Inductive Reasoning in Folkbiological Thought

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October 16, 1996

To appear in Medin, D. L. & Atran, S. (Eds.), Folkbiology. Cambridge, MA: MIT Press.

Overview

How do people understand the world of plants and animals and in what specific ways do these understandings vary with culture, experience or expertise? These are the basic questions addressed by researchers in the field of folkbiology, originally by cognitive anthropologists and more recently by cognitive and developmental psychologists. We see our work, like the other chapters in this volume, as bringing together contributions from anthropology and psychology (and perhaps linguistics and philosophy as well) to support an inter-disciplinary cognitive ethnoscience. Each of these disciplines brings strengths--and weaknesses--to the task; by incorporating their complementary perspectives, we gain a clearer vision of the phenomena under study.

Cognitive anthropology is responsible for initially mapping out folkbiology as a field of study (Conklin, 1962; Frake, 1962). Anthropological studies reveal the richness of folkbiological thought. They consider context and provide thoughtful, detailed analyses of entire systems of folkbiological categories. By investigating disparate cultures in many parts of the world, this research has also revealed universal principles underlying folkbiological category organization (see Atran, 1990; Berlin, 1992; Malt, 1995, for reviews). However, anthropological research also has limitations. For example, the methods for eliciting names and identifications of flora and fauna are sometimes quite informal and it is often unclear whether the informant or informants comprise a representative sample of the general population or merely a select set of local experts. Indeed, variation within a culture is rarely of interest (see Boster, 1995, for an exception). More generally, description tends to be at the level of culture, rather than the individual, which makes it difficult for psychologists to extract individual psychological process. Moreover, the very methods that provide rich anthropological data can be a limitation from an experimental point of view; lack of methodological rigor can raise skepticism about the conclusions drawn. Overall, the data are rich but perhaps not as "hard" as psychologists would like, nor analyzed with the sort of precision required to yield tightly constrained models of cognition.

Thus, from a psychologist's perspective, ethnobiological studies have certain limitations. Experimental psychology has different strengths and weaknesses. Laboratory studies of conceptual structure allow for tight experimental controls, and for precise tests of well-articulated models of categorization and reasoning. However, tightly controlled paradigms and methodologies may actually prevent informants from displaying forms of knowledge that would be most incisive for the questions under consideration. In addition, stimulus materials are often selected with little concern for representativeness or systematic sampling. Finally, the heavy use of college sophomores as research participants reflects great faith in the generality of any findings, a faith that is rarely subjected to empirical test.

We believe that cross-fertilization of these two fields is critical to advance our understanding of human cognition. To give but one example, Brent Berlin and his colleagues found one level (or rank) in a folktaxonomic hierarchy that is especially salient and psychologically privileged (Berlin, Breedlove, and Raven, 1973). This important idea was transported to psychology and elaborated in an important series of studies by Eleanor Rosch and her associates (Rosch, Mervis, Gray, Johnson and Boyes-Braem, 1976) which continue to influence psychological research on concepts (e.g. Medin and Coley, in press). More generally, cross-cultural studies of cognition by anthropologists help establish (or undermine) claims about generality or universality of psychological models.

We believe that there is much to be gained by applying field methods in the laboratory and laboratory methods in the field. In our own research, we have employed methods that combine tests bearing directly on computational models of cognition with more open-ended, less-constrained procedures that often prove to be more informative. In many respects we have come to view our research participants more as collaborators than as subjects. The difficulties in carrying out these intentions completely undermine any smugness and our goal is to make "stumbling progress" (the stumbling part is guaranteed).

Our overall aim has been to use cross-cultural comparisons of folkbiological taxonomic systems and associated reasoning processes to better understand universal and culturally-specific aspects of folkbiology. Our initial studies compared Itzaj Maya from Peten, Guatemala, who know a great deal about the natural world with American undergraduate students, who do not. For a variety of reasons our research has quickly evolved to a “triangulation strategy” where the third group of informants consists of different types of American experts (e.g. people who know a lot about trees). As we shall see, often the within culture differences are more striking than the cross-cultural ones.

In the present chapter, we focus on two findings having to do with patterns of inductive inference. A great deal of research in ethnoscience has been devoted to describing and explaining the structure of folk biological taxonomies (e.g., Berlin, Brown, Hunn). However, much less research has examined how such categories are used in reasoning. Yet, some psychologists (e.g. Anderson, 1990) have argued that the single most important purpose of categories is to support predictions and inferences. By inductive reasoning we mean the process by which people generalize from a particular instance or category to another, often more inclusive one. For example, using the knowledge that a white oak benefits from a certain fertilizer to infer that other oaks would also benefit is category-based induction. Much of what we take to be true about the world we have learned through induction; indeed, it would be impossible to learn that, for example, “snakes bite” or “dogs bark”--without having encountered all snakes or all dogs--unless we could readily infer a general principle on the basis of limited experience with a few exemplars. Thus, induction is too important a function of concepts to be ignored.

