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REASONING ABOUT CULTURAL AND GENETIC TRANSMISSION

DEVELOPMENTAL AND CROSS-CULTURAL EVIDENCE FROM PERU, FIJI, AND THE US 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 1) biological taxa and 2) culturally-evolved ethnic categories, from 3) a broader set of beliefs and categories using 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 US. 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 and social identities 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 US expecting parents to have much social influence over their children. We provide a reinterpretation of the differentiation of trait transmission pathways in light of human’s evolutionary history as a cultural species.

Keywords: folksociology ; folkbiology ; cross-cultural psychology; cognitive development; dual inheritance theory; adoption paradigm, vertical transmission; social learning

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 non-human animals engage in social learning, this process affects a modest number of behaviors in a limited set of domains (Marler, 1997; Galef, 1993; Kenward et. al., 2006). Humans, on the other hand, acquire a vast range of their beliefs and behaviors by social learning, and evolve cumulative cultural traditions (Henrich & Henrich, 2010; Henrich & McElreath, 2003; Richerson & Boyd, 2005). Cultural transmission has given rise to stable cultural differences among both individuals and groups (Henrich et. al., 2010; Chudek & Henrich, 2011), 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 in order to reason about cultural patterns. Structured learning mechanisms, such as Quinnian bootstrapping (Carey, 2009) or Hierarchical Bayesian-like inferential processes (Tenenbaum et. al., 2011) could solve this problem without being specifically designed for reasoning about conspecifics. We will refer to these hypothesized cognitive mechanisms as 1) folkbiology, 2) folksociology, and 3) 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 non-parental 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 according as an individual socially or individually learns how traits are transmitted.

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

		Research Question	
		1. Cultural v. Prenatal transmission	**2. Parental v. non-parental social transmission**
Cognitive Mechanism	**Folkbiology**	prenatal transmission bias	asocial parental transmission bias
	Folksociology	Reliably developing differentiation of cultural and prenatal transmission	Reliably developing differentiation of parental and non-parental social transmission
	Structured learning	Culture-specific differentiation of cultural and prenatal transmission	Culture-specific differentiation of parental and non-parental 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 suggests that this pattern, labeled the "differentiated pattern", develops reliably by middle childhood in the US (Solomon et. al. , 1996; Taylor, Rhodes, & Gelman, 2009), by adolescence in India (Mahalingam, 1998a), and by adulthood in Madagascar (Bloch, Solomon, & Carey, 2001; Astuti, Carey, & Solomon, 2004).

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 (Johnson & Solomon, 1997; Astuti et. al., 2004 ; 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 their 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 non-humans.

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 (Solomon et. al., 1996; Johnson and Solomon, 1997; 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 non-kin prestigious group members (Henrich and Henrich 2010; Henrich and Broesch 2011), 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 a second hypothesis that incorporates folksociological cognitive mechanisms accounts for the differentiated pattern better. While folksociology might be construed more broadly (Hirschfeld, 1996), for the purposes of this paper 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 non-cultural 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 (Richerson & Boyd 2005; Henrich & Henrich 2010). 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 different kinds 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 paper 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 non-parental 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 non-kin. 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 – i.e. 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 non-parental 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 non-parental models are often more important than parents in cultural transmission (Harris, 1995; Reyes-García et al., 2009; Hewlett, Fouts, Boyette, & Hewlett, 2011). Moreover, it is precisely because non-parental 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 non-parental adults or peers. If human folksociology is designed to be sensitive to non-parental 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 non-parental 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 non-parental 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) used migration vignettes, the stories specified the target characters' language use – thus giving away information about his cultural traits – and only asked about his ethnic identity.

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 – e.g. 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 site. In this section we describe the fieldsites, experimental procedures, and analyses.

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, mean = 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, mean = 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, mean =32). We will refer to this as the "US 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). It is likely that the boundaries between ethnolinguistic indigenous identities, like Aymara and Quechua speakers, are as fluid and non-racialized as the boundary between indigenous and non-indigenous groups (Moya & Boyd, n.d.; 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.'s adoption vignettes (2004), 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 Supplementary Materials 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).

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

			Vignette Condition		
			Adoption	Migration	Total
Puno	Group conditions	Ingroup	26	-	193
		Intergroup	57	110	
Yasawa		Ingroup	26	-	155
		Intergroup	82	47	
US		Ingroup	119	-	302
		Intergroup	96	87	

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 SM 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.

Table 3. Traits by Kind

Identity	Norms and Skills	Personality
Child's Group ID	Health practices [1, 4]	Selfish[5]
Grandchild's Group ID	Has a small family [1, 4]	Quick to anger
	Knotting knowledge	Friendly[4]
Beliefs	Good fisherman[5]	Intelligent[5]
'Bats have x# of teeth'	Good sense of direction [1]	
Food taboo [1]	Beqa healing hand[2]	**Morphology**
Music preference [1]	'It is rude to stand above'[2]	Finger length [4]
'There are tigers in Africa' [1]	Birth Ritual[2]	Good eyesight[5]
'Eels are poisonous'[3]		Ear shape
		Liver size[5]

[1.] Not used in Yasawa. [2.] Only used in Yasawa Migration vignette. [3.] Not used in Puno or US
[4.] Not used with children in Puno. [5] Used in Yasawa, but not in Migration vignette.

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 non-independence 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 SM 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 from all 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) using a negative exponential function of age (Moya, 2013) Specifically, $SI = 1 - e^{(-0.2*age)}$. This reflects the asymptotic way in which adult competence is acquired, that is, socialization effects are largest at early ages, 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 SM section 3 for derivation of the best fit SI, and section S6 for comparative analysis of models using different SIs.

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 SIs 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 US sample as 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 (Socialization Index), 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 (Figure 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, Socialization Index, and their interaction fit each site's data better than any simpler model (see SM 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 towards choosing an adoptive parent similarity, a birth parent similarity, or differentiating between morphological and belief traits (see SM 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 (Figure 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 (Figure 2, also see SM sections 4 & 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 non-parental sources. In other words, "folkbiological plus ToM" abilities alone cannot account for participants' reduced 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 less than 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 about norms/skill and personality traits (Figure 2, SM 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 might not be a natural kind, rather than due to a lack of consensus. Most participants perceived certain personality traits like intelligence and skills like good sense of direction as prenatally inherited, while most participants believed other traits like selfishness to be socially acquired. On the other hand, people's expectations about morphological traits being prenatally acquired seem to be more consistent and less labile.

Figure 1. Predicted probability of choosing prenatal transmission by Trait Types – Adoption condition.

For (a) Puno, (b) Yasawa, and (c) US from random effects logistic regression models. For the US 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 SM section 2).

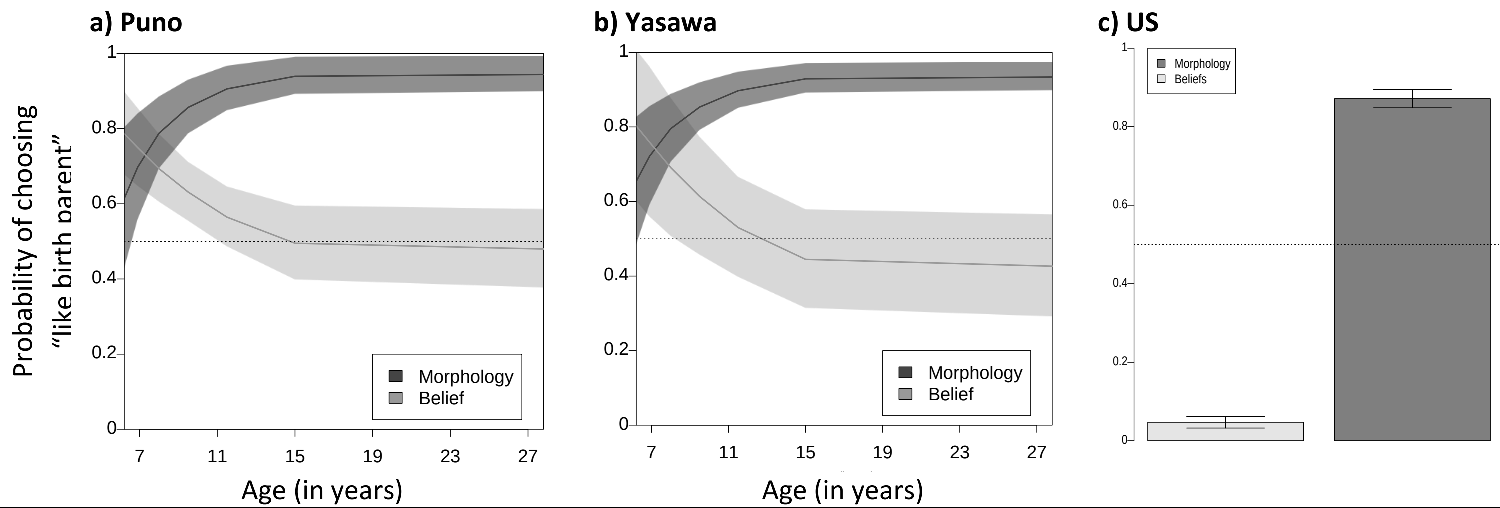
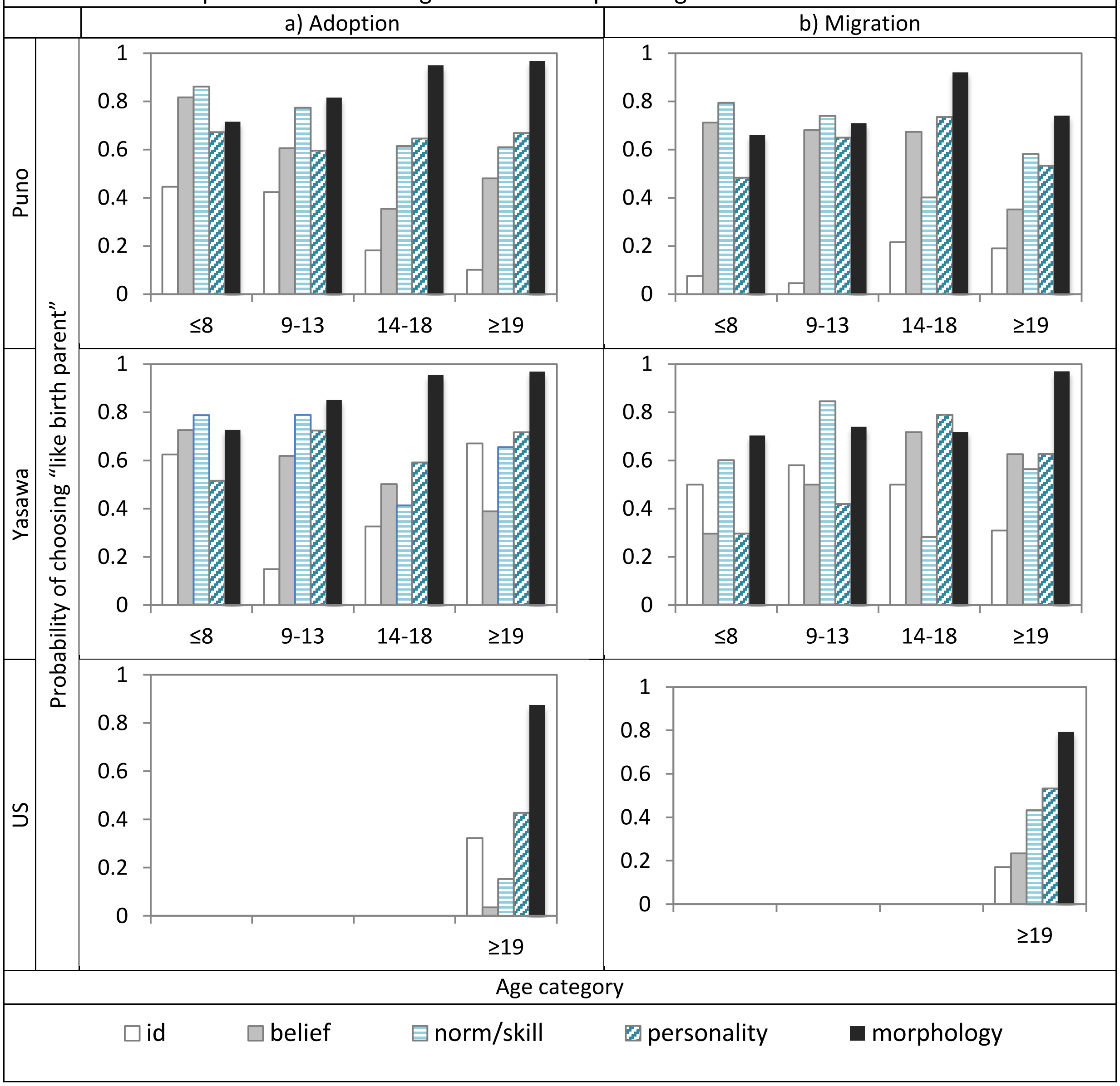


