* (fish
 369 and invertebrates), (3) *plants*, and (4) *inanimates*. We then conducted separate 3
 370 (age group) \times 4 (target group) ANOVAs for each population exploring projections
 371 from *human* and *wolf* as a function of the phylogenetic distance from these bases
 372 to the targets. Projections based on biological similarity should show decreasing
 373 strength with phylogenetic distance from the bases; moreover, differences in pro-
 374 jection to each base group may also be informative. Third, biological similarity
 375 predicts that projections from *goldenrod* should be relatively high to plants, and
 376 higher to animals than to inanimates. Moreover, this pattern of projections from

Table 5
R-squared values for linear trend analyses of projections from *human* and *wolf*

Group	From human	From wolf
Boston		
Young	No trend	No trend
Middle	.47*	.90**
Old	.77**	.87**
Shawano		
Young	.74**	.74**
Middle	.90**	.89**
Old	.86**	.85**
Menominee		
Young	.54**	.64**
Middle	.65**	.91**
Old	.81**	.87**

Note: (*) $P < .05$, (**) $P < .001$.

377 goldenrod can also be taken as evidence for some unified concept of *living thing*
378 subsuming plants and animals. We therefore examined projections from *goldenrod*
379 using the same analysis strategy.

380 3.3. Urban children

381 Patterns of projection for young urban children differed from middle and older
382 children in several ways. First, trend analyses show no decreasing projections
383 from *human* or *wolf* as a function of phylogenetic distance (see Table 5). Young ur-
384 ban children show evidence of biological similarity only at a very gross level.
385 Projections from *human* did not differ by target; young urban children were
386 no more likely to project properties from *human* to *bear* than from *human* to
387 *rock*. However, projections from *wolf* to other animals and plants were higher
388 than to inanimates ($F(3, 39) = 4.78$, M.S.E. = .053, $P = .0062$). Also, pro-
389 jections from *goldenrod* to plants were higher than to other target categories
390 ($F(3, 39) = 5.15$, M.S.E. = .069, $P = .0043$), although this seems to be due
391 to local similarity rather than any sense of *living thing* as a coherent concept;
392 projections from plants to animals didn't differ from projections from plants to
393 inanimates.

394 In contrast, middle and older urban children both showed reliable linear trends;
395 projections decreased with decreasing biological similarity between base and target
396 (see Table 5). Moreover, projections from *human* to higher animals were stronger
397 than projections to lower animals and plants, all of which were stronger than
398 projections to inanimates ($F(3, 117) = 26.41$, M.S.E. = .083, $P < .0001$).
399 Projections from *wolf* to higher animals were stronger than projections to lower
400 animals which were stronger than projections to plants, which were stronger than
401 projections to inanimates ($F(3, 120) = 78.06$, M.S.E. = .049, $P < .0001$).
402 Projections from *goldenrod* to plants were higher than to animals, which in turn
403 were higher than to inanimates ($F(3, 120) = 58.56$, M.S.E. = .063, $P < .0001$)
404 suggesting both biological similarity and some idea of affinity between plants and
405 animals. Thus, projection patterns for middle and older urban children reflect a
406 much more refined sense of biological similarity than for younger children.

407 3.4. Rural children

408 Unlike urban children, Shawano children's projections showed linear decreases
409 with decreasing biological similarity at all ages (Table 5). Projections from *hu-*
410 *man* to higher animals were stronger than projections to lower animals which
411 were stronger than projections to plants, which were stronger than projections to
412 inanimates ($F(3, 144) = 29.16$, M.S.E. = .074, $P < .0001$). Likewise, projec-
413 tions from *wolf* decreased significantly to each increasingly distant target group
414 ($F(3, 147) = 59.88$, M.S.E. = .057, $P < .0001$). Finally, like the two older ur-
415 ban groups, projections from *goldenrod* to plants were higher than to animals,
416 which in turn were higher than to inanimates ($F(3, 147) = 79.10$, M.S.E. = .052,

417 $P < .0001$) indicating both biological similarity and some idea of affinity between
418 plants and animals. The only age difference in responses was that older children
419 were more likely to project from *goldenrod* than were middle or younger children
420 ($F(2, 147) = 4.45$, M.S.E. = .148, $P = .0167$). Thus, there is clear evidence of
421 projections based on biological similarity at all ages in the rural majority culture
422 population.

