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EVOLVED PRIORS FOR ETHNOLINGUISTIC CATEGORIZATION: A CASE STUDY FROM THE QUECHUA–AYMARA BOUNDARY IN THE PERUVIAN ALTIPLANO

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Abstract: Ethnic categories uniquely structure human social worlds. People readily form stereotypes about these, and other social categories, but it is unclear whether certain dimensions are privileged for making predictions about strangers when information is limited. If humans have been living in culturally-structured groups for much of their evolutionary history, we might expect them to have adaptations for prioritizing ethno-linguistic cues as a basis for making predictions about others. We provide a strong test of this possibility through a series of studies in a field context along the Quechua-Aymara linguistic boundary in the Peruvian Altiplano where the language boundary is not particularly socially meaningful. We find evidence of such psychological priors among children and adults at this site by showing that their age, and social categories' novelty affect participants' reliance on ethno-linguistic inductive inferences (i.e. one-to-many predictions). Studies 1-3 show that participants make more ethno-linguistic inferences when the social categories are more removed from their real-world context. Additionally, in Study 4 when the category is marked with acoustic cues of language use, young children rely heavily on ethno-linguistic predictions, even though adults do not.

1. INTRODUCTION

Humans are the only species structured into ethnic categories – that is they live in symbolically marked groups whose members share cultural norms, beliefs, expectations, and skills. Virtually no aspect of a person's behavioral repertoire and daily life is unaffected by local culture. In this paper we address whether people have psychological adaptations for categorizing others and making inferences about them based on their ethnic category. There are various reasons to believe that this may be the case. First, there is currently no place on earth where people do not assort into ethnic groups, and this has been the case as far back as there are historic records (Levine & Campbell, 1971). Second, the paleoanthropological record suggests that humans were symbolically marking themselves with shell beads and ochre as far back as 110,000 years ago (Henshilwood et al., 2011; d' Errico, 2005). However, it is unclear what these markers meant, and how they mapped onto other cultural attributes or social identities. Furthermore, the pace of evolution is much debated, and it is unclear whether people have lived in culturally structured ethnic categories long enough for selection to produce psychological adaptations.

Here we test one possible component of a psychological adaptation for reasoning about ethnic groups; namely a bias towards making predictions about others based on their ethno-linguistic category. Categorizing others according to their ethnic membership may foster useful predictions, particularly in situations where information about others is limited or difficult to acquire. Generally, categories are useful when their members are homogenous relative to non-category members and when this is true for multiple traits (Mervis & Rosch, 1981; Murphy, 2002). The higher the relative homogeneity and the number of attributes, the richer the inductive potential of the category is –i.e. it has greater predictive power or information-richness. Rich inductive potential has often been discussed as the functional reason for essentialist beliefs about various kinds (Atran, 1998; Barrett, 2001; Coley et. al, 1997, Gelman, 1988), such as species.

Ethnic categories are likely to have rich inductive potential thanks to various cultural evolutionary processes. Conformist or prestige biases in social transmission have the effect of reducing the amount of within-category variation, thus homogenizing ethnic units (Henrich & McElreath, 2003; Perreault et. al. 2012; Richerson & Boyd, 2005). Additionally, multiple cultural traits tend to cluster with one another (Holden & Mace, 2003; Richerson & Boyd, 2005). This covariance of traits can result from the fact that people learn several attributes from the same model set, and that cultural information may be transmitted in packages since various attributes functionally depend on one another (e.g. learning to cook acorns only makes sense if one knows how to leech them of toxins beforehand). Ethnic categories have the additional benefit of being readily detectable because they are often symbolically marked with visual or acoustic cues such as clothing or language, and thus allow quick predictions. In this paper we test whether the human categorization system evolved to expect this kind of culturally clustered world organized around ethno-linguistic categories.

It is worth clarifying that this account does not require ethnic stereotypes to be correct representations of the world. While there are several empirical and theoretical reasons to believe that social concepts are not always accurate or useful to individuals (Lee, et. al. 1995; O'Flaherty & Sethi, 2008), a full discussion of these possibilities is beyond the scope of the current paper. In fact, a mismatch between evolved biases like the ones we are investigating and modern social taxonomies might be one of various sources of stereotype inaccuracy.

1.1 A PROPOSAL FOR AN ETHNIC CATEGORIZATION SYSTEM

Humans may have an evolved prior expectation that ethnic category membership will be predictive of a variety of cultural features. While we use terms such as "expectation" or “hypothesis” to describe a child’s prior beliefs, we mean this in the Bayesian sense (Tenenbaum et. al., 2011; Tenenbaum et. al., 2006) of a probability distribution of values before observations are taken into account, and do not intend to imply that this needs to be a theory-rich conceptualization. Simply put, an individual learning about their social world might start with some greater weight assigned to the likelihood that categorizing others based on ethnic cues is useful for making inferences about novel individuals and their attributes. As a child develops, such a prior should be updated based on their observations, either strengthened if they get confirmatory evidence, or weakened if it’s contradictory.