Figure 2. Predicted probabilities of choosing prenatal transmission pathway by Trait Type and Age category for the a) Adoption and b) Migration Vignette conditions. Random effects logistic regression models were run separately for each site and Vignette Condition and only Intergroup conditions were used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



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

The effect of Vignette condition distinguishes whether “like adoptive parents” responses imply parental social influence or non-parental 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 inter-cultural migration context (SM 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 (Figure 2, 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 non-morphological 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 SM 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 SM 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. Below 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 the Puno and Yasawa sites (Henrich & Broesch, 2011; Henrich & Henrich, 2010). Adoptions in Fiji and temporary alloparenting arrangements in Peru are also more common than in the US, 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 SM 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 and identity. 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 non-morphological 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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Supplementary Material
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SUPPLEMENTARY MATERIALS FOR REASONING ABOUT CULTURAL AND GENETIC TRANSMISSION

S1. EXPERIMENTAL STIMULI AND METHODOLOGICAL DIFFERENCES BY SITE

Table S1.1 summarizes the differences between the Adoption and Migration Vignettes. The full text of the Vignette conditions can be seen in Table S1.2 and the set of traits used as questions is shown in Table S1.3. At two of the sites there are unequal numbers of responses per participant because 1) some participants online and in Puno did not complete all questions, either due to fatigue or unexpected interruptions, and 2) children in Puno were administered an abridged version with fewer questions (Table S1.3). Because trait question order was randomized, this should not have changed the distribution of questions asked, and we assume that those who dropped out prematurely are missing at random with respect to our hypotheses. Additionally, a slightly different, but overlapping, smaller set of traits was used in Yasawa. At that site the set of traits varied some between the Adoption and Migration vignettes. Where necessary all statistical comparisons are made between the same subset of traits.

Table S1.1 Changes to vignette between Adoption and Migration Vignettes.
The Migration condition makes the birth parents responsible for vertical cultural influences and increases the salience of horizontal influences from peers.

	Adoption Vignette	Migration Vignette
Birth parents' influences	1. Prenatal	1. Prenatal 2. Cultural Vertical
Others' influences	2. Cultural Vertical 3. Implied Cultural Horizontal	3. Cultural Horizontal

Table S1.2 Other Vignettes Conditions Text of Vignettes used in studies for 1) Puno, 2) Yasawa and 3) US samples.
1. Puno
Linguistic Group Adoption Condition
Many years ago a couple from Huatasani was moving from their home town Huatasani , where Quechua is spoken) to Inchupalla (where Aymara is spoken). On the way, almost reaching Inchupalla, their bus crashed and all the passengers died except this young couple's baby. Some Aymara people from Inchupalla were coming along the same path and found the baby and decided to adopt it. They named him Marco. They took the baby to Inchupalla and raised it with much love as if he were one of their other two sons. Now Marco is an adult, he married an Aymara woman there and had his own children.
Linguistic Group Migration Condition
Many years ago a Quechua couple from Huatasani was moving from their home town Huatasani (where Quechua is spoken) to Inchupalla (where Aymara is spoken). On the way, almost reaching Inchupalla, their bus crashed and all the passengers died except this young couple. They continued their trip to Inchupalla bought their house and stayed to live there. After some years they had a child Marco who was born in Inchupalla, played with other Inchupalla kids, and was raised there. Now Marco is an adult, he married an Aymara woman

from Inchupalla and had his own children.
Regional Group Adoption Condition
Many years ago a couple from Huatasani was moving from their hometown Huatasani to Lima. On the way, almost reaching Lima, their bus crashed and all the passengers died except this young couple's baby. Some people from Lima were coming along the same path and found the baby and decided to adopt it. They named him Marco. They took the baby to Lima and raised it with much love as if he were one of their other two sons. Now Marco is an adult, he married a woman from Lima and had his own children.
Regional Group Migration Condition
Many years ago a couple from Huatasani was moving from their home town Huatasani to Lima. On the way almost reaching Lima, their bus crashed and all the passengers died except this young couple. They continued their trip to Lima bought their house and stayed to live there. After some years they had a child Marco who was born in Lima, played with other Lima kids, and was raised there. Now Marco is an adult, he married a woman from Lima and had his own children.
Ingroup Adoption Condition
Many years ago a couple from Huatasani was moving from their hometown Huatasani to Inchupalla. On the way, almost reaching Inchupalla, their bus crashed and all the passengers died except this young couple's baby. Some people from Huatasani were coming along the same path and found the baby and decided to adopt it. They named him Marco. They took the baby to their home in Huatasani and raised it with much love as if he were one of their other two sons. Now Marco is an adult, he married an Quechua woman there and had his own children.
2. Yasawa
Racial Group Adoption Condition
A long time ago, a young couple from Kadavu and their baby set sail in a tiny boat from one island to another. It is when they were close to the island during which time they begin to experience strong winds and very rough seas. The young mother was so sacred and terrified that she tied the baby to the bench right in the middle of the boat. Not for long a huge wave fills the boat with water and strong currents carry the young couples out to sea where they drowned. But it was a miracle that the boat neither sank nor capsized and the baby was still alive. After a while, the boat drifted ashore on an island and was found by an Indian couple. Then the couple named and took great care of the child as if the child were their own. The child was raised in the same manner in which their other two children were brought up and that is with love, compassion and understanding. The child became a responsible adult and later starts a family.
Racial Group Migration Condition
Some years ago, a young couple was traveling from one island to another with their newborn child in a small boat. Both the husband and wife were Indians from Viti Levu. As they neared their destination, the wind came up suddenly and the waves grew large. The boat ran aground on a reef and broke apart. The crew and the passengers were thrown into the rough seas. The couple were the only ones who survived. They drifted ashore on a beach alive but very exhausted. The next morning when the hurricane passed, some people from a nearby village, somewhere in the Yasawa islands, found the couple, gave them food and took care of them. The couple had lost all their belongings and was amazed by the love and hospitality of the Yasawans. With the villagers' approval, the couple decided to stay in the village for the rest of their lives. After some years they had a son. The boy's father survived by managing the village

shop, while his son attended the local school with the rest of the kids in the village learning how to fish, farm, drink grog, and speak the village dialect. Later, still living in the village, the boy became an adult, married a local girl and had a child
Native Fijian Group Adoption Condition
A long time ago, a young couple from Kadavu and their baby set sail in a tiny boat from one island to another. It is when they were close to the island during which time they begin to experience strong winds and very rough seas. The young mother was so sacred and terrified that she tied the baby to the bench right in the middle of the boat. Not for long a huge wave fills the boat with water and strong currents carry the young couples out to sea where they drowned. But it was a miracle that the boat neither sank nor capsized and the baby was still alive. After a while, the boat drifted ashore on an island and was found by a couple from Yasawa. Then the couple named and took great care of the child as if the child were their own. The child was raised in the same manner in which their other two children were brought up and that is with love, compassion and understanding. The child became a responsible adult and later starts a family.
Native Fijian Group Migration Condition
Some years ago, a young couple was traveling from one island to another with their newborn child in a small boat. Both the husband and wife were Fijians from Kadavu. As they neared their destination, the wind came up suddenly and the waves grew large. The boat ran aground on a reef and broke apart. The crew and the passengers were thrown into the rough seas. The couple were the only ones who survived. They drifted ashore on a beach alive but very exhausted. The next morning when the hurricane passed, some people from a nearby village found the couple, gave them food and took care of them. The couple lost all their belongings and were amazed by the love and hospitality of the Yasawans. With the villagers approval, the couple decided to stay in the village for the rest of their lives. After some years they had a son. The boy's father survived by managing the village shop, while his son attended the local school with the rest of the kids in the village learning how to fish, farm, drink grog, and speak the village dialect. Later, still living in the village, the boy became an adult, married a local girl and had a child.
Ingroup Adoption Condition
A long time ago, a young couple from Kadavu and their baby set sail in a tiny boat from one island to another. It is when they were close to the island during which time they begin to experience strong winds and very rough seas. The young mother was so sacred and terrified that she tied the baby to the bench right in the middle of the boat. Not for long a huge wave fills the boat with water and strong currents carry the young couples out to sea where they drowned. But it was a miracle that the boat neither sank nor capsized and the baby was still alive. After a while, the boat drifted ashore on an island and was found by a couple from Kadavu. Then the couple named and took great care of the child as if the child were their own. The child was raised in the same manner in which their other two children were brought up and that is with love, compassion and understanding. The child became a responsible adult and later starts a family.
3. US
Regional Group Adoption Condition
Some years ago, a young couple was traveling from one island to another with their newborn child in a small boat. Both the husband and wife were Fakians from Faka Island. As they neared their destination, the wind came up suddenly and the waves grew large. The wife was very frightened and tied her baby to a bench in the center of the boat. A moment later, a huge

