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Reasoning About Cultural and Genetic Transmission: Developmental and Cross-Cultural Evidence From Peru, Fiji, and the United States on How People Make Inferences About Trait Transmission

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Abstract

Using samples from three diverse populations, we test evolutionary hypotheses regarding how people reason about the inheritance of various traits. First, we provide a framework for differentiating the outputs of mechanisms that evolved for reasoning about variation within and between (a) biological taxa and (b) culturally evolved ethnic categories from (c) a broader set of beliefs and categories that are the outputs of structured learning mechanisms. Second, we describe the results of a modified "switched-at-birth" vignette study that we administered among children and adults in Puno (Peru), Yasawa (Fiji), and adults in the United States. This protocol permits us to study perceptions of prenatal and social transmission pathways for various traits and to differentiate the latter into vertical (i.e., parental) versus horizontal (i.e., peer) cultural influence. These lines of evidence suggest that people use all three mechanisms to reason about the distribution of traits in the population. Participants at all three sites develop expectations that morphological traits are under prenatal influence, and that belief traits are more culturally influenced. On the other hand, each population holds culturally specific beliefs about the degree of social influence on non-morphological traits and about the degree of vertical transmission—with only participants in the United States expecting parents to have much social influence over their children. We reinterpret people's differentiation of trait transmission pathways in light of humans' evolutionary history as a cultural species.

Keywords: Folksociology; Folkbiology; Cross-cultural psychology; Cognitive development; Dual inheritance theory; Adoption paradigm; Vertical transmission; Social learning

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1. Introduction

Cultural transmission is a more important source of variation in humans than in other species (Richerson & Boyd, 2005; Whiten, Hinde, Laland, & Stringer, 2011). While many nonhuman animals engage in social learning, this process affects a modest number of behaviors in a limited set of domains (Galef, 1993; Kenward, Rutz, Weir, & Kacelnik, 2006; Marler, 1997). Humans, on the other hand, acquire a vast range of their beliefs and behaviors by social learning, and they evolve cumulative cultural traditions (Henrich & Henrich, 2010; Henrich & McElreath, 2003; Richerson & Boyd, 2005). Cultural transmission has given rise to stable cultural differences between both individuals and groups (Chudek & Henrich, 2011; Henrich, Heine, & Norenzayan, 2010), and this generated a new adaptive problem: How should people best use information about social relations and population structure to make predictions about the features of individuals and groups?

There are at least three different kinds of cognitive mechanisms that could be used to solve this problem. First, people may reason about cultural variation using mechanisms that evolved for reasoning about genetically transmitted variation in other species. Second, people may reason about cultural variation using mechanisms that evolved in the human lineage in response to novel culturally evolved social environments. A number of researchers have proposed accounts of social cognition that incorporate some combination of such folkbiological and folksociological adaptations (Gil-White, 2001; Henrich & Henrich, 2007; Hirschfeld, 1996; Kanovsky, 2007). Finally, people may use structured learning mechanisms that evolved to be applied to a broad range of inputs to reason about cultural patterns. Structured learning mechanisms, such as Quinnian bootstrapping (Carey, 2009) or hierarchical Bayesian-like inferential processes (Tenenbaum, Kemp, Griffiths, & Goodman, 2011), could solve this problem without being specifically designed for reasoning about biological taxa or conspecifics. We will refer to these hypothesized cognitive mechanisms as (a) folkbiology, (b) folksociology, and (c) structured learning respectively. Here, we use cross-cultural developmental data to address two specific questions:

1. Do people differentiate between the cultural and prenatal (e.g., genetic and epigenetic) transmission of traits? That is, are they predisposed to believe that some traits (e.g., morphology) are transmitted prenatally from parents to offspring, while others (e.g., beliefs) are socially transmitted?
2. Do people differentiate between parental and nonparental social influences? That is, are people predisposed to believe that parents are the main social influence?

As is detailed in Table 1, the answers to these questions can help determine the relative importance of folkbiology, folksociology, and structured learning in human social cognition. These mechanisms are not mutually exclusive, and all three may be brought to bear on any given question. For example, the first two mechanisms may include evolved prior beliefs about how traits are distributed across kin and other social networks, while structured learning mechanisms can update these prior expectations as a person socially or individually learns how traits are transmitted.