Given that dialect or language use are cross-culturally and historically common cues to ethnic category membership (Bourhis & Giles, 1977; Labov, 1972; Michalopoulos, 2012; Nettle, 1998), children may start off with a second additional expectation that linguistic features are predictive of ethnic category membership. A child learning about his social world faces an adaptive challenge in picking out which of the infinite number of distinctions between humans designate the locally relevant ethnic boundary. Therefore, an evolved prior that weighs cues like language or dialect use, as likely indicators of the ethnic boundary would help direct the child’s attention and learning processes.

However, to be of any use, the adaptation must direct children’s development into competent adults and allow them to update their prior expectations about the predictive power of language in their local context. While ethnic boundaries are pervasive, the exact ways in which they are marked are cross-culturally variable. For this reason, a fixed prior expectation that language category stereotypes will be useful bases of predictions will backfire in cases where, for example, religion, territorial boundaries, or sartorial markers denote the socially meaningful local ethnic boundary. Furthermore, even in cases where ethnic units are marked by linguistic features, human cognitive systems face the challenge of determining which features of language use matter (e.g., phonemic or language differences).

Natural selection faces a tradeoff between efficiency and accuracy when selecting how immutable to make this evolved prior. How strong should the prior expectation that ethno-linguistic categories have rich inductive potential be? In Bayesian terms, the stronger the prior that language is predictive of ethnic category membership, the more resistant this belief will be to updating in the face of contradictory information. The strength of the prior that natural selection would favor should be a function of 1) the cue validity of linguistic markers – i.e. the conditional probability that individuals belong to a specific ethnic category given that they have the corresponding marker (Rosch & Mervis, 1975) – , 2) the likelihood that non-category members shared the same marker, and 3) how consistently language was a cue to ethnic category membership over evolutionary time. This would have the benefit of quickly guiding learning and reducing the amount of sampling that a child would have to engage in, but the cost of increasing the error rate when language was not in fact predictive of ethnic category membership and other corresponding cultural features.

We propose that humans may have adaptations for acquiring local social taxonomies that are analogous to a language acquisition device. Most evolutionary researchers agree that humans alone have adaptations that allow them to learn languages with complex structure quickly (Chomsky, 1965; Pinker, 1995), although the exact nature of these cognitive mechanisms is much debated (Evans & Levinson, 2009; Hauser et. al., 2002). However, this adaptation requires cultural input to develop normally and must be capable of acquiring any human language. Children are not born knowing whether they will have to learn to speak Quechua, Spanish or any of the thousands of languages that humans have culturally evolved. Similarly, we propose that humans have adaptations that allow them to readily acquire social taxonomies, including ethnic ones, but that these mechanisms require cultural inputs to develop normally and to determine the nature of the local social boundaries. Minimally, such cognitive mechanisms would include priors about cues that are predictive of ethnic category membership, priors about the traits that cluster along ethnic boundaries, and rules for updating both of these.

In this paper we consider just one possible component of this adaptation, namely, that humans have evolved priors for making inductive inferences based on language use, and that they update these through the course of development in the face of contradictory information. While there is some evidence for similar folkbiological adaptations for acquiring knowledge about the natural world (Atran, 1990), we believe it is worth investigating folksociology as a separate system. Our proposal is similar to Hirschfeld's (1996), but focuses on reasoning about ethnic kinds and provides an account of why these categories specifically would have had rich inductive potential thanks to various cultural evolutionary processes.

1.2 LANGUAGE USE AS A PRIVILEGED DIMENSION OF CATEGORIZATION

Several developmental psychologists have documented that children treat various category boundaries as having rich inductive potential. Children reason that animals denoted with the same label have more inductive potential than those characterized by visual similarity (Gelman & Markman, 1986). Similarly, labeling increases object categorization even in infancy (Fulkerson & Waxman, 2007; Xu, 2002) suggesting that humans are designed to consider social input early on to guide inferences. However, there may be some domain specificity to this effect. While labels also increase the inductive potential of social categories, they have no such effect when the same visual stimuli are described as dolls (Heyman & Gelman, 2000).

Children also treat personality traits (Heyman & Gelman, 2000a) and social categories, such as gender, religiosity, ethnicity, and social status (Diesendruck & HaLevi, 2006), as having rich inductive potential. In the latter study children in Israel treated the Arab-Jewish distinction as the most information-rich even though adults made more personality-based assessments on the task. However, it is difficult to gauge to what extent children's responses are the output of cognitive mechanisms designed for ethnicity-based predictions. Instead, they might be outputs of learning mechanisms that allow children to learn various beliefs from adults, including views that the latter do not wish to express in a laboratory setting because of social desirability concerns.

