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Maya Folk Botany and Knowledge Devolution: Modernization and Intra-Community Variability in the Acquisition of Folkbotanical Knowledge

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Abstract One potential source of folkbiological knowledge loss is changing patterns of interaction with the natural world stemming from ''modernizing'' material change. This article compares models of plant knowledge among age-matched groups of children and adults in two communities of a municipality located in the highlands of Chiapas, Mexico. Use of the Cultural Consensus Model (CCM), analysis of residual agreement, and examination of model content show that while plant knowledge remains fairly robust in the municipality, devolutionary change is ongoing and manifests in the urbanized municipal town center relative to a rural outlying hamlet. Quantifying disparities in folkbiological knowledge is considered as a preliminary step in understanding general processes of culture change. Recent investigations into domain-specific folkbiological expertise in adults and the acquisition of folkbiological models in children shows that differences in propositional knowledge interact with culture-specific reasoning strategies and have profound consequences for value complexes and environmental behavior. [knowledge devolution, child development, culture change, folkbotany, Tzotzil Maya]

Environmental and cognitive anthropologists have long documented the vast breadth and depth of ecological knowledge among traditional peoples (e.g., Berkes 1999; Berlin 1992; Berlin et al. 1974; Conklin 1954). Because of the implications that biological knowledge "devolution" may have for environmental decision making and behavior, environmental knowledge disparities in both traditional and postindustrial communities have become the subject of much recent discussion in ethnobiology (e.g., Atran and Medin 2008; Atran et al. 1999, 2004; Coley et al. 1999; Nabhan and St. Antoine 1993; Ross 2002a, 2002b, 2003; Wolff et al. 1999; Zent 2001).

Biological knowledge devolution has been linked both to material and ideational bases. For example, the introduction of "modern" infrastructure like roads, electricity, running water, or health clinics could have consequences for cultural practices and shared values, resulting in changes in knowledge about the natural world. Atran and Medin's recent "devolution hypothesis" posits that modernization leads to a lack of "hands on, visceral contact with other forms of life" (2008:38). In this account material change parallels, and may even be causally related to, concomitant shifts in what the authors call "cultural support": cultural media, talk, and value complexes (Atran and Medin 2008). Other authors have noted that "modernizing" influences, such as the transition of traditional peoples to sedentism and

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compulsory formal education may lead to folkbotanical knowledge loss (Heckler 2001; Ross 2001, 2002a, 2002b; Zarger 2002; Zent 2001).

Our assumption regarding the process of biological knowledge acquisition follows from that outlined in the work of Hatano and Inagaki (Hatano and Inagaki 1994, 2002; Inagaki and Hatano 2002). These authors make the case for a theory of folkbiological conceptual development typified by "domain specific constraints" (Hatano and Inagaki 2002) that, while possibly innate, take the form of "biases and preferences" (Inagaki and Hatano 2002), rather than specific knowledge or universal reasoning strategies. Although disparate cultural groups show similarities in folkbiological cognition (Berlin 1992; López et al. 1997), pointing to its possibly innate cognitive architecture (Medin and Atran 2004), acquisition and maintenance of such knowledge may simultaneously be sensitive to the cultural importance placed on certain types of ideas about, and interactional experience with, the biotic world (Waxman et al. 2007). Looked at from this perspective, systematic knowledge devolution becomes part of the complex process of cultural change (Atran et al. 1999, 2002; cf. Ross and Medin in press for a more general argument).

This formulation stands in contrast to the influential hypothesis of folkbiological development put forth by Carey (1985) that attempted to formulate a universal scheme for biological knowledge acquisition. Carey claimed that children universally reason about the nonhuman biological world from the perspective of folk psychology (i.e., based on a non-domain-specific anthropocentrism), at least until the age of about seven (Carey 1995). In our view, Carey's idea that folk psychology provides a universal template for folkbiological knowledge acquisition is an artifact of her focus on testing children living in postindustrial societies with an impoverished biotic context (Ross et al. 2003) and may reflect the very devolutionary processes that we seek to measure here.

The question of biological knowledge devolution is intimately linked to domain expertise. However, developing an expert model consists in more than just being able to identify species tokens. The development of expertise has been shown to have quantifiable effects on the strategies that individuals use for making inferences about domain-specific knowledge (e.g., Burnett et al. 2005; López et al. 1997; Medin et al. 1997; Proffitt et al. 2000). Being an expert, for example, has the universal effect of rendering individuals more "flexible" in their strategies for inference making: although nonexperts tend to use category-based similarity judgments for such inferences, experts can use this or other bases, such as causal reasoning (Burnett and Medin 2008; Ross and Medin in press; Zarger 2002). The "flexibility" that expertise affords, however, is not universal according to an "expert" template (Boster and Johnson 1989; Johnson et al. 2004), but is guided by culture-specific frameworks (Medin et al. 2002; Ross et al. 2007). Culture-specific reasoning strategies act as further inputs for knowledge generation and learning (Ross and Medin in press).