wave crashed over the boat and both the husband and wife were swept overboard and drowned. Amazingly, the boat righted itself, and the baby survived. Later that day the boat washed up on the coast. There it was found by a man and his wife who were Nonuans from Nonu Island. They brought the baby home and named him M. They raised M with affection and love, just like their other two children. M is now fully grown and married with his own children.
Regional Group Migration Condition
Many years ago, a young Fakian couple was traveling by ship from Faka, their homeland island to a new island, Atafu, where they planned to live. As they passed near Nonu island their ship was caught in a huge cyclone, hit a reef, and broke apart. Passengers and crew were thrown into the turbulent waters, and all perished, except for the young couple who washed up on the beach exhausted but alive. The next morning the cyclone had passed and the young couple were found by Nonuans from a nearby village who fed and cared for them. The young couple had lost all of their possessions in the shipwreck, and impressed with the kindness and generosity of the Nonuan villagers decided to live the rest of their lives in the village. After some time, the couple had a son named M, who grew up in the village, played with the village children, and looked just like the other village children. M is now fully grown and married to a village girl and with his own children.
Ingroup Adoption Condition
Some years ago, a young couple was traveling from one island to another with their newborn child in a small boat. Both the husband and wife were Fakians from Faka Island. As they neared their destination, the wind came up suddenly and the waves grew large. The wife was very frightened and tied the baby to a bench in the center of the boat. A moment later, a huge wave crashed over the boat and both the husband and wife were swept overboard and drowned. Amazingly, the boat righted itself, and the baby survived. Later that day the boat washed up on the coast. There it was found by a man and his wife who were also Fakians from Faka Island. They brought the baby home and named him M. They raised M with affection and love, just like their other two children. M is now fully grown and married with his own children.

Table S1.3 All Traits Used

Belief 1. shows the full wording. All other trait questions followed the same format.

Traits were used in all sites with the following exceptions:
a. Not used in Yasawa.
b. Only used in Yasawa migration vignette.
c. Not used in Puno or US
d. Not used with children in Puno.
e. Used in Yasawa, but not in Migration vignette.

Identity

1. Now that the child is grown, is the child an {Group A} or {Group B}?
2. Are his children {Group A} or {Group B}?

Beliefs

1. M's father (the man who sired M) believed that fruit bats had 32 teeth. The man who raised M, his adoptive father, believed that fruit bats had 28 teeth. Now that he is grown, do you think that the child believes that fruit bats have 32 teeth or 28 teeth? *('bat' replaced with 'toad' in Puno).*
2. believed eating pregnant tufted deer is a delicacy
   like most people, thought it was immoral to eat pregnant deer [a]
3. did not care much for percussion music
   really enjoyed percussion music [a]
4. believed that there were tigers in Africa
   thought that there were no tigers in Africa [a]
5. believes that the eel is poisonous when eaten as most people think so
   does not necessarily believe that the eel is poisonous when eaten [c]
6. believed that Beqans cannot heal by touching burned skin
   believe this to be true and that they can heal.[b]
7. believed that it is not rude if one sits on a high chair while others are sitting on the floor
   believe this to be rude [b]
8. believed that when there is a new born baby, they must sacrifice a chicken
   did not believe in this practice [b]

Norms and Skills

1. avoided getting ill by eating a nutritious diet to keep his immune system healthy
   avoided getting ill by avoiding other people who seemed sick [a, d]
2. wanted a family with three children
   wished to have a much larger family [a, d]
3. knew how to tie about the same number of knots as most people
   knew how to tie an exceptionally large number of knots
4. was a good fisherman
   was not a good fisherman [e]
5. had a really good sense of direction
   had an average sense of direction [a]

Personality		
1.	was like most people, sometimes helpful and sometimes selfish was exceptionally helpful and altruistic [e]	
2.	became angry easily was slow to anger	
3.	was outgoing was shy [d]	
4.	was exceptionally intelligent is of normal intelligence [e]	
Morphology		
1.	had a third finger that was longer than his index finger had an index finger that is longer than his third finger [d]	
2.	had very good eyesight and can see distant objects much better than most people had normal eyesight [e]	
3.	had pointed ears had rounded ears	
4.	had a normal sized liver had a very large liver [e]	

S2. ALTERNATE ANALYSES

This section includes analyses that are 1) alternatives to the random effects models and 2) use categorical age as a predictor.

S2.1 DO PEOPLE DIFFERENTIATE BETWEEN THE CULTURAL AND PRENATAL TRANSMISSION OF TRAITS?

S2.1.1 INDIVIDUAL LEVEL SCORES

It is possible that aggregate patterns obscure between-individual variation. For example, while the population as a whole may not show a differentiated pattern, some individuals might. To assess this possibility we assigned people codes given their reasoning pattern. Separate binomial tests were run for each participant in order to assign these codes since participants at different sites, and in different conditions, were asked different numbers of questions.

In order to assign *differentiated* pattern codes we restricted our analysis to responses on belief and morphological traits. If the joint probability of having the target individual's number of birth parent ascriptions or *higher* on the morphological traits *and* their number of birth parent ascriptions or *lower* on the belief traits by chance alone was lower than 0.05, then the participant was assigned a *differentiated* code.

If the participant did not show a *differentiated* pattern then we determined whether they had a *birth* or *adoptive bias*, using the whole set of responses to non-identity traits in this analysis. If a participant predominantly answered that the child will resemble his adoptive parent regardless of traits he was coded as having an *adoptive bias* (if these responses were more than expected by chance alone at the p=0.05 level). If the participant overwhelmingly chose a birth parent resemblance then he was coded as having a *birth bias*. If the participant did not show any of these patterns he was assigned a *mixed* code.

Next we ran 2nd order binomial tests to determine whether there were more individuals showing a particular pattern than would be expected from chance alone. Bear in mind that assuming individuals are coin flippers it is statistically more unlikely to be assigned a *differentiated* pattern than a *mixed* pattern so that even if fewer than a quarter of respondents show a *differentiated* pattern this may be significantly more than expected by chance in the 2nd order binomial test.

We analyze the distribution of patterns for children (≤ 13 years old) and adults (≥18 years old) separately. We chose this age cut-off for children to parallel that used by Astuti, Carey and Solomon on a similar task (2004), and the 18 year cut off for adults to match the age range of the US sample. Unfortunately, we do not have enough adolescents in the intermediate age range to analyze them separately.

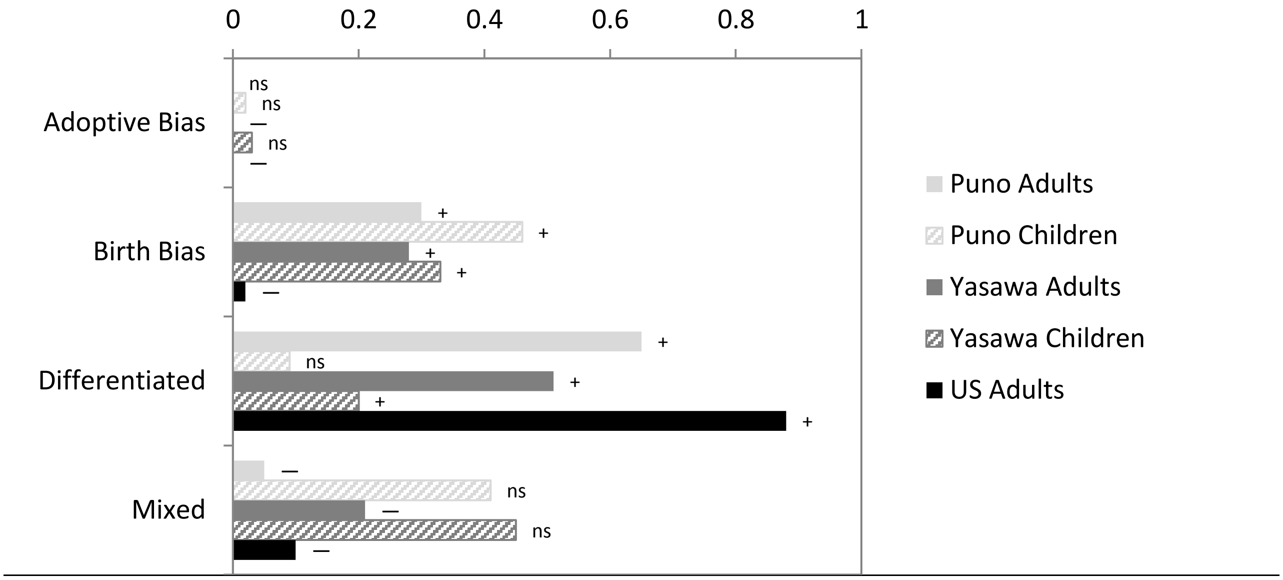
Table S2.1 and Figure S2.1 show that for all age and site categories except Peruvian children, the *differentiated* pattern is more common than expected by chance. For all age and site categories except for American adults, the birth bias is also more common than expected by chance alone.
These patterns parallel those discussed in the main text, and provide a robustness check.

Table S2.1 Trait transmission reasoning patterns distribution by Site and Age – Adoption Condition.
All participants in the Adoption Condition are assigned to having an Adoptive bias, a Birth bias, a Differentiated pattern, or a Mixed pattern. Adults (≥18 years old) are presented on top and children (≤ 13 years old) are represented on the bottom of the table. The top portion of each table represents the proportion of participants showing each pattern, and the bottom represents the participant count for each cell. Signs in parentheses represent the results of 2nd order binomial tests such that there are more people assigned to cells with a (+) than would be expected by chance alone (at *p*=0.05 cutoff values), and there are fewer people represented in the (–) cells than would be expected by chance alone.

		Adoptive	Birth Bias	Differentiated	Mixed
Adults	**Proportion**				
	Yasawa	0 (–)	0.28 (+)	0.51 (+)	0.21 (–)
	Puno	0	0.30 (+)	0.65 (+)	0.05 (–)
	US	0 (–)	0.02 (–)	0.88 (+)	0.1 (–)
	Number				
	Yasawa	0 (–)	17(+)	31 (+)	13 (–)
	Puno	0	6 (+)	13 (+)	1 (–)
	US	1(–)	3 (–)	175 (+)	20 (–)
Children	**Proportion**				
	Yasawa	0.03	0.33 (+)	0.20 (+)	0.45
	Puno	0.02	0.46 (+)	0.09	0.41
	Number				
	Yasawa	1	13 (+)	8 (+)	18
	Puno	1	25 (+)	5	22

Figure S2.1 Proportion of individuals per Site and Age category with each trait transmission reasoning patterns – Adoption Condition.