There is some limited data regarding how much inductive potential children ascribe to linguistic categories. American pre-schoolers do treat language use as predictive of various features such as skin color, dwelling, and clothing (Hirschfeld & Gelman, 1997). However, these data come from a social context where language organizes various social boundaries and the children's responses broadly matched those of adults. Therefore children's responses might reflect a more general capacity for social learning, rather than an evolved prior expectation. Some recent work suggests that infants and children have early developing biases to learn from and interact with others who share their own, or their ingroup's, accent (Kinzler et. al., 2011; Kinzler et. al., 2007; Kinzler et. al., 2009), at least when it is cost-free (Cohen & Haun, 2013). However, ingroup linguistic preferences do not necessarily entail beliefs that language categories have rich inductive potential, or that they are a good basis for stereotypes. Children also expect language identity to be inherited from birth parents rather than from their social context (Gelman & Hirschfeld, 1999, Moya et. al. in prep), and at least young European-American children infer that language use is more stable through the life course than race is (Kinzler & Dautel, 2012). However, while such "biologization" is often considered a component of essentialism, it need not correspond to inductive potential. Similarly, even newborns can differentiate languages from each other (Ramus, 2000), but this does not mean that they expect these categories to be information-rich.

The cross-cultural importance of language in demarcating social boundaries suggests that ethno-linguistic boundaries are of evolutionary relevance or intuitively appealing. Ethno-linguistic boundaries often delineate institutions such as reciprocity or risk-sharing networks

(Nettle, 1998; Wiessner, 1983). Ideologies about language use commonly motivate social distancing, stereotyping, and political action (Irvine & Gal, 2000; Schieffelin et. al., 1998). Furthermore, individuals are remarkably sensitive to minor variations in speech patterns when they are socially meaningful and discriminate on the basis of such evidence (Labov, 1972; Purnell et. al., 1999). Such category encoding along linguistic lines seems to be rather automatic and robust in the face of information about others' cross-cutting phenotypic differences (Rakic, Steffens, & Mummendey, 2011) and coalitional membership (Pietraszewski & Schwartz, 2007). This contrasts with participants' flexible race encoding in an experiment similar to the latter one (Kurzban et. al., 2001). However, as with the previously discussed literature, these findings do not directly address the extent to which adults believe linguistic categories to be information-rich, rather than predictive of cooperative intent, for example. In fact, how and whether linguistic markers can stabilize cooperation in large groups is still much debated (Cohen, 2012), while our hypotheses regarding their utility for making predictions about unfamiliar others do not rely on the plausibility of such mechanisms.

In the following studies we examine whether humans have evolved priors that linguistic boundaries correspond to information-rich social categories. We test this possibility in a cultural context where language categories are not strongly marked or particularly socially meaningful in comparison to socio-economic categories by asking; 1) Do children treat language use as predictive of novel traits more than adults do? 2) Do novel fictitious social categories increase reliance on ethno-linguistic inductive inferences relative to real world social categories? 3) Do participants, especially children, respond more strongly to acoustic stimuli of language use than to labels of language categories? As our predictions regarding these questions are contingent on the particulars of the fieldsite, we elaborate on them at the end of the next section.

2. FIELDSITE DESCRIPTION

To provide a strong test of our hypothesis we ran inductive inference tasks with children and adults in a rural town in the Peruvian Altiplano where the local Aymara-Quechua language boundary does not mark large social differences. Huatasani is a town with approximately 3,000 inhabitants on the Quechua speaking side of the Quechua-Aymara linguistic boundary (Primov, 1974). These are mutually unintelligible languages with distinct phylogenetic histories, despite much linguistic borrowing and contact over hundreds of years (Hardman et. al. 1985; Mannheim, 1991). Relationships between Quechua and Aymara speakers are amicable, there are many Aymara speakers living in the Quechua-speaking town, and nearly all inhabitants are multilingual. Most residents use Spanish as the *lingua franca*, though some older individuals are Quechua-Aymara bilingual, or monolingual in one of the indigenous languages. In semi-structured interviews adult participants downplayed any significant differences between Quechua and Aymara speakers, including power or racial differences.

In contrast to the linguistic boundary, occupational boundaries associated with degree of market integration are indicative of economic power, cultural differences, and, at a larger regional scale, indigenousness. At the local scale of provinces surrounding Huatasani, variation in market integration crosscuts the linguistic divide. Nearly all Huatasani residents are subsistence agro-pastoralists. Though several people own stores with limited stocks of market goods, most of them still claim that agro-pastoralism is essential to their subsistence. However, several residents rely more heavily on professional or market activities, often by engaging in labor migration at gold mines about a 5-hours bus ride from town, trading goods up and down the eastern slopes of the Andes, and more rarely being schoolteachers or working for the municipality.

2.1 CONTEXT-SPECIFIC HYPOTHESES

In light of the relative importance of occupational categories compared to linguistic categories in Huatasani, we can make context-specific predictions about the ways 1) individuals' age, 2) the familiarity versus novelty of the social categories used in the study scenarios, and 3) the stimuli used to cue category membership will influence participants' assessments about the language categories' inductive potential. First, as individuals learn about their local social context they should adopt the prevailing beliefs about the importance of occupations associated with market integration in structuring behavioral and trait diversity. If humans enter the world with a contradictory prior that linguistic categories *does* structure cultural variation, then we should see a shift with age from language-based predictions early on, to relatively more occupation-based predictions later as children are socialized.