Table 1
Predictions for each research question by hypothesized cognitive mechanisms engaged

	Research Question	
	1. Cultural Versus Prenatal Transmission	2. Parental Versus Non-Parental Social Transmission
Cognitive Mechanism		
Folkbiology	Reliably developing Prenatal transmission bias	Reliably developing a social parental transmission bias
Folksociology	Reliably developing differentiation of cultural and prenatal transmission	Reliably developing differentiation of parental and nonparental social transmission
Structured learning	Culture-specific differentiation of cultural and prenatal transmission	Culture-specific differentiation of parental and nonparental social transmission

2. Theoretical background

First, we discuss the predictions of each evolutionary account and review the literature about relevant cognitive mechanisms involved.

2.1. *Do people differentiate between the cultural and prenatal transmission of traits?*

Several studies using "switched-at-birth" vignettes suggest that people reason differently about cultural and genetic influences (Hirschfeld, 1996; Solomon, Johnson, Zaitchik, & Carey, 1996). In these studies, participants are asked to make predictions about a child who is born to one set of parents but is adopted in infancy by an unrelated set of parents. People tend to answer that the child will inherit his adoptive parents' beliefs, but his birth parents' bodily traits. That is, people reason *as if* beliefs are socially inherited and bodily traits are prenatally acquired (i.e., due to genetic, epigenetic, or environmental influence *in utero*) and fixed at birth. Cross-cultural data suggest that this pattern, labeled the "differentiated pattern," develops reliably by middle childhood in the United Studies (Solomon et al., 1996; Taylor, Rhodes, & Gelman, 2009), by adolescence in India (Mahalingam, 1998), and by adulthood in Madagascar (Astuti, Carey, & Solomon, 2004; Bloch, Solomon, & Carey, 2001).

Various accounts may explain such folk beliefs about inheritance. First, many researchers believe that the differentiated pattern results from folkbiology, although they debate the extent and kinds of naturally selected conceptual structures involved (e.g., the role of essences) (Atran, 1998; Carey, 1985). The developmental emergence of the pattern is often interpreted as an indicator of a mature causal understanding of biological inheritance (Solomon et al., 1996). Furthermore, adults also show a differentiated pattern when reasoning about cross-species adoptions (Astuti et al., 2004; Johnson & Solomon, 1997; Taylor et al., 2009), strengthening the implication that a folkbiological system is at play.

This interpretation is puzzling because other animals are not much affected by cultural transmission (Richerson & Boyd, 2005) and a folkbiological notion may well include expectations that beliefs are prenatally inherited (Sousa, Atran, & Medin, 2002). Information about social influences does not improve predictions about much of nonhuman animals' behavior—ducks raised by cows do not start mooing and still believe insects to be delicious. Well-designed folkbiological theories for reasoning about other species should ignore cultural transmission and either use species category to infer species-typical behavior or use kinship to make inferences about heritable features that vary within a species. Only rarely, for traits such as birdsong, would an expectation of social inheritance be useful in nonhumans.

There is evidence that a folkbiological heuristic that ignores social influence develops earlier than mechanisms responsible for the differentiated pattern. Children reason about the inheritance of all traits, including belief and behavioral traits, as if they were prenatally inherited in cross-species adoption scenarios (Gelman & Wellman, 1991; Sousa et al., 2002). Additionally, more 4–7 year olds maintain prenatal inheritance theories for cross-species adoption scenarios than for within-human adoption vignettes (Johnson & Solomon, 1997; Solomon et al., 1996; Taylor et al., 2009).

A more plausible version of the folkbiological hypothesis is that the differentiated pattern emerges from a combination of folkbiology and Theory of Mind (ToM) mechanisms. The former would lead people to believe that morphological features are inherited prenatally (i.e., participants would respond with a "birth bias"), while (ToM) capacities would let people infer that the child in the vignette cannot acquire beliefs from dead birth parents. Relatedly, the differentiated pattern is consistent with claims that humans are innately predisposed to Cartesian dualist theories, having evolved separate systems for reasoning about physical objects (bodies) and social agents (their beliefs) (Bloom, 2004).

Others have argued that such an account of the differentiated pattern being derived from folkpsychological reasoning is an artifact of studying urban American subjects who are more likely to anthropomorphize animals (Atran et al., 2001). Furthermore, even this combination of folkbiological and ToM mechanisms would lead to incorrect predictions about beliefs under a wide range of circumstances. Folkbiological heuristics would track cues of genetic relatedness while ToM mechanisms would lead people to infer that beliefs could only be transmitted between individuals who know each other. However, people frequently adopt the cultural beliefs of unrelated individuals even when close kin are present (Boyd & Richerson, 1985; Harris, 1995) and the folkbiology plus ToM mechanism would not clearly lead people to make this prediction. For example, imitation of nonkin prestigious group members (Henrich & Broesch, 2011; Henrich & Henrich, 2010), or of peers when there is intergenerational change, would decouple the pathways of genetic and cultural transmission, even when kin are available to transmit their mental states.