Few studies have analyzed folkbiological knowledge devolution as an ongoing process of acquisition and retention among members of a given community. We assume that such changes in knowledge take place on the time-scale of generations and might not be readily detectable at the level of the individual. Thus, here we attempt to link patterns inherent in knowledge devolution to differences in community-wide patterns of knowledge acquisition, by focusing on both child and adult subjects (cf. Inagaki 1990 for a pioneering study in this regard that illustrates the potential for disparities in propositional knowledge to have far-reaching ramifications for inference making). Specifically, we explore here whether communities with different default levels of exposure to the biotic world correlate with measurable differences in their domain-specific structure of folkbotanical knowledge and with differential patterns of knowledge acquisition.

To accomplish this we elicited folkbotanical knowledge from children and adults in two communities within the Tzotzil Maya municipality of Chenalhó, located in the Highlands of Chiapas, Mexico. Critically, our communities differed in the local extent to which material modernization has been introduced into each community.

Our specific questions are as follows:

First, does a consensual model of plant knowledge acquisition exist within the municipality of Chenalhó?
Second, do systematic differences in models of plant knowledge exist between areas of the municipality above and beyond the consensual model?
Third, do these differences correlate with material and practice-based disparities that might be related to modernization?

We recognize that a fully nuanced emic model of "environmental knowledge" is vastly more complex than the model we construct here (cf. Atran et al. 2002). In this study, however, we were specifically interested in understanding patterned differences in plant name acquisition within the municipality of Chenalhó. To that end we used a relatively small list of salient local plant names to elicit an etic model that could stand in as a reasonable proxy for plant knowledge. This etic model, in turn, could then be interrogated for patterned differences. In this study when we refer to "plant knowledge," we are in fact referring to the knowledge of the name of a specific plant. Measuring such material and conceptual change in the municipality of Chenalhó is part of a longitudinal project in which we seek to document processes of culture change in the Chiapas highlands from both a quantitative and qualitative perspective.

Our exploration of within-group differences in folkbiological knowledge acquisition does have some precedents (e.g., Boster 1987; La Torre-Cuadros and Ross 2003; Reyes-Garcia et al. 2003, 2005; Ross 2002a, 2002b), but these have in some respects been plagued with methodological difficulties (Godoy et al. 2009). This study extends these projects by exploring differential patterns of knowledge acquisition among children in closely related but importantly different social and material contexts. We are not, moreover, the first to address the thorny relationship between patterns of knowledge acquisition and modernization in the Chiapas highlands. Zarger and Stepp (2004), for one, provide an important account of the dynamic between persistence and devolution of plant knowledge in Tenejapa, a Tzeltal-Maya speaking municipality adjacent to Chenalhó. The authors claim that for the community of Mahosik', Tenejapa, modernizing change brought to Chiapas since the 1970s has *not* been reflected by a concomitant loss in plant knowledge. The researchers conducted a restudy of a plant identification paradigm conducted by Stross (1970, 1973). The original study (Stross 1970) consisted of a "plant trail," in which community children were taken along a path near their town and asked to identify 209 local plants by name. Approximately 30 years later Zarger and Stepp used the same methodology and a representative sample of 85 of the plants used in the original study. Their results indicate that the overall pattern of plant identification from 1999 looked remarkably similar to that elicited 30 years earlier. In fact, children interviewed in 1999 showed higher rates of plant identification both overall and by age group. The authors note that while Mahosik' has undergone significant shifts in mobility (paved roads, trucks), population levels (from about 300 in 1968 to about 1,500 in 1999), and healthcare access (via a local governmental health clinic) over recent decades, most families have not shifted away from the traditional economy of subsistence farming and resource gathering. They add that while there has been ecological degradation in the region surrounding the community, children's day-to-day practices in the environment have not shifted remarkably. Children still spend a significant amount of time farming and in the forest, and learn much of what they know about the biophysical environment from a small local network of people. The authors conclude from this study that the local model of plant knowledge remains robust.

We agree with Zarger and Stepp that the most direct way of making sure a person is "familiar" with a plant is to use a "plant trail" paradigm (cf. Collins 2001; Zarger 2002 for other examples; cf. Hunn 2002 for a slightly different but related method). However, this proved impossible for our study (see "Methods"). In addition, the kind of data Zarger and Stepp collected are extremely powerful for quantifying knowledge resiliency or change. However, their argument is based on a negative result and relies on the idea that there is a fundamental cognitive and practice-based continuity in a community that has undergone significant material change. In our study we extend this research by directly comparing a group that has undergone not only material change but also deep practice-based change vis-à-vis nature to a closely related community that has not seen such changes. Comparing communities synchronically allows us to follow up in future studies with an exploration of possible behavioral, material, and ideational causes for any differences we observe, as well as consequences that these may have for inductive inference and cultural change. We also believe that the method of residual analysis we employ offers a lens with unprecedented resolution for detecting subtle changes in the community-wide structure of propositional knowledge.