Second, even if individuals update their prior expectations to reflect the poor predictive power of local linguistic categories (e.g. Quechua vs. Aymara), they may expect novel ethno-linguistic categories that are divorced from the local context to have predictive power. This prediction is premised on people having different mental representations for different ethnic groups, which do not share a common set of priors. Were this the case, updating representations of specific ethnic groups, such as Quechua and Aymara, might leave unchanged an individual's priors with respect to other linguistic categories. In this case, learning that local language cues are not predictive of cultural variation would still allow people to reason that other language categories might cluster cultural variation.

However, if people have evolved priors that linguistic boundaries correlate with other traits, there are alternate ways in which novel information that is inconsistent with these priors can affect their representations of the social world. For example, humans may have a single concept of ethnicity, with a common set of priors that is extended to all of the ethnic categories they represent (e.g., a single prior for the cue validity of language in predicting ethnicity, that extends to all ethnic groups). If this unitary ethno-linguistic concept is updated based on examples of a specific ethnic boundary, this would update in unison the expected cultural clustering for all ethnic boundaries. In the case of Huatasani, learning that Quechua and Aymara use does not correlate with much behavioral variation would lead people to the inference that generally language use and community of origin do not correlate with behavior. Of course, intermediate results are also possible, wherein updating on a given ethnic boundary, affects priors regarding other ethnic boundaries as well, but to a lesser extent.

Our final hypothesis is that participants might respond differently to more externally valid cues of ethno-linguistic category membership. More specifically, it may be the case that people most commonly assess an individual's ethno-linguistic category membership by listening to them speak. Furthermore, young children may not be fully aware of the names of the local language categories, but even young infants differentiate between their mother's language and foreign languages (Sundara & Scutellaro, 2010). Thus, we might expect a more pronounced bias towards ethno-linguistic inference when children are exposed to acoustic stimuli rather than language labels denoting ethno-linguistic category membership.

3. METHODS

In the following set of studies we test these three predictions using modified triad inductive inference tasks (Diesendruck & HaLevi, 2006; Gelman & Markman, 1986; Heyman & Gelman, 2000) that force participants to choose between making prediction about a stranger based on ethno-linguistic or occupational cues. In order to test the developmental hypothesis we recruited participants of all ages for each of the following four studies. We heavily recruited children under 8 years of age through the local elementary school and pre-school. (See Table S1 for demographic descriptions).

To test the second hypothesis about category novelty we manipulated whether the strangers in the triads were characterized as belonging to real world or fictional categories. This was manipulated across the first three studies, each in sequence increasingly divorcing the social categories from the Huatasani social context.

Finally, to test the third prediction, we manipulated how the characters' social category membership was cued. In Studies 1–3 the experimenter denoted the social categories by pointing to illustrated characters and saying s/he "speaks language X and lives in community Y" and "works doing A and B." Because category membership is denoted by the experimenter referring to labels, we call these studies that use "Reference" category cues. Study 4 used a cue to category membership that has greater external validity, namely the characters' use of language in an audio clip. We will refer to this as a "Speech" cue to category membership. Table 1 outlines these design features of each of the studies.

3.1 GENERAL PROCEDURE

In Studies 1-3 participants were told about 8 triads and asked to make a prediction about a new trait for one of the characters in each triad. In each triad scenario, subjects were presented with three new characters; two exemplars, and one target individual, about whom they had to make the prediction. These inferences could either be made based on the target's shared occupational or ethno-linguistic category membership with one of the exemplars.

Subjects were presented with drawings of the exemplar characters and told each of their occupation and ethno-linguistic group labels. The exemplar characters always differed from each other along both of these dimensions. For example, one character could be a Quechua-speaking agro-pastoralist, and the other could be an Aymara-speaking mechanic (see Table S2 for all social category cues). A target character was then introduced as sharing one social category with each exemplar (see Figure 1 for sample stimuli). Participants were then told that the exemplar characters had contrasting novel traits, for example either liking "mipu" or "padu" music (see Table S3 for all traits). Participants were asked to guess whether the target character would like “mipu” music like exemplar 1, or “padu” music like exemplar 2. The illustrations were cleaned up and set up anew for each of 8 triad scenarios. This resulted in 8 predictions per participant, each about a different novel trait. See SOM 15 for randomization and counter-balancing procedures.

3.2 INCREASING CATEGORY NOVELTY

To increase category novelty in Studies 2 and 3, fictional ethnic and occupational labels were used. These were pretested with two informants to make sure they did not have any connotations in local dialects of Quechua, Aymara or Spanish. In Study 2 the categories were of intermediate novelty as the task was prefaced with a brief story that analogized the foreign social setting to the local situation (See Table S2). In this introduction the fact that two languages were spoken, each corresponding to communities that were within three hours walking distance from each other, was analogous to the local setting. This preface made it difficult to refer to more than two ethno-linguistic units. We address this limitation in Study 3 by using an equal number of pairs of novel language and occupation cues. Study 3 further increased novelty by cutting the analogizing preface. See SOM 4 for further explanation of novel label choices.