We propose that a second hypothesis incorporating folksociological cognitive mechanisms accounts for the differentiated pattern better. While folksociology might be construed more broadly (Hirschfeld, 1996), for the purposes of this article we mean mechanisms that evolved for reasoning about social structures within humans. According to such an account in addition to folkbiological expectations that track the effects of genetic variation within or between species, people would have more recently evolved "cultural transmission" expectations for making predictions about cultural influences in humans. Phylogenetically older folkbiological mechanism shared with noncultural species may be used to reason about bodily traits, and the latter about culturally influenced traits, such as beliefs. According to this account, individuals should reliably develop the differentiated pattern cross-culturally.

Finally, a third hypothesis relies on more domain-general, but structured learning mechanisms. These might be sufficient to allow individuals to acquire local beliefs about how various traits are transmitted, without the need for psychological adaptations specifically evolved for folksociological or folkbiological reasoning. In this case, the fact that concepts were functional for making predictions in the local environment would be a result of individual learning and cultural evolutionary processes rather than natural selection (Henrich & Henrich, 2010; Richerson & Boyd, 2005). Such a process could produce cross-cultural convergence on a differentiated pattern if morphology and beliefs are similarly affected by prenatal and cultural transmission processes across sites. However, it might also lead to cross-cultural divergence in transmission beliefs depending on the population-specific heritabilities of characteristics. Both the folksociological and structured learning accounts are premised on people's beliefs reflecting useful and generally accurate ways of interacting with their world, given the distribution of traits across the social landscape. However, the structured learning mechanisms allow beliefs to adapt to local realities more quickly through cultural evolution.

In this article, we examine the development of the differentiated pattern of reasoning about trait transmission in two new cultural contexts with markedly disparate beliefs about the transmission of group identity. Additionally, we compare reasoning patterns regarding beliefs to other cultural norms.

2.2. Do people differentiate between parental and nonparental cultural influences?

The "switched-at-birth" vignettes describe a situation that is rare in the real world. In these vignettes an infant is adopted by nonkin. Adoption is rare in most societies, and when it does occur, it is almost always among kin (Silk, 1987). Thus, it is unlikely to be the context for which an adaptation for reasoning about cultural transmission was selected—that is, adoptions are unlikely to be the proper domain of the adaptation (Sperber, 1996).

It is plausible that folksociological mechanisms are attuned to expect much social influence from peers and nonparental adults (McElreath & Strimling, 2008; Richerson & Boyd, 2005). Empirical evidence—including from the Fijian site studied in the current paper (Henrich & Broesch, 2011; Henrich & Henrich, 2010)—suggests that nonparental models are often more important than parents in cultural transmission (Harris, 1995; Hewlett, Fouts, Boyette, & Hewlett, 2011; Reyes-García et al., 2009). Moreover, it is precisely because nonparental social influences are important that there is a need to distinguish genetic from cultural transmission pathways. Otherwise, folkbiological mechanisms that assumed individuals would resemble their birth parents for both morphology and beliefs would produce reasonable predictions.

"Switched-at-birth" vignettes provide no information about nonparental adults or peers. If human folksociology is designed to be sensitive to nonparental cultural transmission, participants should attempt to infer the child's traits using attributes of other cultural models. Since the infant described in the vignettes is adopted by people unrelated to his birth parents, it is likely that his other cultural models will be more similar to his adoptive parents than to his birth parents. Therefore, we hypothesize that participants use the adoptive parents in these scenarios as proxies for other nonparental social influences. For example, if the adoptive parents are described as having a food taboo, participants might infer that the adopted child will grow up in a social environment in which most people share this taboo.

To the best of our knowledge, no one has tested the extent to which humans reason about nonparental versus parental (i.e., vertical) cultural transmission pathways. To address this question, we compare an "Adoption vignette" (i.e., the usual "switched-at-birth" task), with a "Migration vignette" in which the focal child and his birth parents from group A migrate to group B, where the child is raised by his group A parents among group B peers. While Kanovsky (2007) and Moya and Scelza (2015) used migration vignettes, the stories in the first study specified the target characters' language use—thus giving away information about cultural traits—and neither study asked about several non-identity traits.