The signs reflect the results of 2nd order binomial tests for proportion of individuals with each reasoning pattern. A (+) indicates this pattern was observed more often than would be expected by chance alone (at p=0.05 cutoff values), and a (–) indicates fewer individuals showing this pattern than would be expected by chance alone. Children are <13 yo and Adults are >18



S2.1.2 DESCRIPTIVE STATISTICS AND RUNNING MEANS

While we heavily sampled children in the field settings (Figure S2.2), we may still have little statistical power to characterize the earliest developmental trajectories. In this section we attempt to visualize distributions of "like birth parent" choices as a function of age using other categorical age cut offs (Table S2.2) and by plotting running averages of "like birth parent" choices in 4-year age bands (Figure S2.3). They broadly confirm the patterns shown by the random effects models using Socialization Index as a predictor instead.

Figure S2.2 Age distributions by site

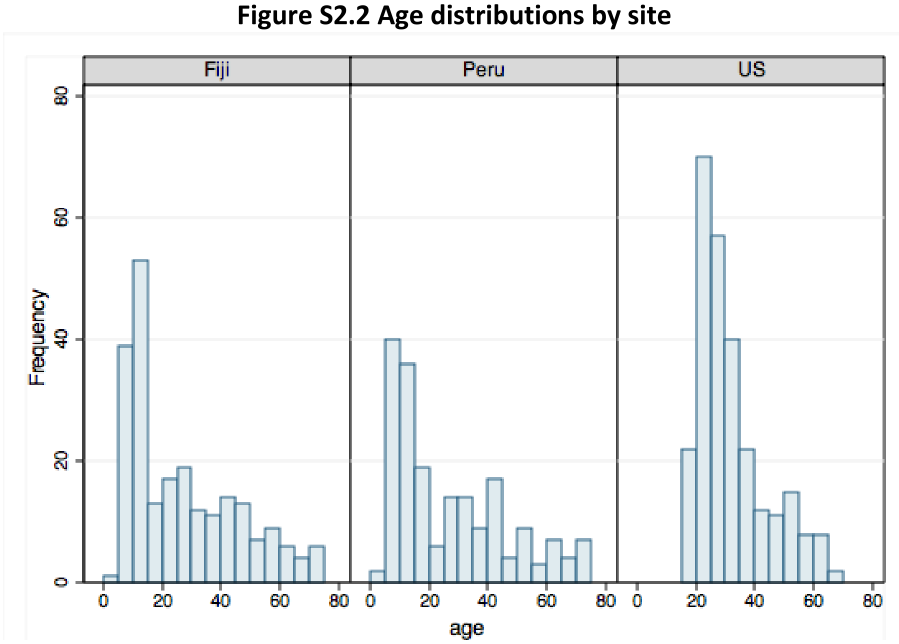
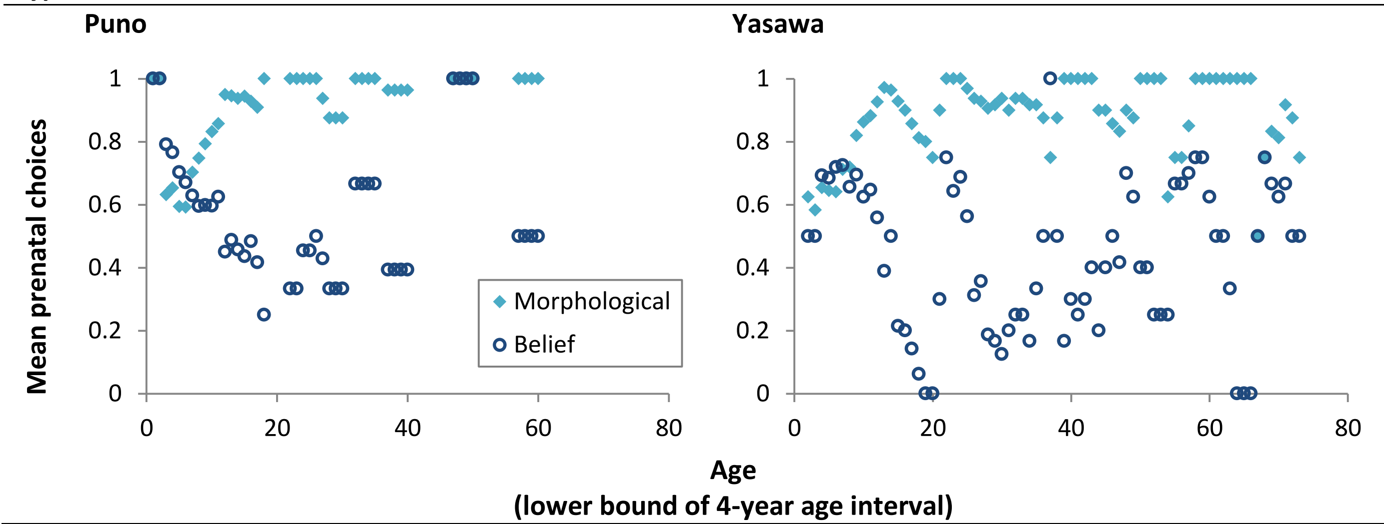


Table S2.2 Percent of questions answered as prenatal transmission in Adoption vignette, by trait type and age category. Number of questions represented shown in parentheses.

	3-5	6-10	11-15	16-20	21-75	total
Puno						
morph	100 (7)	67.48 (123)	88 (50)	92.86 (28)	96.61 (59)	81.27 (267)
belief	100 (8)	63.46 (156)	57.14 (56)	48.39 (31)	46.67 (60)	58.52 (311)
Yasawa						
morph	62.5 (16)	69.32 (88)	90 (80)	85.71 (28)	92.27 (220)	85.65 (432)
belief	50 (8)	70.45 (44)	57.5 (40)	14.29 (14)	41.82 (110)	49.07 (216)
US						
morph	(0)	(0)	(0)	90.91 (88)	86.9 (664)	87.43 (756)
belief	(0)	(0)	(0)	4.55 (87.9)	4.67 (663.8)	4.63 (755.9)

Figure S2.3 Running averages of prenatal transmission choices in 4 year age bands in Adoption vignette, by trait type and site.



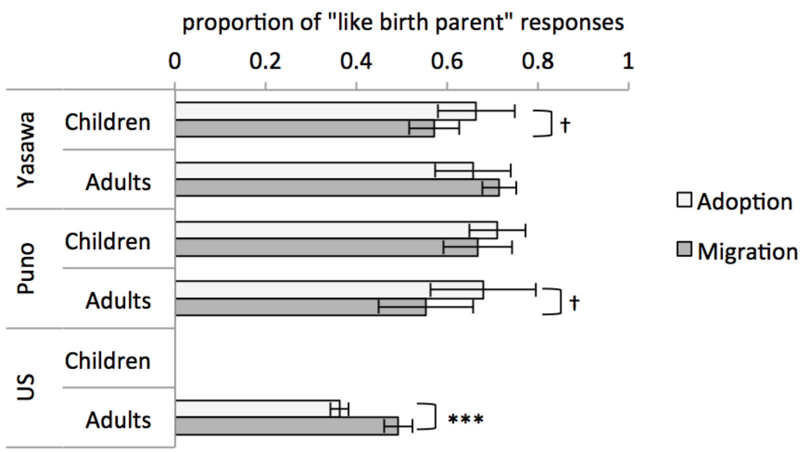
S2.2 DO PEOPLE DIFFERENTIATE BETWEEN PARENTAL AND NON-PARENTAL CULTURAL INFLUENCES?

For this analysis we compared people's reasoning across all non-identity traits in the Migration and the Adoption condition to assess the importance of parental social influences. We calculated a score for each individual that was the proportion of non-identity traits on which they chose "like the birth parent." Only questions that were both used in the Migration and the Adoption vignettes were used to calculate this score (see SM section 1). Furthermore, we exclude the Ingroup Adoption condition responses from analysis since these are not comparable to the Ingroup Migration condition.

The results of this analysis show that only American adults strongly expect that parents will socially influence their children in the Migration vignette (Figure S2.4). In other words, they make significantly more "like birth parent" ascriptions in the Migration vignette than in the Adoption vignette. In the latter condition the birth parents are only responsible for pre-natal influences on their child. The effect for Yasawa adults is in the same direction but not significant, and for all other groups the result is in the opposite direction. This suggest that in Yasawa and Puno participants are less convinced about the relative importance of vertical transmission, at least in a social context where parents are migrants and thus members of a cultural minority in the group. This suggest that the "nurture assumption" may be particularly unusual feature of Westerners or Americans.

Figure S2.4 Proportion of each individual's responses that were "like the birth parent" – By Vignette Condition.

Analysis is restricted to non-identity traits. Children are at most 13 years of age, and Adults are at least 18. Results of paired t-tests are coded as *** p<0.001, † p<0.1.



S3. DERIVING THE BEST FIT SOCIALIZATION INDEX SI

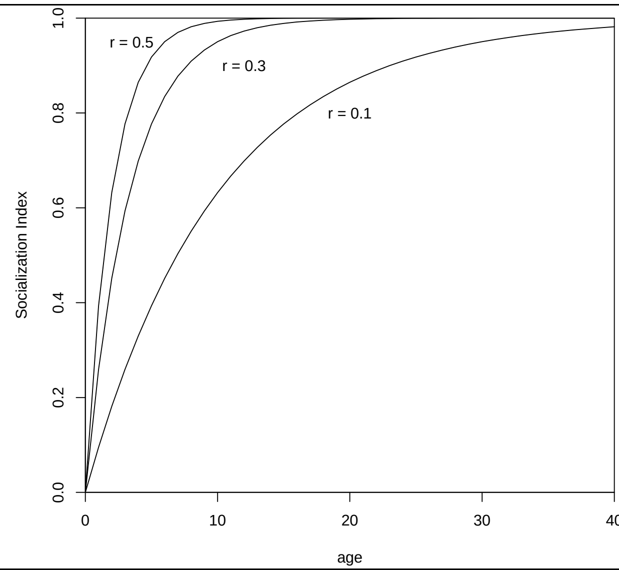
For the purposes of this paper we are not interested in changes in later adulthood that are likely to reflect historical changes rather than cognitive development. Therefore, we develop a Socialization Index (SI) which is simply a negative exponential function of raw age. The negative exponential function is asymptotic and so collapses all variation at higher values of age.

