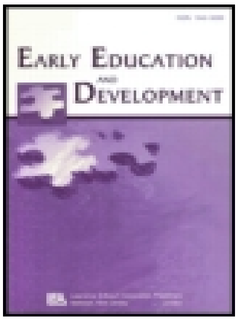

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"Inhabitants of the Earth": Reasoning About Folkbiological Concepts in Wichi Children and Adults

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ABSTRACT

Across the world, people form folkbiological categories to capture their commonsense organization of the natural world. Structured in accordance with universal principles, folkbiological categories are also shaped by experience. Here we provide new evidence from the Wichi—an understudied indigenous community who live in the Chaco rainforest and speak their heritage language. A total of 44 Wichi (6- to 8-year-olds, 9- to 12-year-olds, adults) participated in an induction task designed to identify how broadly they attribute an invisible biological property (e.g., an internal organ) from 1 individual (either a human, nonhuman animal, or plant) to other humans, nonhuman animals, plants, natural kinds, and artifacts. *Research Findings*: These results (a) clarify the content of the Wichi's categories and the words they use to describe them, (b) showcase the power of covert (unnamed) categories, and (c) fortify the view that human-centered reasoning is not a universal starting point for reasoning about nature. *Practice or Policy*: Implications of these findings for early science education are discussed. In particular, we discuss (a) how the Wichi's construal of the natural world may be best integrated when they reach the (Western science–inspired) classroom and (b) how the current results bear on central issues in early science education more broadly.

Humans make their homes in nearly every corner of the earth, in the deserts of Africa, the tundra of the arctic, the farms of the Great Plains, and in inner cities like Chicago and Beijing. Children raised in any one of these communities will be surrounded by objects and events that children raised elsewhere may never encounter. Yet despite these striking differences in experiences, there are strong similarities in how people represent their natural habitats. People from across the world's communities form folkbiological categories. These folkbiological categories—a commonsense organization of the natural world—are structured in accordance with strong universal principles of hierarchical structure (Berlin, Breedlove, & Raven, 1973). More specifically, people across cultures tend to establish categories of objects that are nested within a hierarchical structure (e.g., TERRIER–DOG–ANIMAL). Moreover, within these structures, basic-level categories (those occupying an intermediate hierarchical position; e.g., DOG) have the strongest inductive force (Berlin et al., 1973; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Indeed, Berlin (1992) described basic-level categories as "beacons on the landscape" that serve to help people "carve the natural world at its joints" (p. 26). Of course, the content of the categories people form (e.g., basic-level categories like jaguars and chaguar in the Chaco rainforest or squirrels and tulips in Chicago) also bear the indelible stamp of experience within their surroundings.

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This interplay between cultural universals and cultural specifics, so apparent in the folkbiological systems people create, has served as fertile ground for clarifying which aspects of human development might be universal and how these are shaped by experience. Adopting a cross-cultural and cross-linguistic developmental approach, psychologists have asked how young children acquire fundamental biological concepts, including ANIMAL, PLANT, and LIVING THING. Three powerful shaping forces have been identified: *language* (e.g., whether and how key folkbiological categories are marked in the native language; Anggoro, Waxman, & Medin, 2008; Berlin et al., 1973; Leddon, Waxman, & Medin, 2008; Leddon, Waxman, Medin, Bang, & Washinawatok, 2012; Taverna, Waxman, Medin, Moscoloni, & Peralta, 2014; Waxman, 2005), *forms of contact with the natural world* (e.g., the kinds of interactions people have with the different kinds [e.g., artifact-rich vs. artifact-sparse] of environments; Atran et al., 2001; Tarlowski, 2006; Taverna et al., 2014; Winkler-Rhoades, Medin, Waxman, Woodring, & Ross, 2010), and *culture* (e.g., community-wide belief systems about the natural world; Astuti, Solomon, & Carey, 2004; Atran & Medin, 2008; Taverna, Waxman, Medin, & Peralta, 2012; Waxman, Medin, & Ross, 2007).

Here we provide new evidence from another population—the Wichi, an understudied indigenous Amerindian group from a remote region of the Chaco forest (northern Argentina) who continue to speak their heritage language. Our work in this community is cross-disciplinary and cross-cultural at its core. Our team, which includes psychologists, linguists, and native members of the community, offers a rare opportunity to witness how folkbiological knowledge emerges in circumstances that differ rather dramatically from our own language, experiences of the natural world, and community-held belief systems. Perhaps more important, this work is also very timely. In 1984, the government of Argentina established an intercultural system of public schools aimed at providing the Wichi children with access to the Spanish language and to Western education in both the arts and sciences while preserving their cultural knowledge and native language ("Ley Argentina de Educación Nacional 26.206, 2006"). Unfortunately, however, curricular decisions have thus far been implemented by nonnative people (e.g., Zidarich, 2014). It is therefore important to identify what knowledge young Wichi children bring with them to their classrooms and to design curricula to augment this knowledge.

In the current article, we focus on folkbiological knowledge among the Wichi, asking how children and adults reason about the relations among living things and how their language and belief systems shape their systems of reasoning. We consider three distinct age groups, tapping into the knowledge in young children (to identify what knowledge they bring with them as they begin their education at 6 to 8 years of age), in older children (to identify their knowledge after a few years of schooling at 9 to 12 years of age), and in adults with little formal schooling (to identify how adults in the community reason about the natural world). This work, designed to broaden the empirical base in order to specify the universal and culture-specific processes underlying conceptual development, also has pressing implications for early science education, not only within the Wichi community but for education more broadly.

An Overview of The Wichi Community

This work is part of a broader investigation examining folkbiological knowledge in this indigenous Amerindian community. Although the Wichi have been described in the linguistics and anthropology literatures (e.g., Nercesian, 2011; Palmer, 2005; Suárez & Montani, 2010; Terraza, 2009; Vidal & Nercesian, 2009), to the best of our knowledge ours is the first investigation to have adopted a cognitive and developmental approach (Taverna et al., 2012, 2014).

In what follows, we describe in brief experiences in the natural world, Wichi beliefs, and the names the Wichi use to describe key folkbiological concepts.

Experience

The Wichi people are an indigenous population from the Chaco forest in the South American lowlands of Argentina. This region spans 1 million square kilometers and includes primarily grassy plains interspersed with distinct areas dominated by scrub growth, small woody plants, or palm groves. Our work takes place in the Wichi lawet community (Laguna Yema, Formosa), and in this community both children and adults have extensive and varied direct contact with different species of plants and animals, many of which have strong cultural functions and significance (Alvarsson, 1988; Arenas, 2003; Koschitzky, 1992; Maranta, 1987; Palmer, 2005; Suárez & Montani, 2010; Wilbert & Simoneau, 1982). The Wichi in this community depend economically on traditional activities, including hunting, fishing, and gathering; they engage in seasonal slash-and-burn horticultural practices. Textile weaving, pottery, and, to a lesser extent, ranching and farming are also important economic practices. Both women and men are engaged directly with plants and animals, but their activities reflect a strongly gender-based differentiation of labor and expertise. Men are responsible for hunting; fishing; and manufacturing wooden tools, furniture, and handicrafts. Women are responsible for gathering fruit, wood, and other plants, a task that typically requires full-day expeditions deep into the Chaco forest, on which they typically are accompanied by their children. In addition to going on these expeditions, children are engaged daily in activities embedded within the natural environment, including trapping lizards, walking in the forest, and swimming in the canal, among others (Taverna et al., 2012).

Beliefs

The cultural and religious beliefs held by the Wichi differ from those of most Western-oriented, technologically saturated communities. As in many other Amerindian communities, humans are seen as a part of—rather than apart from—the natural world (Bang, Medin, & Atran, 2007; Medin & Bang, 2014; Palmer, 2005; Pierotti, 2011; Wilbert & Simoneau, 1982). For example, there is a strong affinity between humans and nonhuman animals: In the Wichi origin myth, humans (males) emerged from the earth, climbing through a hole provided by the animals of the forest. It is interesting that because the first woman was pregnant and unable to pass through this hole, she arrived later climbing from a ladder in the sky. The Wichi believe that some humans and nonhuman animals have remained in the sky and that they become visible as the constellations of the night sky (Palmer, 2005; Wilbert & Simoneau, 1982). The narratives that support these beliefs—among many others—are of extraordinary importance and are frequently recounted in gatherings, spontaneous conversations (Wilbert & Simoneau, 1982), and school materials (Zidarich et al., 2006).