3.3 USING ACOUSTIC CUES

Finally, for Study 4, when acoustic stimuli were used, several changes were made to the triad task to reduce the memory demands, and simplify the procedure for participants. Only one set of characters was used as the triad (Figure S1). The character set was all male and used more realistic illustrations generated using FaceGen software (http://facegen.com/). The stimuli were presented on laptops to allow for easier coordination of acoustic and visual stimuli. We reduced the number of scenarios per participant to four and asked about half as many traits (see Table S3 and SOM 4). To further simplify the task we described one exemplar character as having a particular novel trait, and then asked which of either the “Language-Match” or the “Occupation-Match” target would also have the same trait.

Most importantly, each character was presented one at a time and introduced himself by saying “Hi, how are you? Are you well? My name is {name},” in either Quechua or Aymara, followed by the same greeting and “I know how to speak {Quechua/Aymara} and work in the {mine/fields},” in Spanish. Three young adult males from Huatasani who were native speakers of both Quechua and Spanish, and had learned basic Aymara, were recorded for all necessary combinations of the stimuli. Because Quechua and Aymara are mutually unintelligible and most of the children in the sample were from Quechua speaking households, the Aymara speech clip would have been unintelligible to them. This is why, despite the redundancy, we decided to have the characters repeat all the information spoken in Quechua or Aymara in Spanish as well, which all of the children spoke. If anything, including Spanish speech would make the characters seem more similar along the linguistic dimension, and likely decrease participants’ reliance on ethnic cues in this study.

Additionally, after each character triad was introduced we conducted a memory check, asking participants which characters spoke the same language and which had the same occupation. If either was answered incorrectly, we repeated all category designations and asked again. We continued with the protocol even if participants answered incorrectly a second time.

3.4 ANALYSIS

We present two analytical methods to test for developmental changes in the use of ethnic inferences. First, we calculated an ethnic inference score for each participant. This score is the proportion of responses which were based on ethno-linguistic category. Any questions that an individual refused to answer were not used towards calculating this score. We divided participants into three age categories; less than 8 years of age, between 8 and 20 inclusive, and greater than 20. The first cutoff at age 8 reflects the fact that we recruited many children below this age through preschools at elementary schools, while the older cutoff at age 20 corresponds to an age after which we assume adult knowledge levels regarding social categories. The intermediate age category is a hodgepodge collapsing later childhood and the teens. Analyses using binary age splits at age 8 give qualitatively similar results (Table S5).

Second we used random effects logistic regression models to predict the probability of making an ethnic inference on any given question as a function of socialization. These models are more statistically powerfully and allow us to examine features of individual questions that affect the probability of making an ethnic inference (SOM 11). Since each individual answered multiple questions, we incorporated a random effect of participant identity within which responses are clustered (see SOM 7 for discussion of non-independence).

Additionally, because we sampled individuals of diverse ages we have the opportunity to examine the developmental trajectory in more detail than a categorical analysis allows. To do so we compared the fit of various random effects logistic regression models with different treatments of age. We constructed a Socialization Index (SI) that is a function of age, but captures the asymptotic way in which adult competence is acquired. The SI uses a negative exponential function to reflect the fact that socialization effects are largest at early ages, and gradually decline. For example, the amount of cognitive change due to socialization is much smaller between the ages of 50 and 55 than it is between the ages of 5 and 10, despite the fact that each of the two intervals spans the same number of years. Using such an index has the additional benefit of collapsing variation among adults that might be due to secular historical changes and which are not of immediate interest for testing our hypotheses.

We used the following formula for the Socialization Index: $SI = 1 - e^{-r*age}$ and compare models with rates of development, *r,* between 0.01 and 0.2 in 0.01 unit increments. To use the former example, an SI function with r= 0.08 would mean the socialization difference between a 5 and 10 year old would be 37 times larger than one between a 50 and 55 year old. We also compared these negative exponential models to baseline ones without age as a predictor, and with linear and squared age terms. Those with lowest AIC scores, fit best among the alternatives models, i.e. they maximize the likelihood of the data given the model with the fewest parameters. For ease of interpretation we graphed all predicted probabilities of making an ethno-linguistic inference over age in years, even for models that were fit using the SI.

Stimuli and participant gender, question order, trait and occupation type did not have consistent effects on the degree of ethno-linguistic inference (SOMs 10-12), so we did not consider them further.

4. RESULTS

4.1 ETHNIC INFERENCES ABOUT REAL WORLD CATEGORIES DECREASE WITH AGE

Figure 2 shows that mean ethnic inference scores are lower in adults than in children under 8, but only in the studies – 1 and 4 – that used real world categories (Table S12). Two-tailed t-tests show that the difference between these two age categories is significant in Study 4, and marginally so in Study 1. These two studies also confirm that adults in this context are unconvinced about the inductive potential of local ethno-linguistic categories and rely on occupation-based predictions approximately 57% of the time. This is a small bias, indicating some indecision that is consistent with participants' unsolicited justifications of their answers. Participants often came up with reasons to make either language- or occupation-based inductive inferences in many cases. For example, several participants reasoned that the two

Aymara speakers might share the same preference for brighter colored clothing, but that alternately the two with the same occupation might be able to afford similar clothing.