However, we have little *a priori* reason to expect a particular negative exponential function since we know relatively little about this developmental trajectory. For this reason we compare models with varying negative exponential functions and choose the best fit one as determined by the lowest AIC score. We test the SI's derived from the following function:

$$SI = 1 - e^{-r*age}$$

for values of *r* ranging from 0.1 to 0.5 in 0.01 unit increments. The higher *r* is, the faster the developmental trajectory. We chose this lower bound on *r* to ensure that adult variation is largely collapsed and not driving the effect. For example, at the lower bound of *r*=0.1 we expect that by 20 years of age, participants are 86% as likely as the oldest individual of responding affirmatively. Figure S3.1 illustrates trajectories for several values of *r.* We restrict the SI functions to ones where all age variation translates to 1 unit of change in SI – namely where the coefficient of *e* is equal to 1.

Figure S3.1 Illustration of various Socialization Indices as a function of varying *r,* rates of change. From left to right r=0.5, 0.3 and 0.1



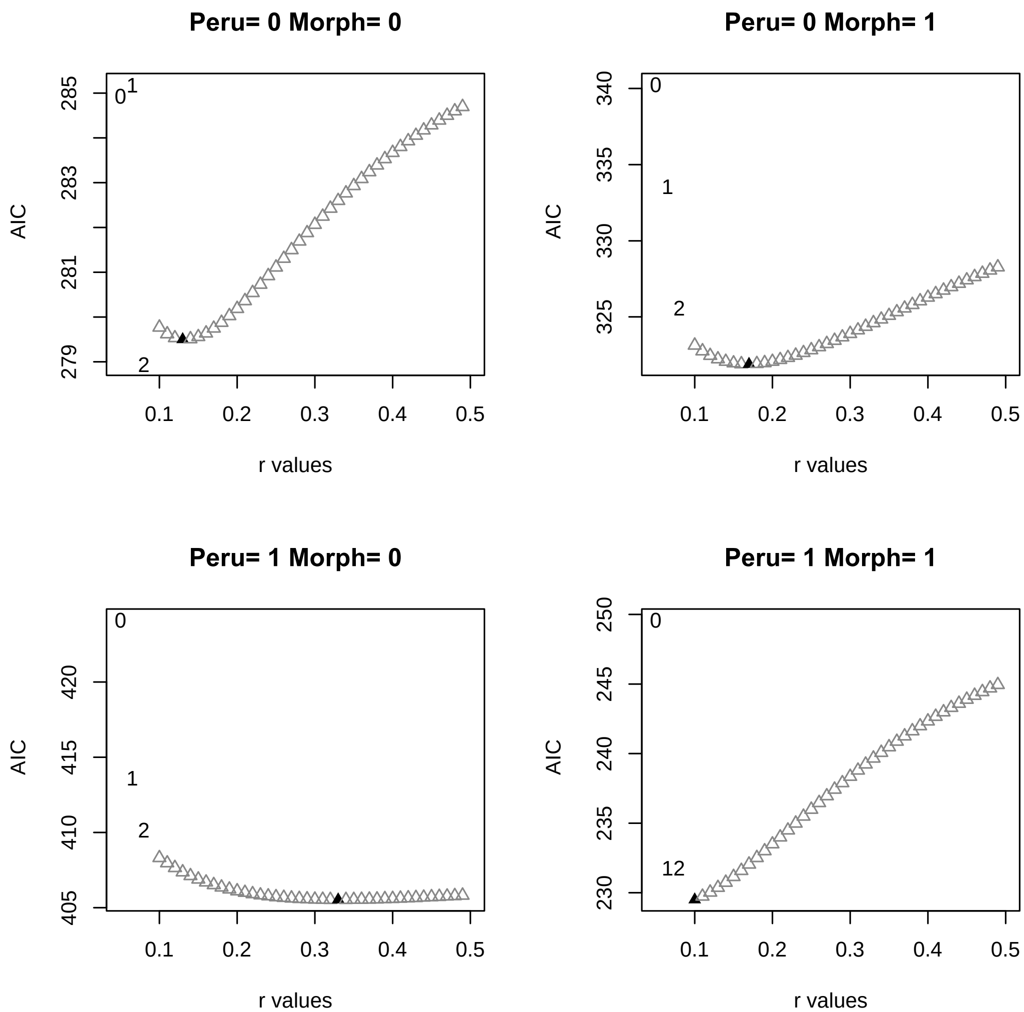
We also compare AIC scores of three different models of age; a baseline model without age as a predictor, a model with a linear raw age term, and a model with age and age squared as predictors. AIC's for these alternate models are shown as 0, 1, and 2, respectively, in Figure S3.2 alongside AICs for various SI's as a function of values of r. While in some cases linear or squared age terms fit the data better, we still report SIs in the main models because we do not wish to capture changes in adulthood. Table S3.1 shows the r-values for the SI with the minimum AIC scores for each model at each site. It also shows the "half-way" age for the given r-value. This is the age at which children are expected to be half-way between their "initial belief" and the adult belief – i.e. age at which SI=0.5. Low values may be due to faster socialization or beliefs that are more similar between 5 year olds and adults. Given this vast diversity of best-fit SIs, we take the average of these r-values (0.2) for ease of comparison to make our Socialization Index for all future models. Table S4.4 shows a robustness check using other r-values and shows that the differentiated pattern is robust to other r-values, although for extremely large values of r, some different models fit the Yasawa data better.

Table S3.1 Best fit Socialization index. r-value with minimum AIC for each model and corresponding ½ way age, by site.

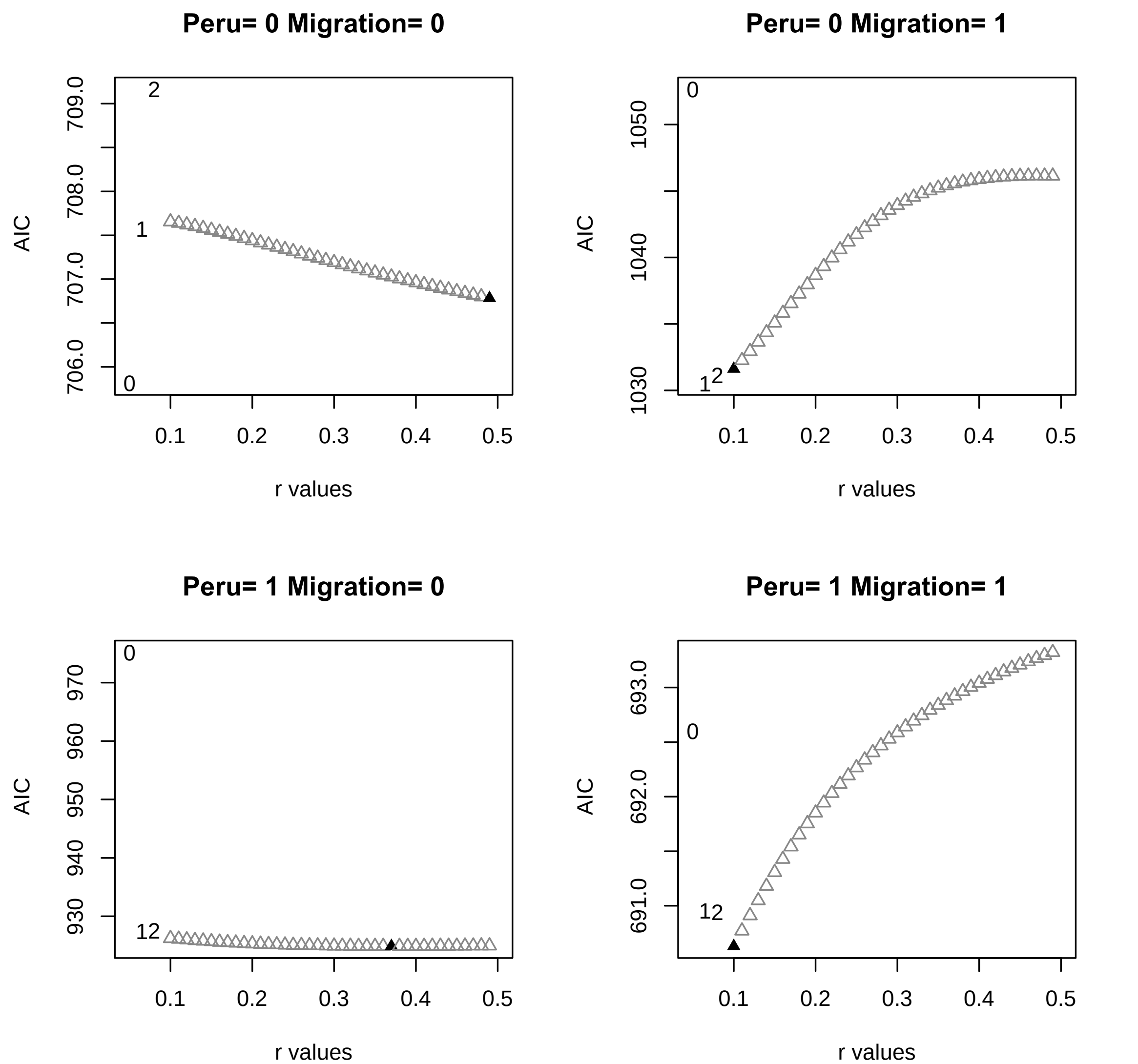
	Peru		**Fiji**	
	r	**½ way age**	**r**	**½ way age**
Beliefs	0.13	5.33	0.33	2.10
Morphology	0.17	4.08	0.1	6.93
Adoption	0.49	1.41	0.37	1.87
Migration	0.1	6.93	0.1	6.93
Non-racial	0.1	6.93	0.14	4.95
Racial	0.1	6.93	0.27	2.57

Figure S3.2 AIC scores for various models of age predicting ID responses. Triangles indicate AIC scores for models using Socialization Indices with varying r-values in the negative exponential function. The numeric markers denote AIC scores for a baseline model with different orders of age terms; without predictors (0), a model with a linear age term as a predictor (1) and a model with a linear and squared age terms (2). The position around r=0.05 for these is arbitrary and is just meant to allow easy comparison. The SI with the lowest AIC score is filled in black. Section a) shows the results for the development of beliefs about Morphological and Belief traits in the Adoption condition, b) for non-ID traits in the Migration versus Adoption condition, and c) for 1st generation Identity in the Racial versus Non-racial Group conditions.

a)