This close affinity between humans and nonhuman animals is also evident in the Wichi belief in *husek*, a concept that aligns roughly with Western notions of *spirit* or *soul*. Often identified with individual and collective goodwill (Palmer, 2005), *husek* is at the center of daily community life. The Wichi attribute *husek* equally to humans, nonhuman animals, and spiritual entities (*ahot*) but typically not to plants (Taverna et al., 2012).[1] The belief in *husek*, and the resulting close alignment between humans, nonhuman animals, and spiritual entities, links the biological and spiritual worlds: For both children and adults, spiritual entities, although invisible to the human eye, are not considered unreal or magical (Woolley, 1997) but instead are well-ensconced in folk theories of the natural world.

Language

In contrast to the languages of most Amerindian communities studied to date, the Wichi language is very much alive. Acquired naturally from infancy, it is the primary language within the family and in community life. Although some community members also speak some Spanish (especially schoolteachers and men doing commerce outside the community), Spanish is rarely used in conversations

[1]In Palmer's (2005) view, the term *husek* also has a secondary sense (vital will) that invokes a notion of vitality and may include certain species of plants imbued with magical properties (see Suárez & Montani, 2010, for a discussion); *husek* also appears to have a third sense (shamanistic will) that applies exclusively to a person who has become a shaman. This third sense was never mentioned in our interviews within the community (Taverna et al., 2012).

within the community. In our research, we focus on the Wichi folkbiologic lexicon rather than its grammar (but see Nercesian, 2011) because of strong cross-linguistic developmental evidence that naming and categories are intimately linked (Berlin et al., 1973; Waxman & Hall, 2004).

Why Naming Is Important

There is considerable evidence that even before infants utter their first words, language and conceptual development are linked: Naming supports the formation of object categories (see Waxman & Lidz, 2006, or Waxman & Gelman, 2009, for a review). For example, when infants observe a set of disparate members (e.g., dog, horse, duck) of a given object category (e.g., animal), they have difficulty noticing the category-based commonality among them. But when the very same members are introduced with a shared name, infants' categorization improves dramatically (Ferry, Hespos, & Waxman, 2010; Fulkerson & Waxman, 2007; Waxman & Markow, 1995).

This observation is directly relevant to cross-cultural and cross-linguistic work on folkbiology. After all, if naming supports object categorization in infants and young children, and if object categories serve as a basis for inductive inference, then the names children learn for biological entities should influence the categories they establish and their inductive strength. Recent experimental evidence has documented that language-specific differences in naming practices for biological entities do indeed influence children's concept acquisition (Anggoro, Medin, & Waxman, 2010; Anggoro et al., 2008; Hatano et al., 1993; Leddon et al., 2012; Stavy & Wax, 1989; Waxman, 2005; Winkler-Rhoades et al., 2010). For example, Anggoro et al. (2008) showed that 4- to 9-year-old English-speaking but not Indonesian-speaking children endorsed two different meanings of *animal*—ANIMAL$_{\text{INCLUSIVE}}$ and ANIMAL$_{\text{EXCLUSIVE}}$—and that this difference was mirrored in children's free sorting. When asked to identify entities that are "alive," older Indonesian-speaking children selected both plants and animals, but their English-speaking counterparts tended to exclude plants, which suggests that they may have misaligned *alive* with one of the *animal* senses (ANIMAL EXCLUSIVE).

The Wichi's Folkbiological Lexicon

To a Westerner's ear, this folkbiological lexicon is as surprising for the concepts that remain unnamed as for those that are named. See Figure 1 for a schematic representation of the Wichi folkbiological lexicon. The first thing to notice is the large number of categories that remain unnamed. According to Berlin (1992), among indigenous communities, it is not uncommon for higher order categories (which he described as "unique beginners" p. 15) to remain unnamed. In the anthropological and psychological literature, unnamed categories are described as *covert* categories (Berlin et al., 1973; Hays, 1976; Waxman, 2005).

Consider first the broad overarching folkbiological category that includes all living things. In English, this is described phrasally—*living things*. In Wichi, this is described using a compound noun—*hunhat lheley* (translated as "inhabitants of the earth")—whose scope includes not only all humans and nonhuman animals and plants but spiritual beings (see Taverna et al., 2012). Among these, only one category—*ahot* (spiritual beings)—is named.

The category corresponding to PLANTS remains unnamed in Wichi, but its constituent categories are named. Notice, though, that these named categories differ considerably in content from the taxonomic groupings named in most Western languages (e.g., trees vs. bushes). In Wichi, the named plant categories mark habitat-based groupings, including *hal'o* (wild trees and shrubs with woody trunks that inhabit the forest) and *tokos* (cultivated plants), among many others.

Similarly, although the category corresponding to (NONHUMAN) ANIMALS is unnamed, the Wichi lexicon includes superordinate names for *kinds* of animals. Again, these differ in content from the taxonomic groupings named in most Western languages (e.g., mammals vs. birds). In Wichi, the names mark habitat-based groupings, including *tshotoy* (animals of the forest), *tshotoy inot lheley* (animals of the water), *tshotoy fwiy'ohen* (animals of the air), and others, including *laloy* (domestic animals). Although there is strong consensus that this is the primary meaning of *tshotoy*, there is

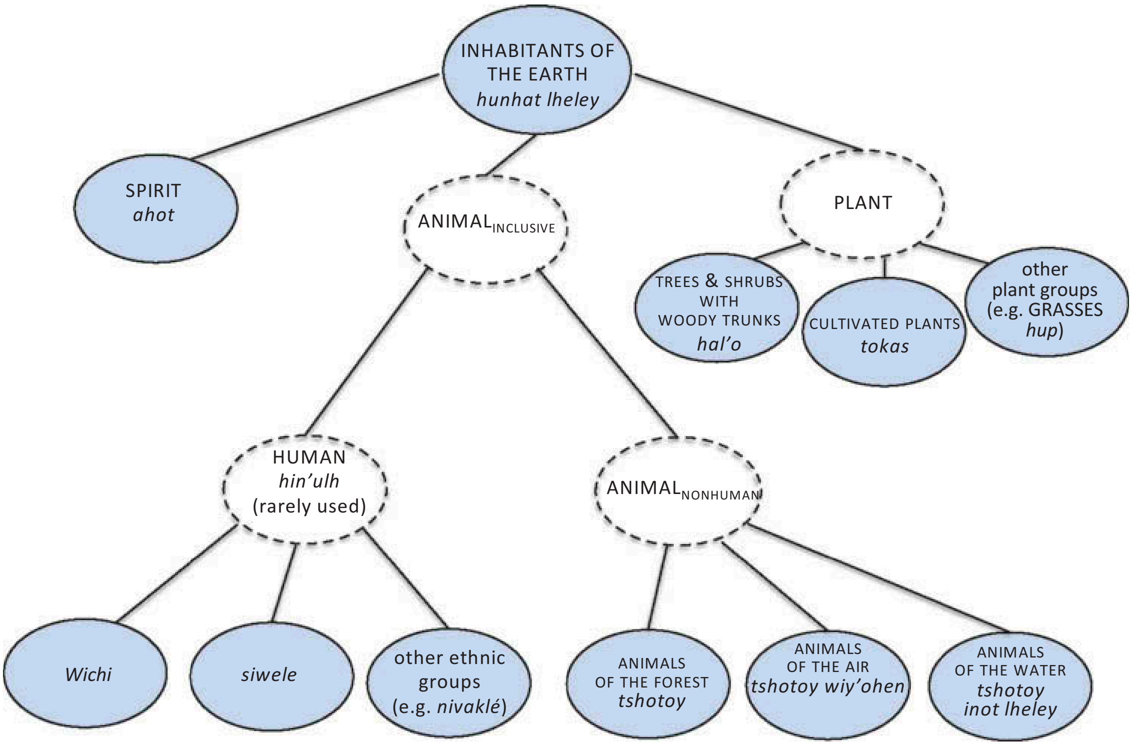

Figure 1. A schematic depiction of Wichi names for fundamental folkbiological concepts. Note that the nodes corresponding to $\text{ANIMAL}_{\text{INCLUSIVE}}$ (human and nonhuman combined), $\text{ANIMAL}_{\text{NONHUMAN}}$, and PLANT are unnamed.

considerable debate about whether *tshotoy* can also refer (more inclusively) to all nonhuman animals. Some suggest that in certain conversational contexts it can; others argue strenuously that *tshotoy* cannot be used to refer to any animals other than the animals of the forest (Taverna et al., 2012; see Berlin et al., 1973, for a discussion of the phenomenon in which the same word may be used for both a superordinate category and a kind within it).