Given the limited cultural transmission in other species, a folkbiological account would not predict differences across the Migration and Adoption conditions. A well-designed folksociological account predicts that children should resemble others in their social environment, including but not limited to their parents. This might manifest itself as a reliably developing expectation that parents influence some traits more than others—for example, skills that require much teaching (Kline, Boyd, & Henrich, 2013). Finally, a structured learning account would predict cross-cultural variation in beliefs about parental influence depending on the actual local importance of such transmission pathways.

3. Methods

We attempted to maintain methodological consistency across the three sites where we collected data, while making the methods ecologically valid for participants at each. In this section we describe the fieldsites, experimental procedures, and analyses. Additional information and alternate analysis can be found in the Supporting Information (SI).

3.1. Participants and fieldsites

Participants were recruited in three different contexts: a rural town in the Peruvian Altiplano state of Puno, two rural Fijian villages, and from Anglophone volunteer sites online. In Peru, the sample (n = 193, ages 4–75, M = 26) was collected in Huatasani, an agro-pastoralist town on the Aymara-Quechua linguistic border. The Fijian sample (n = 155 from 119 unique participants, ages 5–73 years, M = 27) was collected in Teci and Dalomo, neighboring villages on Yasawa Island with a total of 240 inhabitants. Residents rely on subsistence fishing and horticulture. A minority of participants were recruited into more than one condition across field seasons or from another neighboring village of Bukama because of limited numbers of young children. At both field sites, participants were interviewed individually, in private. We also recruited 297 Anglophone online volunteers, 84% of whom were from the United States (n = 302, ages 18–64, M = 32). We will refer to this as the "U.S. sample" and to the Peruvian and Fijian samples by the regional designations of Puno and Yasawa, respectively, since they are not representative of these nations.

The residents of Puno and Yasawa have very different ideologies about social group identities. The ethnographic literature emphasizes that in the Andes ethnic and racial identities are fluid. Indigenous migrants to cities who conform to local norms are perceived as losing some of their indigenous status (Orlove, 1998). The boundaries between ethnolinguistic indigenous identities, like Aymara and Quechua speakers, are at least as fluid and nonracialized as the boundary between indigenous and nonindigenous groups (Moya & Boyd, 2015; Primov, 1974).

On the other end of the spectrum, Yasawans have strongly essentialist notions of prenatal identity transmission. As an illustration, group membership must be designated by the use of the prefix "kai" meaning "from," or "of," to denote provenience and the term for Indo-Fijians is "kai India" despite the fact that most Indo-Fijians were born in Fiji, descended from 19th-century immigrants, and have spent little or no time in India. Similarly, the identity of urban Fijians is traced to their "home villages" even when they have never visited these places (see Henrich & Henrich, 2010, for further details about the Yasawan fieldsite).

The Anglophone online sample mostly represents urban Americans. While the American ethnic taxonomy is dominated by racialized groups (Hirschfeld, 1996), it is unclear whether this reflects a strongly biological folk theory of ethnic identity generally, or such beliefs only about specific groups.

3.2. Procedures

We used a protocol based on Astuti et al. (2004)'s adoption vignettes, modified for each cultural context. Participants were randomly assigned to one of two Vignette conditions: (1) an Adoption vignette—where they are told of a boy born to one set of parents and raised by another set when he is orphaned in infancy or (2) a Migration vignette—where they are told of a boy who is raised by his biological parents who migrate from group A when he is an infant and raise him in group B. The latter vignette stressed the boy's new adoptive community, particularly his peers (full text in SI Section 1).

Participants were also randomly assigned to a Group condition—Ingroup or Intergroup. In the Ingroup condition both the biological parents and the cultural models are drawn from the same group. In the Intergroup condition, biological parents and the people who served as cultural models (i.e., adoptive parents in the Adoption vignette, and individuals from the community in the Migration vignette) are identified as belonging to different social groups. While the Ingroup condition was constant at all sites, the specific groups used for the Intergroup conditions varied by site (Table 2).

Group conditions were crossed with the Vignette conditions with one exception. The Ingroup condition was only run with the Adoption vignette since the migration always happened *between* groups. In the Adoption vignette, participants were told that a child's birth father had one feature, and the adoptive father had a different feature. Participants were asked whether the child would be more likely to share the same trait as his adoptive or birth father once he reached adulthood. In the Migration vignette the parents' features and the peers' features were contrasted.

