Running Head: ESSENTIALISM AND CULTURAL BELIEF IN FOLKBIOLOGY

Folkbiological reasoning from a cross-cultural developmental perspective:

Early essentialist notions are shaped by cultural beliefs

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Abstract

Two experiments examine the evolution of folkbiological reasoning in children (4 to 10 years of age) and adults from four distinct communities (rural Native American, rural majority culture, and suburban and urban North American communities). Using an adoption paradigm, we examine participants' intuitions regarding the inheritance of properties and the mechanisms underlying the transmission of kindhood. Across all communities and ages, there was a strong biological component underlying reasoning about the inheritance of properties. There were also differences in children's intuitions about the mechanisms underlying kindhood: Native American children were more likely than their counterparts to consider blood as a candidate biological essence. This suggests that as children search to discover the underlying *essence* of a biological kind, they are guided by broad essentialist notions that are shaped by discourse within their community.

Biological Reasoning from a Cultural and Developmental Perspective

To interpret the natural course of everyday events, we depend heavily upon intuitive notions about the objects and events in the physical world, about the entities and processes in the biological world, and about the rather specific beliefs and predilections of our fellow human beings. These intuitive ideas, dubbed naïve physics, naïve (or folk) biology, and naïve (or folk) psychology, respectively, have been the focus of active investigations by cognitive and social psychologists alike. At the same time, developmental psychologists have considered the origins and emergence of these notions (e.g., Astuti, Solomon & Carey, 2004; Hirschfeld & Gelman, 1994). The present paper is concerned primarily with the emergence of intuitive understandings of living things (folkbiology) in individuals raised in distinct communities in the US and ranging in age from four years to adulthood.

Developmentalists have long been interested in children’s acquisition of knowledge about living things and the biological world. In his detailed observations of children’s reasoning, Piaget (1964) proposed that young children have a rather unstable notion of the concept *alive*, judging virtually anything that appears to move on its own (e.g., clouds, the wind, heavenly bodies) an animate being, and imbuing it with intentions and even beliefs and emotions. In Piaget’s view, this *childhood animism* is illogical and atheoretical, and ultimately must give way to the more mature, truly biological system of organization that characterizes adult thought.

In 1985, Carey’s work revitalized interest in this issue, bringing new experimental evidence to bear in support of a new claim. Like Piaget, Carey argued that the concept alive undergoes substantial developmental change, that children’s understanding of this concept differs radically from that of adults, and that a truly biological concept of living things is not available until children reach roughly 9-10 years of age. Where Carey’s view parted company with Piaget’s was in her characterization of the young child’s mind. In her view, although young children’s thinking differs radically from that of the adult, it is neither illogical nor unstable. On the contrary, she proposed that young children's understanding of living things is initially embedded in a folk psychological, rather than a folk biological, explanatory framework. Two points follow from this assertion. First, that as a consequence of their folk psychological framework, young children view humans as the prototypical animal; and second, that children must undergo a fundamental conceptual change if they are to move from a folk psychological (in which humans are at the very center) to a folk biological framework, in which they come to view humans as one animal among many.

Carey's bold claims served to stimulate a large body of research. Currently, there appears to be consensus within this active field of research on three points: First, that young children do indeed have intuitive theories that guide their reasoning about biological phenomena; second, that these theories may indeed be distinct from their theories concerning psychological phenomena (for extensive reviews, see Carey, 1999; Gelman, 2003; and Inagaki & Hatano, 2002); and third, that these early theories differ systematically from both the more elaborate theories held by adults and the more formal theories that form the core of Western science curricula.

But there is also ample ongoing debate, which has focused primarily on characterizing the scope of children's intuitive biological theories, and this calls up the issue of domain-specificity. Some have argued that when reasoning about biological phenomena, children do not invoke domain-specific biological causal mechanisms until about seven years of age (see Carey, 1995; Carey & Spelke, 1994; Johnson & Carey, 1998; Johnson & Solomon, 1997; and Solomon, Johnson, Zaitchik & Carey, 1996). Others have interpreted the evidence differently, arguing that children's reasoning about biological phenomena is guided from the start by skeletal principles or naïve theories that invoke domain-specific biological causal mechanisms (see Atran, 1987, 1990; Atran, Medin, Lynch, Vapnarsky, Ek & Sousa, 2001; Gelman & Wellman, 1991; Hatano & Inagaki, 1994; Keil, 1989; Sperber, Premack & Premack, 1995; Springer, 1995; and Springer, 1996).

The concept of biological essentialism has figured largely in these recent discussions. Biological essentialism, put simply, is a commonsense assumption (a) that each and every biological entity has an underlying essence, or internal causal force, and (b) that this essence is responsible for maintaining the identity of that entity within its species, even as it causes the entity to grow, change form, and transmit features from one generation to the next (Ahn, Kalish, Gelman, Medin, Luhmann, Atran, Coley & Shafto, 2001; Atran, 1998; Atran, Estin, Coley & Medin, 1997; Coley, Medin, & Atran, 1997; Gelman, 2003; Gelman & Wellman, 1991).[1] Inherent in this notion, then, is a commitment to tracing the essence of unique individuals as well as the essence of kinds (or species) of individuals. The notion of biological essentialism involves causal mechanisms that dictate how and why biological (but not non-biological) phenomena unfold and is, in this sense, domain-specific.

What is very interesting, especially from a developmental vantage point, is that this overarching "in principle" belief in an underlying biological essence has been shown to guide reasoning and learning even in children and adults who lack specific information about what that essence might be (Gelman, 2003; but see also Strevens, 2000). The idea is that, even when they are naïve with respect to what this essence might be, adults and children nonetheless believe that an (as yet unknown) underlying essence does exist, and that it is responsible for the identity of an individual within its kind and therefore responsible for the appearance, characteristic behaviors, and ecological preferences of individuals within the kind. This in principle belief, which has been described as an *essence placeholder* (Medin & Ortony, 1989), is perhaps best characterized as a skeletal principle, for it guides the acquisition of knowledge within the biological domain, but does not specify precisely the content of the knowledge (see Gelman & Williams, 1998 for a discussion of the role of skeletal principles in conceptual development).

The idea of an *essence placeholder* fits well with the evidence that an overarching belief in biological essentialism may be universal, but the more precise intuitions about what that essence actually might be varies rather dramatically across cultural settings and historic time. To the best of our knowledge, a range of vital biological (e.g., blood, heart, liver, brain, and even mothers' milk) and spiritual (e.g., the soul, karma, mind) elements have been considered, at one time or another, as harboring the essence of an individual (Stoler, 1997; Zimmer, 2004). The idea that biological essentialism is a skeletal principle also fits well with the observation that the precise range of entities that are considered to be biological also varies across cultural settings and historic time. For example, the Itza Maya appear to consider the sun and even the "forest spirits" to be biological entities. In other cultures, these entities are not conceptualized as biological and therefore are not expected to be governed by a biological essence. This point is important. Although there is developmental and cross-cultural variation in the boundary conditions on the entities that are considered to be biological (and of these, on the entities that are judged to be alive) and in the precise candidate essences, an overarching belief in essentialism appears to be universal and to guide the reasoning of young children.

Returning to the developmental issues at hand, one important question has been whether young children invoke specifically biological causal mechanisms in reasoning about entities in the biological world (see Gelman, 2003 for an excellent review; see Keil, 1989, and Inagaki and Hatano, 2002, for discussion of several candidate mechanisms). To get to the core of this issue, several experimental tasks have been designed, but one in particular – an adoption task – has been especially popular. This task focuses squarely on children's developing intuitions regarding the inheritance of properties from one biological entity to another (see, e.g., Astuti, et al., 1994; Astuti, 2001; Atran et al., 2001; Bloch, Solomon & Carey, 2001; Johnson & Solomon, 1997; Solomon et al., 1996; Sousa, Atran & Medin, 2002; and Springer, 1996). Typically in this task, a participant is told a story about a baby who was separated at birth from its biological mother and then reared exclusively by an adoptive mother. The participant is then presented with a series of follow-up questions, designed specifically to assess their intuitions about whether the baby, once grown, will resemble its biological or adoptive parents in its physical and behavioral characteristics. For example, in a story involving a baby who was born to a pig, but then raised exclusively by cows, participants are asked to judge whether the baby, once grown, will exhibit a) the physical characteristics of the biological or adoptive parent (e.g., a short curly tail or a long straight tail, respectively) and b) the behavioral characteristics of the biological or adoptive parent (e.g., oink or moo). In addition, participants may be asked to make a judgment regarding kindhood (e.g., whether the baby will grow up to be a pig or a cow).