Finally, consider how the Wichi refer to humans. There is a word that refers to all humans (*hin'uhl*), but it is very seldom used. Instead, the Wichi favor more specific terms that mark community affiliation: *Wichi* (Wichi people), *siwele* (White, non-Wichi people), and a number of other nouns that apply to people of other cultural groups (e.g., *nivaklé*).

This descriptive information about the community, its beliefs, and its language provides the backdrop for our investigations of folkbiological reasoning in Wichi children and adults.

Tapping Into Wichi Folkbiological Knowledge

What is the relation between humans, nonhuman animals, and plants in Wichi child and adult reasoning about the natural world? To tap into their reasoning, we used a *category-based induction* task, one that has been instrumental in investigations of biological reasoning in children and adults from a range of communities, from urban to rural communities, from majority-culture to indigenous communities (e.g., Anggoro et al., 2010; Atran et al., 2001; Carey, 1985; Gelman, 1988; Herrmann, Waxman, & Medin, 2010; Ross, Medin, Coley, & Atran, 2003; Tarlowski, 2006; Waxman et al., 2007). In this task, participants are introduced to a novel property of an entity (the *base*) and then asked whether this property can be generalized to other entities (the *targets*). For example, they may be taught that dogs have a novel biological property (e.g., an omentum) and asked whether other entities (typically including a range of animals, plants, and artifacts) also share this property. These attributions—or generalizations—of the novel biological property shed light on how people construe the relations among entities in the natural world, especially the relation between human and nonhuman animals.

In her pioneering work with this task, Susan Carey (1985) argued that in reasoning about the natural world (a) young children (roughly 4- to 6-year-olds) universally adopt an anthropocentric stance in which humans serve as a stronger inductive base than do nonhuman animals and that (b) this human-centered stance is replaced in middle childhood as children begin to realize that humans are one kind of animal among many.

Although over the years Carey has amended the details of her position (Carey, 1995, 1999; Carey, Zaitchik, & Bascandziev, 2015), to the best of our knowledge the central tenet has not changed. The claim is that children universally begin reasoning about the natural world from a human-centered (anthropocentric) perspective and that their initial understanding of the natural world is initially embedded in a *folk psychological* rather than a *folk biological* explanatory framework. Nonetheless, there have been challenges to this claim documenting, for example, that preschool-age children distinguish biological and psychological construals of living things (Coley, 1995; Inagaki & Hatano, 1993) and use explicitly biological causal mechanisms to explain biological phenomena (e.g., Rosengren, Gelman, Kalish, & McCormick, 1991; Solomon & Cassamites, 1999; Springer, Ngyuen, & Samaniego, 1996).

In addition, cross-cultural studies based on populations that differ in important ways from the ones observed by Carey have overturned this notion of a universal anthropocentric starting point for biological reasoning. First, this pattern appears to be unique to 4- and 6-year-old majority-culture children raised in urban settings, primarily in the United States[2]: Human-centered reasoning has never been observed in children growing up in rural U.S. or indigenous groups (Atran et al., 2001; Coley, Medin, & James, 1999; Herrmann, Medin, & Waxman, 2012; Inagaki, 1990; Ross et al., 2003). Second, even within this population, human-centered reasoning is not the starting point for reasoning about the biological world (Herrmann et al., 2010; Waxman, Herrmann, Woodring, & Medin, 2014). These studies documented that children younger than 5 years of age are decidedly not anthropocentric in their reasoning. Therefore, human-centered reasoning is not a universal starting point but is instead an acquired perspective, supported (however briefly) in some, but by no means all, communities. We have proposed that this anthropocentric stance in urban-raised children reflects their relative paucity of direct contact with other species of natural world, coupled with the frequent and powerfully engaging anthropocentric images in children's books, movies, and other media (Herrmann et al., 2010).

What Can Be Learned From Using Category-Based Induction to Tap Into Folkbiological Knowledge Among Wichi Children and Adults?

We focus on four key issues.

(1) What is the inductive status of the (covert) category NONHUMAN ANIMAL? Although unnamed in Wichi, does this category nonetheless function as a coherent, albeit covert, base for reasoning? Or do the named habitat-based categories (e.g., forest, water, air) provide distinct inductive power?

(2) What is the inductive status of the category ANIMAL (including HUMAN AND NONHUMAN ANIMALS)? Although no single word refers to both humans and nonhuman animals (Taverna et al., 2014), there is nevertheless a close affinity between humans and nonhuman animals. We therefore suspect that the Wichi represent a covert category—encompassing humans and nonhuman animals—that guides their reasoning about the biological world.

[2]In the original design, Carey presented children with only a single base—either a dog or a human. Some subsequent studies have maintained this between-participants design, but others (Anggoro et al., 2010; Atran et al., 2001; Ross et al., 2003) have presented more than a single base to each child. Close analysis of these studies reveals that the order in which the bases are presented has consequences for young urban children's patterns of performance. Anggoro et al. (2010) documented base order effects in young urban children from Chicago and Jakarta: If a nonhuman animal serves as the child's first base, the child's tendency to extend the novel biological property to the (subsequent) human base is much weaker. See Medin et al. (2010) and Anggoro et al. (2010) for a discussion.

(3) How do the Wichi construe the relation between humans and nonhuman animals? The Wichi's extensive direct experience with the natural world, coupled with the absence of anthropocentric media images for children, led us to predict that even the youngest Wichi children in our investigation would not adopt a human-centered (anthropocentric) stance but would instead view humans and nonhuman animals as comparable in inductive strength.

(4) How do plants fit in with the Wichi's reasoning about the natural world? Because the Wichi have such extensive firsthand experience with plants and accord them strong cultural significance, we expected the category PLANT to have strong inductive power. At issue is the inductive status of this (covert) category. Do the Wichi reason about plants as a cohesive category, even though it is unnamed? Although we included fewer plants than animals in the induction task, the results should nonetheless offer initial insight into how the Wichi extend novel biological properties both to and from members of this unnamed category.

Method

Participants

A total of 44 native speakers of Wichi participated: 16 children ages 6 to 8 years old (nine females, *M* age = 7.1), 16 children ages 9 to 12 years old (seven females, *M* age = 10.6), and 12 adults (10 females, *M* age = 32.0, range = 18–49 years). The participants, who spoke exclusively Wichi in the home and had very limited knowledge of Spanish, were interviewed exclusively in Wichi. All children attended the Wichi *Lako* School, a public school in Laguna Yema, Formosa (Argentina). This is one of several Wichi schools implemented by the Argentine government in 1984 as part of the Intercultural Education Program. The teachers in these schools include both native Wichi teachers who are bilingual in Spanish and nonnative teachers who are monolingual speakers of Spanish. Although some Spanish is introduced (lightly) in the first grade (at roughly age 6), children communicate almost exclusively in Wichi in school until the later grades (at roughly age 9 or 10); they overwhelmingly use Wichi outside of school. As for the adults, most had limited contact with Western education: Six had not completed elementary school, four had completed elementary school, and only two had completed secondary school.