The comparisons of the random effects logistic regression models concur with the above analyses. They reveal that a Socialization Index with rate parameters, r=0.08 and r=0.09 for Studies 1 and 4, respectively, fit the data better than any other SI tested, and than models with and without linear and squared age terms (see SOM 6.4 for analysis). Using these parameter estimates we can estimate the age at which children are expected to be half-way between their initial and adult ethnic inference rates. For Study 1 this predicted “half-way” point is 8.7 years of age and for Study 4 it is 7.7. In contrast, for Studies 2 and 3 the baseline model with no age predictor fits best meaning the developmental trajectory in these studies is weak at best.

Figure 3 illustrates these developmental trajectories in each study using an SI index with an intermediate value of r= 0.085. It also compares the predicted probabilities from this SI model to those from a comparable random effects logistic regression model with age as a categorical predictor (overlaid dot chart). Results are robust, but less nuanced with the categorical age models.

4.2 ETHNIC INFERENCES INCREASE WITH CATEGORY NOVELTY

With each increase in social category novelty we see an increased reliance on ethnic inferences, although the rates are only significantly different between Studies 1 and 3. Results are similar whether we use ethnic inference scores or RE logistic regression models. Figure 2 shows that the effect of novelty is larger for adults who go from a mean of 42% of their responses being ethnic based in Study 1 to 57% in Study 3, while children under 8 go from 50 to 55% of their responses being ethnic based. These correspond to effect sizes of $OR=1.65, SE=0.33$ and $OR=1.26, SE=0.04$, for adults and children respectively, in RE logistic regressions using categorical age. Overall, controlling for age as a linear term to account for slightly different demographic compositions of the samples, the odds of making an ethnic inference in Study 2 are 1.14 higher relative to Study 1 *(SE=0.13),* and 1.27 times higher in Study 3 than Study 1 *(SE=0.11).*

4.3 ACOUSTIC CUES INCREASE ETHNIC INFERENCES FOR CHILDREN

When speech cues are used to denote linguistic category membership in Study 4, children show a strong bias towards making language-based inductive inferences, even though adults tend to make more occupational inferences on the task (Figure 3.4). This is also the only study in which we can be fairly confident that children under 8 are not choosing randomly between the two options (SOM 16 provides further evidence that children understood the triad tasks). The best-fit model predicts that up until about 11 years of age children make more language-based inferences than expected by chance. Both the analyses using ethnic inference scores and binary outcomes suggest that under 8 years of age, children make ethno-linguistic based predictions approximately 61% of the time. This is compared to 50% of the time in Study 1 when the categories are also real world ones, but are denoted by reference rather than speech cues. Adult rates of ethnic inference on the other hand are comparable in Studies 4 and 1 suggesting that the external validity of the acoustic cues does not alter their decision-making.

The effect of SI in Study 4 (*OR=0.29, SE=0.12*), is even stronger when we control for participants' responses on the memory check (*OR=0.09, SE=0.06*). In this study linguistic information was provided through more channels than was the occupational information (i.e., through the character's speech and his labeling himself). Therefore, it might be that children's preferential use of language for inductive inference was driven by a memory bias due to this redundancy. If this were the case then the socialization effect should disappear once we control for performance on the memory check. However, Figure S6 shows that, if anything, children remembered the occupational information better than the linguistic information.

5. DISCUSSION

We provide two lines of evidence consistent with the hypothesis that humans have evolved priors that linguistic differences will be predictive of social categories with rich inductive potential. First, children showed a bias towards making language-based predictions when they are given speech cues to language use in Study 4, even though adults did not. This suggests that as children learn about their social worlds they begin with a naïve "hypothesis" that linguistic categories will structure trait variation, and then update their priors on the matter as they incorporate evidence acquired through individual and social learning. While this bias in children was particularly marked when the social category is marked acoustically – as might be expected if language-use were a more externally valid or evolutionarily salient cue than language name labels – the developmental trajectories documented in both studies using real world categories are remarkably similar. It is worth noting that in a separate study with 3-7 year olds using the same stimuli as in Study 4, we found explicit linguistic ingroup favoritisim only emerged around age 6 (see SOM 13). This suggests that developmental trajectories for explicit in-group biases and stereotype use can diverge.

Second, in Studies 1-3 more novel categories fostered more language-based inductive inferences than did real-world language categories, both in children and adults. This suggests that even though participants updated their priors about the importance of language categories for structuring variation in the local context, they retained an expectation that other unknown language categories would have rich inductive potential. This was particularly the case when the framing was completely divorced from the local context (Study 3).