Performance on this task has typically been interpreted as follows. If participants favor the biological over the adoptive parent in attributing characteristics to the offspring, this is taken as evidence of a specifically biological mechanism of transmission, favoring the influence of nature over nurture. If participants favor the adoptive over the biological parent, this is taken as evidence of the importance of the environment, favoring nurture over nature. Some researchers have gone further to argue that evidence for a truly domain-specific biological causal theory requires a *differentiated pattern* of responses, in which physical properties (which are presumably transmitted by biological mechanisms) are attributed to the biological parent, and behavioral or psychological properties (which are presumably transmitted by environmental mechanisms) are assigned to the adoptive parent (Astuti, et al., 2004; Bloch et al., 2001; Solomon et al., 1996).

Although this line of argument is plausible, it is not unimpeachable. There are logical reasons to question the position that the differentiated pattern is a litmus test for a truly autonomous biological theory. Just as it is naïve to assume that development is guided by *either* nature *or* nurture, so it is naïve to argue that attributions regarding properties are guided *either* by biological *or* environmental mechanisms (see Sousa et al., 2002 for a similar argument). The two are not mutually exclusive. Some clearly physical properties (e.g., bone density, muscle strength, height, and weight) are influenced heavily by the environment as well as by biology; some behavioral properties (e.g., activity level and diurnal rhythms) are influenced heavily by biology as well as by environmental happenstance. Following this logic, if the expression of any given property may be under both biological and environmental control, a failure to distinguish between physical and behavioral properties in the inheritance of properties may, in fact, reflect participants' appreciation of the necessary interaction between nature and nurture.[2]

In the face of these interpretive issues, what should count as evidence for an autonomous theory of biology, one that is organized around distinctly biological causal mechanisms? In our view, what is required *in theory* is evidence of causal reasoning that operates in a broadly coherent manner upon entities unique to the biological domain, and what is required *in practice* is that we move beyond the inheritance task, to examine in greater detail the causal mechanisms underlying the transmission of kindhood.[3]

This is precisely the strategy adopted in two recent research programs, and the strategy that we advance in the experiments reported here. Focusing on the Yukatek Maya, Atran et al. (2001) uncovered a strong biological component underlying the inheritance of properties and the judgments of kindhood. Both adults and children (ranging from 4 to 7 years of age) revealed a robust tendency to attribute properties of the birth parent to the offspring. This "birth parent bias" was observed for all properties, whether they were behavioral or physical, familiar or novel. In other words, the differentiated pattern was not observed in this population (even in adults).

Crucially, this experiment went one step beyond examining intuitions regarding inheritance of properties. In addition, the experimenters asked participants to reason about the *mechanisms* responsible for the transmission of an individual's kindhood. After each participant had answered questions regarding the inheritance of properties (described above), the experimenter presented one last scenario. This scenario was designed to tap into participants' intuitions regarding the mechanism underlying the transmission of kindhood, and focused on the possibility that *blood* was essential to kindhood. Participants were told that when the baby was still young, it had become very sick and that to heal the baby, a doctor had to take out all of its blood and replace it with blood from the adoptive mother. Participants were then asked what kind of animal the baby would grow up to be. Adults and children alike continued to favor the birth parent, suggesting that in their view, an individual's kindhood is transmitted by birth and is unlikely to be changed even by an intervention as radical as a blood transfusion from the adoptive parent. This suggests that for the Yukatek Maya, blood is not judged to harbor the "essence" of an individual.

A subsequent study by Sousa et al. (2002), involving urban children and adults in Brasilia (Brazil), reported converging evidence for a strong biological component underlying property inheritance. Brazilian children and adults showed a strong birth bias for all properties, and this was especially pronounced for familiar as compared to novel properties. But when queried about the effects of the complete blood transfusion, there was an intriguing effect. Although Brazilian adults, like the Yukatek Maya, denied that the blood transfusion from the adoptive parent would influence the individual's kindhood, Brazilian children performed quite differently. They judged that the blood transfusion could indeed change kindhood. Sousa et al. (2002) linked this finding to the considerable discourse concerning blood within Brazilian urban culture. They speculated that, as a consequence of this discourse, Brazilian children hear a great deal about blood and therefore may be more likely than children in other cultures to seize upon blood as a plausible candidate biological essence, as a mechanism that underlies the transmission of kindhood from one individual to another.

In the present studies, we sought to pursue this very intriguing effect in several directions. A first goal was to broaden the empirical base and to this end, we recruited participants from four distinct communities. Two of these communities are situated in adjacent areas in rural Wisconsin, one European American and the other Native American (Menominee Tribe). Participants from these communities were included in Experiments 1 and 2. The other two communities are situated in adjacent towns in Illinois, one urban and the other suburban. Participants from these communities were included only in Experiment 2. We presented adults and children from each of these communities with three adoption scenarios, examining their judgments regarding the inheritance of physical and behavioral properties.

Perhaps more importantly, we pursued questions concerning the mechanism underlying the transmission of kindhood. To address this question, we solicited participants' intuitions regarding two potential candidates for essence: blood (Experiments 1 and 2) and nurture (Experiment 2). The Native American Menominee population was especially important in this enterprise, because it offered an opportunity to test Sousa et al.'s interpretation of the Brazilian data.

Menominee tribal membership is based on blood quantum. Because both federal and tribal regulations depend on formal tribal enrollment, blood quantum measures have important practical consequences in the lives of individuals, families, and for the community at large. For example, hunting and fishing are frequent activities for Menominee adults and children, and the products of these activities are very visible within the context of family life. However, hunting and fishing regulations draw a three-tiered distinction between enrolled Menominees, "descendents" (individuals who have at least one Menominee parent but who do not themselves meet the blood quantum requirements), and non-tribal residents (e.g. a non-Menominee spouse of an enrolled Menominee). Enrolled members are allowed to take more fish and game and enjoy a longer season than do their descendents, and descendants are permitted more fish and game and a longer season than their non-tribal counterparts. As another example, the Menominee tribal school receives financial aid from the Bureau of Indian Affairs, but this aid is based on the number of children who are enrolled Menominees; no funds are provided for descendents or non-tribal residents. As a result of this federal regulation, the parents of any child who is a descendent (or non-tribal counterpart) must pay tuition if they wish to send their child to the tribal school. In short, tribal membership status, which is based strictly on blood quantum, has very tangible and practical implications for Menominee families. Because tribal membership status has an impact on parents and children alike, there is considerable community-wide discourse concerning blood (quantum).

This provides an intriguing research opportunity. If young children do indeed have an overarching *in principle* belief that there is an underlying biological essence that is responsible for kindhood, and if they are as yet naïve with respect to the precise content of that essence, then they should be especially sensitive to the discourse of the adults in their communities as they seek to identify plausible candidate essences. As a consequence, community-wide discourse about blood should elevate the plausibility of blood as a candidate essence for children. If this is the case, the Menominee children (like their Brazilian counterparts in Sousa et al., 2002) should be more likely than children from the non-Native US communities to judge that a complete blood transfusion is relevant to an individual's kindhood.

To anticipate, the results of the two experiments reported here suggest that across diverse cultural communities, (1) there is a strong biological component underlying people's reasoning regarding the inheritance of traits, (2) there is a strong bias to attribute an individual's kindhood membership on the basis of the kindhood of its biological parent, (3) this bias emerges in early childhood, and (4) it is accompanied by skeletal notions about causal biological mechanisms that underlie the transmission of kindhood from one individual to another.