Our study offers three possible response patterns. First, children in the two communities could display the same content and trajectory of plant name acquisition, learning both the same plants and the same number of plants at each age. This pattern would essentially mirror the findings reported by Zarger and Stepp, for example, that "modernizing" influences (incl. an expansion to practice-based differences) do not inevitably lead to developmental differences in plant knowledge. Second, children in the two communities could differ in which and how many plants they learn during plant name acquisition. This would indicate a transformation in the acquisition of plant knowledge. Third, and finally, children in the two communities could learn essentially the same plants, although children in one community might acquire this knowledge earlier and possibly learn more plant species overall. This third pattern would indicate ongoing shifts within a generally shared framework of plant knowledge. Either of these last two patterns would be equivalent to nascent cultural change across generations, which we hypothesize to be the case in Chenalhó.

Folkbotanical Knowledge and Culture Change in Chiapas, Mexico

The Maya municipalities in the highlands of Chiapas, Mexico have undergone sweeping changes over the last several decades (cf. Cancian 1992 for an account of these changes in the Tzotzil speaking municipality of Zinacantán). These changes include, but are not limited to, access to paved roads (and a rise in mobility and motor vehicle ownership) and a newfound diversity of employment options in addition to traditional *milpa* (diversified cornfield agriculture) farming. These opportunities include trade in nearby cities, the transport of people and goods, wage labor such as construction work, and fruit, flower, cattle, and coffee production. Nonagricultural modernizing changes are most strikingly manifested in the municipal town centers, which function as each municipality's political and economic base and harbor the largest population. The town center of Chenalhó is no exception to this pattern. Most political business takes place there and almost everyone who wants to travel to or from San Cristóbal de las Casas, the nearest city, has to travel through it. The only high school in the municipality is located in the town center, where a secondary school serving the needs of both the town center and several surrounding hamlets is also located. Most households have access to water, electricity, and a sewer system. Phones, television, and the internet are available. Although most cooking is still done over open fires, some people use gas stoves, freeing them from the burden of procuring firewood. Most streets in and around the town center are paved. A medical clinic and several pharmacies address much of the local demand for medical care, but work in complement to traditional curers who practice spiritual interventions using prayers and offerings. Some of the indigenous families in the town center still have land in their hamlet of origin, but often they do not work this land themselves, either renting it out or paying someone to tend their cattle or coffee.

Most Tzotzil Maya speakers living in the town center speak at least some Spanish. Although there is a small community of nonindigenous *mestizos*, Tzotzil Maya is still the predominant language. Secondary school attendance is becoming standard, although this is still not the case for high school. Children regularly watch television and play video games. Children of poorer families often work as street vendors, in restaurants, or as domestic helpers in wealthier households and shops. Firewood collection still takes place in the forest surrounding the town, although these resources are becoming increasingly scarce and many families now buy firewood delivered by truck to the town center from more distant hamlets. In all, life bears very little resemblance to the historical pattern, in which most of the population lived in outlying hamlets and visited the town center only occasionally (Hill and Monaghan 1987; Ross 1997).

Life in the hamlet of Linda Vista, however, more closely coheres to this older pattern. Linda Vista was created in 1994 as a result of both internal political factionalism within Chenalhó's hamlet structure and a rapidly increasing municipal population. At the time of research Linda Vista was located approximately one hour by car from the town center, and there were no paved roads. No resident of Linda Vista owned a car, and access to any kind of transportation required an approximately 40-minute walk. Linda Vista's center contains a community-meeting hall, a kindergarten, an elementary school, and a basketball court. The community holds a weekly market where food and small household items are traded. To this day, most local families persist as subsistence milpa farmers, and work in the milpa is a staple occupation from an early age, at least for boys. The community has several small stores that sell food items (pasta, sugar, canned food, etc.) as well as sodas and candies. No individual self-identifying as *mestizo* lives in Linda Vista and, by and large, people in the community are monolingual Tzotzil Maya speakers. Access to the Spanish language is mostly restricted to men, the majority of whom are not fluent and use Spanish only in restricted contexts such as economic transactions. Access to running water, electricity, and mass media is present, but limited compared to the town center. Although forest cover has been severely reduced in recent decades, people in Linda Vista still have local access to firewood as well as wood for construction purposes. Children spend considerable time in the forest gathering firewood or hunting birds with slingshots.

The two study sites are located in slightly different ecological zones, but are comparable enough that differences in the incidence of plant species manifest much more in terms of local species distribution than extant plant types. All of the species we tested for familiarity were present in both locations. The Chenalhó town center is located in a warm, humid, narrow valley, while Linda Vista is located approximately 200 meters higher in elevation on an exposed plateau. The rugged terrain of the Chiapas Highlands guarantees, however, that residents of both locations are exposed to flora at multiple elevations. For example, milpa fields belonging to residents of the town center are often located on the higher elevations surrounding the town, while in Linda Vista fields are located on the valley floor below.