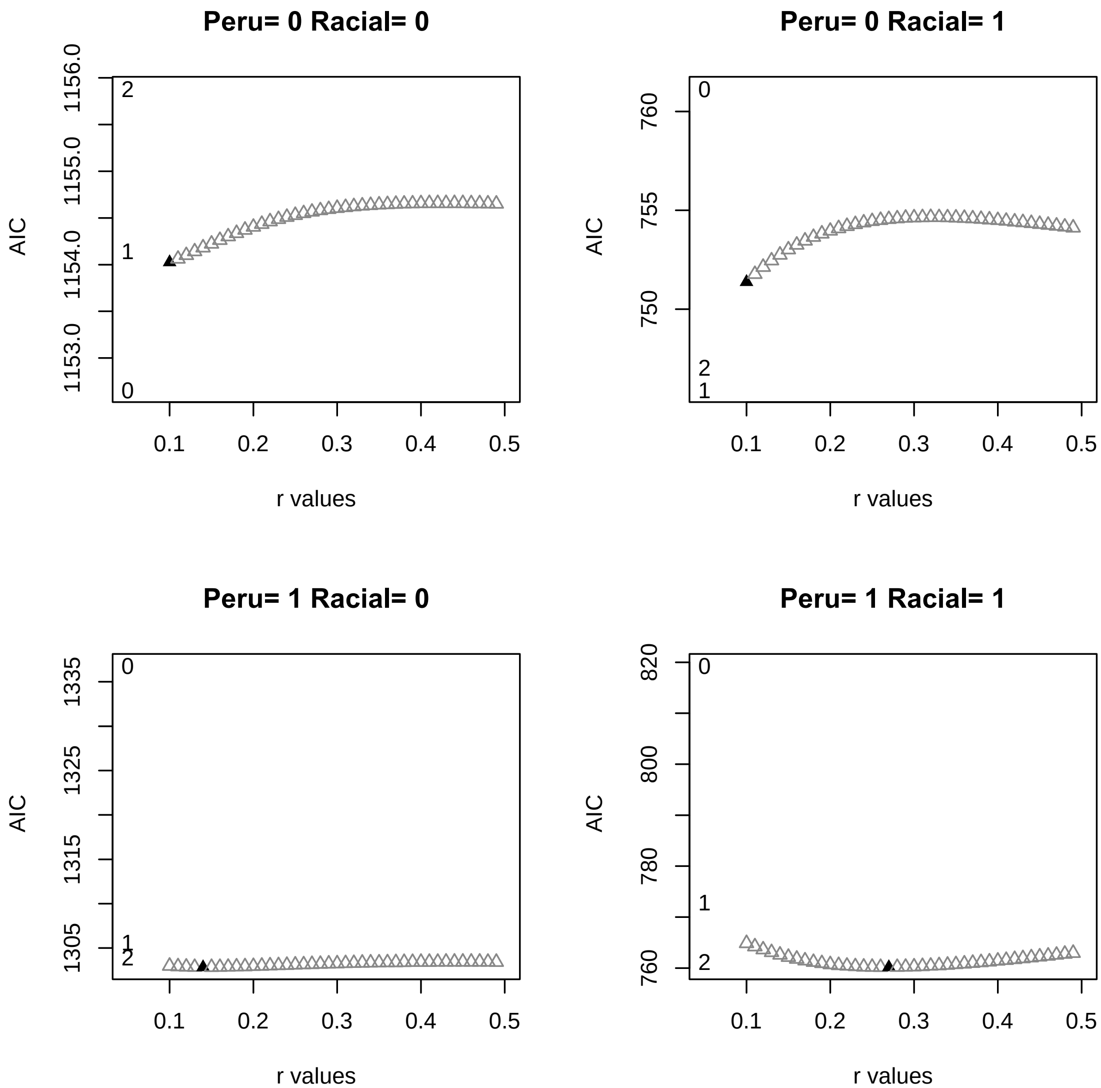


b)



Peru= 0 Migration= 0
Peru= 0 Migration= 1
Peru= 1 Migration= 0
Peru= 1 Migration= 1
AIC
r values

c)



Peru= 0 Racial= 0
Peru= 0 Racial= 1
Peru= 1 Racial= 0
Peru= 1 Racial= 1
AIC
r values

S4. MODEL COMPARISONS

Our data analysis is based on the model-fitting approach (Wagenmakers & Farrell, 2004; Wagenmakers & Waldorp, 2006). We pit different logistic regression models against each other to see which ones explain best whether or not participants choose that "the child is like the birth parent" for each site. This tells us which predictors are more associated with prenatal transmission folk beliefs. Different models correspond to the different hypotheses, but discriminating between some hypotheses requires examining effects within a given model. We report the logit regression coefficients, their corresponding standard errors and significance values *as well as* corrected Akaike Information Criteria (AICc) scores and Akaike weights for each model (Anderson, 2008). AICc's are a function of the probability that the data would be observed given the model, and of the number of predictors in the model. The model with the lowest AICc score maximizes the probability of the data given the model while penalizing overfitting resulting from multiple predictors. Akaike weights may be easier to interpret. They vary between 0 and 1 and tell us the relative likelihood that a given model provides the best fit among the ones being tested.

Tables in this section provide the full models compared to address each of our questions for each site using the Socialization Index we derived in the previous section (S3). Table S4.4 provides a robustness check by comparing the same models from Tables S4.1-S4.3 for the Puno and Yasawa samples, but using the extreme values of the Socialization Index (SI) that we tested above (r=0.1 and r=0.5). This analysis shows that the results from Puno are the same regardless of which of these three SI we use. Additionally, regardless of which SI we use, the choice of pre-natal transmission is best explained at each site by trait kind, SI and their interaction, in the Adoption condition. The remaining Yasawa results are less stable however. The majority of the discrepancies between models with r=0.1 and r=0.5 in Yasawa result from the worse fits of models with SI's in them when the development rate is assumed to be very fast or when it assumes that there is little difference between children and adult beliefs (r=0.5). Only with respect to 2^{nd} generation identities in Yasawa does increasing r to 0.5 improve the fit of a model with SI, suggesting a fast development rate for these beliefs.

The overall pattern from this robustness check suggests that generally more moderate developmental rates fit the data better. Additionally, larger developmental changes that happen throughout various stages of childhood – such as the development of the differentiated pattern – are detectable regardless of the SI we use.

Table S4.1 Development of Differentiated Pattern - Adoption Condition
Relative fit of random effects logistic regression models predicting probability of choosing "like the birth parent". Predictors include Trait Type (dummy coded as 1 for morphological traits, and 0 for belief traits), Socialization Index (a negative exponential transform of real age), and the interaction of SI and Trait Type.

	Puno					Yasawa					US				
	logit	SE	p	AICc	AICc weight	logit	SE	p	AICc	AICc weight	logit	SE	p	AICc	AICc weight
Model 1				708.07	<.001				748.49	<.001				2090.55	<.001
constant	0.89	0.13	<.005			1.10	0.12	<.005			-0.16	0.05	<.005		
Model 2				670.65	<.001				644.74	<.001				861.08	0.37
Trait type	1.26	0.21	<.005			2.12	0.23	<.005			4.96	0.20	<.005		
constant	0.40	0.16	0.01			-0.04	0.17	0.81			-3.03	0.17	<.005		
Model 3				710.09	<.001				747.96	<.001				2092.27	<.001
SI	-0.11	1.26	0.93			1.67	1.03	0.11			-3.24	6.01	0.59		
constant	0.99	1.11	0.38			-0.45	0.96	0.64			3.06	5.96	0.61		
Model 4				672.59	<.001				644.39	<.001				862.13	0.22
Trait type	1.26	0.21	<.005			2.12	0.23	<.005			4.97	0.21	<.005		
SI	-0.41	1.37	0.77			2.07	1.33	0.12			-10.71	11.04	0.33		
constant	0.76	1.21	0.53			-1.96	1.25	0.12			7.61	10.96	0.49		
Model 5				629.18	1.00				606.45	1.00				860.90	0.41
Trait type	-11.92	2.17	<.005			-9.63	1.98	<.005			28.15	1.85	-3.01		
SI	-6.45	1.92	<.005			-5.31	1.93	0.01			21.40	23.83	0.37		
SI X Trait type	15.27	2.53	<.005			12.90	2.18	<.005			-47.48	28.30	0.09		
constant	6.10	1.71	<.005			4.89	1.80	0.01			-24.29	23.69	0.31		

Table S4.2 Development of Differentiated Pattern - Migration Condition
Relative fit of random effects logistic regression models predicting probability of choosing "like the birth parent". Predictors include Trait Type (dummy coded as 1 for morphological traits, and 0 for belief traits), Socialization Index (a negative exponential transform of real age), and the interaction of SI and Trait Type.

	Puno					Yasawa					US				
	logit	SE	p	AICc	AICc weight	logit	SE	p	AICc	AICc weight	logit	SE	p	AICc	AICc weight
Model 1				341.08	0.02				947.15	<.001				868.55	<.001
constant	0.68	0.17	0.00			0.36	0.08	<.005			0.06	0.08	0.47		
Model 2				338.92	0.06				855.78	0.11				686.18	0.66
Trait type	0.56	0.27	0.04			1.81	0.21	<.005			2.40	0.20	0.00		
constant	0.44	0.21	0.03			-0.15	0.11	0.17			-1.12	0.14	0.00		
Model 3				341.63	0.02				944.23	<.001				870.55	<.001
SI	-1.64	1.34	0.22			1.90	0.86	0.03			1.22	10.35	0.91		
constant	2.10	1.17	0.07			-1.42	0.80	0.08			-1.15	10.28	0.91		
Model 4				339.27	0.05				852.84	0.49				688.18	0.24
Trait type	0.57	0.27	0.04			1.81	0.21	<.005			2.40	0.20	0.00		
SI	-1.78	1.36	0.19			2.25	1.01	0.03			1.72	13.02	0.90		
constant	1.96	1.18	0.10			-2.25	0.95	0.02			-2.83	12.93	0.83		
Model 5				333.51	0.86				853.21	0.40				690.05	0.10
Trait type	-5.01	2.04	0.01			-0.48	1.78	0.79			12.36	24.86	0.62		
SI	-4.73	1.83	0.01			1.52	1.13	0.18			6.55	17.86	0.71		
SI X Trait type	6.46	2.35	0.01			2.48	1.93	0.20			-10.03	25.03	0.69		
constant	4.51	1.60	0.01			-1.57	1.06	0.14			-7.62	17.74	0.67		

Table S4.3 Development of reasoning about parental and non-parental social transmission.
Relative fit of random effects logistic regression models predicting probability of choosing "like the birth parent" across all non-identity traits that are constant across Vignette conditions. Predictors include Vignette Condition (dummy coded as 1 for Migration Condition, and 0 for Adoption Condition), Socialization Index (a negative exponential transform of age), and their interaction.