Experiment 1

Two primary goals motivated this experiment. First, we sought to broaden the empirical base by examining the developmental course of biological reasoning in two additional populations, European Americans and Native Americans living in two neighboring communities in rural Wisconsin. To flesh out the developmental trajectories of biological reasoning, we included children in three different age-groups (4- to 5-year-olds, 6- to 7-year-olds, and 9- to 10-year-olds) as well as adults. A second goal was to pursue questions concerning the mechanisms underlying the transmission of kindhood from one individual to another. We presented participants in each community with the blood transfusion scenario (Sousa et al., 2002). If children's reasoning about kindhood is guided by biological essentialism, and if they seize upon candidate biological causal mechanisms that are present in community-wide discourse, then Native American children should show a tendency to judge that a complete blood transfusion can have consequences on an individual's kindhood. However, this should not be the case in the rural European American sample.

Method

Populations and participants

Native American. The Menominee ("Wild Rice People") are the oldest continuous residents of Wisconsin. There are 4000 to 5000 Menominee living on tribal lands in and around this area of Wisconsin. As in the past, the reservation is heavily forested. Hunting and fishing are important activities for most adult males and for many females and children. The Menominee have a clan system organized around five major clans (bear, thunder or eagle, wolf, moose and crane).

All of the children that participated in this experiment were recruited from elementary schools on the Menominee reservation.[4] Adult participants were parents of children attending these reservation schools. These Menominee children and adults are best considered monolingual English speakers: Although they know at least a few Menominee words, especially those for clan animals, they are not fluent in the language and do not converse in it at home, at school, or at work.

Rural. Adjacent to the Menominee reservation is Shawano County, which consists of farmland, small forest plots (typically 40-80 acres), and numerous lakes and rivers. Hunting, fishing, water recreation in the summer, and snow-mobiling in the winter are popular activities for adults and children. All of the majority culture children were recruited from public elementary schools in Shawano. Adult participants were parents of children attending these schools.

See Table 2 for the number of participants at each age group and in each community.

Materials and Procedure

Adoption scenarios. Each participant heard three cross-species adoption stories, each of which was followed by a series of questions about the offspring, including its inheritance of properties, kindhood, and the effect of a blood transfusion. To familiarize children with the format of this task, the experimenter first told them a warm-up story, explaining, "A baby deer grew up with other deer in the forest. When the baby is all grown up will it drink water or coffee? Will the baby be brown or green?"

Each of the three cross-species adoption stories involved a baby animal that had been separated from its birth parent and raised exclusively by an adoptive parent from a different species. These stories were identical to those used in Sousa et al. (2002) and Atran et al. (2001), and involved the following species pairs: turtle/toad, cow/pig, and pigeon/turkey. For each participant, the animal serving as the birth parent was assigned randomly. Simple black and white line drawings were used to represent each parent and various properties.[5] See Table 1 for a complete list of properties. In what follows, we use a scenario in which the cow serves as the birth parent to illustrate.

The experimenter began by saying, "I'm going to tell you a story. One day a cow gave birth to a little baby. Here's a drawing of the cow that gave birth to the baby [drawing of the cow is shown]. Right after the baby was born, the cow died without ever seeing the baby [drawing of the cow is removed]. The baby was found and taken right away to live with pigs in a place where there are lots of pigs. Here's a drawing of the pig [drawing of the pig is shown] that took care of the baby the whole time that the baby was growing up [drawing of pig is removed]. The baby grew up with pigs and never saw another cow again. Now the baby is all grown up and I'm going to ask some questions about what it's like as an adult."

Each story was followed by a series of questions.

Comprehension assessment. Immediately following the story, the experimenter assessed participants' comprehension, asking "Who gave birth to the baby? Point out the drawing of who gave birth to the baby" [drawings of the two parent animals are shown], and “Who did the baby grow up with? Point out the drawing of whom the baby grew up with” [drawings of the two parent animals are shown].

Inheritance of properties. Next, participants heard four questions concerning the inheritance of properties. As in previous work (Atran et al., 2001; Sousa et al., 2002), two questions involved behavioral properties and two involved physical properties (see below), and for each type of property, one question focused on a familiar property, and one focused on a novel (unobservable) property. This design feature is crucial, for it permits us to ask whether participants’ reasoning is restricted to their knowledge of familiar properties, or whether they can go beyond known properties to make inferences about novel ones. This latter alternative would be consistent with the proposal that a causal biological framework guides participants’ judgments of novel properties.

The following questions were presented in counterbalanced order.

Behavioral properties:

(i) familiar behavior: “The cow mooed and the pig oinked. When the baby is all grown up, will it moo like a cow or oink like a pig?” [drawings of the two parent animals are shown], and

(ii) novel behavior: “The cow ran after chickens and the pig ran after ducks. When the baby is all grown up will it run after chickens like a cow or after ducks like a pig?” [drawings of the two parent animals are shown]

Physical properties:

(i) familiar physical property: “the cow had a straight tail and the pig had a curly tail” [drawings of the properties are shown —see Sousa et al, 2002 for figures]. “When the baby is all grown up will it have a straight tail like a cow or a curly tail like a pig?” [drawings of each parent are shown], and

(ii) novel (unobservable) physical property: “The cow’s heart got flatter when it sleeps and the pig’s heart got rounder when it sleeps” [drawings of the traits are shown]. “When the baby is all grown up, when it sleeps does its heart get flatter like the one of the cow or get rounder like the one of the pig?” [drawings of the two parent animals are shown]

The familiar properties were always paired with their appropriate species; the novel properties were paired with either species, counterbalanced across participants.

Control Question. The experimenter asked, “When the baby was growing up, did it eat with animals that looked like a cow or animals that looked like a pig? Point out the kind of animals the baby grew up with [drawings of the two parent animals are shown].[6] Because the correct response to this question was the adoptive parent rather than the birth parent, it permitted us to identify participants whose responses were so biased as to select the birth parent exclusively.

Kindhood Judgment. Next, participants were asked explicitly to judge the kindhood of the offspring: “Now that the baby is all grown up, what kind of animal is it? Point out the kind of animal the baby grew up to be” [drawings of the two parent animals are shown].

Mechanism of transmission: blood transfusion. Next, the experimenter introduced the blood transfusion scenario, saying, “When the baby was growing up it became sick. A doctor came and, with a needle, took out all of the old blood that the baby got from its mother [the drawing of the birth parent is shown] when it was born. The doctor then went to the animal that was taking care of the baby [the drawing of the adoptive parent is shown] and took some of its blood to give to the baby. So the baby got all new blood like the blood of the pig.” The experimenter then asked, “Now that the baby is all grown up, what kind of animal is it? Point out the kind of animal the baby grew up to be” [drawings of the birth and adoptive parent are shown].

Each participant completed this procedure for all three cross-species pairs.

Results

The results are summarized in Table 3. Notice first that at all ages, performance on the control question was excellent, suggesting that participants understood the task and were attentive throughout. More pertinent are the responses to questions concerning the inheritance of properties, kindhood judgment, and mechanisms of transmission. We consider each in turn.

Insert Table 3 about here

Inheritance of Properties

An examination of Table 3 reveals that in both populations, there is a strong overall bias to attribute properties on the basis of the birth parent, and this increases with age. We first examined adult responses to identify the patterns of reasoning characteristic of the mature members of each community. In general, adults in both communities strongly favored the birth parent over the adoptive parent. More specifically, they also revealed a stronger birth bias for physical than behavioral properties. This differentiated pattern, consistent with evidence from Sousa et al. (2002) and Solomon et al. (1996), was especially evident on questions concerning novel properties.

Statistical tests reinforce these impressions. These data were submitted to a 3-way ANOVA, with Property-type (2: Physical vs. Behavioral) and Familiarity (2: Familiar vs. Novel) as within-participants factors and Community (2: Native American vs. Rural) as a between-participants factor. The main effects for Property-type, $F(1, 32)=54.77$, $MSE=3.47$, $p<.001$, and Familiarity, $F(1, 32)=27.50$, $MSE=.82$, $p<.001$, indicate that across populations, adults show a stronger birth bias for physical ($M=.98$) than for behavioral ($M=.66$) properties, and for familiar ($M=.90$) than for novel ($M=.74$) properties. A Property-type x Familiarity interaction, $F(1, 32)=22.09$, $MSE=.60$, $p<.001$, reveals that for physical properties, adults' birth bias was equally strong for both familiar ($M=.99$) and novel ($M=.97$) properties, but that for behavioral properties, adults' birth biases were stronger for familiar ($M=.80$) than for novel ($M=.51$) properties. Finally, a Property-type x Community interaction, $F(1, 32)=4.22$, $MSE=.27$, $p<.05$, reveals that the difference between physical and behavioral properties is more pronounced in the Menominee ($M=.98$ and .57, respectively) than in the Euro-American adults ($M=.98$ and .75, respectively).