Each participant was asked to make this assessment for a series of traits (Table 3). Traits were chosen to represent various domains (identity, beliefs, norms, skills, personality, and morphology) and to minimize participants' prior beliefs about the distribution of the trait across groups (see SI Section 1 for full text). Identity traits ("Will the child be, or belong to, group A or group B) could not be asked in the Ingroup condition since this story made no mention of alternate groups. When included, identity questions were always asked first, and all other questions were presented in random order for each participant.

3.3. Analysis

We tested our hypotheses using logistic regressions predicting the probability of choosing "like birth parent" as a function of age and condition. To control for the nonindependence of each individual's responses across traits, we included a random effect of participant. Psychologists usually average a participant's observations into a single score. These analyses are shown in the SI Section 2 and give qualitatively similar results. Using individual random effects models yield increased statistical power, and allows easier comparison across a wider array of experimental structures.

Because we sampled people older than 4 or 5 years of age in the fieldsites, we examined the developmental trajectory in more detail than a categorical analysis allows. We constructed a Socialization Index ($SI\times$) using a negative exponential function of age (Moya, 2013) Specifically, $SI\times = 1 - e^{(-0.2 \times \text{age})}$. This reflects the asymptotic way in which adult competence is acquired; that is, socialization effects are largest at early ages

Table 2
Sample sizes in each between-subjects condition. Numbers can include repeat participants

		Vignette Condition		
		Adoption	Migration	Total
	Group Conditions			
Puno	Ingroup	26	–	193
	Intergroup	57	110	
Yasawa	Ingroup	26	–	155
	Intergroup	82	47	
United States	Ingroup	119	–	302
	Intergroup	96	87	

Table 3
Traits by kind

Identity	**Norms and Skills**	**Personality**
Child's Group ID	Health practices[a,d]	Selfish[e]
Grandchild's Group ID	Has a small family[a,d]	Quick to anger
Beliefs	Knotting knowledge	Friendly[d]
"Bats have x# of teeth"	Good fisherman[e]	Intelligent[e]
Food taboo[a]	Good sense of direction[a]	**Morphology**
Music preference[a]	Beqa healing hand[b]	Finger length[d]
"There are tigers in Africa"[a]	"It is rude to stand above"[b]	Good eyesight[e]
"Eels are poisonous"[c]	Birth ritual[b]	Ear shape
		Liver size[e]

Notes. [a] Not used in Yasawa.
[b] Only used in Yasawa Migration vignette.
[c] Not used in Puno or United States.
[d] Not used with children in Puno.
[e] Used in Yasawa, but not in Migration vignette.

and gradually decline. Using this index has the benefit of collapsing variation among adults that might be due to recent historical changes and which are not of immediate interest for testing our hypotheses. See SI Section 3 for derivation of the best fit SI×, and SI Section 6 for comparative analysis of models using different SI×s.

To visualize these developmental trajectories we plotted the predicted probabilities from the models as a function of age in years. This is for ease of interpretation, even though we used SI×s as predictors in the model. The shaded areas on graphs represent the 95% confidence intervals of the predicted probabilities and were calculated using the Delta-Method of Standard Error estimation. We did not plot developmental trajectories for the U.S. sample because it only included adults.

4. Results

4.1. People differentiate cultural and genetic influences by middle childhood

First, we tested whether people reason that morphological traits are inherited from birth parents and beliefs from adoptive parents. We replicated previous work using data from the Adoption condition, and then ran the same analysis in the Migration condition. We pooled data from all the Group conditions as these did not affect the results. The models we evaluate include SI×, trait type (morphological traits vs. beliefs) and their interaction as predictors of choosing "like birth parent"—i.e. of choosing a prenatal transmission pathway for the trait.

Analyses of the Adoption condition strongly support the hypothesis that a differentiated pattern develops reliably around middle childhood (Fig. 1). By middle to late childhood participants reason that morphological traits are more likely to be prenatally inherited than belief traits. Regression models with trait type, SI×, and their interaction