Methods

Although all the plant species we tested were present in both study locations, the different distributions of plant species in the two communities made it impossible to construct identical plant trails in both locales that our child participants could complete in a realistic timeframe. Because the between-community comparison was the main objective of this study, rather than elucidating an exhaustive folkbotanical database from local residents we chose to employ a verbal name-based plant familiarity task. The plants chosen for the current study were identified through a freelisting exercise, in which randomly selected members of the current parental generation in the town center ($N = 20$, ten female) were asked to list plants with which they were "familiar." Testing consisted of the researcher reading in sequence each of the 35 plant names elicited in the freelisting task, in the following form: "Are you familiar with the plant X?" Informants responded by indicating either "yes" or "no." We acknowledge that reported knowledge is not equivalent to the ability to correctly identify a plant, as informants might either overreport or misidentify species.[1] In this study we were exclusively interested in the interinformant systematicity of propositional knowledge related to the domain of plant names in Chenalhó as revealed by cultural consensus modeling ([CCM], see below). Although our methods do not allow us to address directly whether our subjects accessed a common "database" of shared knowledge when they claimed to be "familiar" with a given plant, the fact that we found strong agreement within our sample groups using the CCM and a clear developmental pattern provide strong post hoc justification for our methods and lead us to believe that, at least in this case, "familiarity" functions as a decent proxy for "knowledge."[2] Additionally, our good rapport in the community allowed our informants to admit to not knowing a plant, something that happened frequently.

Because the plant names in this study were elicited through a freelisting exercise, we recognize that we targeted only the most culturally salient local plant names. For our purposes it was only necessary to include a sufficient number of plant names such that we could trace their acquisition trajectory. Although we would not argue that a subset of 35 local plants is a fair representation of "folkbiological knowledge" in Chenalhó, it stands to reason that any systematic differences in plant name knowledge we detect here would have to be robust to be present in a sample with relatively high saliency. Indeed, because we were most interested in intercommunity differences in name recognition, rather than knowledge per se, the actual list of plant names we used was less relevant than having a common, restricted set of stimuli. Because our sample was elicited in the town center, our plant selection is, if anything, biased toward participants there. We might therefore expect, a priori, that residents in the town center should have more direct knowledge of the plant names in our sample. Because this bias runs counter to our hypotheses regarding domain-specific knowledge in Chenalhó, any "devolutionary" patterns we observe in the town center should be relatively robust. We do, however, believe that our plant sample is relatively representative of the salient flora across the municipality of Chenalhó (see supporting information in Appendix A available online for a full list of the plant names elicited for our sample as well as some of their potential uses).

The study was conducted in Tzotzil by fluent Tzotzil speakers (either our research assistants or the study's principal investigator, NR). These interviewers also completed the data sheets. Only native Tzotzil Maya speakers were included as informants. Adults were interviewed in a location of their choosing (usu. their home). Children were interviewed as part of a summer school that we have organized over the last several years in three communities within the municipality of Chenalhó. The summer school consisted of activities relevant to elementary-age schoolchildren such as reading, drawing, crafts, and sports; botanical knowledge was not explicitly taught as part of the school curriculum. This setting has the advantage that the interviews were conducted in an extremely relaxed atmosphere. Interviews took an average of 45 minutes, split into two sessions for children. As one of our goals was to understand the developmental trajectory of plant knowledge acquisition, we interviewed adults from the parental generation of the children we tested. Adult respondents were between 28 and 35 years of age, and were randomly selected from the parental population of children at the summer school ($N = 23$, 15 from the town center [three female], mean age 31.4 ± 2.13 years, and eight from Linda Vista [six female], mean age 31.75 ± 2.92 years). Children ($N = 80$) were split into three age groups, under eight years ($N = 30$, 3 from the town center [one female], mean age 7 ± 0 years, and 27 from Linda Vista [12 female], mean age 6.04 ± 1.02 years), eight–ten years ($N = 25$, 6 from the town center [two female], mean age 8.67 ± 1.03 years, and 19 from Linda Vista [seven female], mean age 8.84 ± .76 years), and over ten years ($N = 25$, six from the town center [one female], mean age 12.33 ± 1.63 years, and 19 from Linda Vista [seven female], mean age 11.84 ± .83 years). These age group cutoffs were selected to create groups of approximately equal size. For the town center, all the eligible children participating in the summer school are represented.

Three children were removed from the analysis because they contained no variability in their responses and thus could not be evaluated with the CCM (see below). Interestingly, the two participants removed from the town center group both indicated that they were *not* familiar with *any* of the plants in our sample. The one participant removed from the Linda Vista group reported familiarity with *all* of the plants in our sample. Although we are excluding these children's responses it is important to note that these data might represent extreme versions of our overall argument for knowledge "devolution" ongoing among children in the town center.

Based on each individual's "yes" or "no" responses we generated an interinformant agreement matrix. The input for this matrix consisted of the average agreement for each pair of informants across all responses. Agreement was assumed if both informants either did know or did not know a plant name. In our analysis individuals with the highest scores do not necessarily know more plants; they are simply in higher agreement with the consensual model, which, for certain plants might be "I don't know." In this case an "expert" might disagree with the rest of his or her peers.

To explore the patterns of agreement and disagreement within and across age groups and communities we employed the CCM paired with an analysis of residual agreement (Nakao and Romney 1984; Romney et al. 1986; Ross 2004). The CCM is a factor analytical model that explores the observed participant agreement matrix in terms of variance explained by the first factor. Consensus can be assumed if (1) the ratio of first and second factor eigenvalues is greater than three, (2) the first factor explains a large amount of variance, and (3) all participants' first factor loadings are high and positive. If consensus is found, then each individual's first factor score indicates that individual's level of agreement with the overall consensus.

