

Chapter 6

**ONE ANIMAL AMONG MANY?
CHILDREN'S UNDERSTANDING OF
THE RELATION BETWEEN HUMANS
AND NONHUMAN ANIMALS**

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ABSTRACT

How do children come to understand the relation between human and nonhuman animals? This relation is central to endeavors as diverse as scientific reasoning and spiritual practice. Recent evidence reveals that young children appreciate each of the two concepts – human and non-human animal. Yet it remains unclear whether they also appreciate that humans are indeed part of the animal kingdom. In this study, we adopt a cross-cultural, developmental perspective to examine children's interpretation of fundamental biological concepts, focusing on children from three distinctly different US communities (urban European Americans; rural European Americans and rural Native Americans (Menominee) living on ancestral tribal lands) that vary in their habitual contact with the natural world and in their cultural perspective on the human-nonhuman animal relation. Using structured interviews, we trace 160 children's understanding of concepts including 'human,' 'mammal,' and 'animal', and the relations among them. We include 5- to 6-year-olds (who have had relatively little formal science education) and 9- to 10-year-olds (who are well into a Western-science curriculum). The results reveal a surprising convergence across all communities: At both ages, children in all communities largely deny that humans are animals. The younger children strictly maintain the uniqueness of humans; the older children accept that humans are mammals (and that mammals are animals) but nonetheless deny that humans are animals. The implications of this finding for our understanding of early cognitive and language development, early

reasoning about biological phenomena, and early understanding of religious or spiritual practices are discussed.

INTRODUCTION

Despite decades of research, questions remain concerning the way(s) in which young children understand the biological relation between human and nonhuman animals. On one hand, there is considerable evidence that even in the preschool years, children appreciate that humans and non-human animals alike share certain fundamental biological processes (including birth, growth and death) and biological requirements (including air, water and food) (Anggoro, Waxman, & Medin, 2008; Backscheider, Schatz, & Gelman, 1993; Hatano, Siegler, Richards, Inagaki, Stavy & Wax, 1993; Inagaki & Hatano, 1996; Leddon, Waxman, & Medin, 2008; Opfer & Siegler, 2004; Springer & Keil, 1989, 1991; Waxman, 2005). Indeed, even infants are sensitive to commonalities shared by humans and non-human animals (e.g., that they are agents, that they engage in biological motion) and distinguish animate objects (humans and non-human animals) from inanimates (Berthenthal, 1993; Carey, Diamond, & Woods, 1980; R. Gelman, 1990; R. Gelman, Durgin, & Kaufman, 1995; S. Gelman & Gottfried, 1996; Johnson, Slaughter, & Carey, 1998; Opfer, 2002; Opfer & S. Gelman, 2001; Poulin-Dubois & Shultz, 1990; Woodward, 1999; Woodward, Sommerville, & Guajardo, 2001).

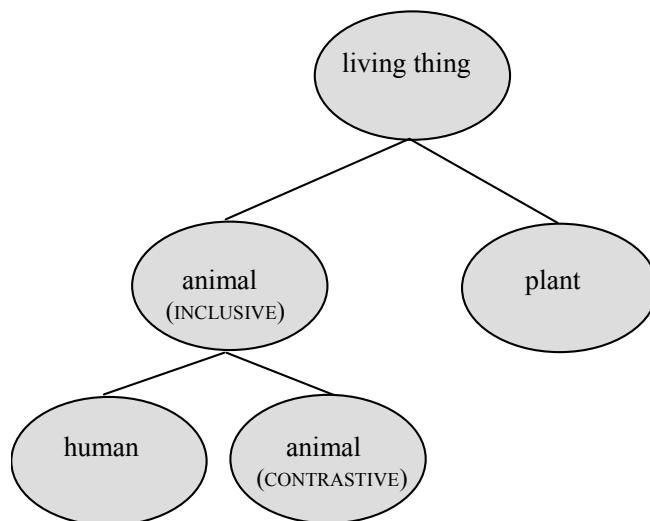


Figure 1. Schematic of the conceptual hierarchy containing living things. Note that the concept *mammal* intervenes between *animal_{inclusive}* and *animal_{contrastive}*, encompassing humans and a subset of *animal_{contrastive}* (namely, nonhuman mammals).

At the same time, however, there is also strong evidence that most children have difficulty incorporating humans into the same category as non-human animals (e.g., Anggoro, Medin, & Waxman, 2010; Carey, 1985, 1995; Herrmann, Waxman, & Medin, 2010; Herrmann, Medin, & Waxman, 2011). In a striking demonstration of this phenomenon, researchers have presented children (from several different linguistic and cultural

communities) with a picture of a human and asked ‘Could this (the human) be called an animal?’ English-speaking children, ranging from 6 to 9 years of age, agreed that the human was an animal less than 30% of the time (Anggoro, Waxman, & Medin, 2008). Converging evidence reveals that children’s failure to accept that the word ‘animal’ applies to humans persists well beyond the elementary school years. Indeed, at 14 years of age, only 2 out of 3 children in one study agreed that humans are animals (Bell & Barker, 1982). Clearly, then, the ability to incorporate humans into an overarching category called ‘animal’ is far from universal, even at age 14.

This tension about the place of humans – as members of the animal kingdom, yet simultaneously set apart from it – is also reflected in the English language. There are (at least) two senses of the word ‘animal’: one that encompasses both humans and nonhuman animals (*animal_{inclusive}*) and another that includes only nonhuman animals (*animal_{contrastive}*)¹. See Figure 1.