To examine the emergence of these adult response patterns, we consider next the children's responses. Table 3 reveals that like adults, children show a strong overall bias in favor of the birth parent, and that this preference also undergoes some developmental change. These observations are supported by an ANOVA, with Property-type (2: Physical vs. Behavioral) and Familiarity (2: Familiar, Novel) as within-participants factors and Community (2: Native American vs. Rural) and Age (3: ages 4-5, 6-7, and 9-10) as between-participants factors. A main effect for age, $F(2, 133)=4.23$, $MSE=.64$, $p<.05$, indicated that the birth bias became more pronounced over development. Main effects for Property-type, $F(1, 133)=11.75$, $MSE=.33$, $p<.01$, and Familiarity, $F(1, 133)=43.73$, $MSE=3.10$, $p<.001$, echoed those in the adult communities, with children showing a stronger birth bias for physical ($M=.76$) than behavioral ($M=.71$) properties, and for familiar ($M=.83$) than for novel ($M=.64$) properties. This parallels the pattern observed with adults in each community. In addition, both Property-type and Familiarity interacted with age, $F(2, 133)=8.17$, $MSE=.58$, $p<.001$ and $F(2, 133)=3.85$, $MSE=.11$, $p<.05$, respectively, and this suggested that the differentiation between physical and behavioral properties and between familiar and novel properties becomes more pronounced with age.

We also conducted a separate analysis to examine any potential differences among the three cross-species pairs. There was no main effect for story. However, this factor did enter into several interactions, all of which indicate that the effects from the main analysis (above) held up in all three stories, but were more pronounced in some than in others.[7]

Kindhood Judgment

An examination of Table 3 reveals in children and adults from both communities a strong tendency to judge that an individual's kindhood reflects that of the parent of birth. (The birth parent bias was significant in all but one group—the youngest Menominee children–where the sample size was only five.)

Mechanism of transmission

Menominee and Rural adults, like their Yukatek Maya and Brazilian counterparts, reveal an overwhelming tendency to attribute kindhood on the basis of birth parentage, even in the face of a complete blood transfusion from the adoptive parent. Importantly, however, children's intuitions regarding the consequences of the transfusion vary as a function of their community. As predicted, the rural children from Shawano, like adults, show a strong preference for the birth parent. However, this is not the case for young Menominee children, who show a rather dramatic shift toward the adoptive parent in the face of the transfusion.

These observations are supported by an ANOVA, with Age (3: ages 4-5, 6-7 and 9-10) and Community (2: Native American vs. Rural) as between-participants factors. The main effect for community, $F(1, 133)=7.37$, $MSE=.56$, $p<.01$, revealed that the tendency to judge that a blood transfusion has consequences for kindhood is more pronounced in Menominee children ($M=.90$) than in rural Shawano children ($M=.75$). This is consistent with the hypothesis that in a community in which discourse about blood is salient, and in which issues concerning blood have strong consequences, children seize upon blood as a candidate biological essence and consider its potential in the transmission of kindhood. Although the status of blood as a biological essence is ultimately replaced, as is evident from the adult responses, the data suggest that Menominee children do indeed consider blood to be a strong candidate for a biological essence.

Discussion

The results of Experiment 1 make three contributions. First, the evidence from rural Native American and European American populations supports the claim for a strong biological component in reasoning about the inheritance of properties, about kindhood, and about potential mechanisms of kindhood transmission. Participants of all ages and in both populations judged that the kindhood status of an animal, born to a member of one species but raised by a member of another, is determined by the birth parent. Second, the current data suggest that in both communities, a differentiated pattern, with stronger birth biases on physical than on behavioral properties, emerges gradually over childhood. Moreover, as in previous work (Atran et al., 2001; Sousa et al., 2002), this pattern was stronger for familiar properties, but held up for novel properties as well. This is consistent with the possibility that a causal biological framework guides inferences about novel properties.

The third major result from Experiment 1 concerns participants' intuitions regarding the mechanisms underlying the transmission of kindhood. Although adults from both communities strongly denied that a complete blood transfusion from the adoptive parent could change the kindhood of the baby, children revealed a different pattern. Menominee children, like Sousa et al.'s (2002) Brazilian children, tended to judge that the transfusion could change kindhood. This is consistent with the hypothesis that children have skeletal notions concerning the kinds of mechanisms that may be responsible for the transmission of kindhood, and that as they search to identify this biological mechanism, they seize upon ideas that are salient in community-wide discourse. Given the significance of this finding for developmental theory, it will be important to replicate this effect, and this is a major goal of the next experiment.

Experiment 2

Experiment 2 was designed to address three primary goals. A first goal was to replicate the effects of Experiment 1 while, at the same time, extending the work to include two additional populations. Therefore, in addition to interviewing Menominee and rural Shawano residents, we recruited participants living in adjacent urban (Chicago, IL) and suburban (Evanston, IL) towns.

A second goal was to clarify the sources of young children's varying intuitions concerning mechanisms by which kindhood is transmitted. Based on the results of Experiment 1 and Sousa et al. (2002), we suggested that Menominee children's intuitions regarding the consequences of the blood transfusion were guided by biological essentialism and influenced specifically by the discourse surrounding blood and blood quanta in their community. But it is also possible that the effect is more general. Perhaps children from this community are especially attuned to information regarding mechanisms of any sort. We address this issue in the current experiment by comparing participants' intuitions for two different potential mechanisms of transmission. As in Experiment 1, we asked participants to consider the consequences of an adoptive mother providing a complete blood transfusion. But we also asked participants to consider the consequences of an adoptive mother providing nurturance (including care-taking and nursing).

We selected nurturance as a potential mechanism of transmission for several reasons. First, we expected that children across the four communities would be familiar with the concept of maternal nurturance, based on their experiences within their own families and those of their friends. Further, the concept of an adoptive mother nurturing a young member of another species figures largely and universally in children's folklore. For example, stories like The Ugly Duckling, which are popular with majority culture children, and the classic Menominee tribal stories (including the creation story), which are well-known by young Menominee children, are replete with examples of cross-species nurturance and transformation (Hoffman, 1892; Keesing, 1987). If the Menominee children's intuitions regarding blood as a potential causal mechanism is related specifically to the heightened discourse about blood in the Menominee community, then these children should once again stand out for their responses to the blood transfusion question, but should perform comparably to children from the other communities on the nurturance question.

Third, we introduced a few methodological improvements. Most importantly, we conducted the interview concerning the two potential mechanisms (blood transfusion, nurture) at a different time and with different species from the interview concerning the inheritance of properties and kindhood judgments. This permitted us to explore participants' intuitions regarding potential mechanisms more independently than in Experiment 1 (and in all previous experiments) when the mechanism question was merely tagged on to the tail end of the inheritance of properties and kindhood tasks. Another methodological change concerned the criteria for inclusion. Following Sousa et al. (2002), we used participants' performance on the initial two comprehension questions as a gateway for inclusion in Session 1: Only those participants who correctly answered both comprehension questions for each story were included in the data analysis for the inheritance and kindhood questions. See Table 2 for the number of participants included in data analysis for Sessions 1 and 2. Finally, we systematically counter-balanced several factors, including the order in which the adoption scenarios were presented, the order in which the property questions were posed, and the order in which the birth or adoptive parent was mentioned on the various property, kindhood, and mechanism probes.

Method

Populations and Participants

In each population, all participants completed Session 1. However, a small subset of the children in each population was unavailable for Session 2. See Table 2 for the number of participants at each age group and in each community.

The Menominee and rural majority (Shawano) participants were drawn from the same population as in Experiment 1.