423 3.5. Menominee children

424 As with the rural majority culture children, reliable linear trends for Menominee
425 children of all ages show clear conceptions of biological affinity in their
426 projections from *human* and *wolf* (Table 5). Projections from *human* to higher
427 and lower animals were stronger than projections to plants, which were stronger
428 than projections to inanimates ($F(3, 153) = 51.09$, M.S.E. = .068, $P < .0001$).
429 Interestingly, unlike the two majority culture groups, Menominee children did not
430 differentially attribute properties from humans to higher versus lower animals.
431 This might reflect a different sense of the place of humans in the biological world.
432 Like rural children, Menominee projections from *wolf* decreased significantly
433 to each increasingly distant target group ($F(3, 153) = 43.08$, M.S.E. = .085,
434 $P < .0001$). Finally, like the older urban children and all rural groups, Menominee
435 projections from *goldenrod* to plants were higher than to animals, which in
436 turn were higher than to inanimates ($F(3, 153) = 50.20$, M.S.E. = .068, $P < .0001$).
437 The only age difference in responses was that older children were more
438 likely to project from *human* than were middle or younger children ($F(2, 153) = 5.03$,
439 M.S.E. = .165, $P = .0101$). Thus, there is clear evidence of projections
440 based on a refined sense of biological similarity at all ages among Menominee
441 children.

442 Another notable trend, most evident in the children's justifications, is that
443 Menominee children often made inferences in terms of ecological relations. All
444 age groups showed a propensity for generalizing from bees to bears and they often
445 mentioned that a bee might sting a bear or that a bear would eat honey. These sorts
446 of justifications only appeared in older rural majority culture children and not at
447 all with the urban children.

448 3.6. Summary

449 Biological similarity guided the projections of middle and older urban children,
450 and of all age groups of rural and Menominee children. Likewise, stronger projec-
451 tions from *goldenrod* to animals versus inanimates suggests some unified concept
452 of living thing in all of these groups. Young urban children showed evidence of
453 biological similarity only at a very gross level; indeed, examination of Appendix
454 A suggests a largely indiscriminate pattern of projection for this group. In contrast,
455 young rural and Menominee children show clear evidence of a differentiated sense
456 of biological similarity. Finally, Menominee children were just as likely to project

457 properties from human to lower animals as to higher animals, which may reflect a
458 greater perceived intimacy between humans and nonhuman animals.

459 3.7. Anthropocentrism

460 An anthropocentric folkbiological predicts that, on average, projections from
461 humans — the central exemplar of *living thing* — should be stronger than projec-
462 tions from other living things. To examine this, we compare average projections
463 from *human*, *wolf*, *bee*, and *goldenrod* to all targets. Furthermore, according to
464 Carey, children’s anthropocentric folkbiology leads to asymmetries in projection
465 favoring humans. To measure asymmetries in projection, for each child the average
466 of projections from *human* to mammal, insect, and plant targets was calculated, as
467 was the average of projections from *wolf*, *bee*, and *goldenrod* to *human*. If asym-
468 metries exist, then average projections from *human* to specific targets should be
469 higher than average projections from related bases to human targets. Our three
470 populations showed clear differences in the presence and developmental course of
471 anthropocentric reasoning.

472 3.8. Urban children

473 The urban sample showed mixed evidence of anthropocentric reasoning. Each
474 age group showed a different pattern of overall projections from the four living
475 bases, although contrary to the anthropocentric prediction, humans did not emerge
476 as privileged. For younger children, there were no differences between average
477 projections ($F(3, 39) = 1.18$, M.S.E. = .034, $P = .330$). Remember, however,
478 that their projections were broad and indiscriminate. For the middle age group,
479 projections from *human*, *wolf*, and *bee* did not differ from each other, but all
480 were stronger than projections from *goldenrod* ($F(3, 42) = 8.46$, M.S.E. = .013,
481 $P = .0002$). For older children, projections from *human* were only marginally
482 stronger than projections from *goldenrod*; projections from *wolf* and *bee* differed
483 from neither ($F(3, 75) = 2.58$, M.S.E. = .013, $P = .059$).