The polysemy of ‘animal’, and the fact that its two meanings correspond to nested concepts in an inclusion hierarchy, has been proposed to present to young children a distinct challenge in the process of developing fundamental biological concepts (Anggoro, Waxman, & Medin, 2008; Waxman, 2005). And while it is almost certainly the case that children understand ‘animal’ to refer to nonhuman animals (as a label for *animal_{contrastive}*), it remains an open question whether they can also map this term to a concept that includes humans (as a label for *animal_{inclusive}*).

This is an important question, because developing a scientific understanding of humans as biological entities requires students to appreciate the commonalities that humans and nonhuman animals share as ‘animals’. Thus clarifying children’s interpretation of this term may provide a window into their understanding of the relations between humans and nonhuman animals.

Of course, children’s tendency to group humans and nonhuman animals together in a larger overarching concept *animal_{inclusive}*, may vary as a function of their experience. Previous studies suggest that the development of biological concepts is influenced by the forms of contact children have with the natural world (Atran, Medin, Lynch, Vapnarsky, Ucan Ek', & Sousa, 2001; Proffitt, Coley, & Medin, 2000; Ross, Medin, Coley, & Atran, 2003; Waxman & Medin, 2007), and is also influenced by the belief systems of children’s communities (Astuti, Solomon, & Carey, 2004; Atran & Medin, 2007; Bang, Medin, & Atran, 2007; Medin, Ross, Atran, Cox, Coley, Proffitt, & Blok, 2006; Waxman & Medin, 2007; Waxman, Medin, & Ross, 2007).

In particular, recent work shows that urban children (as compared to their rural counterparts) demonstrate a greater tendency to base their reasoning about nonhuman animals on humans (demonstrating anthropocentric reasoning) (Medin, et al., 2010; Waxman & Medin, 2007; Ross, Medin, Coley, & Atran, 2003), and that urban 5-year-olds demonstrate more anthropocentric reasoning than 3-year-olds (Hermann, Waxman, & Medin, 2010).

The ways that children reason based on humans versus nonhuman animals has also been shown to vary across cultural communities, in particular, across rural European-American and rural Native American children (Medin, Waxman, Woodring, & Washinawatok, 2010). This fact -- that rural children, and rural Native American children in particular, are *less* inclined

¹ Throughout, we will distinguish words from the concepts they refer to by putting words in quotes, and concepts in italics.

than their urban counterparts to privilege humans as an inductive base for reasoning about other animals -- begs the question of other potential differences in their understanding of the human-nonhuman animal relationship more generally.

In the current study, we trace children's understanding of the relation between humans and nonhuman animals, focusing specifically on their interpretation of the word 'animal', and whether they map it to the concept *animal*_{inclusive}. We adopt a cross-cultural, developmental perspective to examine children's interpretation of fundamental biological concepts, focusing on children from three distinctly different US communities. First, we consider children from three distinct US populations (urban European Americans; rural European Americans, and rural Native Americans (Menominee) living on ancestral tribal lands) that vary in their forms of habitual contact with the natural world and in their cultural perspective on the human-nonhuman animal relation. Second, we trace how children's understanding changes over the primary school years, examining 5- to 6-year-olds who have had relatively little formal science education, and 9- to 10-year-olds, who are well into the science curriculum. Finally, we examine an intriguing possibility: that the concept *mammal* serves as an entry point toward discovering that humans are indeed animals (Coley, 2007; Johnson, Mervis, & Boster, 1992).

On this view, it is by learning that humans are mammals that children begin to understand that humans, too, are one species of animal amongst many. If correct, children who accept that humans are mammals should also be more likely to accept that human are animals, and demonstrate knowledge of the *animal*_{inclusive} sense of "animal".

To address these questions, we move beyond the standard object categorization tasks, which have previously dominated research in this arena, to elicit children's reasoning about the concepts *human*, *mammal*, and *animal*. We probe their interpretation of the words that describe these fundamental concepts, and examine their explanations of the relations among them. In doing so, we show how the explanations children provide amplify our understanding of their developing knowledge of these fundamental biological concepts. (See Wellman, 2011 for discussion about the importance of examining children's explanations).

EXPERIMENT

Our goal was to unveil whether young children in three distinct US communities extend the term 'animal' to include humans, how their understanding of this key term evolves over the primary school years, and how it is impacted by the acquisition of the related concept *mammal*. We developed a task, modeled after the Truth Value Judgment Task (Crain & McKee, 1985) and Piaget's structured interviews (e.g. Piaget, 1929). In this task, children are engaged in a series of probes, introduced within a playful context in which children were enlisted to help a puppet who 'has a lot of questions'. This permitted us to gather both forced choice judgments as well as more extensive, explicit justifications from children.

METHOD

Participants

We recruited 5- to 6-year-old and 9- to 10-year-old participants ($n = 160$) from three distinct US communities: a rural European-American community (Shawano, WI); a rural Native American Community (the Menominee Indian Reservation adjacent to Shawano County); and an urban, racially diverse community (Chicago, IL). The contrast between the rural and urban communities allowed us to consider the influence of forms of experience with the natural world on children's reasoning; the contrast between the rural European American and rural Native American communities allowed us to consider the influence of cultural orientations towards the relationship between humans and nonhuman animals. Trained experimenters from each of these communities interviewed children in their respective locations.