Although the CCM is normally used to explore patterns of shared agreement across individuals, we extend the use of the CCM to the exploration of systematic patterns of disagreement. We do this through an analysis of "residual agreement," that is, the agreement of any pair of individuals not explained by their participation in the overall consensus (cf. Ross 2004). Residual agreement is calculated by subtracting each pair of individuals' predicted agreement (the product of two participants' individual agreement with the consensual model) from their observed agreement. The resulting residual agreement matrix can then be explored with respect to a priori group differences (e.g., whether within-group residual agreement is higher than between-group residual agreement). If this is found, the group is said to possess a "submodel" of shared knowledge, above and beyond that found in the CCM. In the current study we used "community" and "age" as our a priori groupings. First, we performed a CCM across residents of both communities for each age group to see whether a consensus for plant knowledge existed among age-matched residents of both communities. We then used "community" as a grouping for our residual analysis, testing whether "community" (town center or Linda Vista) captured more agreement than was evident in the cross-community CCM.

Finally, we examined the content of the elicited consensual models. Model content was calculated based on the number of participants in each community who indicated familiarity with the plant name: a plant was "known" if 66 percent or more of community members responded as being familiar with the plant name, "not known" if 33 percent or fewer of the members responded as being familiar with the plant name, or "split" (i.e., neither known or not known) when between 33 percent and 66 percent responded as being familiar with the plant name (see Tables 1–5 in online supporting documentation). For "split" plants it is probable that they show no clear consensual pattern because they are either in the process of being acquired by children, or, for adults, are plant names with restricted, idiosyncratic, or degraded distribution within the population.

Consensus and Submodels: Adults

When adults from both communities were considered together in a single CCM, the analysis revealed a single factor solution for all subjects (ratio 1st/2nd factor eigenvalue: 12.5; mean first factor score .87; variance accounted for by the first factor 75.9 percent). This indicates that a common consensual model exists for plant familiarity among adults in both communities. Residual analyses revealed the existence of submodels for each community: for the town center ($F[1,21] = 6.95$; $p = .015$); for Linda Vista: ($F[1,21] = 6.53$; $p = .018$). Furthermore, based on details of the model content we can say with confidence that the submodel for adults in Linda Vista is based on consensual agreement of knowledge of additional plant names above and beyond the common consensual model, while the submodel for adults in the town center is based on consensual agreement on not knowing additional plant names. Adults in Linda Vista thus have more consensual plant knowledge than their counterparts in the town center.

Model Content for CCM

As expected, adults in both communities agree on knowing the majority of plant names in our set (20 of 35; see online Table 1). Adults in both communities only agree on *not* knowing three plants: *ch'a te'*, *ik'al te'*, and *ts'op*. As we were unable to elicit familiarity with *ch'a te'* and *ts'op* in a post hoc check of our plant sample conducted subsequently to our task, we think that these are idiosyncratic names with only a small distribution in the community. This is also true for the plant *bak ts'op*, which, while "split" for adults in Linda Vista, is "not known" by every other group in the study. Because these plants are "not known" by all of the other groups in our sample (see online Table 1), the result provides us with a fortuitous internal control, giving us more confidence in the internal validity of our informants' responses. *Ik'al te'* is a tree whose use has traditionally been associated with witchcraft; it is unsurprising to us that knowledge of this plant was not widely distributed, as practices associated with witchcraft are not a subject of public discourse but are, rather, treated as esoteric (Vogt 1990). Four other plants were "split," that is, they showed no clear modal response: *ch'ilivet*, *k'oxox te'*, *nam te' chuj*, and *paj 'ul*. In the adult models, we assume that any "split" plants represent species for which knowledge is not widely distributed within either community, or is restricted to experts. None of these four plants is "known" by any of the child groups, showing that they are generally less culturally salient.

Model Content for Community Submodels

For the town center submodel, online Tables 2 and 3 show that only one plant, *potoj te'*, is "known" by the adults in the town center but not in Linda Vista, and one plant, *yisim bolom*, is "split" in the town center and "not known" in Linda Vista. *Potoj te'*, however, barely makes it into the "known" category of the town center at 67 percent, while 25 percent of Linda Vista participants know this plant name (see online Tables 4 and 5 for percentages known on individual plants). Also, while 53 percent of town center adults know *yisim bolom*, 25 percent of Linda Vista adults *also* know this plant. Concerning the Linda Vista submodel, online Table 3 shows that three plants are "known" to adults in Linda Vista, but are "split" in the town center: the Linda Vista–town center split comparison for *atsam te'* is 88 percent versus 47 percent, for *chich ni* 100 percent versus 60 percent, and for *yuch' max* 75 percent versus 47 percent. In addition, three plants are "split" in Linda Vista but "not known" in the town center. For two of these plants, the difference in knowledge rates is high: for *bak ts'op* 63 percent versus 0 percent, and for *ch'ix jul 'ak* 63 percent versus 13 percent. For *sakil te'* the comparison is less pronounced (38 percent vs. 33 percent).