	Puno					Yasawa					US				
	logit	SE	p	AICc	AICc weight	logit	SE	p	AICc	AICc weight	logit	SE	p	AICc	AICc weight
Model 1				1618.06	0.08				1762.28	0.14				3848.28	<.001
constant	0.77	0.09	0.00			0.70	0.08	0.00			-0.31	0.04	0.00		
Model 2				1617.63	0.10				1764.16	0.05				3807.36	0.57
Migration condition	-0.29	0.18	0.12			-0.05	0.15	0.72			0.52	0.08	0.00		
constant	0.89	0.12	0.00			0.73	0.12	0.00			-0.55	0.05	0.00		
Model 3				1615.54	0.27				1759.75	0.48				3850.24	<.001
SI	-1.71	0.80	0.03			1.52	0.71	0.03			1.00	5.10	0.85		
constant	2.26	0.70	0.00			-0.71	0.66	0.28			-1.30	5.06	0.80		
Model 4				1614.72	0.41				1761.47	0.20				3809.36	0.21
Migration condition	-0.30	0.18	0.09			-0.08	0.15	0.59			0.52	0.08	0.00		
SI	-1.76	0.79	0.03			1.55	0.71	0.03			-0.36	4.60	0.94		
constant	2.43	0.70	0.00			-0.69	0.66	0.29			-0.20	4.57	0.97		
Model 5				1616.73	0.15				1762.39	0.13				3809.22	0.22
Migration condition	-0.41	1.38	0.77			-1.44	1.31	0.27			-13.01	9.24	0.16		
SI	-1.82	1.09	0.10			0.76	1.04	0.46			-6.05	5.99	0.31		
SI X Migration condition	0.12	1.57	0.94			1.48	1.42	0.30			13.64	9.30	0.14		
constant	2.48	0.97	0.01			0.03	0.95	0.98			5.44	5.94	0.36		

Table S4.4 Model comparison with alternate Socialization Indices. AIC weights are shown, the largest in bold. SI's with r=0.1 and r=0.5 are compared. Best fit models from the main results where r=0.2 are noted in left most column (P for Puno, and Y for Yasawa)

		Puno		**Yasawa**	
Model	**Variables**	**r=0.1**	**r=0.5**	**r=0.1**	**r=0.5**
Differentiation – Adoption (Table S4.1)					
1	none	<.001	<.001	<.001	<.001
2	Trait	<.001	<.001	<.001	<.001
3	SI	<.001	<.001	<.001	<.001
4	Trait + SI	<.001	<.001	<.001	<.001
5 (P,Y)	Trait X SI	**1**	**1**	**1**	**1**
Differentiation - Migration (Table S4.2)					
1	none	0.008	0.084	<.001	<.001
2	Trait	0.024	0.251	0.01	**0.559**
3	SI	0.01	0.041	<.001	<.001
4 (Y)	Trait + SI	0.034	0.128	0.127	0.316
5 (P)	Trait X SI	**0.924**	**0.497**	**0.863**	0.124
Vignette Condition (Table S4.3)					
1	none	0.083	0.118	0.037	**0.484**
2	Mig. Cond.	0.103	0.147	0.015	0.19
3 (Y)	SI	0.282	0.219	**0.412**	0.194
4 (P)	Mig. + SI	**0.379**	**0.361**	0.175	0.076
5	Mig. X SI	0.152	0.156	0.361	0.056

S5. RAW PROPORTIONS OF ADULT RESPONSES BY SITE AND QUESTION

Figures S5.1-S5.2 show the raw proportions of adults' responses that are "like the birth parent" implying a pre-natal transmission pathway in the Adoption vignette (S5.1) and a pre-natal or parental social influence in the Migration vignette (S5.2). The vertical axis at 0.5 denotes equal responses of "like birth parent" and "like adoptive parent or community." To distinguish between questions that were not asked at the specific site, proportions corresponding to the bars are included in the figures. In other words, questions to which 50% of people responded with "like birth parent" choices will have a subscript of "0.5" next to the vertical axis, whereas those that were not asked at the site will be blank.

Figure S5.1 Proportion of adults (>18 y.o.) choosing "similar to birth parent" for each trait, by site. – Adoption Condition. Note: not all traits were used at each site.

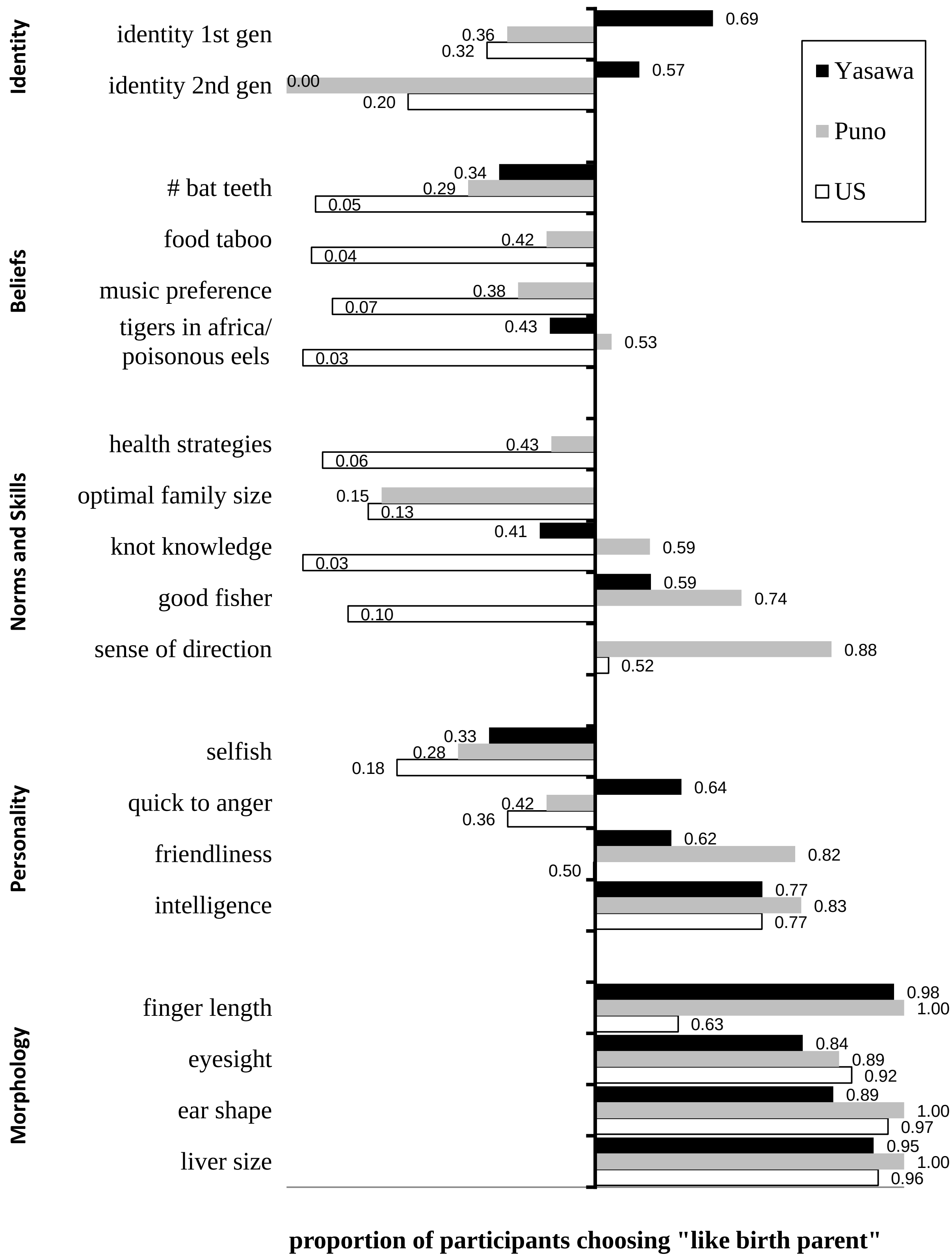
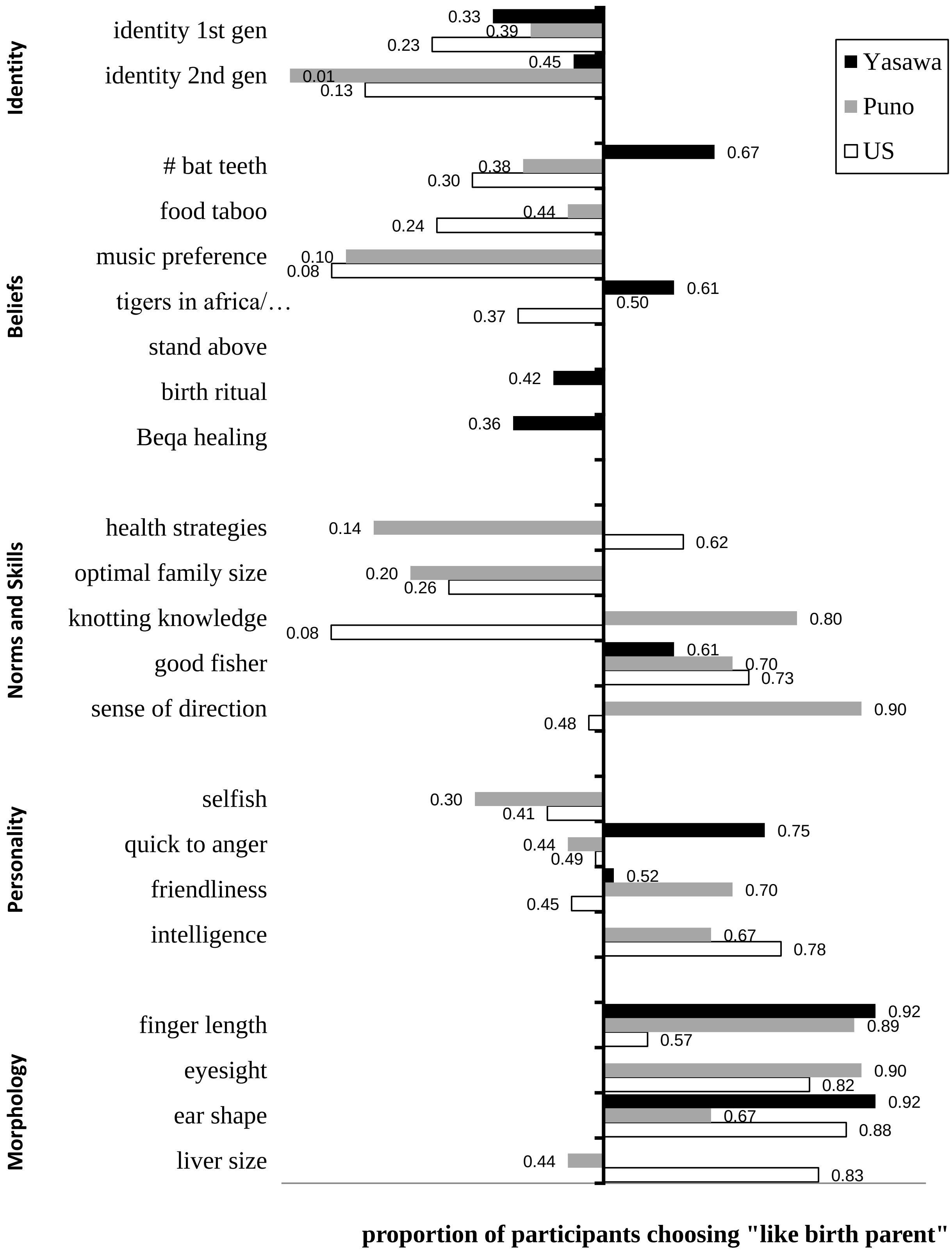


Figure S5.2 Proportion of adults choosing "similar to birth parent" for each trait, by site. – Migration Condition. Note: not all traits were used at each site.