Suburban. Evanston, IL is an ethnically and racially diverse suburban community that borders Lake Michigan and the city of Chicago. All of the children were recruited from either a public elementary school or private preschools in Evanston. All adult participants were parents of children attending these schools. The school population includes a diverse range, including 41% African American, 10% Hispanic, 16% Asian and 30% European American students. The children and adults in our sample reflected these proportions.

Urban. Chicago is an ethnically and racially diverse city. All of the children were recruited from a large public magnet school which draws students from throughout the city to achieve a racially diverse mix. All adult participants were parents of children attending this school. The school population includes 35% African American, 12% Hispanic, and 35% European American students. The majority of the remaining 19% of the students are of Asian descent. The children and adults in our sample reflected these proportions.

Insert Table 4 about here

Materials and Procedure

The procedure was similar to Experiment 1, with a few notable exceptions. The procedure, which now included two potential mechanisms of transmission (blood transfusion and nurture) rather than one, was divided into two sessions. Session 1, which focused on the inheritance of properties and judgments of kindhood, was conducted with one set of species pairs; Session 2, which focused on the mechanisms of transmission (blood transfusion and nurture), was conducted with different species pairs (see Table 4). For adults, both sessions took place on the same day, separated by approximately 20 minutes and a series of intervening tasks. For children, Sessions 1 and 2 were separated by several days, typically ranging from 2 to 10. For all participants, the order in which the scenarios were presented within their respective session, and the assignment of the birth parent or adoptive parent within each species pair were counterbalanced. On the property questions, which were presented in randomized fashion, familiar properties were always associated with the appropriate species; novel properties were assigned to species in a counterbalanced fashion.

Session 1

As in Experiment 1, children began with a warm-up story, in which the experimenter explained, “A baby deer grew up with other deer in the forest. When the baby is all grown up will it drink water or coffee?” “Will the baby be brown or green?” The remainder of the session was devoted to adoption scenarios and the interview about inheritance and kindhood.

Adoption scenarios. As in Experiment 1, each of the cross-species adoption stories involved a baby animal that had been separated from its birth parent and raised exclusively by an adoptive parent from a different species. These stories were patterned closely after those in Experiment 1, and involved the following species pairs: turtle/toad, cow/pig and cardinal/seagull. Adults completed the last two adoption scenarios (due to time constraints associated with fitting their interviews into one day); children completed three adoption scenarios. For adults and children alike, realistic color depictions were used to represent the birth and adoptive parents; properties were not depicted. See Table 4 for a complete list of properties.

As in Experiment 1, after each adoption scenario, the experimenter posed a series of questions, including a) comprehension assessment, b) inheritance of properties (familiar and novel; physical and behavioral), c) control question, and d) kindhood judgement. These questions were identical in form to the questions described in Experiment 1. Recall, however, that in the current experiment, only participants who answered both comprehension questions correctly were included in the analysis of Session 1.

Session 2

In Session 2, participants heard two new adoption scenarios, using rabbit/raccoon and deer/sheep as species pairs to elicit their intuitions regarding potential mechanisms of transmission: blood and nurture. For half of the participants in each age group in each community, the rabbit/raccoon pair figured in the blood transfusion scenario; for remaining participants, the deer/sheep pair figured in the blood transfusion scenario. All participants answered questions regarding each scenario. Several factors were counterbalanced: the order in which the scenarios were presented, the matching between species pair and scenario, and the assignment of birth versus adoptive parent. In what follows, for simplicity, we use a scenario in which the rabbit serves as the birth parent to illustrate both the blood and the nurture scenarios.

Both scenarios began as follows: "I'm going to tell you a story. One day a rabbit gave birth to a little baby. Here's a picture of the rabbit that gave birth to the baby [picture of the rabbit is shown]. Right after the baby was born, the rabbit died without ever seeing the baby [picture of the rabbit is removed]. The baby was found by some raccoons and brought home by the raccoons to live with them in a place where there were lots of raccoons. The baby grew up with raccoons and never saw another rabbit again. And there was one raccoon that took special care of the baby the whole time that the baby was growing up [picture of raccoon is shown]. Here's a picture of the raccoon that took special care of the baby [picture of raccoon is removed].

At this point, the scenarios diverged, continuing as follows:

(i) Blood transfusion. "One day, the baby became sick. To make the baby well again, a doctor came to change the baby's blood. So the doctor took out all the blood that came from the rabbit from when it was born, [picture of rabbit is shown] and then the doctor put in some blood from the raccoon that took special care of the baby while it was growing up [picture of raccoon is shown]. So, then the baby had blood like the blood of raccoon. Remember, the rabbit gave birth to the baby and the baby grew up with the raccoon [both pictures are shown]. So, when the baby was all grown up, what kind of animal was it? Go ahead and point out the kind of animal the baby grew up to be."

(ii) Nurture. "She (the adoptive mother) snuggled with the baby every night, and the baby slept right next to her like this [demonstrate cuddling]. Whenever the baby was hungry, she gave the baby milk from her own body (nursing), and whenever the baby was scared, it ran over to cuddle with her, and she would take care of the baby until the baby felt all better. Remember, the rabbit gave birth to the baby and the baby grew up with the raccoon [show both pictures]. So, when the baby was all grown up, what kind of animal was it? Go ahead and point out the kind of animal the baby grew up to be.

Results

The results for Session 1 (the inheritance of properties and kindhood questions) and Session 2 (the mechanism question) are depicted in Table 5.

Insert Table 5 about here

Session 1

Inheritance of properties. A glance at Table 5 suggests that adults in all four communities show an overall birth bias, and that this is more pronounced for physical than for behavioral properties. This differentiated pattern echoes the results of Experiment 1 and extends it to two new communities.

Statistical tests reinforce these impressions. Adult participants' birth choices were submitted to an ANOVA, with Property-type (2: Physical vs. Behavioral) and Familiarity (2: Familiar vs. Novel) as within-participants factors and Community (4: Native American, Rural, Suburban, and Urban) as a between-participants factor. Adults from all four communities performed comparably, producing neither a main effect nor any interactions involving Community. As in Experiment 1, the main effect for Property-type, $F(1, 74)=113.06$, $MSE=10.77$, $p<.001$, revealed that adults' birth bias is more pronounced for physical properties ($M=.98$) than for behaviors ($M=.60$). The main effect for Familiarity, $F(1, 74)=10.03$, $MSE=.40$, $p<.01$, indicated that their birth bias was reliably stronger for novel ($M=.83$) than for familiar ($M=.75$) properties. Finally, a Property-type x Familiarity interaction, $F(1, 74)=11.44$, $MSE=.49$, $p<.01$, indicated that for judgments involving physical properties, adults' birth biases were equally strong for Novel ($M=.98$) and for Familiar ($M=.99$) properties. This mirrors the results of Experiment 1. However, for judgments regarding behavioral properties, adults produced stronger birth biases for novel ($M=.67$) than for familiar ($M=.51$) behaviors. This is a counterintuitive finding, and it departs from Experiment 1, where adults produced stronger birth biases for familiar than novel behaviors. We suspect that this unanticipated outcome is related to the particular properties and kinds that we presented in the current experiment, and we return to this issue in the General Discussion.

Turning next to the children's responses, a review of Table 2 suggests that this task was difficult for the youngest children. In all four communities, roughly one third of the youngest children who were interviewed were excluded from analysis in Session 1 because they failed to answer the comprehension questions correctly. Even among those young children who did meet the comprehension criterion, and were therefore included in the analysis of Session 1, a review of Table 5 shows that their responses to questions concerning the inheritance of properties were often indistinguishable from chance. Despite these concerns, as was the case in Experiment 1, children did tend to attribute properties of the offspring on the basis of the birth parent, as did the adults in their respective communities. Moreover, like adults, the 9- to 10-year-olds exhibited a differentiated pattern, with a stronger birth bias for physical than for behavioral properties. Finally, the magnitude of this birth bias appears to increase with age for physical, but not behavioral, properties.