Rural European-American Community

Shawano county is a predominantly rural area in northern Wisconsin encompassing farmland, small forest plots (typically 40-80 acres), and numerous lakes and rivers. Members of this community tend to spend quite a bit of time outdoors: hunting, fishing, water recreation in the summer, and snow-mobiling in the woods in the winter are popular activities for adults and children.

Children were recruited from public elementary schools in Shawano. Sixty children participated: 26 5- to 6-year-olds ($M = 5.84$, $SD = .15$; 13 female), and 34 9- to 10-year-olds ($M = 10.05$, $SD = .41$; 20 female).

Rural Native American Community

The Menominee ('Wild Rice People') are the oldest continuous group of residents of Wisconsin. Four thousand to 5,000 Menominee live on heavily forested tribal lands in Wisconsin. Members of this community also tend to spend much time outdoors: hunting and fishing are important activities for most adult males and for many females and children. In the Menominee creation story, humans come from certain nonhuman animals, which form the basis for 5 major clans (bear, thunder/eagle, wolf, moose, and crane). Even young children are familiar with the clan system.

Children were recruited through Keshena Primary School (KPS) on the Menominee reservation. At least 99% of children attending KPS are American Indian/Alaska Native, and the majority of these children are formally enrolled as Menominee Tribal members². Children in this community are typically monolingual English speakers: although they have learned some of the Menominee language (e.g., greetings, names for clan animals), they are not fluent. English is spoken in their homes. Fifty-four children participated: 31 5- to 6-year-olds ($M = 6.31$, $SD = .31$; 15 female), and 23 9- to 10-year-olds ($M = 9.80$, $SD = .59$; 16 female).

² To enroll as a Menominee Tribal member, one must be able to establish at least 25% Menominee lineage. In 2004, 77% of children aged 5-9 living on the Menominee reservation were enrolled Menominee (Menominee Indian Tribe of Wisconsin, 2004).

Urban Community

Urban participants were recruited from a large public magnet school in Chicago, IL. This school draws students from across the city to achieve a racial and ethnic diversity that goes beyond that typically found in neighborhood schools (it does not select for particular aptitudes (e.g. math, performance arts)). The student population in 2009 was roughly 41% African-American, 19% Hispanic, 17% White, 13% Asian, 9% Multi-Racial, and 1% Native American. There is considerably less participation in outdoor or nature-oriented activities in this urban sample as compared to the two rural samples. Forty-six children participated: 24 5- to 6-year-olds ($M = 5.73$, $SD = .2$; 14 female), and 22 9- to 10-year-olds ($M = 9.89$, $SD = .26$; 11 female).

Procedure

The task was administered in a quiet room on the child's school premises. To begin, the experimenter would introduce the puppet, a doll named Sara, who would guide them through the task. The experimenter would say to the child: 'I'd like to introduce you to my friend, Sara (a doll). Sara is really little, and is just learning about things. She needs your help to learn more! So I'll tell you what we're going to do. Sara is going to tell us some things that she thinks. Sometimes she'll be right, and sometimes she'll be wrong. It is your job to decide if she's right or if she's wrong, and to help her learn. Remember that she really wants to learn, so you'll have to be careful to teach her and explain to her why she is right or wrong!' To keep the task consistent across participants, Sara was used even with children in the older age group. These children were told that the game was sometimes played with younger children, which was why the doll was being used.

After being introduced to the doll, children would hear a series of 30 statements. For each, children were asked first whether Sara was right or wrong; they then were asked to provide justifications. To limit the length of the task, we did not insist on justifications for every statement. However, we did prompt children consistently for justifications on key statements, particularly the target items concerning the relation between humans and non-human animals.

Items

The task included three distinct types of items. See Appendix A³.

- (1) *Filler items* (e.g., 'Cows eat grass,' 'Trees can walk') were included to maintain children's interest and to mask the focus of our investigation. These were constructed in such a way as to elicit both 'yes' and 'no' responses.
- (2) *Benchmark items* (e.g., 'X's are alive'; X's are animals') were included to establish that performance in the current task converges with evidence from prior investigations.

³ To maintain a focus on the relation between humans and nonhuman animals, we did not analyse items pertaining to plants or nonliving natural kinds here.

- (3) *Target items* (e.g., ‘Humans are mammals’; ‘Mammals are animals’; and ‘Humans are animals’) were designed specifically to delve deeper into children’s appreciation of the relation between humans, mammals and non-human animals.

Items were presented one at a time, in random order, with one exception: because we were especially interested in children’s responses to ‘Humans are animals’, we introduced this item before any other statements about humans or mammals, to avoid any influence from these other items. Sessions were audio taped. The experimenter recorded children’s responses.

Coding and Analysis

Acceptances, or ‘yes’ responses, were coded as 1, ‘no’ responses were coded as 0. Children’s forced choice judgments were analysed using both standard parametric and non-parametric tests. We report the non-parametric analyses; in all cases, parametric tests yielded the same effects.