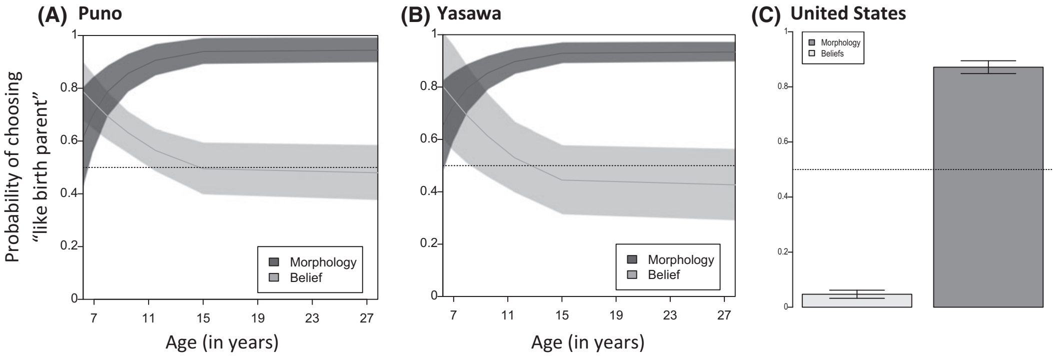

Fig. 1. Predicted probability of choosing prenatal transmission by Trait Types—Adoption condition. (A) Puno, (B) Yasawa, and (C) United States, from random effects logistic regression models. For the U.S. sample, predicted probabilities are calculated at the mean age of the participants as all were over 18 years old. Shaded regions represent the 95% confidence intervals for the model predictions. A restricted adult age range is plotted below to improve resolution. Reversals in the youngest children are not significant if run independently (see SI Section 2).

fit each site's data better than any simpler model (see SI Section 4 for full model comparisons). Not only do younger participants fail to differentiate the two kinds of traits, they show a slight birth bias for all traits, choosing a birth parent resemblance around 60%–80% of the time.

The pattern is similar if, instead of looking at the aggregate patterns across participants, we examine the *proportion of individuals* who show a bias toward choosing an adoptive parent similarity, a birth parent similarity, or differentiating between morphological and belief traits (see SI Section 2). Even in adulthood more individuals than would be expected by chance alone show a birth bias in Yasawa and Puno. This analysis reveals that a significant number of children in Yasawa, but not Puno, show a differentiated pattern, although this difference may be due to the younger average age of the under 13 year olds in the Puno sample.

Importantly, the differentiated pattern persists in the Migration vignette when the child in the story lives with his birth parents (Fig. 2B). The differentiation is muted in the Migration condition relative to the Adoption conditions among adults, although it seems to develop earlier in the Yasawa sample (Fig. 2, also see SI Sections 4 and 6). This shows that it not just the fact that birth parents are dead in the Adoption vignette that leads people to reason that beliefs are acquired from nonparental sources. In other words, "folkbiological plus ToM" abilities alone cannot account for participants' lower prenatal transmission responses for beliefs, since the parents' mental states are accessible to the child as he grows up in the Migration condition.

Although differentiation of transmission pathways for belief and morphological traits reliably develops, there is notable cross-cultural variation in the extent to which adults respond that beliefs are prenatally inherited. American adults show the fewest such responses at <5%, while Yasawa and Puno adults' respond as if beliefs are prenatally transmitted about half of the time. Cross-cultural diversity is also apparent for responses