This pattern of results is particularly surprising in light of the fact the study site reflects a social context where the language border is not particularly socially meaningful; it does not correspond to marked political, power or racial differences, and speakers of the same language do not exhibit particularly group-ish or coalitional behavior. The fact that adults relied more on occupation based inferences than ethno-linguistic inferences in the Studies about real world categories confirms the ethnographic observation that the Aymara and Quechua language boundary structures relatively little cultural, economic, or political variation..

Each result might be consistent with other accounts that do not entail an evolutionary origin of the priors. We will consider each in turn and explain why we find these alternatives implausible.

First, since the study is cross-sectional rather than longitudinal, the putative developmental shift from ethno-linguistic inferences to a greater weighting of occupational information may instead reflect cohort effects. This is very unlikely given that indigenous language categories have been losing social significance with the spread of Spanish and the increase in socio-economic variation due to market integration. The primary mine in the region, which draws many labor migrants from Huatasani, has grown dramatically within the last 10 years, and the road to Huatasani was paved in 2009, further integrating it with other urban centers in the region. These developments have improved Huatasani's Aymara and Quechua speakers' access to the market economy about equally, but some individuals have taken advantage of these opportunities more than others. Consistent with this recent historical trend, Figure S3 shows that there might be a slight secular trend for participants over 50 to make more ethnic based inferences than younger adults, although confidence intervals are wide given the few participants in the older age bracket. Thus, it seems unlikely that the bias towards ethnic predictions seen in children was individually learned by observing a different social environment from their parents', and unlikely that it was vertically transmitted from parents to children.

Second, the novelty effects might be explained by participants' experiences with real world language categories other than Aymara and Quechua. The most likely candidate languages that could serve as exemplars for this generalization about the inductive potential of unfamiliar languages would be Spanish (which all participants spoke) and English (which no one in town spoke). English is unlikely to be the basis of such generalization since the stories in Study 2 and 3 were introduced as being about speakers of various languages *within* a given country, while most participants associated speaking English with national divisions, not divisions within countries.

Similarly, Spanish is unlikely to have fostered such generalization to novel languages. In Study 2 the language categories corresponded to differences between neighboring communities. Spanish is not structured along such community lines in participants' social worlds. It is slightly more plausible that the higher rates of language-based inferences seen in Study 3 – where the language categories were most removed from the local context – are due to such a generalization from participants' knowledge of Spanish speakers. While locally not speaking Spanish is highly predictive of indigenousness and living rurally, this correlation only holds for older individuals since virtually everyone below 50 years of age speaks Spanish. All of the characters on the triad tasks were depicted as physically similar young adults, so it is unlikely that participants interpreted their use of a different fictitious language as an indicator of their market integration or indigenousness.

These studies add to the growing literature suggesting that language boundaries are an important dimension along which humans categorize others, and that such assessments develop early. However, it also demonstrates' children's ability to learn alternate relevant social taxonomies despite such biases. Furthermore, an evolved expectation that language categories have rich inductive potential is consistent with an adaptation for reasoning about cultural clusters that afford predictions about multiple traits. This lends support to the view that ethno-linguistic cultural clusters have been important for enough of human evolutionary history for natural selection to have shaped psychological priors.

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FIGURES & TABLES

Figure 1. Triad scenario setup and stimuli for Studies 1-3.

The cards did not have text on them and all information was verbally administered. The bottom character represents the target about whom a prediction had to be made. The top two characters are exemplar characters. Each was introduced one at a time, the target always last.

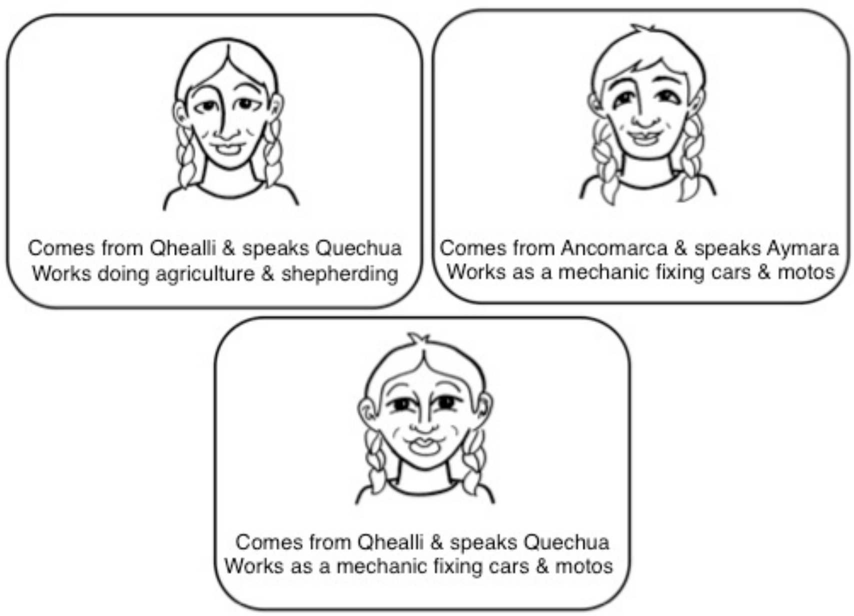

Figure 2. Mean ethnic inference score by Study and Age category.