Justifications for children’s forced choice judgments were transcribed and then assigned to a coding category:

- (1) I don’t know/no justification provided.
- (2) Appeals to shared properties (e.g. ‘Humans and animals both need water to live’), which reveals explicit knowledge in reasoning about the concepts in question and their relation.
- (3) Appeals to distinct properties (e.g. ‘Humans don’t walk on 4 legs like animals do’), which reveal explicit knowledge in reasoning about the concepts in question and their relation.
- (4) Tautologies (e.g. ‘Humans are humans and animals are animals’), where children highlight the separation of the concepts mentioned, suggesting that they do not have any deeper explanations available to support their response.
- (5) Appeals to an authority (e.g. ‘I heard it from my mom,’ ‘My science teacher told us,’ ‘It says so in the Bible’).
- (6) Hedges (e.g. ‘Some animals are mammals and some aren’t’), revealing children’s attempt to reconcile the concepts in question, but not to endorse the relation outright.
- (7) Other, or all other responses (e.g. Comments involving concepts other than those in the question; comments whose relevance to the question was difficult to ascertain).

RESULTS

The results reveal that while children in all three communities are adept at this task, their responses unveil their difficulties extending the term ‘animal’ to humans, or mapping ‘animal’ to *animal_{inclusive}*. Moreover, an understanding of the concept *mammal* does not appear to influence children’s ability to consider humans as animals. This difficulty persists

throughout the elementary school years, highlighting the challenges facing children as they establish a relation between humans and nonhuman animals.

Filler and Benchmark Items

Children's uniformly accurate responses to the filler items accord well with previous work, and document that children were able to respond appropriately with either 'yes' (accepting the true fillers) or 'no' (rejecting the false fillers). See Table 1.

Table 1. Mean Proportion of 'Yes' Responses for Filler Items

		True Items			False Items	
		<i>Cows eat grass</i>	<i>Worms crawl in the mud</i>	<i>Pencils have erasers</i>	<i>Trees can walk</i>	<i>Humans have wings</i>
5-6-year-olds	Rural European American	.88*	.69	1.00*	.04*	0*
	Rural Native American	.90*	.73*	.97*	.03*	.07*
	Urban	.79*	.83*	.96*	.04*	.04*
9-10-year-olds	Rural European American	.97*	.94*	1.00*	0*	0*
	Rural Native American	.87*	.91*	1.00*	0*	0*
	Urban	1.00*	.95*	.95*	.05*	0*

Note. Asterisks indicate that the proportion of 'yes' responses differs from the rate expected by chance (.5) by a binomial test, $p < .05$.

Responses to the benchmark items also provide strong assurances that children responded appropriately⁴. Echoing prior reports, on questions concerning the biological predicate 'alive', children agreed that both humans and a range of nonhuman animals are alive, but that artifacts are not (e.g., Anggoro, Waxman, & Medin, 2008; Carey, 1985; Leddon, Waxman, & Medin, 2008; Opfer & Siegler, 2004; Piaget, 1929). See Table 2. Children were just as likely to accept that 'Humans are alive', 'Cows are alive,' 'Birds are alive,' or 'Worms are alive,' all p 's $> .15$.

On questions concerning the concept *animal*, children's responses also converged well with prior work, asserting that nonhuman animals—but not artifacts— are animals. Interestingly, although children readily accepted that cows, birds, and fish are animals (and largely excluded bikes or pencils), they were more equivocal about the status of worms and bees. See Table 3. This converges with prior evidence (Coley, Shafto, Stepanova, & Barraff, 2005; Inagaki & Sugiyama, 1988), and underscores the challenge of with establishing the scope of the concept animal.

⁴ Because we did not require children to justify each of these items, and because their forced-choice responses were so straightforward, we do not include an analysis of the justification data here.

Table 2. Mean Proportion of ‘Yes’ Responses for Items Invoking the Concept Alive

		Human	Cow	Bird	Worm	Bike
5-6 year-olds	Rural European American	1.00*	1.00*	.96*	.92*	.19*
	Rural Native American	.97*	.97*	1.00*	.93*	.10*
	Urban	.96*	1.00*	1.00*	1.00*	.21*
9-10 year-olds	Rural European American	1.00*	1.00*	1.00*	.97*	0*
	Rural Native American	1.00*	1.00*	1.00*	.96*	0*
	Urban	.95*	1.00*	1.00*	1.00*	.09*

Note. All statements are of the form ‘X’s are alive’. Asterisks indicate that the proportion of ‘yes’ responses differs from the rate expected by chance (.5) by a binomial test, $p < .05$.

Table 3. Mean Proportion of ‘Yes’ Responses for Items Invoking the Concept Animal

		Human	Cow	Bird	Fish	Worm	Bee	Bike	Pencil
5- 6 year- olds	Rural European American	.04*	.96*	.81*	.69	.64	.65	.04*	0*
	Rural Native American	.03*	.90*	.80*	.80*	.50	.63	.03*	.03*
	Urban	.13*	.96*	.79*	.88*	.54	.63	0*	.04*
9- 10 year- olds	Rural European American	.42	.97*	.97*	.76*	.53	.36	0*	0*
	Rural Native American	.17*	.96*	.91*	.78*	.50	.48	0*	0*
	Urban	.27*	.91*	.91*	.82*	.68	.55	.05*	0*

Note. All statements are of the form ‘X’s are animals’ Asterisks indicate that the proportion of ‘yes’ responses differs from the rate expected by chance (.5) by a binomial test, $p < .05$.