S6. FURTHER ANALAYSIS OF MIGRATION CONDITION

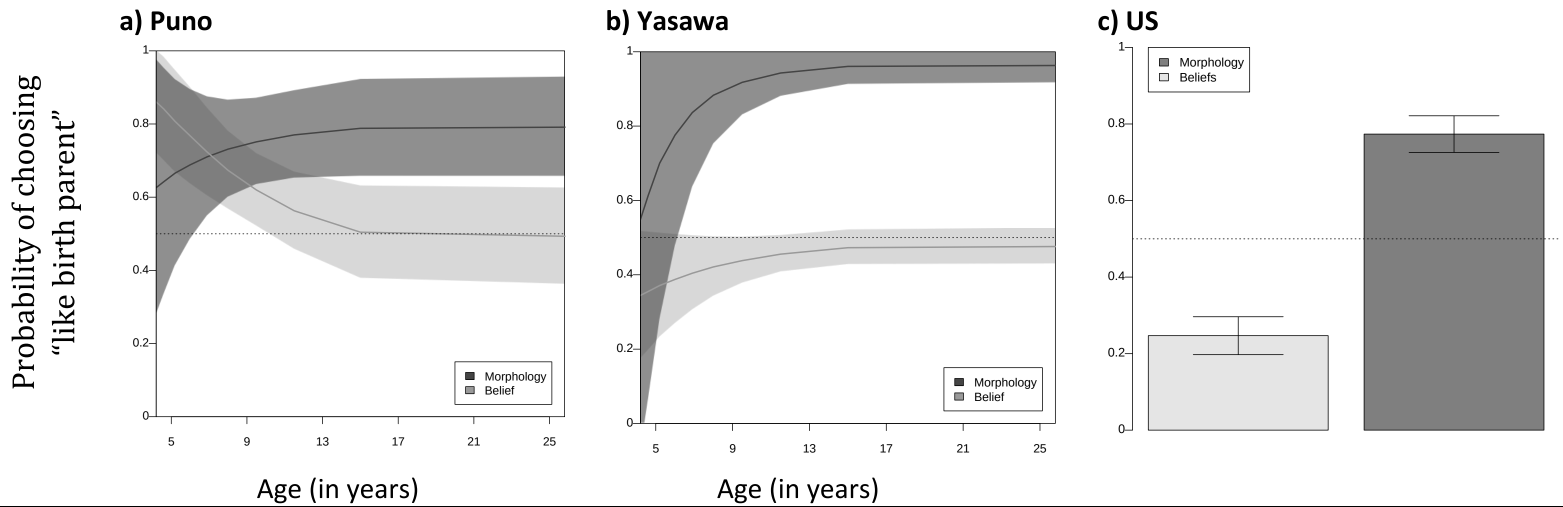
S.6.1 DIFFERENTIATION IN THE MIGRATION CONDITION

The differentiated pattern persists in the Migration vignette. It is muted in the Migration vignette relative to the Adoption condition in Puno and the US, but exaggerated in Yasawa.

Figure S6.1 Predicted probability of choosing prenatal transmission by Trait Types – Migration condition.

For (a) Puno, (b) Yasawa, and (c) US from random effects logistic regression models. For the US 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. Models were fit using the full range of the Socialization Index as a predictor, but age is plotted for ease of interpretation. A restricted adult age range is plotted below to improve resolution.



S.6.2 MIGRATION CONDITION INTERACTION WITH TRAIT TYPE

It is possible that participants believe some kinds of traits are more likely to be horizontally transmitted than others. For example, people might reason that morphological traits will be under pre-natal influence whether or not a biological parent raises a child, but that beliefs are more likely to be socially learned from peers. In other words, we might expect that the Vignette condition (Migration versus Adoption) will not affect pre-natal ascription rates regarding morphological traits. Furthermore, the Migration condition might reduce "like birth parent" ascriptions regarding beliefs if people think horizontal transmission is important, or increase "like birth parent" ascriptions of beliefs if people think vertical transmission is important.

In order to test this, we ran models with two-way interactions between Vignette condition and Trait type (belief versus morphological) by age category (<13 and ≥18) rather than SI for ease of interpretation. Contrary to our expectations of stability, both in the Puno and US samples participants decreased their "like birth parent ascriptions" of morphological traits in the Migration condition (Figure S6.2). In other words, priming peer influences in the new social setting made fewer people reason that a child would resemble his birth parents with respect to morphological traits. With respect to pure belief traits both Yasawa and US adults show an expectation of vertical transmission, while children in Yasawa act as if they expect horizontal transmission to swamp the effects of having a birth parent still alive in the Migration condition. The Puno samples show no marked differences in reasoning about pure beliefs between the two Vignette conditions. Table S6.1 shows the size of the interaction effects by site and age category. All of the interaction effects among adults are significantly negative, meaning that the Migration condition was *less* likely to promote birth parent (vertical transmission) ascriptions of morphological than of belief traits.

Figure S6.2 Effect of Vignette Condition by Trait type interactions. Figures show predicted probabilities of choosing "like birth parent" ascriptions from random effects models using Trait type, Vignette condition and their interaction as predictors. Models were run separately for children (<13) and adults (≥18). 95% CI shown.

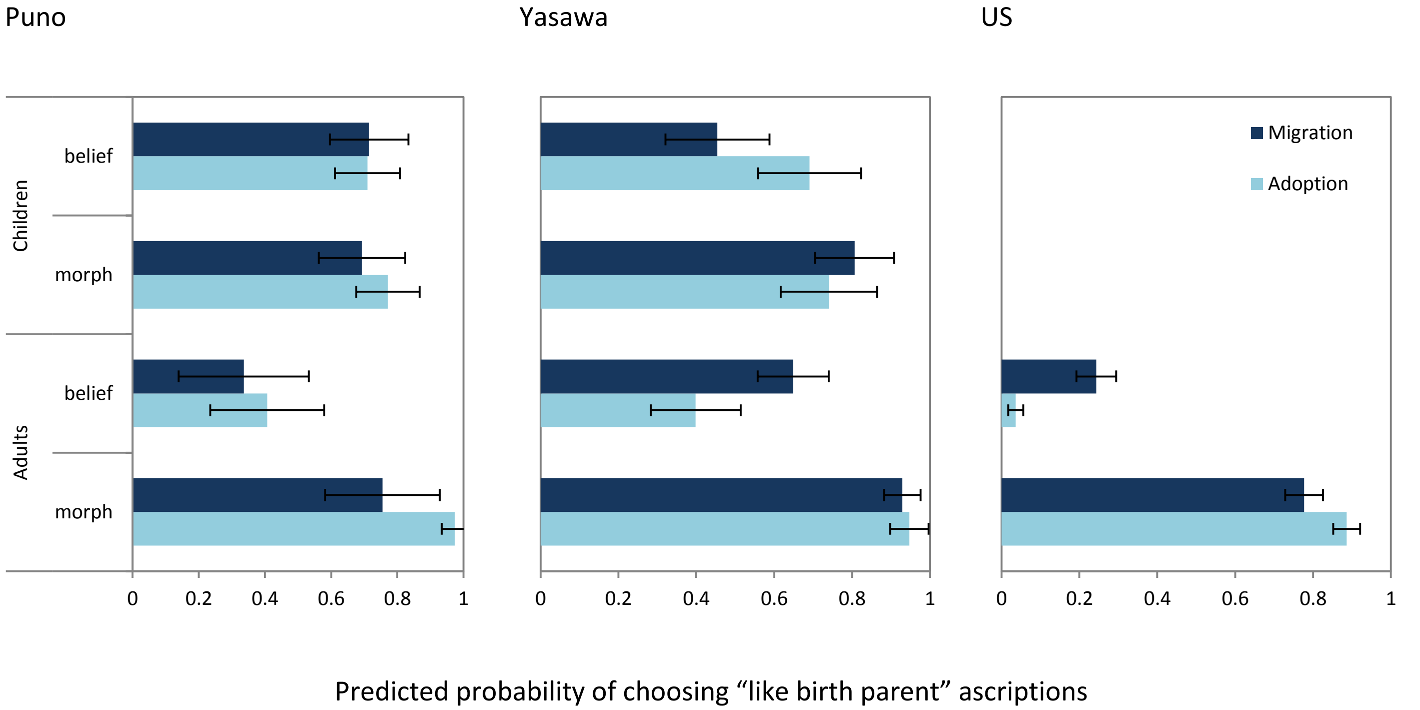


Table S6.1 Interaction effects between Vignette condition and Trait type by site and age category. From random effects logistic regression models with Migration condition and morphological trait dummy coded as 1.				
site	age	Logit coef.	SE	p
Puno	≥18	-2.19	.98	0.03
	<13	-.42	.47	0.37
Yasawa	≥18	-1.34	.66	0.04
	<13	1.37	.57	0.02
US	≥18	-2.94	.37	<0.001

S7. EMPIRICAL LIMITATIONS OF THE CURRENT STUDY

Our data have limitations common to cross-cultural and evolutionary projects. First, it is possible that the traits chosen for the questions connoted different concepts in different settings (e.g., being a good fisherman could imply rod and line fishing to the US participants and thus require less physical prowess compared to that required for net fishing in Puno, and spear fishing in Yasawa). However, we doubt this can explain the overall patterns given that we asked about various traits precisely to avoid such concerns. Second, we chose locally appropriate, and therefore diverse, Group conditions. This diminishes our ability to differentiate cross-cultural variation in beliefs from universal human beliefs about specific kinds of groups. This might be particularly problematic in the case of the American group condition which referenced fictional categories. Future studies using fictional social categories across societies, or making use of analogous regional boundaries in each society can help distinguish whether these design choices affect comparability.

Finally, developmental data are not always informative about the evolved nature of conceptual primitives. When children's responses differ from adults' it suggests that they have yet to be fully socialized and that the differences reflect innate biases. But a failure to show a difference between children and adults' reasoning does not mean that children did not have cognitive biases either in line with, or earlier in development at odds with, adults' folk beliefs. We did not test participants younger than 4 or 5 years of age, and given the method probably could not do so. Furthermore, a late, but reliably developing pattern does not imply that the conceptual structures are not innate (e.g., consider adaptations that should only develop after sexual maturity).

S8. BIBLIOGRAPHY

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