Consensus and Submodels: Children under Eight Years

Cross community consensus analysis revealed a common model (ratio 1st/2nd factor eigenvalue: 9.33; mean first factor score .80; variance accounted for by the first factor 65.1 percent). We did not explore community-based residual analyses for these groups, as only three children comprised the sample group in the town center once we removed the subjects with no response variability. However, the knowledge patterns for the children in this group mirror, in a descriptive way, the patterns of our other age groups. Children under eight in Linda Vista show a significant amount of plant name familiarity above and beyond their counterparts in the town center and show a potential for a much more robust and nuanced model overall.

Model Content for CCM

The consensual model for children under eight in both communities comprises six plants (see online Table 1): *chiki te'*, *cipres*, *makum*, *nispero*, *pajal potoj*, and *sitit*. With the exception of *sitit*, all of these plants are highly known by all age groups in all communities. These are plants that are either frequently the subject of conversation (*cipres*, e.g., is planted as part of ongoing reforestation projects, and is often used in carpentry), highly valued for the food or medicine they provide *(pajal potoj*, *nispero*, and *makum)*, or both. Moreover, *sitit* is found in the "known" category for all age groups except eight–ten-year-olds in the town center, where it is "split" (50 percent). There is, thus, generally highly shared familiarity with this plant. Children in this group agree on "not knowing" 15 plant names.

Model Content for Community Submodels

The pattern of submodels for these children is striking (see online Tables 2 and 3): while there are no plants that children under eight in the town center "know" that their counterparts in Linda Vista do not know, there are fully 13 plants that Linda Vista children "know" (one plant) or for whom knowledge is "split" (12 plants) that town center children do not know. Further, 11 of these 12 plants (with the exception of *yisim bolom*, which is not generally known in either community) end up eventually in the "known" category of Linda Vista adults. Thus, we believe that these "split" plants in the model for children under eight represent plant names that children are actively acquiring.

Consensus and Submodels: Children Eight–Ten Years Old

Cross community consensus analysis revealed a common model (ratio 1st/2nd factor eigenvalue: 6.02; mean first factor score .80; variance accounted for by the first factor 64.3 percent). Residual analysis revealed clear submodels in each community: for the town center: $F(1,23) = 13.09$; $p = .001$; for Linda Vista: $F(1,23) = 10.14$; $p = .004$. Like both the under-eight children and the adult groups, analysis of the submodels' content indicates that eight–ten-year-old children in Linda Vista show consensual agreement on knowledge of additional plants above and beyond the common consensual model, while the submodel for such children in the town center is based on consensual agreement of not knowing additional plants. Eight to ten year olds in Linda Vista have more plant knowledge than their counterparts in the town center.

Model Content for CCM

As shown in online Table 1, eight–ten-year-old-children agree on knowing five plants: *chiki te'*, *cipres*, *makum*, *nispero*, and *pajal potoj*, all of which are also "known" by children under eight years in both communities. These children agree on not knowing nine of the plant names in our sample.

Model Content for Community Submodels

As shown in online Tables 2 and 3, the pattern of submodels is strikingly similar to the under-eight-year-old group: while there are no plants known by children from this age group in the town center that are not also known by their peers in Linda Vista, seven plants are known by eight–ten-year-old children in Linda Vista that are either "not known" (five plants) or "split" (two plants) in the town center. Finally, 13 plants are "split" in Linda Vista that are "not known" in the town center. Further, 11 of these 13 plants (the exceptions being *potoj te'* and *yisim bolom*) end up in the "known" category (nine plants) or the "split" category (two plants) of Linda Vista adults. As with the under-eight group, these "split" plants in the model for children in the eight–ten-year-old group represent plant names that subjects are actively acquiring.

Consensus and Submodels: Children over Ten Years

Cross community consensus analysis revealed a common model (ratio 1st/2nd factor eigenvalue: 7.44; mean first factor score .81; variance accounted for by the first factor 66.2 percent). Residual analysis revealed an asymmetrical pattern: only children in Linda Vista had a submodel (marginally significant [$F(1,23) = 3.58$; $p = .071$]). No such trend was found for this group in the town center. We believe that this pattern results from the fact that knowledge above and beyond that captured in the CCM is not widely shared. However, the overall pattern for knowledge of children over ten, when compared to adults in their own communities, indicates that the marginally significant submodel observed for children in Linda Vista reflects additional plant knowledge above and beyond the consensual model that is shared with the town center. Specifically, while by about the age of ten children in the town center have closely approximated the impoverished model of plant knowledge they will possess as adults, their counterparts in Linda Vista continue on a trajectory of steadily increasing plant knowledge.

Model Content for CCM

As shown in online Table 1, 9 plants are "known" across communities by children over ten *(chiki' te'*, *cipres*, *k'an te'*, *lima*, *makum*, *nispero*, *pajal potoj*, *sitit*, and *tok 'oy)*. Children in this age group agree on not knowing eight plants *(bak ts'op*, *ch'a te'*, *chix jul ak'*, *chikinum tulan*, *ik'al te'*, *k'oxox te'*, *nam te' chuj*, and *ts'op)*.