484 In contrast, both the middle and older urban children show clear asymmetries
485 in their projections. To test for asymmetries, mean projections from *wolf*, *bee*,
486 and *goldenrod* to human were subtracted from mean projections from *human* to
487 mammals, insects, and plants. Higher values represent stronger anthropocentric
488 asymmetries in projection. One-tailed t -tests were used to compare these difference
489 scores to zero for each age group. Although young urban children showed no
490 asymmetries, middle ($M = .289$, $t(14) = 5.77$, $P < .0001$) and older ($M =$
491 $.250$, $t(25) = 4.02$, $P = .0002$) urban children clearly favored projections from
492 humans over projections to humans. The lack of asymmetries in the youngest
493 urban group may be a byproduct of their relative lack of systematic projections
494 over these stimuli; we return to this point in [Section 4](#). Results for the older groups
495 are consistent with Carey’s predictions about anthropocentric folkbiology. It is
496 interesting to note, however, that in our urban population there was no reduction in

497 asymmetries over time; the pattern was as strongly evident among fourth graders
498 as among second graders.

499 3.9. Rural children

500 The rural, majority culture sample also showed mixed evidence of anthro-
501 pocentric reasoning. Age groups did not differ in overall patterns of projections
502 from the four living bases; no differences between average projections emerged
503 ($F(3, 144) = .25$, M.S.E. = .023, $P = .8596$). Some anthropocentric asym-
504 metries were evident, although the differences were smaller than for the urban
505 children, and asymmetries weakened and disappeared among older rural chil-
506 dren. Specifically, young rural children showed reliable asymmetries ($M = .167$,
507 $t(15) = 1.91$, $P = .0379$), middle children showed marginal asymmetries ($M =$
508 $.136$, $t(21) = 1.71$, $P = .0506$) and older rural children showed no asymmetries at
509 all. Like the urban children, rural children show some evidence of anthropocentric
510 reasoning, but in striking contrast to urban children, anthropocentrism declines
511 over time.

512 3.10. Menominee children

513 Menominee children showed virtually no evidence of anthropocentric reason-
514 ing. Like the urban, majority culture group, all age groups projected equally from
515 the four living bases ($F(3, 153) = .79$, M.S.E. = .041, $P = .5001$). Unlike
516 the other groups, Menominee young and middle age groups showed no anthro-
517 pocentric asymmetries. Interestingly, older Menominee children did show reliable
518 anthropocentric asymmetries ($M = .238$, $t(13) = 2.74$, $P = .0084$). This, how-
519 ever, is the only evidence of anthropocentric reasoning to emerge from Menominee
520 children.

521 3.11. Summary

522 The three populations show distinct developmental trajectories with regards to
523 anthropocentric reasoning. For the urban population, anthropocentric reasoning
524 seems to accompany increasingly organized folk biological projections, and re-
525 mains strong in 10-year-olds. For the rural population, anthropocentric reasoning
526 is present early on, but is waning in 8-year-olds and disappears altogether in older
527 group. For Menominee children, there is almost no evidence of anthropocentric
528 reasoning at all.

529 3.12. Ecological reasoning

530 By ecological reasoning we refer to cases in which the inductive reasoning
531 of the children is not based on biological similarity but on a relation the two
532 species entertain. An example for the former would be that A and B share a

533 property because they are both mammals. An example for the latter would be
534 that A (bees) and B (bears) share a property because bears eat honey or bees sting
535 bears. Obviously, the two reasoning strategies are distinct and one might argue that
536 ecological reasoning has to be grounded in more specific knowledge. Our stimuli
537 were not designed to measure ecological reasoning. However, other results (e.g.,
538 López et al., 1997; Medin et al., 2002; Proffitt et al., 2000) give us reason to ask
539 whether culture and/or experience may heighten the salience of causal/ecological
540 relations as a basis for inductive projection, especially in rural and Native American
541 children.