Materials

Images

Eighteen colored photographs depicting a range of living and nonliving entities served as visual stimuli. Four of the entities served as bases (human, jaguar, dog, carob tree); the remaining 14 photographs served as targets (see Table 1). We selected items that were familiar to both children and adults in the Wichi community. Each photograph was presented on an 8.5 × 5.5" laminated card.

One other aspect of our stimulus selection bears mention: Because most of our questions concerned the Wichi's interpretation of the relation among animals—both human and nonhuman animals—and their inductive status, it was essential that we include animals from each of the habitat-based named groupings. This demand, coupled with our decision to keep the number of targets and bases comparable to other closely related work with adults and children, meant that we presented more animals than plants. Nonetheless, we included one bush and one tree among our plant targets in an effort to gather preliminary insight into whether and when the Wichi treat plants as a cohesive category with inductive potential.

Property Names

Working in collaboration with several adult native Wichi speakers, we created four novel words (*t'i, l'hele, lachuwej, lawit'ui*) to be used as names for the novel properties in the induction task (described in "Procedure").

Table 1. Complete List of Items Used as Bases and Targets.

Bases	Targets
Human	Human
Jaguar	Anteater[a]
Dog	Turtle[a]
Carob tree	Worm[a]
	Caracara[b]
	Parrot[b]
	Fly[b]
	Cayman[c]
	Piranha[c]
	Hardwood tree
	Acacia bush
	Water
	Chair
	Bicycle

[a]Animals of the forest. [b]Animals of the air. [c]Animals of the water.

Procedure

Participants were interviewed individually in Wichi, sitting across from the experimenter in a quiet room. Children were interviewed in a quiet section of a community center; adults were interviewed in their homes. Before the experiment began, children participated in a warm-up task; after the experiment ended, adults were asked to provide justifications for their responses. Each participant completed the induction task four times, each time with the same targets but a different base and novel property. The order in which bases were presented was randomized across participants. Here we use the jaguar base to illustrate.

Warm-Up Task (Children Only)

For children, the experimenter began the session with a brief warm-up task designed to clarify that it was acceptable to answer either "yes" or "no" to the questions she would be posing. For example, the experimenter showed the child a line drawing of a shape (e.g., a red triangle), asking, for example, "Is this red? Is it a square?" All children readily answered "yes" and "no" and did so correctly.

Induction Task (Children and Adults)

All participants completed the induction task across four trials, each trial using a different base; bases were presented in one of four Latinized orders. Before each trial began, the targets were shuffled and presented in random order.

Training phase. To begin, the experimenter presented one base (e.g., a photograph of a jaguar) and asked participants to name it. If they named it correctly, they were given positive feedback. If not, they were gently corrected. Next the experimenter handed the participant a line drawing of the base (e.g., a jaguar) and took one for herself as well. She then introduced a novel biological property (e.g., "Jaguars have *t'i* inside them. *T'i* is a greenish substance, and it goes inside!"). She then handed the participant a crayon, saying, "Look! I'm drawing *t'i* in my picture of a jaguar! Will you draw *t'i* in yours?" She then gathered the line drawings and moved on to the test phase.

Identifying the target cards. Before beginning the initial test (the first of four), participants participated in a naming event designed to ensure their familiarity with the depicted entities. The experimenter revealed each of the photographs, in random order, asking the participant to identify each by name, then providing feedback. If the participant named an entity incorrectly, the experimenter supplied the correct name by saying, for example, "It may *look* like a [X], but it's actually a [Y]." At this point, the induction task began. This naming event was not repeated on the three subsequent induction tasks.

Test phase. The experimenter shuffled (randomized) the target photographs, saying, for example, "Remember when we talked about *t'i*? And we said that jaguars have *t'i* inside? Some other things have *t'i* too. Please tell me: Which of these [pointing to her pile of target photographs] have *t'i* inside too, okay?" At this point, she revealed each target sequentially, in random order, asking, "What do you think? Do [Xs] have *t'i* inside, like jaguars do?" She recorded the participant's response and then moved on to the next target, and so on. Questions were phrased in the generic, focusing on the kinds in question ("Do anteaters have *t'i* inside, like jaguars do?") rather than on the particular individuals depicted ("Does this anteater have *t'i* inside, like this jaguar does?").

Participants then completed the training and test phases for the remaining three bases; a different novel property was introduced for each base.

Justifications (Adults Only)

After completing the induction task for all four bases, adults were asked to justify their responses on the final round. The experimenter said, for example, "You told me that these [pointing to the entities to which the participant attributed the novel property] have *t'i* like jaguars do. Why do you think that is so?"

Results

Before analyzing the results formally, we sought some assurances that this task was a suitable one for tapping into the Wichi children's and adults' reasoning about the natural world. We reasoned as follows: If the Wichi remember the novel properties, and if they are willing to judge the likelihood that various other entities might share these properties, then they should provide a systematic pattern of responses as a function of the similarity of the base to the target categories or in terms of Figure 1, as a function of distance within the hierarchy. An examination of Table 2, which presents the proportion of generalizations from each base to each of the targets for each age group, suggests that they were indeed systematic.

Consider, for example, the Wichi's responses to the artifact targets. If this task did indeed tap into the Wichi's considerable knowledge about the natural world, then they should have rarely extended a novel biological property, introduced in conjunction with a biological entity (any of our four bases), to an artifact (chair, bicycle). A glance at Table 2 reveals that they rarely extended novel properties to the manmade artifacts at any age. Consider next their responses to the human target. If the Wichi were responding systematically to this task, then they should have been more likely to extend a novel property to the human target if the property was introduced on the human base than on a nonhuman base (either the jaguar, the dog, or the carob tree). Table 2 reveals that extensions to the human target were uniformly high when the novel property was introduced on a human base and attenuated when it was introduced on a nonhuman base.

Taken together, these observations provide assurances that the current paradigm tapped into a systematic set of inferences about the natural world among Wichi children and adults. With this as a foundation, we go on to consider more precisely the Wichi's patterns of inductive inference.

What Is the Inductive Status of the (Covert) Category NONHUMAN ANIMAL?

In reasoning about entities in the natural world, do the habitat-based distinctions among the named animal kinds (*tshotoy, tshotoy wiy'ohen, tshotoy inot lheley*) hold distinct inductive power? Or does participants' reasoning reveal the inductive power of the more inclusive, though by most accounts covert, category NONHUMAN ANIMAL?

To test this, we calculated each participant's mean response to three animal categories—animals of the forest (anteater, turtle, worm), animals of the air (caracara, parrot, fly), and animals of the water (caiman, piranha)—and submitted these animal category scores to an analysis of variance (ANOVA) using base (4: human, jaguar, dog, carob tree) and animal target category (3: forest, air, water animal) as within-participants factors and age (3: 6- to 8-year-olds, 9- to 12-year-olds, adults) as a between-participants factor (see Figure 2). The ANOVA revealed a main effect for base, *F*(3,

Table 2. Means (*SD*) for Generalizations From Each Base to Each Target at Each Age.