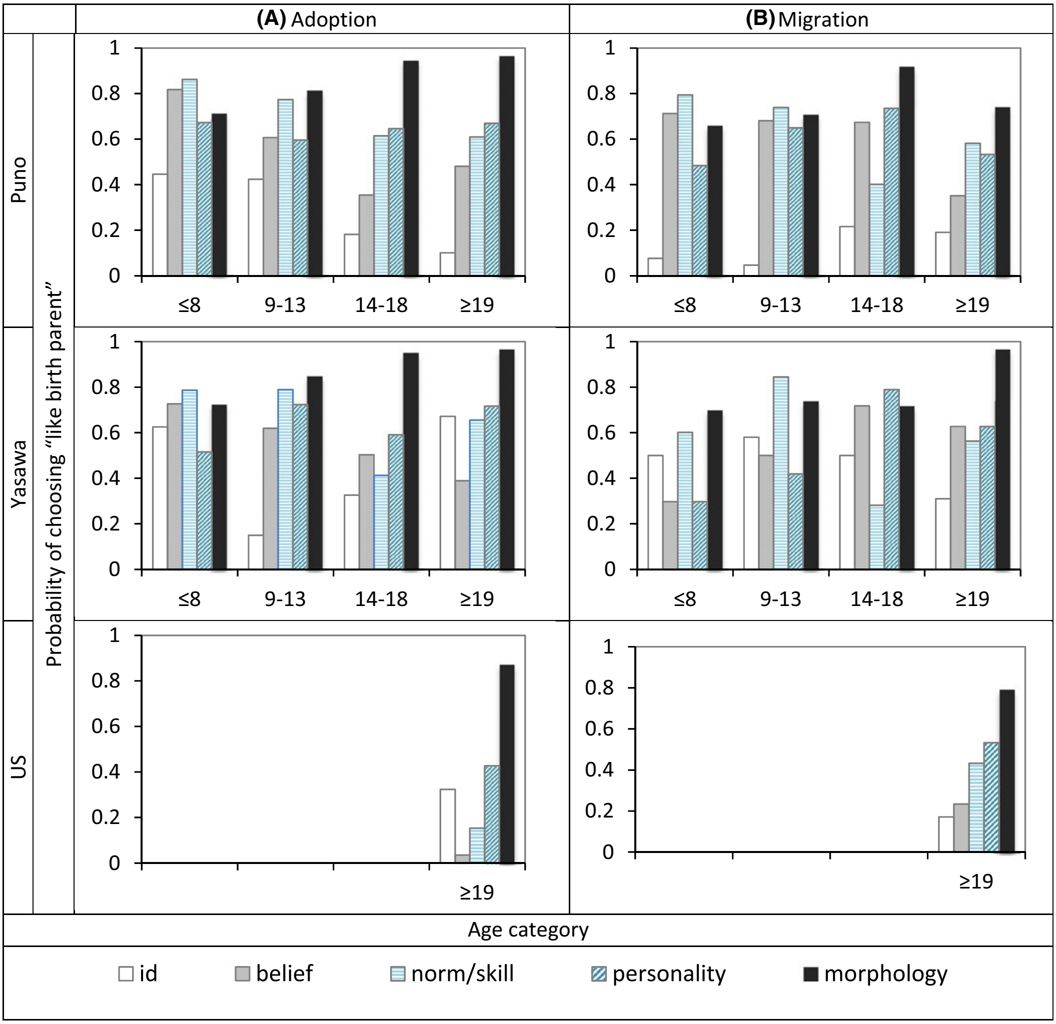

Fig. 2. Predicted probabilities of choosing prenatal transmission pathway by Trait Type and Age category for the (A) Adoption and (B) Migration Vignette conditions. Random effects logistic regression models were run separately for each site and Vignette Condition and only Intergroup conditions were used to allow comparison between Migration and Adoption vignettes.

about norms/skill and personality traits (Fig. 2, SI Section 5). By adulthood norms, skills, and personality traits tend to be treated as intermediate between beliefs and morphological traits. This is in part because the category of "skills and personality traits" is not a natural kind; rather, it is due to a lack of consensus. Most participants agreed that certain personality traits like intelligence were prenatally inherited, while other traits like selfishness were socially acquired. On the other hand, people's expectations about morphological traits being prenatally acquired seem to be more consistent and less labile.

4.2. There is cross-cultural variation in the perceived importance of nonparental and parental cultural transmission

The effect of Vignette condition distinguishes whether "like adoptive parents" responses imply parental social influence or nonparental social influences from other community members close to the adoptive parents. In the Migration vignette birth parents do not die and thus can influence the child both through prenatal and cultural pathways, whereas in the Adoption condition the birth parents can only influence the child prenatally. Higher rates of "like birth parent" choices in the Migration vignette relative to the Adoption vignette are therefore evidence that subjects place importance on vertical cultural transmission (i.e., the additional effect of having one's birth parent raise them). However, the Migration vignette also emphasized that the peers in the adoptive group had different traits from the birth parents. This means that any reduction in "like birth parent" choices in the Migration vignette likely results from the belief that peers will have a greater social influence than parents, at least in this intercultural migration context (SI Section 3).

For comparability's sake, we only include Intergroup conditions. We collapse across Intergroup scripts for the analysis as they did not interact with Vignette condition at either site. We include all non-identity traits that were used in both Vignette conditions in the analysis.

Only Americans show a modest belief that vertical cultural transmission occurs, as evidenced by their choosing "birth parent" similarity somewhat *more* often in the Migration condition—49% of the time across all traits, compared to 37% in the Adoption condition (Fig. 2, Odds Ratio (*OR*) = 1.68, 95% CI = [1.4, 2.0], where all *OR* control for SI×). In contrast, in Yasawa the best-fit model does not include Migration condition as a predictor since participants are as likely to choose a "birth parent" resemblance in the Adoption as in the Migration condition (*OR* = 0.92, 95% CI = [0.69, 1.24]). And finally, in Puno the best-fit model indicates that people believe that the child will resemble the "birth parents" slightly *less* in the Migration condition (*OR* = 0.74, 95% CI = [0.52,1.05]). This suggests that participants in Yasawa and Puno do not believe that vertical cultural transmission has much of an effect on most traits.