542 We have already mentioned that the Menominee children tended to give eco-
543 logical justifications for inferences from bees to bears. We also find some evidence
544 that the rural majority culture children show ecological reasoning in the projection
545 task. In particular, human interaction with fish and the ecological role of bees seem
546 to be salient knowledge for both of our older rural samples. Consider, for example,
547 projections from bees to humans, bee to bears and from bee to plants. Between the
548 middle and old group of rural majority culture children, the proportions increase
549 from .20, .28 and .30, respectively to .53, .73 and .58. The corresponding propor-
550 tions for the urban middle and old groups of children go from .31, .50 and .40 to
551 .08, .62, and .44. A three (item) by two (age) by two (location) ANOVA revealed
552 a reliable interaction of age and location ($F = 15.5$, M.S.E. = 2.8, $df = 1, 354$,
553 $P = .000$). A common justification for the rural children is that bees might sting
554 or that bears eat honey. Projections from goldenrod to animals also demonstrate a
555 clear increase not seen in urban children. In brief, rural majority culture children
556 not only make inductions based on biological affinity from an early age; but older
557 children also show ecological sensitivity not present in urban children. As noted
558 before, we find the same sensitivity to ecological factors among even younger
559 Menominee children tested.

560 4. General discussion

561 The background for this study was the question of whether an anthropocentric
562 folkbiology would inform reasoning as had been found in previous work with
563 urban populations (e.g., Carey, 1985). However, against the backdrop of studies
564 with adults (Bailenson et al., in press; López et al., 1997; Medin et al., 2002) and
565 Yukatek Maya children (Atran et al., 2001), we expected to find both cultural and
566 experiential differences in the development of folkbiological knowledge. Testing
567 urban majority culture children, rural majority culture children, and rural Native
568 American (Menominee) children, we observed three distinct developmental tra-
569 jectories.

570 *Urban majority-culture children* show a clear development from largely un-
571 differentiated projections to similarity-based patterns of projection. For the two
572 groups of older children we find clear asymmetries in their projections (with
573 stronger projections from humans than to humans). However, humans do not

574 emerge as privileged or prototypical animals, nor are they seen as one animal
575 among many. Instead, it appears that humans are seen as atypical animals and
576 justifications for not generalizing from some animal to humans tend to appeal to
577 the claim that humans are not animals (see also [Johnson et al., 1992](#) who report
578 related findings).

579 *Rural majority-culture children* exhibited a clear pattern for reasoning in terms
580 of biological affinity even at the youngest age tested. Asymmetries between humans
581 and other animals found among the youngest children tend to disappear with
582 development. Furthermore, rural majority children show a developing sensitivity
583 to ecological relations not observed among urban children.

584 *Menominee children* provide yet a third profile. The youngest children show
585 broad, similarity-based projection from the four living bases, and exhibit signs
586 of clear ecological reasoning. These trends did not appear to change much with
587 age and none of the age groups showed asymmetries in their projections between
588 humans and other animals.

589 In a sense we expected this precocious ecological responding among Menomi-
590 nee children given the adult data cited earlier ([Medin et al., 2002](#)) suggesting that
591 Menominee fishing experts pay much more attention to ecological relations than
592 do their majority culture counterparts. Although we expect that this cultural differ-
593 ence in “habits of the mind” is passed on to children, we are only now beginning
594 to explore the social channels and cognitive mechanisms of cultural transmission
595 ([Atran et al., 2002](#); [Medin et al., 2002](#)).

596 These findings undermine the universality of Carey’s claim of an anthropocentric
597 development of folkbiological thought. Evidence seems to point at anthro-
598 pocentrism as being largely an effect of the lack of relevant knowledge about
599 the environment. Hence, with an increase of knowledge of biological affinity and
600 ecological relations, anthropocentrism disappears. The only exceptions are urban
601 children. The lack of knowledge among the younger children of this group seems
602 to inhibit any kind of patterned reasoning about plants and animals. It is logically
603 possible that our rural populations (both Menominee and majority culture) are sim-
604 ply advanced in their development and passed through the anthropomorphic stage
605 at an earlier age compared to their rural counterparts. However, there is no empir-
606 ical support for such an assumption. Even 4–5-year-old Yukatec Maya children in
607 Mexico fail to show evidence for an anthropomorphic folkbiology (see [Atran et al.,](#)
608 [2001](#)). Furthermore, later aspects of the developmental trajectories (both within
609 our data and looking at adults) do not coincide across the three groups. This means
610 that there is no compelling reason to entertain the idea of parallel developmental
611 processes.