Target Items

Children’s responses to the filler and benchmark items provide strong assurances that they understand the task and responded appropriately. This set the foundation for going on to examine their responses to the target items, which were specifically designed to probe children’s understanding of the relation between humans, mammals, and animals, and gauge

whether children would extend the term ‘animal’ to include humans. Following Rhodes et al. (2010), children’s forced-choice responses were analyzed with generalized linear models (SPSS 19) to assess main effects and interactions. The results, depicted in Figures 2 and 3, demonstrate that (1) throughout the primary school years, children in all three communities rejected the statement “Humans are animals”, and that (2) by the close of the primary grades, although children largely accepted the statements “Humans are mammals” and “Mammals are animals”, they continued to reject the statement “Humans are animals”. Considered together, these observations suggest that an appreciation of humans as mammals does not necessarily provide a stepping stone for appreciating that humans are animals, or for coordinating humans, (non-human) mammals, and other animals into a systematic hierarchical system. In what follows, we consider responses to each target item in turn.

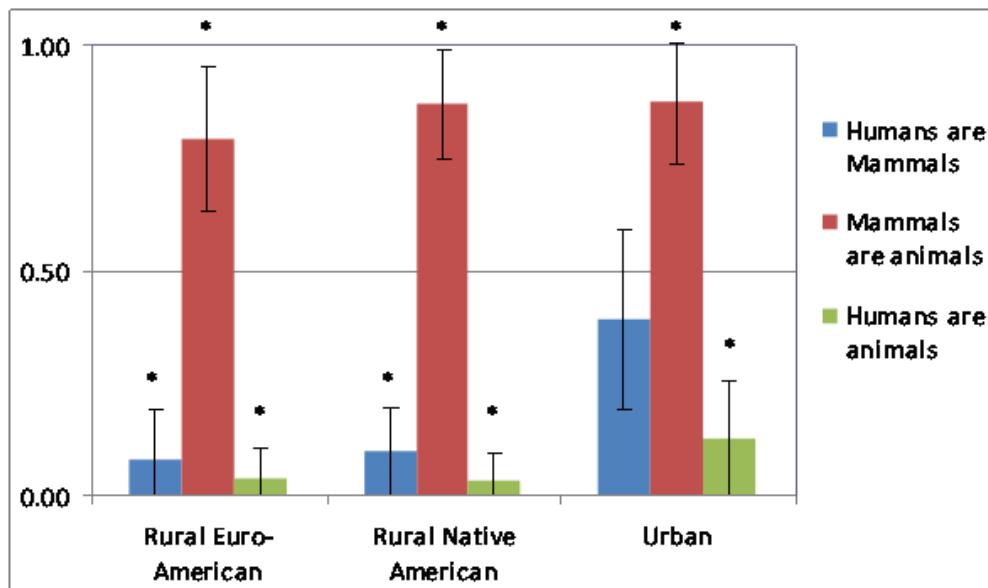


Figure 2. The proportion of ‘yes’ responses to all target items, for 5- to 6-year-olds in each community. Error bars represent 95% Wald confidence intervals. Asterisks indicate a statistically significant difference between the proportion of ‘yes’ responses and the proportion expected by chance (.5), $p < .05$.

Humans are Mammals

Forced choice responses. Children’s responses to ‘Humans are mammals’ revealed a main effect of Age, $\chi^2(1) = 52.13$, $p < .001$, and a main effect of Community, $\chi^2(2) = 7.09$, $p = .029$; urban children were more likely than those in the two rural populations to respond in the affirmative. See Figure 2. The interaction between Age and Community was not significant, $\chi^2(2) = 2.67$, $p = .264$. In essence, then, 9- to 10-year-olds in all three communities largely affirmed that ‘humans are mammals’, but 5- to 6-year-olds did not.

Justifications. Children’s justifications amplified their interpretation of this target item. See Appendix B, Table B1. In all three communities, the 9- to 10-year-olds (who largely agreed that humans are mammals in their forced-choice responses) offered justifications that appealed primarily to attributes that are shared by humans and other mammals (e.g., giving

birth to live young, having hair/fur, etc.). In contrast, the 5- to 6-year-olds (who did not agree that humans are mammals in their forced-choice responses) offered justifications of a very different flavor. Consider first the 5- and 6-year-olds from the two rural communities. These children, who systematically denied that humans are mammals in the forced choice task, tended to mention attributes that distinguish humans from non-human animals (e.g., not having 4 legs, not eating grass, etc.). Yet they also tended to offer tautological justifications (e.g., humans are humans, and therefore not mammals), or to offer no justification at all. The high number of responses in these categories underscores young children's difficulty with this question, and suggests an underlying uncertainty about the relation between these concepts.