		Animals of the Forest			*Animals of the Air*			*Animals of the Water*		*Plants*			*Artifacts*	
Base	*Human*	*Anteater*	*Turtle*	*Worm*	*Caracara*	*Parrot*	*Fly*	*Caiman*	*Piranha*	*Hardwood*	*Acacia*	*Water*	*Chair*	*Bicycle*
6- to 8-year-olds														
Human	0.87 (0.34)	0.5 (0.51)	0.44 (0.51)	0.63 (0.5)	0.63 (0.5)	0.44 (0.51)	0.44 (0.51)	0.63 (0.5)	0.50 (0.51)	0.31 (0.47)	0.25 (0.44)	0.25 (0.44)	0.06 (0.25)	0.19 (0.4)
Jaguar	0.75 (0.57)	0.75 (0.44)	0.56 (0.51)	0.75 (0.44)	0.81 (0.4)	0.75 (0.44)	0.87 (0.34)	0.87 (0.34)	0.94 (0.25)	0.50 (0.51)	0.37 (0.50)	0.25 (0.44)	0.19 (0.40)	0.19 (0.4)
Dog	0.56 (0.51)	0.75 (0.44)	0.75 (0.44)	0.69 (0.47)	0.63 (0.5)	0.56 (0.51)	0.75 (0.44)	0.81 (0.4)	0.75 (0.44)	0.31 (0.47)	0.25 (0.44)	0.13 (0.34)	0.13 (0.34)	0 (0)
Carob tree	0.60 (0.49)	0.47 (0.50)	0.40 (0.49)	0.53 (0.50)	0.60 (0.49)	0.40 (0.49)	0.53 (0.50)	0.60 (0.49)	0.40 (0.49)	0.93 (0.25)	0.53 (0.50)	0.33 (0.47)	0.20 (0.40)	0.13 (0.34)
9- to 12-year-olds														
Human	0.94 (0.25)	0.81 (0.40)	0.75 (0.44)	0.50 (0.51)	0.75 (0.44)	0.69 (0.47)	0.69 (0.47)	0.69 (0.47)	0.69 (0.47)	0.44 (0.51)	0.19 (0.40)	0.31 (0.47)	0 (0)	0 (0)
Jaguar	0.56 (0.51)	0.94 (0.25)	0.75 (0.44)	0.81 (0.40)	0.75 (0.44)	0.81 (0.4)	0.63 (0.50)	0.81 (0.40)	0.81 (0.40)	0.38 (0.50)	0.13 (0.34)	0.13 (0.34)	0.13 (0.34)	0 (0)
Dog	0.69 (0.47)	0.75 (0.44)	0.50 (0.51)	0.56 (0.51)	0.69 (0.47)	0.50 (0.51)	0.38 (0.50)	0.63 (0.50)	0.44 (0.51)	0.25 (0.44)	0 (0)	0.13 (0.34)	0 (0)	0 (0)
Carob tree	0.44 (0.51)	0.37 (0.50)	0.31 (0.47)	0.44 (0.51)	0.50 (0.51)	0.37 (0.50)	0.44 (0.51)	0.38 (0.50)	0.44 (0.51)	0.94 (0.25)	0.56 (0.51)	0.13 (0.34)	0.13 (0.34)	0 (0)
Adults														
Human	0.92 (0.28)	0.25 (0.45)	0.17 (0.38)	0.17 (0.38)	0.25 (0.45)	0.33 (0.49)	0.17 (0.38)	0.50 (0.52)	0.33 (0.49)	0.17 (0.38)	0.17 (0.38)	0.08 (0.28)	0 (0)	0 (0)
Jaguar	0.58 (0.51)	0.83 (0.38)	0.33 (0.49)	0.42 (0.51)	0.75 (0.45)	0.33 (0.49)	0.33 (0.49)	0.58 (0.51)	0.33 (0.49)	0.25 (0.45)	0.25 (0.45)	0 (0)	0 (0)	0 (0)
Dog	0.50 (0.52)	0.67 (0.49)	0.42 (0.51)	0.25 (0.45)	0.58 (0.51)	0.25 (0.45)	0.33 (0.49)	0.58 (0.51)	0.33 (0.49)	0.17 (0.38)	0.17 (0.38)	0 (0)	0 (0)	0 (0)
Carob tree	0.17 (0.38)	0.17 (0.38)	0.17 (0.38)	0.17 (0.38)	0.08 (0.28)	0.08 (0.28)	0.08 (0.28)	0.17 (0.38)	0.17 (0.38)	0.92 (0.28)	0.75 (0.45)	0.33 (0.49)	0.08 (0.28)	0 (0)

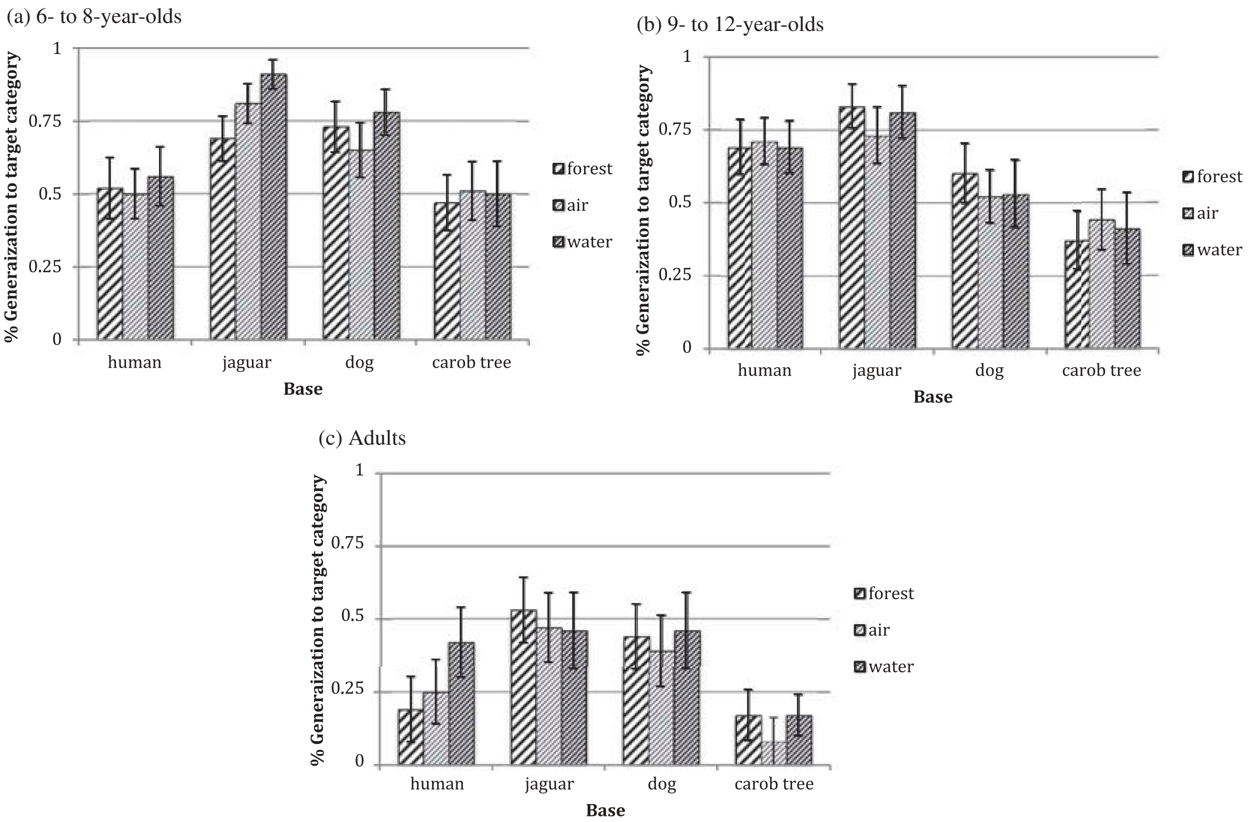

Figure 2. Mean generalizations (and standard deviations) from each base to animal target groups as a function of age.

120) = 12.026, $p < .001$; participants were more likely to project the novel biological property to the animal targets from the jaguar base than from the remaining three bases. There was also a main effect for age, $F(2, 40) = 5.585$, $p = .007$. There were no other main effects or interactions.

This analysis reveals that although the Wichi certainly identify and name distinct habitat-based categories of animals, when it comes to reasoning about the natural world, the covert category nonhuman ANIMAL serves as a coherent basis for induction.

Based on this outcome, in all subsequent analyses we combined participants' responses involving nonhuman animals (either as targets or as bases), treating animals as a single group (see Figure 3). We first submitted these data to an ANOVA with base (3: human, nonhuman animal, plant) and target category (5: human, nonhuman animal, plant, water, artifact) as within-participants factors and age (3: 6- to 8-year-olds, 9- to 12-year-olds, adults) as a between-participants factor. This comprehensive ANOVA revealed a main effect for target category, $F(4, 328) = 70.029$, $p < .001$. This was qualified by an interaction between target category and base, $F(8, 328) = 23.821$, $p < .001$; participants at all ages were more likely to project a novel property to the plant targets when it was introduced on the carob tree than on the human or nonhuman animal bases. The comprehensive ANOVA also revealed a main effect of age, $F(2, 41) = 4.313$, $p < .05$; adults were more conservative in projecting novel properties than were children at both ages.