612 It is important to note that it appears to be the lack of knowledge among young ur-
613 ban children that drives their anthropocentric understanding of folkbiology. Given
614 that we do not find any evidence among children with greater knowledge of the
615 natural environment, the data seem to reflect the fact that urban children use a
616 readily accessible cognitive heuristic that compensates for the lack of sustained
617 contact and interaction with local biodiversity. This readily accessible crutch can

618 be discarded once a certain level of biological awareness and competence has been
619 achieved, leading to the conceptual shift described by Susan Carey. This interpreta-
620 tion is bolstered by two findings. First, it has been documented that western
621 societies since the industrial revolution have indeed steadily lost intimacy and
622 knowledge with respect to local biota (Wolff et al., 1999). Second, studies with
623 Maya children in Yucatan, Mexico, showed gender effects caused by differences
624 in expertise (Atran et al., 2001).

625 The data suggest two future avenues for further work. First, plan to look at
626 exotic species, like those found in zoos, in order to test the role of familiarity with
627 the species. On some grounds one might expect that urban children would fare
628 better as they may be more familiar with exotic species than native animals. Rural
629 children have much less experience with exotic species but, based on Inagaki's
630 (1990) findings on children's ability to use their knowledge about certain species
631 to reason about others, we do not expect different results in rural children. Second,
632 it remains somewhat unclear why Menominee and rural majority culture children
633 differ from one another. Here we will have to isolate these differences and look at
634 the cultural contexts of learning about biology in order to understand the emergence
635 of these different patterns.

636 Finally, it is of considerable practical interest to understand whether and how
637 these group differences carry over to and influence learning in the classroom. It is
638 interesting to consider how one might take advantage of the relative precocity of
639 the rural children (especially the Menominee children), or how one might remedy
640 the relatively impoverished experience of the urban children.

641 5. Conclusion

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

650 One way to capture the difference between the two rural groups is to argue that
651 Menominee children's patterns of folkbiological reasoning reflect a framework
652 where ecological reasoning, the relations between species — including humans —
653 is very salient. Some evidence for such a view comes from studies with Menominee
654 and majority culture fish experts (Medin et al., 2002). Majority culture experts show
655 a clear influence of goal orientation in the ways they perceive local fish while
656 Menominee experts pay more attention to ecological features. Goal orientation,
657 however, is another way to put human beings in the center of the perspective —
658 as different from animals.

659 Both culture and experience play an important role in the development of folk-
660 biological knowledge. We think that analyzing cognitive development in terms
661 of domain-specificity is a very fruitful strategy. Nonetheless, given our results, it
662 seems hazardous to develop universal generalizations on the basis of data from
663 children from populations where both cultural support for, and direct experience
664 with, nature is generally impoverished.

665 The novel empirical implication in this regard is that relative expertise and
666 interaction, rather than mere exposure and observation, with respect to natural
667 biodiversity may be the default condition for most human groups (and perhaps
668 for ancestral humanity). From a theoretical perspective, then, the chief interest
669 (other than mere convenience) in studying “standard groups,” such as urbanized
670 children in and around major western research institutions, may not be to establish
671 a baseline for generalizations about folkbiological knowledge, but to explore the
672 cognitive consequences of limited input and devolutionary cultural processes on
673 theory building in an impoverished environment.

674 **Uncited references**

675 [Anglin \(1970\)](#), [Hirschfeld and Gelman \(1994\)](#), [Ross \(2002b\)](#), and [Sperber et al.](#)
676 [\(1995\)](#).

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687 **References**

- 688 Anglin, J. (1970). *The growth of word meaning*. Cambridge, MA: MIT Press.
689 Atran, S., Medin, D., Ross, N., Lynch, E., Coley, J., Ucan Ek', E., & Vapnarsky, V. (1999). Folkecology
690 and commons management in the Maya Lowlands. *Proceedings of the National Academy of Science*,
691 96, 7598–7603.
692 Atran, S., Medin, D. L., Lynch, E., Vapnarsky, V., Ucan Ek', E., & Sousa, P. (2001). Folkbiology
693 doesn't come from folkpsychology: Evidence from Yukatek Maya in cross-cultural perspective.
694 *Journal of Cognition and Culture*, 1, 3–43.