Model Content for Community Submodels

As shown in online Tables 2 and 3, by the time children reach the age of ten years there is more overlap in their models of plant knowledge across community than for younger children. Although the differences between groups get smaller with increasing age, the fact that adult groups show clear submodels is indicative of long-term change in patterns of plant knowledge model acquisition. Indeed, while the knowledge differentiating the communities in the two over-ten-year-old groups is the same in absolute numbers (eight plants in each community), in the town center only three of those plants *(amuch*, *soi lem chuch*, and *tso' tulan)* are "known" by town center adults given our analysis; the other five *(chich ni*, *ch'ilivet*, *paj'ul*, *yisim bolom*, and *yuch' max)* end up in the "split" category of town center adults. Although two of these five "split" plant names *(chich ni* and *yuch' max)* do fall (paradoxically) into the "known" category of the over-ten-year-old children, they only barely fulfill our definition, at 67 percent "known" (see online Table 4). The adult familiarity rates for these two plants are similar, in the sense that they fall squarely within our definition of "split," at 60 percent and 47 percent, respectively. This pattern indicates that knowledge rates for these eight plants do not in fact change much from adolescence to adulthood. In addition, four of the plant names that make up the town center submodel for children over ten *(amuch, soi lem chuch, tso' tulan*, and *yuch' max)* are also "split" in Linda Vista, reflecting the fact that knowledge of these plant names is not vastly disparate between the two communities. In contrast, six of the eight plant names that make up the Linda Vista submodel *(atsam te', avoj, ch'it, say bon, ukun*, and *xaxim)* are "known" by Linda Vista adults in our analytical model. The exceptions are *sakil te'*, which remains "split" for Linda Vista adults, and *potoj te'*, which is "not known" for Linda Vista adults.

General Discussion

Taken together, these analyses reveal a stable and robust pattern of shared plant name knowledge across both the town center and Linda Vista and for each age group. This knowledge of plant names starts out from a core of (presumably) highly salient plants and expands to include other local plant names (see online Table 1). With the exception of *sitit* (discussed above), the plant names in the "known" category for the under-eight group are the same as those plant names "known" by the eight–ten-year age group. In turn, these plants are a subset of the "known" plants in the over ten-year age group, which in turn is a subset of the adult model. Conversely, the plant names that are "not known" by adults are fully included in the plant names "not known" for the over ten-year age group, which are in turn a subset of the plants "not known" by eight–ten-year-old children; these plants are in turn a subset of the plants "not known" by the under eight-year-old group. The high agreement we observed independently in each CCM, then, is mirrored across age groups by each model's content, reflecting a generally shared process of plant knowledge acquisition within the municipality.

Superficially, these results are in line with those reported by Zarger and Stepp (2004): the "cultural support" hypothesized by Atran and Medin (2008) to have a proximal effect on biological knowledge acquisition patterns may indeed remain largely intact in Chenalhó. At the same time, however, our method of residual analysis allowed us to isolate relatively subtle but clear patterns of knowledge devolution ongoing in Chenalhó's municipal town center. Our results clearly show that residents of Linda Vista, regardless of age, are familiar with more plants than their age counterparts in the town center, and that this familiarity is quantifiably patterned.

When the content of each community's model is examined on its own (see online Tables 4 and 5), it becomes apparent that children in Linda Vista tend to know more plants, and to know them earlier, than their counterparts in the town center. Although for children under eight in the town center seven plants are "known" and 28 plants are not known, in Linda Vista 20 plants are either "known" or "split," while only 15 are "not known." If we assume that plants for which knowledge is "split" are being acquired by children and on the verge of entering into the conceptual model of the group, then children in the under-eight group in Linda Vista know almost three times the number of plants that their counterparts in the town center do. Likewise for the eight–ten-year-old group: while children in the town center agree on knowing five plants and are "split" on another three, their counterparts in Linda Vista agree on knowing 12 plants and are "split" on 14. Eight–ten-year-olds in Linda Vista thus agree on knowledge of over three times the number of agreed-on plants in the town center. Although both the over-ten-year-old and adult groups from the town center and Linda Vista show more of an overlap in plant knowledge by age group (21 vs. 23 "known" or "split" for the over-ten-year-old group and 29 vs. 30 "known" or "split" for the adult group), as discussed above there are other important differences in the models that point to nascent patterns of folkbiological knowledge devolution.

Conclusion

The patterns observed in this study confirm our hypothesis that knowledge devolution is ongoing in the municipality of Chenalhó. Children and adults in the more rural locale of Linda Vista consistently show recognition of more plant names than their age counterparts in the municipal town center. We suggest that these disparities reflect both the delayed uptake of plant knowledge in the town center as well as permanent changes to local folk botanical knowledge. These differences are pronounced among children under eight years old and eight- to ten-year-olds, hinting at a severe lack of knowledge acquisition before the age of ten among children in the town center. The differences become smaller with increasing age but do persist into adulthood. Although it may be the case that this specific profile may be driven by the fact that this study engages only a small set of relatively salient plant names, our claim is that such nascent differences in constellations of propositional knowledge may be importantly linked to material modernization and culture change (Atran et al. 2002; Ross and Medin in press).