In all remaining analyses, we used this comprehensive analysis as a foundation for conducting planned comparisons at each age to address the remaining three questions specifically. For all comparisons, $p < .05$ was set as the threshold for statistical significance.

What Is the Inductive Status of the Category ANIMAL (Including HUMAN AND NONHUMAN ANIMALS)?

An examination of the Wichi's response patterns at every age offers three strong indications that they use a covert category that includes both humans and nonhuman animals (analogous in scope to the English animal-inclusive) in reasoning about the biological world. More specifically, at every age,

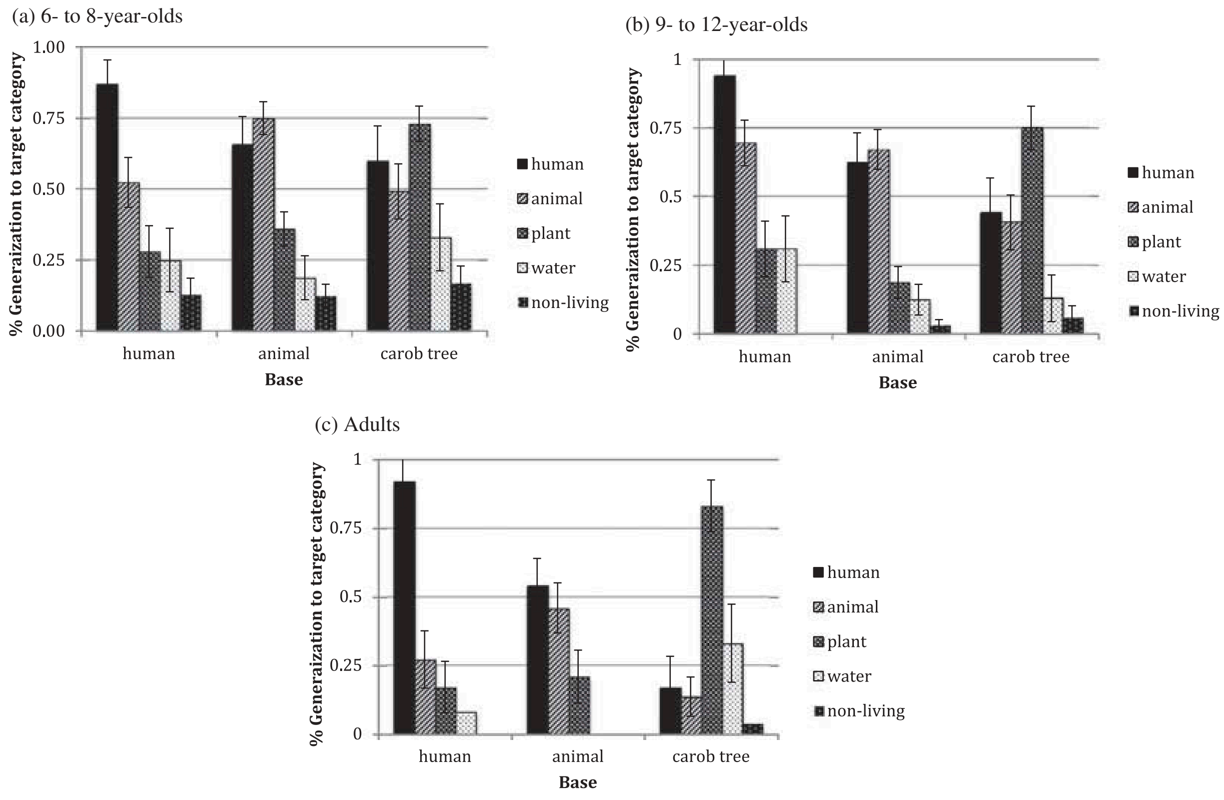

Figure 3. Mean generalizations from human, animal, and carob tree bases as a function of age.

the Wichi were (a) more likely to extend a novel property taught on a nonhuman animal to a human than to plants (all *ps* < .05), (b) more likely to extend a novel property taught on a human to nonhuman animals than to plants (all *ps* < .05),[3] and (c) equally likely to extend a novel property from a plant to either a human or a nonhuman animal.

Thus, although the category that includes both human and nonhuman animals remains unnamed in Wichi, children and adults alike appreciate the close affinity between them, suggesting the use of a covert category that includes both humans and nonhuman animals as a basis for reasoning about the biological world.

How Do the Wichi Construe the Relation Between Humans and Nonhuman Animals?

We address this question by focusing our analysis on the two patterns of inductive reasoning that have served as signatures of anthropocentric reasoning in past research (Anggoro et al., 2010; Astuti et al., 2004; Carey, 1985; Herrmann et al., 2010; Ross et al., 2003). More specifically, we considered whether participants at each age were (a) more willing to project the novel property from the human base to nonhuman target animals than from the nonhuman animal bases to human targets and (b) more willing to project the novel property from the human base to nonhuman target animals than from the nonhuman animal bases to nonhuman target animals. We found no evidence of human-centered reasoning among the Wichi in our sample at any age.

6- to 8-Year-Olds

First, our youngest participants were just as likely to extend a novel property from a human to a nonhuman animal as from a nonhuman animal to a human ($M_{6\text{- to 8-year-olds}}$ = .523 and .656,

[3]There was only a single exception to this pattern: Among adults, among which generalizations from humans were exceedingly low, the difference between their extensions from a human to nonhuman animals (.271) versus from a human to a plant (.167) was in the predicted direction but was not statistically significant.

respectively; p = .25). Second, they were significantly more likely to extend a property from a nonhuman animal to other nonhuman animals (.750) than from a human to a nonhuman animal (.523; $p < .05$). Notice then that these children actually favored nonhuman animals over humans as an inductive base; this is the opposite of a human-centered pattern of reasoning.

9- to 12-Year-Olds

The older children also were just as likely to extend a novel property from a human to a nonhuman animal as from a nonhuman animal to a human ($M_{\text{9- to 12-year-olds}}$ = .695 and .625, respectively; p = .415). They were also equally likely to extend a property from a nonhuman animal to other nonhuman animal (.672) as from a nonhuman animal to a human (.625; p = .753).

Adults

For the adults, nonhuman animals provided a significantly stronger inductive base than did humans. Adults were significantly more likely to extend a novel property from a nonhuman animal to a human than from a human to nonhuman animals (M_{adults} = .542 and .271, respectively; $p < .05$). In addition, they were significantly more likely to extend a property from a nonhuman animal to other nonhuman animals (.458) than from a human to a nonhuman animal (.271; $p < .05$).

In sum, these analyses suggest that among the Wichi, humans do not serve as a privileged inductive base in reasoning about the animal kingdom. In the next analysis, we considered the responses of each individual participant, rather than group means, to assess whether this decidedly non-anthropocentric pattern of reasoning, evident in the mean analyses (described previously), is characteristic of most individuals. To address this question, we tallied each individual's response for each of the two signature comparisons ([a] and [b] above).

For (a), for each participant, we compared the number of projections from the human base to nonhuman target animals against the number of projections from the nonhuman animal bases to human targets. Each participant was coded either as *anthropocentric* (if the number of projections from the human base to nonhuman target animals exceeded the number of projections from the nonhuman animal bases to human targets) or *not anthropocentric* (if the number of projections from the human base to nonhuman target animals was less than or equal to the number of projections from nonhuman animal bases to human targets).

For (b), for each participant, we compared the number of projections from the human base to nonhuman target animals against the number of projections from nonhuman animal bases to the nonhuman target animals. Each participant was coded either as *anthropocentric* (if the number of projections from the human to nonhuman animals exceeded the number projections from nonhuman animals to nonhuman animals) or *not anthropocentric* (if the number of projections from the human to nonhuman animals was less than or equal to the number of projections from nonhuman animals to nonhuman animals).