- 695 Atran, S., Medin, D., Ross, N., Lynch, E., Vapnarsky, V., Ucan Ek', E., Coley, J., Timura, C., & Baran,
696 M. (2002). Folk ecology, cultural epidemiology, and the spirit of the commons. A garden experiment
697 in the Maya Lowlands, 1991–2001. *Current Anthropology*, 43(3), 1–23.
- 698 Au, T. K., & Romo, L. F. (1999). Mechanical causality in children's "folkbiology." In D. L. Medin &
699 S. Atran (Eds.), *Folkbiology*. Cambridge, MA: MIT Press.
- 700 Bailenson, J., Shum, M., Atran, S., Medin, D., & Coley, J. (in press). A bird's eye view: Triangulating
701 biological categorization and reasoning within and across cultures and expertise levels. *Cognition*.
- 702 Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.
- 703 Carey, S. (1995). On the origin of causal understanding. In D. Sperber, D. Premack, & A. J. Premack
704 (Eds.), *Causal cognition: A multidisciplinary debate*. New York: Oxford University Press.
- 705 Carey, S. (1999). Sources of conceptual change. In E. Scholnick, K. Nelson, S. Gelman, & P. Miller
706 (Eds.), *Conceptual development: Piaget's legacy*. Mahwah, NJ: Erlbaum.
- 707 Coley, J. (1995). Emerging differentiation of folkbiology and folkpsychology: Attributions of biological
708 and psychological properties to living things. *Child Development*, 66, 1856–1874.
- 709 Coley, J. (2000). On the importance of comparative research: The case of folkbiology. *Child
710 Development Special Issue*, 71(1), 82–90.
- 711 Coley, J. D., Medin, D. L., Proffitt, J. B., Lynch, E. B., & Atran, S. (1999). Inductive reasoning in
712 folkbiological thought. In D. L. Medin & S. Atran (Eds.), *Folkbiology*. Cambridge, MA: MIT
713 Press.
- 714 Dougherty, J. W. (1978). Salience and relativity in classification. *American Ethnologist*, 5, 66–80.
- 715 Gelman, S., & Hirschfeld, L. (1999). How biological is essentialism. In D. Medin & S. Atran (Eds.),
716 *Folkbiology*. Cambridge, MA: MIT Press.
- 717 Gelman, S., & Wellman, H. M. (1991). Insides and essences: Early understandings of the nonobvious.
718 *Cognition*, 38, 213–244.
- 719 Gutheil, G., Vera, A., & Keil, F. (1998). Do houseflies think? Patterns of induction and biological
720 beliefs in development. *Cognition*, 66, 33–49.
- 721 Hall & Pecore. (1995). *Case study: Menominee tribal enterprises*. Madison, WI: Institute for
722 Environmental Studies and the Land Tenure Center, University of Wisconsin-Madison.
- 723 Hatano, G., & Inagaki, K. (1994). Young children's naive theory of biology. *Cognition*, 50, 171–188.
- 724 Hatano, G., & Inagaki, K. (1999). A developmental perspective on informal biology. In D. L. Medin
725 & S. Atran (Eds.), *Folkbiology*. Cambridge, MA: MIT Press.
- 726 Hickling, A. K., & Gelman, S. A. (1995). How does your garden grow? Early conceptualization of
727 seeds and their place in the plant growth cycle. *Child Development*, 66, 856–876.
- 728 Hirschfeld, L., & Gelman, S. (1994). What young children think about the relation between language
729 variation and social difference. *Cognitive Development*, 12, 213–238.
- 730 Inagaki, K. (1990). The effects of raising animals on children's biological knowledge. *British Journal
731 of Developmental Psychology*, 8, 119–129.
- 732 Inagaki, K., & Hatano, G. (1987). Young children's spontaneous personification as analogy. *Child
733 Development*, 58, 1013–1020.
- 734 Inagaki, K., & Hatano, G. (1991). Constrained person analogy in young children's biological inference.
735 *Cognitive Development*, 6, 219–231.
- 736 Johnson, S., & Carey, S. (1998). Knowledge enrichment and conceptual change in folkbiology:
737 Evidence from people with Williams Syndrome. *Cognitive Psychology*, 37, 156–200.
- 738 Johnson, K. E., Mervis, C. B., & Boster, J. S. (1992). Developmental changes within the structure of
739 the mammal domain. *Developmental Psychology*, 28, 74–83.
- 740 Keil, F. C. (1989). *Concepts, kinds, and cognitive development*. Cambridge, MA: MIT Press.
- 741 López, A., Atran, S., Coley, J. D., Medin, D. L., & Smith, E. (1997). The tree of life: Universal and
742 cultural features of folkbiological taxonomies and inductions. *Cognitive Psychology*, 32, 251–295.
- 743 Medin, D., & Atran, S. (1999). Introduction. *Folkbiology*. Cambridge, MA: MIT Press.
- 744 Medin, D. L., Lynch, E., Coley, J., & Atran, S. (1997). Categorization and reasoning among expert
745 populations: Do all roads lead to Rome? *Cognitive Psychology*, 32, 49–96.
- 746 Medin, D., Lynch, E., & Solomon, K. (2000). Are there kinds of concepts. *Annual Review of Psychology*,
747 51, 121–147.