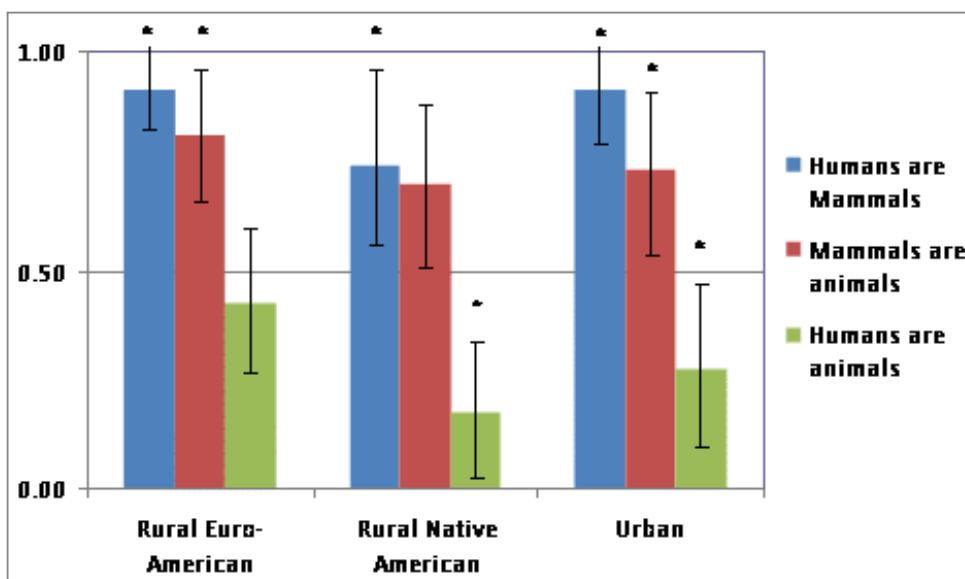


Figure 3. The proportion of 'yes' responses to all target items, for 9- to 10-year-olds in each community. Error bars represent 95% Wald confidence intervals. Asterisks indicate a statistically significant difference between the proportion of 'yes' responses and the proportion expected by chance (.5), $p < .05$.

Consider next the 5- to 6-year-old urban children, whose forced-choice responses were at the chance level. Here, we were able to ask whether the kinds of justifications children provide varies as a function of their forced-choice response. An examination of Appendix B, Table B2 reveals that they did. Children who agreed with the statement 'Humans are mammals' tended to appeal to shared attributes of humans and mammals⁵. In contrast, those who rejected the statement appealed more to the attributes that distinguish humans from (other) mammals.

⁵ Interestingly, the justifications citing shared attributes, largely absent in the other two groups of 5- to 6-year-olds, may reflect a recent lesson on mammals in this particular school. One child mentioned that his class had recently read a book about humans and mammals. While investigating classroom activities is the scope of this particular study, it does underscore one possible explanation for the Community difference in the forced choice responses, which was driven by the younger urban group.

Mammals Are Animals

Forced choice responses. Children at both ages in all communities tended to agree that *mammals are animals*. There was no main effect for Age, $\chi^2(1) = 2.37$, $p = .124$, or Community, $\chi^2(2) = .036$, $p = .982$, and no interaction, $\chi^2(2) = 1.67$, $p = .435$.

Justifications. See Appendix C. In all three communities, the older children, and many of the younger children as well, mentioned shared attributes of animals and mammals. However, many in the younger group appealed to tautologies, offered ‘hedges’, or failed to provide justifications at all. Once again, this pattern of justifications suggests that despite their consistent forced-choice responses, the younger children may not yet have a clear understanding of the relation between these concepts.

Humans Are Animals

Forced choice responses. Children’s difficulty accepting that humans are animals was evident at both ages and in all three communities. See Figures 2 and 3. The main effect of Age, $\chi^2(1) = 10.53$, $p = .001$, reveals that 9- to 10-year-olds were more likely than 5- to 6-year-olds to respond in the affirmative, although even the older children generally remained below chance in accepting this statement (only the rural European-American 9- to 10-year-olds even reached chance levels). There was no effect of Community, $\chi^2(2) = 2.12$, $p = .346$, and no interaction, $\chi^2(2) = 2.17$, $p = .339$.

We next asked whether children are less likely to accept that ‘Humans are animals’ than that nonhuman animals (e.g., cows, birds, fish) ‘...are animals’. See Table 3. At both ages in all three communities, children were significantly less likely to endorse ‘Humans are animals’ than either ‘Cows are animals’, ‘Birds are animals’, or ‘Fish are animals’, all p ’s $< .007$. In other words, children systematically excluded humans from the concept that they name *animal*, rejecting *animal*_{inclusive}, and endorsing an *animal*_{contrastive} interpretation.

In a final analysis, we directly considered the hypothesis that knowledge of the concept *mammal* would facilitate an appreciation of *animal*_{inclusive}. This hypothesis predicts that once children recognize that humans are mammals, they should be more likely to also accept that humans are animals. We therefore focused on the children who agreed with the statement ‘Humans are mammals’, and asked whether they also agreed that ‘Humans are animals’. As shown in Table 4, this was clearly not the case: despite agreeing that humans are mammals, these children continued to largely deny that humans are animals.

While the above results cast doubt on the idea that an appreciation of humans as mammals necessarily facilitates an appreciation of the concept *animal*_{inclusive}, it remained a possibility that those few participants who did agree with the statement ‘Humans are animals’ would demonstrate a clear pattern of also accepting that humans are mammals. In other words, perhaps integrating humans into the concept *mammal* is necessary, but not sufficient, for appreciating the overarching concept *animal*_{inclusive}. To test this possibility, we focused on the children who agreed with the statement ‘Humans are animals’, asking whether they also agreed that ‘Humans are mammals’. As shown in Table 5, this also was not the case, casting further doubt on the suggestions that *mammal* plays a facilitative role in the acquisition of *animal*_{inclusive}.

Justifications. Children articulated strong opinions in response to this item, appealing overwhelmingly to distinctions between human and nonhuman animals (e.g., walking on 4 legs, living in the wild, eating grass or hay, making animals sounds like ‘moo’ or ‘oink,’ etc.). See Appendix D, Table D1. At the younger ages, where children overwhelmingly rejected

this item, appeals to distinct attributes were the most common type of justification. These were followed by tautologies, or no justification given, which suggest some difficulty judging the relation between these concepts (or at the very least, articulating a reason why humans aren't animals).