Participants' responses for each comparison are reported in Table 3. At every age, the number of non-anthropocentric responses outnumbered the number of anthropocentric response by a factor of at least 2 and in most cases by a factor of at least 4.

Following Carey (1985) and Herrmann et al. (2010), we reasoned that the best evidence for anthropocentric reasoning requires an analysis of participants' responses to both comparisons (a) and (b). We therefore tabulated the number of participants at each age who responded in a consistently anthropocentric fashion to both comparisons, responded in a consistently non-anthropocentric fashion to both comparisons, and responded inconsistently (i.e., by providing one anthropocentric and one non-anthropocentric response). As can be seen in Table 4, consistently anthropocentric patterns of response were rare at every age. Moreover, children at both ages were significantly more likely to exhibit a consistently non-anthropocentric than consistently anthropocentric pattern: 6- to 8-year-olds, $\chi^2(1, N=13) = 6.231$, $p = .01$; 9- to 12-year-olds,

Table 3. Individual Participants' Responses at Each Age to the Two Signature Indices of Human-Centered Reasoning.

	(a) (Human:Nonhuman Animal) > (Nonhuman Animal: Human)			*(b) (Human: Nonhuman Animal) > (Nonhuman Animal: Nonhuman Animal)*		
Age Group	*Anthropocentric*	*Non-Anthropocentric*	*Total*	*Anthropocentric*	*Non-Anthropocentric*	*Total*
6 to 8 years	3	13	16	2	14	16
9 to 11 years	5	11	16	3	13	16
Adults	0	12	12	0	12	12

$\chi^2(1, N = 11) = 7.364$, $p = .007$.[4] Not a single adult exhibited a consistently human-centered pattern of reasoning about the natural world.

Clearly then, analyses based on group means and on individual participants' responses converged to suggest that the Wichi do not privilege humans as an inductive base. Moreover, in this population, nonhuman animals appear to be a stronger base for induction to other nonhuman animals than are humans.[5] This outcome suggests that even among the youngest children in our sample,[6] humans are represented as one animal among many, and this despite the fact that the category including human and nonhuman animals is not named.

How Do Plants Fit in With the Wichi's Reasoning About the Natural World?

Although we included fewer plants than animals, the results nonetheless provide a glimpse of Wichi reasoning about the plant kingdom at each age. Planned comparisons revealed that for children and adults alike, the Wichi were significantly more likely to extend a novel biological property to the plant targets if it was introduced on the carob tree than on either the human or nonhuman animal base (all *p*s $< .05$).

Adult Justifications

The adults' justifications, provided in Table 5, offer a different vantage point into Wichi reasoning about the natural world. Fortunately, adults offered justifications on 71% of their opportunities to do so (on 34 of 48 possible [4 bases × 12 adult participants] trials).

Table 4. Number of Individual Participants at Each Age and Their Responses to the Two Signature Indices of Human-Centered Reasoning.

Age Group	*Consistently Anthropocentric (on Both [a] + [b])*	*Consistently Non-Anthropocentric (on Neither [a] nor [b])*	*Inconsistent*	*Total*
6 to 8 years	2	1 1	3	16
9 to 11 years	1	10	5	16
Adults	0	12	0	12

Note. See Table 3 and "How Do the Wichi Construe the Relation Between Humans and Nonhuman Animals?" for descriptions of (a) and (b).

[4]Notice that this analysis is a conservative one; we excluded from the analysis the few children exhibiting inconsistent responses. (Including these children in the analysis did not change the results.)

[5]An analysis of order effects provided even more compelling evidence that the Wichi do not favor humans over nonhuman animals as an inductive base. In prior work, we documented that in populations in which young Western-educated children showed human-centered asymmetries (cf. Chicago, Jakarta), this anthropocentric pattern was most pronounced among children for whom a human served as the first base compared to those who got the human base later (Anggoro et al., 2010). To ascertain whether there was any hint of anthropocentrism among the Wichi, we asked whether anthropocentric reasoning was evident in participants who got human as their first base. There was no hint of human-centered reasoning whether the human base was first or last.

[6]Even among 6-year-olds, the age group revealing anthropocentric patterns of reasoning in Carey (1985), only a single child consistently favored the human over the nonhuman animal bases. All five of the remaining 6-year-olds were consistently non-anthropocentric.

Table 5. Adult Justifications.

Human Base
H1. "because all of them are animals *(tshotoy*), all them can move away and run, if there is something wrong or bad they can run away in contrast to these ones (*gestures to plants*) which they cannot"
H2. "because all of them have husek and can breathe as humans (*hin'ulh*)
However, they (gestures to human and trees) have the same inside … the human (*siwele*) has the blood that runs inside and trees have a green sap, the greenery, it is the same …I have this thought …the person () is different than the trees (*hal'o*) because he feels … and can be moved if there is danger he can run away … trees (*hal'o*) can not and that makes it more helpless …"
H3. "because they eat fruits from the forest, they eat the same"
H4. "because all of them are large"
H5. "because the way they eat, they eat meat"
H6. "because humans () and trees have the same body, are equal, are high and they are standing. At the top are the same, have the foliage which makes them similar, it protects them, and when each foliage grows it is never the same as others. Each person (hin'u) has their own and each tree (*hal'o*) has its own. Never there are two "mistoles" or carob trees alike. They are different because they grow up differently … the place where it is, one is more sheltered and better …"
Jaguar Base
J1. "because all of them have *husek* and are in the land"
J2. "all of them are like the jaguar, the jaguar has a lot of contact with the "pachamama" it is special, it has a lord who is a *duende de monte* and it protects the jaguar"
J3. "because all are animals (*tshotoy*) they move by themselves and are alive"
J4. "because they both are on the forest (*monte*) they come from the same place. That is why the have the same substance inside…the caiman is also in the forest but it spends much time on the river which is a very different place to the forest, both places are different with very different inhabitants (*lheley*) "
J5. "because all them eat the same, have the same substance inside, and all of them are big"
J6. "because they eat the same, meat"
J7. "because all them eat the same, have the same substance inside, and all of them are big"
Dog Base
D1. "because all of them are from the land"
D2."because all of them are animals (*tshotoy*), they eat and are alive"
D3. "because all of them eat meat"
D4. "because all them are big/large animals (*tshotoy*) that is why they have the same substance inside"
D5. "because the dog and the human (hin'u) are in the same place, they do the same and they are together"
Carob Tree Base
C1. "because all them are in the land, in contrast I think the piranha is not like the carob tree and it has not the same substance inside because the piranha is in the river and it is very different than these ones (*gestures to the land animals*). But the piranha has the same inside than the water because she needs it to be alive."
C2. "because they are not animals (*tshotoy*), even though the carob tree is like an animal (*animale*, borrowed from Spanish) they feed us"
C3. "because they both grow up and can die and when we go to the forest and look for the algarroba (carob tree fruit) sometimes we want to pick it up and it refuses, so something inside prevents you not to pick it up because it may damage you, or hurt you"
C4. "because they are green, they give fruits, and the trees (*hal'o*) have the greenness inside, they are in the forest, they grow up there and they stay" there and all of them have the same liquid inside. The carob tree has a very hard bark and it is used for the leather"
C5. "because all of them need themselves that is why they have the same substance"
C6. "because all of them need each other… all need water and that is why they have the same substance"
C7. "the parrot eats the leaves and that is why they can have the same substance inside them. The caiman, water and plants (*plantas*, borrowed from Spanish) also have the same because all need water to live; besides the trees and the caiman have the same substance that is why they both dry when they die". The carob tree is holy because it feeds us every single year"
C8. "because they have the same body, the head and the feet, both are equal and grow up in the same manner"

An inspection of Table 5 reveals that in their justifications, the Wichi frequently invoked taxonomic relations or shared morphology (e.g., J3: "because all are animals [*thsotoy*], they move by themselves and are alive"), either alone or in combination with other more ecological and relational explanations, including explicit mention of shared habitats (e.g., J4: "they are both in the forest … come from the same place"), shared behaviors (e.g., H3: "they eat fruits of the forest"), animacy status (e.g., H1: "all of them can move away and run"), or spiritual status (e.g., "because all of them have *husek* …").