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23

- 748 Medin, D., Ross, N., Atran, S., Burnett, R., Blok, S. (2002). Categorization and reasoning in relation
749 to culture and expertise. *The psychology of learning and motivation* (Vol. 41, pp. 1–41). New York:
750 Academic Press.
- 751 Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. *Psychological*
752 *Review*, 92, 289–316.
- 753 Proffitt, J., Coley, J., & Medin, D. (2000). Expertise and category-based induction. *Journal of*
754 *Experimental Psychology: Learning, Memory and Cognition*, 25, 811–828.
- 755 Osherson, D. N., Smith, E. E., Wilkie, O., López, A., & Shafir, E. (1990). Category-based induction.
756 *Psychological Review*, 97, 185–200.
- 757 Rips, L. (1975). Inductive judgments about natural categories. *Journal of Verbal Learning and Verbal*
758 *Behavior*, 14, 665–681.
- 759 Romney, A. K., Weller, S., & Batchelder, W. (1986). Culture as consensus: A theory of culture and
760 informant accuracy. *American Anthropologist*, 88, 313–338.
- 761 Ross, N. (2002a). Lacandon Maya intergenerational change and the erosion of folkbiological
762 knowledge. In J. R. Stepp, F. S. Wyndham, & R. K. Zarger (Eds.), *Ethnobiology and biocultural*
763 *diversity* (pp. 585–592). University of Georgia Press.
- 764 Ross, N. (2002b). Cognitive aspects of intergenerational change: Mental models, cultural change and
765 environmental behavior among the Lacandon Maya of Southern Mexico. *Human Organization*,
766 61(2), 125–138.
- 767 Solomon, G. E. A., Johnson, S. C., Zaitchik, D., & Carey, S. (1996). Like father, like son: Young
768 children's understanding of how and why offspring resemble their parents. *Child Development*, 67,
769 151–171.
- 770 Sperber, D., Premack, D., & Premack, A. (Eds.). (1995). *Causal cognition: A multidisciplinary debate*.
771 New York: Oxford University Press.
- 772 Stross, B. (1973). Acquisition of botanical terminology by Tzeltal Children. In M. S. Edmonson (Ed.),
773 *Meaning in Mayan languages*. The Hague: Mouton and Co.
- 774 Wellman, H. M., & Gelman, S. A. (1992). Cognitive development: Foundational theories of core
775 domains. *Annual Review of Psychology*, 43, 337–375.
- 776 Wellman, H. M., & Inagaki, K. (Eds.). (1997). The emergence of core domains of thought: Children's
777 reasoning about physical, psychological and biological phenomenon. *New Directions for Child*
778 *Development*, 75.
- 779 Wolff, P., Medin, D., & Pankratz, C. (1999). Evolution and devolution of folkbiological knowledge.
780 *Cognition*, 73, 177–204.