We recognize that this data set does not allow us to draw direct causal connections between what we loosely call "modernization" and folkbotanical knowledge loss. However, we find the results of this study suggestive that the patterns of plant name knowledge acquisition and maintenance elicited here are related to behavior patterns in the two locales, which are in turn partly a function of extant modernizing change. As recent observers have noted, much of children's learning about the environment takes place outside of formal learning contexts during play and work (Bang et al. 2007; Zarger 2002; for a review cf. Paradise and Rogoff 2009). To that end, we have many reports of children in Linda Vista playing in the fields and the forest surrounding the hamlet, while we have almost none from the town center, where children usually spend their days close to the house, the basketball court, or the town's stores (with their TVs and video games). Further, there is some burgeoning awareness of these trends in the town center couched in terms of "loss." For example, one of our informants, a native Tzotzil speaker who also possesses a Ph.D. in education, related to us that he maintains farmland in Chenalhó specifically to give his two sons access to nature from which they are otherwise "estranged." In this sense, the children in the town center have been deprived of a rich learning environment for local flora (e.g., Atran and Medin 2008; Nabhan and St. Antoine 1993). Our data from the adult population indicate that the resulting between-community gap in plant knowledge does not close with increasing age.

Plant knowledge, however, consists of more than simply knowing a plant name. We would argue that the effects of devolution of plant knowledge might be much worse than seen in this article (Atran et al. 2004). Being able to identify individual plants is only the initial step in generating further ecological categorizations that will serve for nuanced inference making about species and their interactions. In fact it seems that knowledge acquisition goes hand-in-hand with knowledge generation, whereby new knowledge is generated by individual actors based on existing information and knowledge structures. For example, Atran et al. (2002) noted that while younger Itza' Maya informants agreed with one another on reported plant–animal interactions, their responses only partially overlapped with patterns reported by older informants. Younger residents' responses, then, were not based on observation or copying the elders, but instead represented ad hoc inferences based on their differing model of environmental knowledge. More limited environmental knowledge on the part of younger residents thus led to differential patterns of inferences that were nevertheless shared among peers. Recently, Ross and colleagues (2011) extended this argument in their examination of disease categories among recent Mexican immigrants in Nashville, Tennessee. The authors found that while participants reliably separated diseases into four groupings in a pile sort task, only two of the groupings constituted "real categories," that is, informed participants' process of inference making. On this logic, a lack of domain-specific knowledge would severely restrict both the capacity to form categories and the potential for inference making.

Finally, beyond constraining residents' ability to make nuanced inferences about causal interrelationships between species in the local environment, a lack of ecological knowledge may have implications for the formation of values of, ideals for, and behaviors toward the local environment (LeGuen et al. in press; also cf. Atran et al. 2002; Ross 2001, 2002a).

In the current study, shifts in knowledge acquisition patterns may have the biggest long-term consequences for categorical inference making and cultural value formation among younger participants. This implies, in turn, that using plant name familiarity as a proxy for folkbiological knowledge may in fact give us a window into elucidating mechanisms related to long-term culture change. Although we cannot address whether there is a "critical age" for plant knowledge acquisition (cf. Hunn 2002) or if processes related to "modernization" might modulate it, we do think that the severing of human-nature links has consequences beyond the sheer knowledge of specific plants (Inagaki 1990; Ross et al. 2003). Indeed, we believe that a child's basic cultural development is severely hindered by an impoverished folkbiological model of local ecology.

The clear devolutionary pattern we report here differs significantly from that claimed by Zarger and Stepp (2004), providing us with important questions for future research on the implications of folkbiological knowledge change and modernization:

What are the specific (ideational, ideological, material, and practice-based) conditions for certain patterns of knowledge acquisition and devolution?

How do patterns of propositional knowledge formation feed into inference making, the generation of framework theories, and further patterns of knowledge-value generation?

These are important questions to be asked not only for understanding the formation and transformation of cultural knowledge but also for the effects that transformations in knowledge may have for pressing concerns regarding environmental values and behaviors worldwide. A decrease in shared knowledge about the physical environment may have consequences that reach much further than anthropology has thus far appreciated.

Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix A and Tables 1–5.

Please note Wiley-Blackwell is not responsible for the content or functionality of any supporting materials provided by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.

Notes

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1. We also conducted a "plant trail" identification task in the town center with children, but were ultimately unable to compare these results to Linda Vista, where a comparable plant trail could not be constructed. However, in all cases during the plant trail study, our informants either identified the plant when asked or replied "I don't know"; in no case did an informant offer an alternative name. This leads us to believe that the list of plant names we use in our "familiarity" study are both reliable and stable.

2. In addition to asking about "familiarity" with each plant name, we also encouraged informants to list potential uses for each of the plants when they indicated familiarity. Although we do not report this data here for reasons of space and simplicity, the consistency with which informants listed uses for familiar plant names is additional evidence that plant name familiarity functions as a proxy for culturally salient plant knowledge.

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