These observations are supported by statistical analyses. A 4-way ANOVA, with Property-type (2: Physical vs. Behavioral) and Familiarity (2: Familiar vs. Novel) as within-participants factors and Community (4: Native American, Rural, Suburban, and Urban) and Age (3: ages 4-5, 6-7 and 9-10) as between-participants factors replicates and extends the major developmental findings from Experiment 1. A main effect for Age, $F(2,259) = 6.49$, $MSE = 1.59$, $p < .01$, indicates that across all populations, the strength of the birth parent bias increases with age. The main effects for Property-type, $F(1, 259) = 117.39$, $MSE = 7.55$, $p < .001$, and Familiarity, $F(1, 259) = 21.39$, $MSE = .68$, $p < .001$, also echo those of Experiment 1, with children revealing a stronger birth bias for physical ($M = .82$) than behavioral ($M = .65$) properties, and for familiar ($M = .76$) than novel ($M = .71$) properties. Moreover, there is a Age x Familiarity x Property-type interaction, $F(2, 259) = 6.08$, $MSE = .18$, $p < .01$. For physical properties, the birth bias increases comparably with age for both novel and familiar properties. For behavioral properties, however, the developmental picture is less straightforward. Table 5 suggests that the birth bias for behavioral properties tends to increase from 4-5 to 6-7 and then to decrease, and these trajectories are more pronounced for the novel than for the familiar behaviors.

Because we suspected that these patterns may have varied as a function of the individual stories, and especially because the finding that adults showed a stronger birth bias for Novel than Familiar behaviors was counterintuitive, we conducted a separate analysis to examine any potential differences among the three cross-species pairs, as in Experiment 1. This analysis revealed that this outcome was largely mediated by one story – the cardinal/seagull story – that was presented in Experiment 2 but not in Experiment 1. This unanticipated result could reflect something about the species pair itself. For example, participants may consider the species in this pair (two birds) to be more closely related than those in the other pairs. Alternatively, the unanticipated result could reflect something about the particular behavioral properties that were assigned to this pair. The Cardinal/Seagull story elicited a stronger birth bias for the novel behaviors (those pertaining to how the birth and adoptive parents incubate eggs) than the familiar behavior (those pertaining to what the birth and adoptive parents eat). In contrast, in the remaining stories, adults' intuitions were comparable for both the novel behaviors (e.g., those pertaining to how the birth and adoptive parents respond to cold weather) and familiar behaviors (e.g., those pertaining to sounds made by the birth and adoptive parents). Perhaps adults and older children consider a species' feeding behavior as a rather flexible behavior, one that is highly responsive to environmental contingencies and therefore less tightly constrained by biological inheritance, but that they consider a species' reproductive behaviors (e.g., egg incubation) as more tightly constrained by biological imperatives and therefore less malleable across species. Additional evidence will be necessary to tease apart these two alternatives.

Kindhood Judgment. Table 5 suggests that children and adults in all communities attribute kindhood on the basis of the identity of the birth parent, and that this increases with age. A Community (4: Native American, Rural, Suburban, and Urban) x Age (4: ages 4-5, 6-7, 9-10 and Adults) ANOVA revealed a main effect for age, $F(2, 252)=11.43$, $MSE=3.88$, $p<.001$, supporting this observation. Notice that with the exception of the rural (Shawano) population, the youngest children performed at chance levels on the kindhood question. We suspect that young children's apparent difficulty with this question reflects their fatigue by the close of Session 1.

Session 2

Mechanism of transmission. The results of Session 2 are depicted in Table 5. A review of this table suggests that for adults from all four communities, the tendency to judge that the kindhood of the baby accords with that of the birth parent persists even when the adoptive parent has provided the baby with either a complete blood transfusion or with considerable nurturing. The table also suggests that children from all four communities, like adults, favor the birth parent on the Nurture question, but that their intuitions regarding the consequences of a blood transfusion vary as a function of their community.

Consider first the responses of the adults. An ANOVA with Community (4: Native American, Rural, Suburban, and Urban) as a between-participants factor and Question-type (2: Blood vs. Nurture) as a within-participants factor yielded a main effect for Community, $F(3, 71)=4.36$, $MSE=.35$, $p < .01$. A contrast analysis revealed that although Menominee adults share with adults from the other communities a strong bias favoring the birth parent, they are nonetheless more likely than adults from the other communities (combined) to attribute kindhood to the adoptive parent when presented with either the blood transfusion or nurturance as a candidate mechanism of transmission, $t(71)=3.27$, $p < .01$, 2-tailed. This suggests that any difference between the Menominee and the other communities, slight in the current experiment and absent in Experiment 1, is not a consequence of specific intuitions regarding either blood transfusions or nurturance as a mechanism of transmission of kindhood.

Consider next the performance of the children. An examination of Table 5 suggests that children in all four communities, like adults, favor the birth parent on the Nurture question, but that their intuitions regarding the consequences of blood transfusion on kindhood vary as a function of their community. Children from the last three populations, like adults, tend to favor the birth parent on the Blood question. But this is not the case for the youngest Menominee, who strongly favored the adoptive parent in the face of a blood transfusion. Indeed, 82% of the youngest Menominee children attributed kindhood on the basis of the adoptive parent in the vignette concerning the blood transfusion. By the time they are 9 to 10 years of age, although Menominee children come to favor the birth parent over the adoptive parent for both scenarios, their birth bias remains more robust in the Nurture than the Blood vignette.

We submitted the children's data to an ANOVA, with Question-type (2: Blood vs. Nurture) as a within-participants factor and Age (3: ages 4-5, 6-7 and 9-10) and Community (4: Native American, Rural, Suburban, and Urban) as between-participants factors. The main effect for Age, $F(2, 329)=18.80$, $MSE=5.54$, $p <.001$, revealed that the tendency to attribute kindhood on the basis of the identity of the birth parent increased with age, for all pairwise comparisons $p< .05$. A main effect for Question-type, $F(1, 329)=22.91$, $MSE=2.40$, $p <.001$, revealed that children were more likely to select the birth parent on the Nurture than the Blood vignette. This was qualified by the Question-type by Community interaction, $F(3, 329)=4.64$, $MSE=.49$, $p <.01$. A contrast analysis pinpointed the locus of this interaction: the difference between the two questions is greater for Menominee children than for children in the other communities (combined), $t(337)=-2.42$, $p <.05$, 2-tailed.

To get a closer look at this phenomenon, we next compared the distribution of responses on the Blood and Nurture vignettes in each community and at each age. Children in Shawano, Evanston, and Chicago performed comparably on the two vignettes at every age. However, Menominee children revealed a different pattern: they were more likely to attribute kindhood on the basis of the adoptive parent on the Blood than the Nurture vignette. This difference between the two vignettes was reliable at 4- to 5-years and 9- to 10-years (both p's < .02, McNemar's test) and was marginal at 6- to 7-years ($p = .125$, McNemar's test).

In sum, these results suggest that blood is more likely to serve as a candidate essence in the biological reasoning of children in the Menominee community than in the other communities. The tendency to view nurture as a candidate mechanism for the transmission of biological kindhood was uniformly low across ages and populations. This outcome is consistent with the possibility that young children seize upon some, but not all, potential mechanisms of transmission for biological kindhood. More to the point, they seize upon only those mechanisms that can be construed as biological (e.g., blood, but not nurture) and of these, only those that have 'valence' or currency in their community (e.g., blood in Menominee, but not in other communities). This finding is important not only because it replicates Experiment 1, but also because it highlights the specificity of the candidate mechanisms that children consider for the transmission of kindhood, and because it underscores the importance of community-wide discourse about these potential biological candidates.

Discussion of Experiment 2

The results of this experiment make three points. First, the results largely replicate those of Experiment 1 and extend them two new populations. In all four communities, a strong biological component was evident in adults' and children's judgments, and this apparently biological focus increased with age. The fact that the replication is so close, despite methodological and procedural changes from Experiments 1 to 2 suggests that these effects are quite robust.

Second, there was one point of divergence on the inheritance task in Experiments 1 and 2, involving judgments about the novel versus familiar behaviors for one particular cross-species pair – the cardinal/seagull pair. Additional research will be required to ascertain whether this point of divergence was related to the taxonomic relatedness of the members of this pair or to the particular behavioral properties that we ascribed to them.