Table 4. Mean Proportion of 'Yes' Responses to 'Humans are animals', for Children Who Also Affirmed that Humans are Mammals

		Humans are animals
5-6-year-olds	Rural European American	0
	Rural Native American	.33
	Urban	.11
9-10-year-olds	Rural European American	.47
	Rural Native American	.24
	Urban	.30

Table 5. Mean Proportion of 'Yes' Responses to 'Humans are mammals', for Children Who Also Affirmed that Humans are Animals

		Humans are mammals
5-6-year-olds	Rural European American	.33
	Rural Native American	.33
	Urban	.10
9-10-year-olds	Rural European American	.24
	Rural Native American	.45
	Urban	.30

Note that tautologies were observed as responses to this item even among the 9- to 10-year-olds. Still, the older children most commonly provided consistent support for their rejection of this statement by citing distinct attributes justifications; shared properties justifications were most frequent among the rural European-American 9- to 10-year-olds, who were the only group to even reach chance in their forced-choice responses to this item. Breaking down their justifications according to forced-choice response reveals that those who accepted it overwhelmingly offer shared attributes justifications, while those who rejected it cited distinct attributes. See Appendix D, Table D2. Thus while children are able to give support for their reasoning, their justifications reveal a clear focus on distinctions between humans and non-human animals, corresponding to their rejection of the idea that humans are animals.

CONCLUSION

The goal of the current experiment was to consider whether young children from three distinct US communities map the term 'animal' to the concept *animal*_{inclusive}, and in doing so, to gain a richer understanding of how children interpret the relation between humans and nonhuman animals. The results reveal that even 9- and 10-year-old children still encounter

obstacles in integrating humans into a concept named ‘animal’, and this difficulty persists despite their apparent mastery of related concepts like *mammal*. Children’s forced-choice responses, considered in conjunction with their explicit justifications, underscore that throughout the primary school years, children are in the process of working out the conceptual hierarchy encompassing humans, mammals and animals. This finding has implications not only for our understanding of cognitive development and the development of biological concepts, but also for the design of science curricula.

Interestingly, children’s understanding of these conceptual relationships was revealed to be largely the same across communities: neither forms of habitual contact with the natural world (e.g. urban versus rural), nor cultural belief systems that privilege the human–nonhuman animal relationship (as in the Native American community) appeared to influence children’s responses. While the communities in our task did not differ, in other tasks, important differences have been revealed (e.g., Astuti, Solomon, & Carey, 2004; Atran & Medin, 2008; Atran, et al, 2001; Bang, Medin, & Atran, 2007; Medin, Waxman, Woodring, & Washinawatok, 2010; Medin, Ross, Atran, Cox, Coley, Proffitt, & Blok, 2006; Proffitt, Coley, & Medin, 2000; Ross, Medin, Coley, & Atran, 2003; Waxman & Medin, 2007; Waxman, Medin, & Ross, 2007). Future research should therefore continue to extend to diverse populations (Medin, et al, 2010), to pinpoint where these differences occur, and how they may be best addressed in science curricula. This process has already begun with an intriguing study that examines children acquiring Indonesian, where the conventions for naming these biological concepts differ markedly from English (Anggoro, 2011).

While the current study uncovered few differences across communities, it did reveal differences across age groups. Children were more likely to agree with the statement ‘Humans are mammals’ as they got older, perhaps reflecting increased knowledge of *mammal*, which is likely to be more aligned with formal education. Children in the older group were also more likely to agree to agree with the statement ‘Humans are animals,’ although they remained at or below chance in doing so. Clearly, even after considerable formal science education, children continue to reject the *animal_{inclusive}* interpretation of ‘animal’. Future research might consider at what point children, or even adults, come to endorse this sense of the term.

While the differences across our age-groups suggests that over the primary school years, children make progress toward appreciating the dual status of humans as mammals and humans as animals, an examination of individual children did not reveal a clear link between the concepts *mammal* and *animal_{inclusive}*. Specifically, children who agreed that ‘Humans are mammals’ did not demonstrate high rates of accepting ‘Humans are animals,’ nor did children who agreed that ‘Humans are animals’ tend to accept that ‘Humans are mammals’. Taking a broader view of children’s responses, an interesting pattern emerges when considering all three target statements together. Note that if children agree that ‘Humans are mammals’, and ‘Mammals are animals,’ it should logically follow that ‘Humans are animals.’ While we did not explicitly elicit children’s judgments about the relation between these statements, we did examine children’s responses for evidence of this logical reasoning.

Interestingly, the younger children, while perhaps not fully understanding the concept *mammal*, at least demonstrate a consistent logic: they accept the statement ‘Mammals are animals,’ but maintain a clear distinction for humans, rejecting the statements ‘Humans are mammals’ and ‘Humans are animals’. In contrast, the older children actually violate a logical syllogism: they accept the statements ‘Humans are mammals’ and ‘Mammals are animals’,

but reject ‘Humans are animals.’ This finding casts doubt on the proposal that *mammal* serves as a gateway for considering humans as one animal amongst many, as the logical inference underlying the human – mammal – animal relationship is apparently absent. It therefore suggests there must be alternative paths to the successful integration of humans with nonhuman animals into the concept *animal*_{inclusive}. Future work might explicitly elicit children’s reasoning about this logical syllogism, and consider whether pointing out these relationships to students increases their tendency to agree that ‘Humans are animals.’