One might argue that the Vignette manipulation should only affect expectations of parent–offspring resemblance on nonmorphological traits, and especially ones that require teaching, since these are more likely to be vertically socially transmitted. This is true for Yasawa adults—who expect beliefs, but not morphological traits to be vertically transmitted. However, for American and Puno adults the Vignette manipulation affects their expectations about morphological traits as well. At these sites adults show *fewer* "like birth parent" responses for morphological traits in the Migration condition (when the birth parent is alive) suggesting that they recognize that social and environmental pathways can affect physical characteristics (see SI Section 6). The interaction effect of SI× and Vignette condition are weak, meaning there are no marked developmental shifts in reasoning about vertical transmission (see SI Section 2 for categorical age analyses).

5. Discussion

The results suggest that humans use a diverse set of cognitive mechanisms to reason about social life, including folkbiological, folksociological, and structured learning mechanisms. Some of these cognitive mechanisms push reasoning patterns toward cross-cultural convergence, while others facilitate learning cross-culturally variable norms. Detecting both kinds of mechanisms necessarily entails integrating ethnographic approaches, tools from cognitive science, and rich functionalist theory not specific to any social science discipline. Without a recognition of the extant anthropological diversity it is unclear why cognitive scientists would be motivated to study adaptations that allow children to learn about a range of belief systems. Without cognitive psychological tools it is difficult to compare empirically the nature of mental heuristics across divergent cultural contexts. Finally, a functionalist evolutionary approach helps us parse research questions according to adaptive problems faced by humans. Given our nature as a culture-bearing species, this framework can aid researchers in integrating the social and natural sciences. Below we consider how the cognitive mechanisms we have discussed are likely to give rise to cross-cultural similarities and differences seen in our data, and we assess the predictions laid out in Table 1 in light of our evidence.

First, these data add to the growing evidence that people reliably acquire folk concepts that cultural transmission processes affect beliefs, but not morphology. Cross-culturally people show a differentiated pattern by late childhood; responding that morphological traits are more likely to be prenatally inherited than are belief traits, despite large differences in their beliefs about the transmission pathways of group identity. This result replicates much of the cross-cultural work on the topic (Astuti et al., 2004; Bloch et al., 2001; Mahalingam, 1998; Solomon et al., 1996) and extends it by showing that the pattern is robust even when birth parents are alive in the Migration vignette. This means that folkbiological and Theory of Mind mechanisms alone cannot account for this differentiated pattern. The developmental consistency suggests that differentiating kinds of influences on traits is a reliably developing feature of folksociology. The fact that reasoning about morphological traits is relatively similar across sites compared to other traits, and that children show “birth biases” suggests that those responses might be an output of a more canalized folkbiological mechanism. Additionally, structured individual and social learning mechanisms are likely responsible for much of the variation across sites regarding base rates of prenatal transmission folk theories and responses to specific traits.

Second, we show that perceptions of parental social influence versus peer influence vary across societies. Only Americans show a commitment to vertical cultural transmission, making the “nurture assumption” (Harris, 1999). Puneños and Yasawans rejected vertical cultural transmission effects for most traits, possibly because of a belief that children use a wide set of cultural models, including peers. This cross-cultural difference may reflect the fact that Americans rely less on peer childcare and socialization compared to Puneños and Yasawans (Henrich & Broesch, 2011; Henrich & Henrich, 2010). Adoptions in Fiji and temporary alloparenting arrangements in Peru are also more common than in the United States, and while these tend to be within kin networks they decouple genetic and cultural transmission pathways to some extent. This cross-cultural variability in folk theories about parental social influence, and the fact that children show few biases on the matter suggest that any evolved expectations about the matter are, at best, weak. Structured learning mechanisms are likely used to acquire culturally-evolved folk theories about the importance of vertical transmission. See SI Section 7 for a discussion of limitations to our interpretations.

These lines of evidence support the need to consider folkbiological, folksociological, and structured learning mechanisms to explain peoples' reasoning about the inheritance of traits. Some components of folksociology may be derived from, or integrate with, folkbiological heuristics such as those for reasoning about morphological traits. Folksociological adaptations may also combine with structured learning abilities for acquiring folk beliefs about parental influence and the extent of social influence on nonmorphological traits. Humans cross-culturally come to expect different effects of social and prenatal influence, but develop culturally-specific beliefs about the degree of parental social influence.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Stimuli and Supporting Analysis.