Third, and perhaps most important, the results of Experiment 2 provide new evidence regarding intuitions about the mechanisms that underlie the transmission of kindhood. Experiment 2 provides a strong replication within the Menominee community, with Menominee children judging once again that a complete blood transfusion from the adoptive parent does indeed have consequences for the kindhood status of the offspring. This not only supports our findings from Experiment 1 but also demonstrates that not just any mechanism will do. In no population did the nurture manipulation have a substantial effect on kindhood judgments.[8] This suggests that children have constrained notions about which mechanisms might underlie kindhood and that cultural factors determine whether and how these candidate mechanisms are taken up.

General Discussion

The current experiments reveal a clear biological component in reasoning about biological entities in young children and adults. Across diverse cultural communities, we found that (1) there is a strong biological component underlying people's reasoning regarding the inheritance of traits, (2) there is a strong tendency to attribute kindhood on the basis of the identity of the biological parent, (3) this biological tendency of attributing kindhood emerges in early childhood, and (4) it is accompanied by broad notions about the essences or mechanisms that underlie the transmission of kindhood.

The results also offer some insights into where and how children search to discover the underlying essence of an individual and the mechanisms by which kindhood is transmitted from one individual to another. Considered in conjunction with other recent demonstrations in the US, Yucatan, and Mexico, the current work suggests that children's biological reasoning is guided by a very broad notion about causal processes that operate upon biological entities, and that these broad notions are then shaped by the particular ideas circulating within a culture.

Across all four communities, children and adults demonstrated an understanding that kindhood is conferred at (or before) birth by the biological parent. Given a scenario where an adoptive parent is a different kind from the birth parent, children judge that the baby's kindhood corresponds to that of the birth parent and further predict that the baby will resemble the birth parent on behavioral and especially physical properties. This broad pattern of responding, which characterized each of the four communities included in the current experiments, echoes the patterns found elsewhere (see, e.g., Atran et al., 2001; Ross et al., 2003; and Sousa et al., 2002). This lends support to the view that a tendency to attribute kindhood according to the kindhood of the birth parent may be a universal feature of biological reasoning. In our view, the overarching tendency to judge that an individual's kindhood and its manifest (physical or behavioral) properties accord with the birth parent is prima facie evidence for the belief that there is a biological mechanism that influences the kindhood of individual at or before birth and that resists the considerable environmental influences associated with adoption.

The current results offer three new points regarding the inheritance of properties. First, in our four communities, older children (9- to 10-year-olds) and adults showed the 'differentiated' pattern, with stronger birth parent responses in attributing physical than behavioral properties. We interpret this as evidence that behaviors are seen as more susceptible to environmental influence than are physical properties. Second, an intriguing difference emerged between Experiments 1 and 2, and this difference concerned the role of familiarity in judgments of the inheritance of behaviors. In Experiment 1, adults showed a stronger birth parent response for familiar than novel behaviors (see Atran et al., 2001, and Sousa et al., 2002, for converging evidence). However, in Experiment 2, the pattern was reversed. We interpret this as evidence that the participants in our experiments do not expect that "all behaviors are created equal". Instead, they expect that some behaviors (c.f., eating behavior; Experiment 1) are more malleable, more responsive to environmental contingencies than others (c.f., reproductive behavior; Experiment 2). In future work, it will be important to pursue this possibility directly, seeking additional evidence based on a wider range of behaviors and a broader sampling of species pairs.

A third comment regarding the inheritance of properties task is in order. It may appear that we have gone to a great deal of trouble to establish our main findings in this task and have paid insufficient attention to population differences. No doubt there are population differences between, for example, Brazilian and USA urban adults and among the four populations that we have studied as well. In particular, there are interactions involving the communities that we have relegated to footnotes. But we have done so because, in every case, although these show that some effect of interest is a bit larger or a bit smaller in one group or another, the central point is that the main findings are clear across these variations.

We noted in the introduction that a significant challenge for current research is to move beyond the now-standard inheritance task in an effort to uncover the causal mechanisms underlying the transmission of kindhood from one individual to another and to gain some precision in describing the presumed nature of these mechanisms. In the current experiments, we considered the influence of two potential mechanisms, one biological (blood transfusion) and the other non-biological (nurturance). Although performance on the Kindhood task revealed that children and adults in our experiments judged that membership in a kind is influenced heavily by the kindhood of its biological parents, performance on the Mechanisms task revealed there was also evidence for some flexibility in this judgment, particularly in the youngest children, and that this flexibility may be related to the search to discover the biological essence that underlies an individual's kindhood.

The responses from the Mechanisms task suggest that in this search, discourse within a community can serve as a powerful prime, providing young children with candidates to consider as potential mechanisms for the transmission of biological kindhood. In both experiments, we replicated the results of Sousa et al's Brazilian children in Menominee children, whose community also includes considerable discourse about blood and therefore elevates its potential as a candidate mechanism of transmission. Importantly, Menominee children's intuitions about nurture as a potential mechanism did not differ from the intuitions of children in the other communities.

We interpret this pattern as evidence that children's skeletal theories guide them in selecting the classes of events that may be candidates for mechanisms for the transmission of kindhood. In sum, the results of Experiments 1 and 2 suggest that children may be more likely to consider biological (blood) than non-biological (nurturance) processes as candidate essences, and that in identifying candidate biological processes, they are sensitive to community-wide discourse.

This interpretation is speculative, at best. It will be important to identify with much greater depth and precision the type of discourse to which children are exposed. There is a pressing need to document what children at different ages and from different cultural milieu hear in naturally occurring discourse about various candidate mechanisms. For example, the fact that formal Menominee tribal membership is determined by blood quantum does not, in and of itself, entail that young children are aware of its definitional status. We have argued that for the Menominee, tribal status and blood quantum are deeply tied to the activities (e.g., hunting, fishing, schooling) in which Menominee children and their families are typically involved, and that as a result, children are exposed to community-wide discourse and sensitive to at least some of its consequences. Nonetheless, a richer and more detailed ethnographic analysis of the naturally occurring discourse is in order.

It will also be important to consider a broader range of candidate essences, including both a) biological and non-biological elements, and b) internal (e.g., transplants, implants) and external (e.g., skin grafts, tattoos) modifications (Gelman & Wellman, 1991; Keil, 1989). We suspect that internal biological elements will hold the most powerful potential as candidate essences, and that within the biological domain, the heart and the brain will figure largely in our reasoning about the essences of individuals and of kinds. Support for this possibility comes from a recent study of adult recipients of heart transplants (Inspector, Kutz & David, 2004) which revealed that despite sophisticated knowledge of anatomy and physiology, almost half the adult heart recipients interviewed harbored a notion (either overt or covert) that they might acquire some of the donor's personality characteristics along with the heart.

Another goal in subsequent work is to examine the range of entities to which these candidate essences are applied. In the current experiments, we have taken a first step, revealing that young children invoke biological reasoning over biological entities. The next step will be to see how broadly this kind of reasoning is applied, and whether these presumably biological essences are also applied beyond the biological domain (for example, to natural kinds or to artifacts).

We close with an observation regarding the tight coupling between empirical and theoretical work in questions concerning the evolution of the concept *alive* and the development of a folk biological framework. As work in this area progresses, it becomes increasingly important to develop measures that will permit us to tease apart participants' conceptions of the causal forces in nature and in nurture. This sort of evidence will provide a richer backdrop against which we can view the evolution of folk biological theories across development and across cultures.

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Footnotes

1) Biological essentialism is more specialized than mere nominal essentialism, which applies to all objects (e.g., desk, gold) and intrinsic qualities (e.g., red, liquid) (Rips, 1995; Atran, 1998).

2) Indeed, this was precisely the pattern revealed by Yukatek Maya (Atran et al., 2001) and Brazilian children and adults (Sousa et al., 2002).

3) We note, however, that one probably should not expect either children or adults to have highly detailed theories about mechanisms that fix or alter kindhood, since peoples' explanation tend to be only as specific as they need to be, which often means they will be quite shallow (Rozenblitt and Keil, 2002).

4) We had access to very few Menominee children from the youngest age group during the time period in which Experiment 1 was conducted. To redress this limitation, we recruited the participation of a preschool program located on the Menominee Reservation. As a result, we report on a larger sample of 4- to 5-year-olds in Experiment 2.