Despite these challenges, children in this task echo previous work by demonstrating knowledge of at least one similarity between humans and nonhuman animals: in particular, that both are alive. What this study reveals, however, is that even within the confines of a single task, children can simultaneously endorse such similarities (e.g., when it comes to the concept *alive*), while also maintaining a clear separation between these two groups (e.g., when it comes to the concept *animal*). As in previous work, children seem to understand many of the biological commonalities between humans and animals, yet they still deny that both can be labeled ‘animals’.

Finally, in future work it will be interesting to examine potential influences on children’s understanding. We saw a hint of the influence of various authority figures in children’s justifications: parents, teachers, and religious influences were all mentioned at least once. It will be important to study more carefully the types of information children receive about the relation between humans and nonhuman animals, both at home, before formal science education begins, at religious or spiritual events, and in the classroom. It will also be interesting to examine how religion bears on this understanding, and if children from different religious backgrounds reveal distinct understandings of the relation between humans and nonhuman animals.

This study represents an important first step in considering the meanings children ascribe to terms for fundamental biological concepts. By understanding the meanings children bring with them to the classroom, we have the opportunity to design curricula that build on students’ existing knowledge, and effectively communicate new information.

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APPENDIX A: FULL LIST OF ITEMS

Filler items

1. Cows eat grass
2. Worms crawl in the mud
3. Pencils have erasers
4. Trees can walk
5. Humans have wings

Benchmark items

6. Humans are alive
7. Cows are alive
8. Birds are alive
9. Worms are alive
10. Bikes are alive
11. Cows are animals
12. Birds are animals
13. Fish are animals
14. Worms are animals
15. Bees are animals
16. Bikes are animals
17. Pencils are animals

Target Items

18. Humans are mammals
19. Mammals are animals
20. Humans are animals

Other items, involving plants and nonliving natural kinds

21. Cows are plants
22. Birds are plants
23. Trees are plants
24. Flowers are plants
25. Trees are animals
26. Trees are alive
27. Plants are alive
28. Flowers are alive
29. Clouds are alive
30. Water is alive

APPENDIX B:
JUSTIFICATIONS FOR ‘HUMANS ARE MAMMALS’

**Table B1. The Proportion of Children Giving Each Type
of Justification for ‘Humans are Mammals’**

		No justifi-cation/ Don’t know	Shared Properties	Distinct Properties	Tautology	Authority	Hedge	Other
5-6- year- olds	Rural European American	.47	.03	.13	.17	0	0	.20
	Rural Native American	.31	.09	.38	.06	0	0	.16
	Urban	.08	.29	.25	.13	.04	0	.21
9-10- year- olds		No justification/ Don’t know	Shared Properties	Distinct Properties	Tautology	Authority	Hedge	Other
	Rural European American	.33	.50	0	0	.05	0	.13
	Rural Native American	.09	.65	.13	0	.04	0	.09
	Urban	0	.59	.05	.05	.09	.05	.18

**Table B2. Proportion of Justification Types Broken Down by
‘Yes/No’ Response for 5-to 6-year-old
Urban Children**

Forced Choice Judgment	No justification/ Don’t know	Shared Properties	Distinct Properties	Tautology	Authority	Hedge	Other
Yes	0.10	0.70	0.00	0.10	0.10	0.00	0.00
No	0.07	0.00	0.43	0.14	0.00	0.00	0.36

APPENDIX C.

JUSTIFICATIONS FOR ‘MAMMALS ARE ANIMALS’

Table C1. The Proportion of Children Giving Each Type of Justification for ‘Mammals are Animals’

		No justification/ Don't know	Shared Properties	Distinct Properties	Tautology	Authority	Hedge	Other
5-6-year-olds	Rural European American	0.43	0.27	0.03	0.07	0.03	0.00	0.17
	Rural Native American	0.28	0.41	0.00	0.13	0.06	0.06	0.06
	Urban	0.13	0.33	0.00	0.04	0.08	0.21	0.21
9-10-year-olds	Rural European American	0.10	0.48	0.08	0.03	0.00	0.25	0.08
	Rural Native American	0.17	0.43	0.04	0.04	0.00	0.13	0.17
	Urban	0.00	0.59	0.05	0.00	0.00	0.23	0.14

APPENDIX D.

JUSTIFICATIONS FOR ‘HUMANS ARE ANIMALS’

Table D1. The Proportion of Children Giving Each Type of Justification for ‘Humans are Animals’

		No justifi-cation/ Don't know	Shared Properties	Distinct Properties	Tautology	Authority	Hedge	Other
5-6-year-olds	Rural European American	0.23	0.00	0.50	0.23	0.03	0.00	0.00
	Rural Native American	0.03	0.03	0.56	0.19	0.03	0.00	0.16
	Urban	0.00	0.04	0.83	0.13	0.00	0.00	0.00
9-10-year-olds	Rural European American	0.05	0.33	0.45	0.05	0.00	0.10	0.03
	Rural Native American	0.13	0.00	0.65	0.04	0.17	0.00	0.00
	Urban	0.05	0.14	0.41	0.09	0.09	0.09	0.14

Table D2. Proportion of Justification Types Broken Down by ‘Yes/No’ Response for 9-to 10-year-old Rural European American Children

Forced Choice Judgment	No justifi- cation/ Don’t know	Shared Properties	Distinct Properties	Tautology	Autho- rity	Hedge	Other
Yes	0.00	0.69	0.00	0.00	0.00	0.25	0.06
No	0.08	0.08	0.75	0.08	0.00	0.00	0.00

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