A covert category of animals? Their performance in the induction task suggested that the Wichi use the covert category ANIMAL in reasoning about the natural world. The adults' justifications offer converging evidence for this interpretation. On only four occasions did an adult make reference to an inclusive category ANIMAL. On three such occasions, *thsotoy* was used (consistent with Berlin et al., 1973). On the single remaining occasion, *lelhey* (inhabitants) was used. It is interesting that this was in the context of describing distinctions between the animals of the forest (*thsotoy*) and animals of the water (*tshotoy inot lheley*). It seems plausible that by using *lelhey* in this context, the speaker was able to maintain the distinction between these two habitat-based groups of animals. Using *tshotoy* in this context, to refer to the more inclusive animal category, would likely have made this distinction difficult to maintain.

A covert category of plants? The Wichi's performance in the induction task suggested that they treat PLANT as a cohesive category as well. The adults' justifications provide converging support. Whenever they referred to plants, it was as a single group. For example, one adult justified her distinction between plants and animals in this way: "because all [animals *tshotoy*] can move away and run. If there is something wrong or bad they can run away, in contrast to these [gestures to the plants] that cannot." Others invoked shared spiritual properties (e.g., "because all of them [gestures to plants] have *husek* …"). It is interesting, however, that the Wichi used not a lexical item in these cases but instead an indexical (e.g., "them," "these") accompanied by gestures toward the plants.

Naming the humans. The adults' justifications also converge well with the observation that although there is a term that includes all and only humans (*hin'ulh*), it is rarely used (Taverna et al., 2014). In our sample, adults referred to people four times, and only when a human was the base. The term *hin'ulh* occurred once, *Wichi* occurred twice, and *siwele* (White people) occurred once.

General Discussion

The Wichi's systematic responses in category-based induction, coupled with adults' justifications, reveal a profile of reasoning about the natural world that shares considerable commonalities with that of individuals from other communities but that also reflects the shaping forces of language, experience, and community-held belief systems in reasoning about the natural world. This work, characterized by strong developmental continuities in the organization of folkbiological knowledge, reveals three overarching themes.

First, this work showcases the power of covert categories. This converges well other evidence documenting the inductive power of categories that, although unnamed, nonetheless guide inductive inferences about the natural world (Anggoro et al., 2008; Berlin et al., 1973; Leddon et al., 2008; Waxman, 2005). This work also illustrates for the first time that although the Wichi may name habitat-based groups of animals and plants, the overarching categories that correspond to ANIMALS (HUMAN AND NONHUMAN) and PLANT support inferences of their own.

Second, these results reveal an emerging precision, over developmental time, in how the Wichi reason about living things. For example, weaving together representations to form categories like PLANT and MAMMAL may be best characterized as a protracted developmental process, evident in adults but not yet in the children. Additional work incorporating more items from each of these categories will be required to flesh out this possibility.

Third, this work fortifies the proposal that anthropocentric reasoning is not a universal developmental starting point for reasoning about the natural world. As predicted, Wichi children did not favor humans as an inductive base in reasoning about the natural world. Moreover, the youngest group of children as well as the adults favored nonhuman animals over humans as an inductive base. This outcome, which contrasts with results from urban, Western-educated children and adults (Carey, 1985; Herrmann et al., 2010), converges well with evidence from several other communities, including rural majority-culture and Native American communities in the United States and Central

America (Atran, Medin, & Ross, 2002; Medin, Waxman, Woodring, & Washinawatok, 2010). In an ideal world, it would have been possible for us to examine younger children as well. However, we did not have access to children in this community who had not yet entered school. We speculate that human-centered reasoning would also be absent in younger children. In future work, we hope to test this speculation with 3-year-olds in the Wichi community; this is the youngest age at which the category-based induction task has been used effectively (Herrmann et al., 2010).

Another goal for future investigations will be to examine whether and how the Wichi understanding of the natural world varies as a function of education level. Recall that most of the adult participants in the current investigation had limited Western-oriented education. A goal in our ongoing work is to consider a larger group of adults to pinpoint the influence (if any) of Western education in adults' folkbiological reasoning.

Implications For Science Education

This experimental work, considered in conjunction with related investigations among the Wichi and other indigenous groups, broadens the empirical foundation for theories of conceptual development and for pedagogy. It also has broader implications for early science education.

Decades of research in the developmental and educational sciences indicate that as children enter the formal classroom, they bring with them their existing knowledge and beliefs about the natural environment and that this knowledge, along with the frameworks children use to organize it, should be taken into account in developing curricula (e.g., Anggoro et al., 2008; Astuti et al., 2004; Coley, 1995; Gelman, 1988; Hatano et al., 1993; Herrmann et al., 2010, 2012; Leddon et al., 2008; Rosengren et al., 1991; Waxman et al., 2007, 2014). First, the current results add to the growing body of evidence on children's frameworks for understanding the natural world. The results underscore that educational practices—even in the natural sciences—are not culturally neutral. They also align well with that view that to advance science education it is advantageous to incorporate culturally based epistemological orientations and cultural practices (Bang & Medin, 2010).

Second, this work provides a foundation for building science curricula that not only take into account children's existing knowledge but harness these strengths in the service of learning. This is especially important in cases like Wichi education. Although officially the goal of the Argentine education system is to root the objectives, contents, and methodologies of the Wichi curriculum in the framework of the indigenous, rural context (EIB Document, Cultural and Educational Ministry, Formosa Province, 2006), curricular decisions are often implemented unilaterally by nonnative educators (e.g., Zidarich, 2014).

For example, we have shown here that Wichi children and adults organize their knowledge of the natural world into a system of categories, some based on taxonomic or perceptual similarities, others based on shared habitat, animacy status, and even spiritual status. The results also show the use of these categories in reasoning about the natural world, even if they are not named. These insights can now be used in developing curricula. In doing so, it will be important to bear in mind that organizing animals into habitat-based categories does not preclude an appreciation of taxonomic categories like those featured in traditional Western science curricula. Moreover, we suspect that the Spanish names for these unnamed categories will be readily borrowed as loan words as soon as the Spanish terms (e.g., *animales, seres vivientes*) are introduced in the curriculum. This phenomenon is already evident in the adults' justifications, in which Spanish loan words appear only for categories that are unnamed in Wichi. Finally, we have shown that even the youngest children in the Wichi community have rich knowledge and models for reasoning about the inhabitants of the earth and that these models differ clearly with the anthropocentric views of the natural world more predominant in Western contexts. We endorse any wariness expressed by Wichi teachers and the community at large about adopting into the curriculum predominantly Western models that so often adopt an anthropocentric stance.

Third, the creation of teaching materials that reflect the Wichi's cultural knowledge is essential to a successful curriculum. This is especially true in the context of the Wichi community because these children have very limited access to written media in their native language (books, magazines, games, etc.), perhaps due to the transmission of the Wichi as written language is socially new. We are currently in the process of starting to redress this limitation by designing a series of books about the inhabitants of earth for school-age children. In designing the materials, we are well aware that the images we offer young children shape their representations of the entities in the natural world and the relations among them. An especially clear example comes from research into the effects of children's media in the United States, which has documented (a) that anthropomorphizing nonhuman animals is far more prevalent in the illustrations and text of books authored by members of the U.S. majority culture compared to those authored by Native Americans (Dehghani et al., 2013) and (b) that young children—especially urban children with little direct contact with the natural world—are sensitive to these representations (Herrmann et al., 2010; Waxman et al., 2014). The media we are developing in the context of the Wichi community are consistent with Wichi categorization patterns and their diverse models of reasoning about the natural world.

In conclusion, as we hope to have made apparent, the Wichi are an especially interesting group to collaborate with from both a research and educational perspective. Our work in this community permits us a glimpse into how folkbiological knowledge is shaped in a community in which the native language and a constellation of experiences and belief systems differ from those of the communities studied in most prior empirical work.

We look forward to continuing to work collaboratively with this community to develop a more strongly indigenous curriculum focusing on native species and on culturally valued characters and beliefs.

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