Error bars denote 95% CIs

* p<0.05, † p<0.1

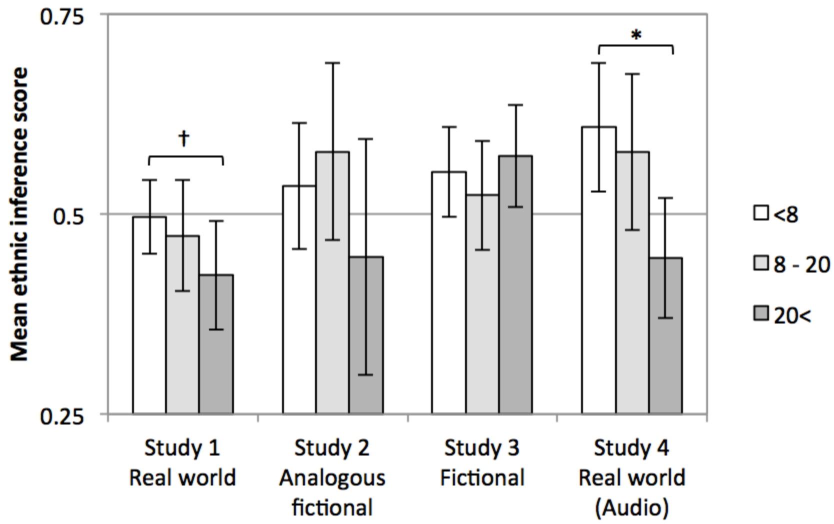

Figure 3. Probability of making language-based inductive inference by Study.

The lines are the predicted values from the random effects logistic regression models predicting probability of making a linguistic inference as a function of Socialization Index with a rate parameter, r=0.085. The 95% confidence intervals for the models are estimated using the Delta-method of standard error estimation. Participants ranged from children three years old to adults in their 70's. Models were fit using the full range of the SI, but restricted age ranges are plotted below for ease of interpretation and to improve resolution. The overlaid dot plots and 95% CIs bars are predicted values from random effects logistic regression models using categorical age (top axis) as a predictor.

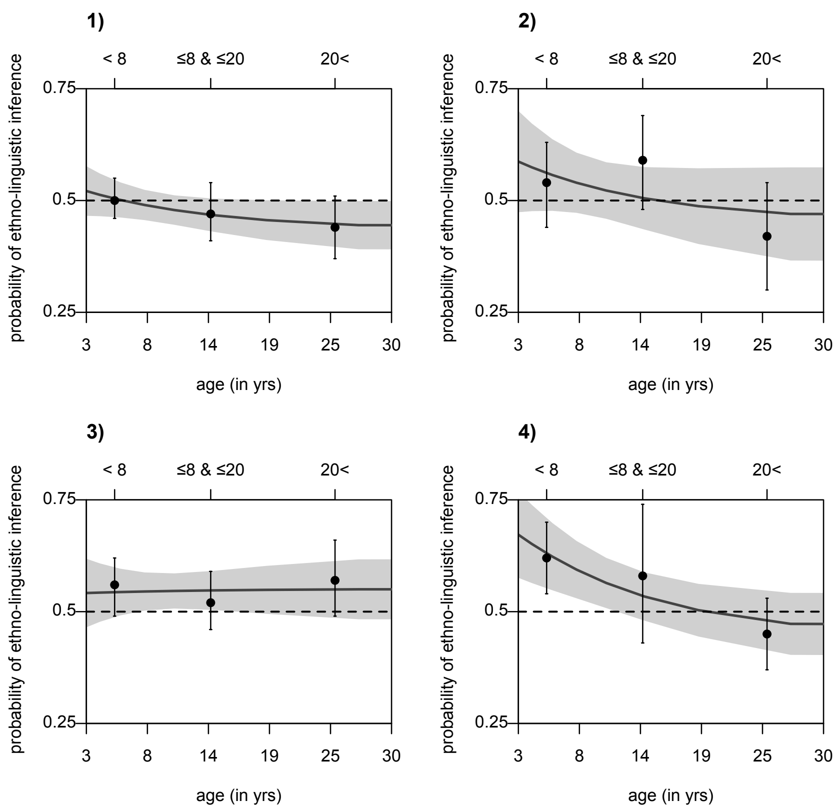

Table 1. Study Structure.

The first three studies all used explicit propositional information ("Reference") to cue the characters' social categories. Between these we manipulated the degree to which the categories mapped onto their real world categories. For Study 4, the characters spoke, thus providing acoustic ("Speech") cues to their ethno-linguistic category, in addition to explicit propositional information about their linguistic and occupational category.

Study	Category Cue	Category Novelty	Category Kind
1	Reference	Low	Real world
2	Reference	Medium	Fictional - Analogous to real world
3	Reference	High	Fictional
4	Speech	Low	Real world