5) In this experiment, following Sousa et al. (2002) and Atran et al. (2001), only some properties were depicted. We could not, for example, depict the familiar behaviors (see Table 5).

6) Sousa et al. (2002) used “play with” and Atran et al. (2001) used “eat with” in their methods. To avoid anthropocentrism we used the latter instruction.

7) For example, the Story x Familiarity interaction, $F(2, 260)=4.77$, $MSE=.75$, $p=.009$, indicates that the difference between the familiar and unfamiliar targets was higher for the cow/pig story ($M=.88$ and .59, respectively) than for the other two (pigeon/turkey: $M=.79$ and .65; turtle/toad: $M=.83$ and .70). The Story x Property-type interaction, $F(2, 260)=3.44$, $MSE=.371$, $p=.034$, indicates that the larger birth bias for physical than behavioral properties is more pronounced on the cow/pig stories ($M=.68$ and .80, respectively) than on the other two (pigeon/turkey: $M=.72$ and .72; turtle/toad: $M=.74$ and .80). Finally, the Story x Property-type x Age interaction, $F(4, 260)=3.41$, $MSE=.37$, $p=.01$, indicates that the age by property type interaction pattern was more pronounced for pigeon/turkey and turtle/toad stories than for the cow/pig story.

8) Although we mentioned nursing within the context of our Nurture scenario, we did not place a strong emphasis on it. However, Susan Gelman and Larry Hirschfeld (personal communication) have some evidence that 4-year-old (but not 5-year-old) children judge that nursing can influence kindhood. (See also Stoler (1995) for a historical review of intuitions regarding the effects of nursing.) Had we stressed the nursing component of the scenario more strongly, it is possible that an adoptive bias might have emerged, particularly since nursing involves the transmission of biological substance. This possibility will be pursued in future investigations.

Tables

Table 1

Experiment 1: Properties associated with the cow/pig, pigeon/turkey and turtle/toad scenarios

Target Animal	*Familiar Behavior*	*Novel Behavior*[a]	*Familiar Physical*	*Novel Physical*[a]
Cow	moos	looks for sparrows	straight tail	heart gets flatter when it’s sleeping
Pig	Oinks	looks for cardinals	curly tail	heart gets rounder when it's sleeping
Pigeon	Very used to flying	stops when it sees a maple tree	short neck	stomach gets harder when it’s sleeping
Turkey	very used to walking on the ground	stops when it sees an oak tree	long neck	stomach gets softer when it’s sleeping
Turtle	walked on slowly	opens its eyes when it’s afraid	shell on its back	blood becomes thick and sticky when it’s sleeping
Toad	hopped	closes its eyes when it's afraid	warts on its back	blood becomes thin and watery when it’s sleeping

[a] Novel behavioral and physical properties were counterbalanced across species.

Table 2

Experiments 1 and 2: Number of participants per community and age group for all tasks

Community	*Age*	*n*		
		Exp. 1	Exp. 2	
			SESSION 1	SESSION 2
		All Tasks	Inheritance Task	Mechanism
Native-American (Menominee)	4-5	5	14	22
	6-7	17	24	32
	9-10	23	30	34
	Adult	15	16	16
Rural (Shawano)	4-5	28	13	26
	6-7	30	23	25
	9-10	22	24	23
	Adult	19	16	16
Suburban (Evanston)	4-5	*X*	11	25
	6-7	*X*	26	29
	9-10	*X*	24	24
	Adult	*X*	19	19
Urban (Chicago)	4-5	*X*	20	30
	6-7	*X*	33	42
	9-10	*X*	29	29
	Adult	*X*	26	26

Table 3

Experiment 1: Mean proportion of birth parent choices for each age group and community on each task[a]

Community	*Age*	*Inheritance of Properties*						*Control*	*Kindhood*	*Mechanism*
		Behavioral			Physical					Blood
		Familiar	Novel	M	Familiar	Novel	M			
Menominee	*4-5*	.67	.60	.64	.67	.80*	.74*	.13*	.60	.33
	6-7	.83*	.73*	.78*	.86*	.69*	.78*	.04*	.79*	.53
	9-10	.76*	.49	.63*	.88*	.55	.72*	.00[b]	.85*	.33
	Adult	.76*	.38	.57	1.00[b]	.96*	.98*	.00[b]	1.00[b]	1.00[b]
Shawano	*4-5*	.86*	.81*	.84*	.88*	.79*	.84*	.15*	.89*	.88*
	6-7	.88*	.62*	.75*	.96*	.63*	.80*	.03*	.95*	.69*
	9-10	.71*	.49	.60*	.95*	.51	.73*	.00[b]	.86*	.75*
	Adult	.85*	.65	.75*	.98*	.98*	.98*	.00[b]	.95*	1.00[b]

[a] All values were compared to chance by means of one-sample t-tests.
* p<.05.
[b] t-test could not be computed in absence of variance.

Table 4

Experiment 2, Session 1: Summary of the various types of probes used for the cow/pig, cardinal/seagull, and turtle/toad scenarios

Target Animal	*Familiar Behavior*	*Novel Behavior*[a]	*Familiar Physical*	*Novel Physical*[a]
Cow	mooed	when it was cold, it ate a lot	straight tail	had 10 bones its foot
Pig	oinked	when it was cold, it ate very little	curly tail	had 4 bones in its foot
Cardinal	Ate seeds	after it laid it eggs, it sat on the eggs, but kept very, very still	bright red	had a brown omentum inside it
Seagull	Ate little fish	after it laid its eggs, it sat on the eggs, but turned them over every hour	white and gray	had a yellow omentum inside it
Turtle	walked	when it saw something scary, it went away as fast as it could	smooth hard shell	had a long sclerma inside it
Toad	hopped	when it saw something scary, it stopped and played dead	soft bumpy skin	had a short sclerma inside it

[a] Novel behavioral and physical properties were counterbalanced across species.

Table 5
Experiment 2: Mean proportion of birth parent choices for each age group and community on each task[a]

Community	*Age*	*Session 1*								*Session 2*	
		INHERITANCE OF PROPERTIES						CONTROL	KINDHOOD	MECHANISM	
		Behavioral			Physical					Blood	Nurture
		Familiar	Novel	*M*	Familiar	Novel	*M*				
Menominee	4-5	.36	.67	.52	.64	.52	.58	.29*	.50	.18*	.64
	6-7	.89*	.64	.77*	.76*	.69*	.73*	.14*	.78*	.53	.69*
	9-10	.76*	.66*	.71*	.98*	.96*	.97*	.04*	.92*	.71*	.91*
	Adult	.59	.66*	.63	.97*	.94*	.96*	.00[b]	.85*	.81*	.75*
Shawano	4-5	.67	.46	.57	.80*	.74*	.77*	.08*	.74*	.62	.50
	6-7	.64	.74*	.69*	.82*	.82*	.82*	.06*	.88*	.64	.72*
	9-10	.67*	.53	.60	.99*	1.00[b]	1.00[b]	.01*	.99*	.87*	.96*
	Adult	.56	.72*	.64	1.00[b]	1.00[b]	1.00[b]	.00[b]	1.00[b]	1.00[b]	1.00[b]
Evanston	4-5	.73*	.64	.69	.70	.64	.67	.06*	.61	.56	.68
	6-7	.73*	.63	.68*	.91*	.91*	.91*	.00[b]	.79*	.66	.83*
	9-10	.62*	.45	.54	.97*	.94*	.96*	.00[b]	.92*	.83*	.92*
	Adult	.55	.71*	.63	.97*	.97*	.97*	.05*	.95*	1.00[b]	1.00[b]
Chicago	4-5	.65	.67	.66	.72*	.72*	.72*	.18*	.62	.47	.47
	6-7	.80*	.77*	.79*	.80*	.79*	.80*	.07*	.72*	.60	.74*
	9-10	.64*	.44	.54	.98*	.92*	.95*	.00[b]	.78*	.72*	.79*
	Adult	.39	.63*	.51	1.00[b]	1.00[b]	1.00[b]	.02*	.92*	.96*	.85*

[a] All values were compared to chance by means of one-sample t-tests.
* $p<.05$.
[b] t-test could not be computed in absence of variance.