The organization of the rest of this chapter is as follows. First we describe research we’ve done on the relation between privileged levels in a conceptual hierarchy and inductive inference. This research reveals suprising cross-cultural agreement as to which level is inductively privileged, and a surprising dissociation of knowledge and expectation for Americans. Then we turn to a further inductive phenomenon associated with a formal model for category-based induction. Here, we find complex patterns of group commonalities and differences which defy easy explanation but certainly raise some new puzzles. Although we do not resolve these puzzles, the results point to some further avenues of exploration. Both sets of studies demonstrate that by looking at how categories guide induction, and by combining the richness of field anthropology with the precision of experimental psychology, progress in understanding the nature of folkbiological thought can be made.

Privileged Levels and Induction

Both psychologists and ethnobiologists take it as given that humans spontaneously organize categories into hierarchical taxonomic systems. Moreover, as we suggested earlier, both disciplines claim that a specific level within the folkbiological taxonomy is privileged--most important, salient, and useful. Ethnobiologists studying systems of classification among traditional peoples (e.g., Berlin, 1976, 1978, 1992; Berlin, Breedlove & Raven, 1973; Brown, 1984; Bulmer, 1967; Bulmer & Tyler, 1968; Hunn, 1977; Hays, 1983) have argued that the core of any folk biological taxonomy, is the folk-generic rank. Folk-generics are named by primary lexemes (unanalyzable names, e.g., tiger, trout, oak), and tend to correspond to biological genera or species. Berlin (1992) argues that:

> … in the categorization of plants and animals by peoples living in traditional societies, there exists a specifiable and partially predictable set of plant and animal taxa that represent the smallest fundamental biological discontinuities easily recognizable in any particular habitat. This large but finite set of taxa is special in each system in that its members stand out as beacons on the landscape of biological reality, figuratively crying out to be named. These groupings are the generic taxa of all such systems of ethnobiological classification, and their names are precisely the names of common speech (p. 53)

According to Berlin, folk generic categories are perceptually salient and identifiable without close study. Generic names are the first offered and the most frequently used in everyday discourse. Among the traditional societies studied by Berlin and colleagues, folk-generic taxa may be among the first learned by children (Stross, 1973).

In a now classic paper, Rosch, Mervis, and their associates (Rosch et al., 1976) set out to test Berlin's notion that a single taxonomic level is psychologically privileged. They argued that -rich bundles of perceptual and functional attributes occur that form natural discontinuities and that basic cuts in categorization are made at these discontinuities" (p. 385). In a series of experiments, they present evidence that the "basic level" is the most inclusive level at which (1) many common features are listed for categories, (2) consistent motor programs are employed for objects in the category, (3) category members have similar shapes, and (4) it is possible to recognize an average shape of the category. In all of these experiments, the logic of locating the basic level was the same; the basic level was the level above which much information was lost, and below which little information was gained. For instance, in a feature-listing task, subjects listed a mean of 3 common features for the superordinate category furniture, a mean of 9 features for basic level furniture categories (e.g., table) and an average of 10.3 features for subordinate furniture categories (e.g., kitchen table). There was a large gain in information when going from the superordinate to the basic level (6 new common features are added, in this example), and only a slight gain going from the basic to the subordinate (1.3 features).

Surprisingly, for biological taxonomies, Rosch et al.'s "basic level" failed to correspond to Berlin's privileged "folk generic" rank; instead of maple and trout, Rosch et al. found that tree and fish functioned as basic-level categories for Berkeley undergraduates. Rosch et al.'s basic level for living kinds corresponds to Berlin's life-form level, superordinate to the folk-generic level. Thus, while both endorse the existence of a privileged level, the disciplines diverge with respect to exactly which level they identify as privileged. Why do anthropological and psychological observations fail to converge on a single privileged level?

One possibility is that differences in the location of the basic level could be a function of differences in expertise (e.g., Dougherty, 1978; Johnson & Mervis, under review; Mervis & Rosch, 1981; Tanaka & Taylor, 1991). If members of traditional societies--like those that make up the bulk of subjects of ethnobiological research--have more expertise than the Berkeley undergraduates that were Rosch's subjects, and expertise leads to more specific basic levels, then

To test these predictions, we examined patterns of inference among the Itzaj Maya and Northwestern University undergraduates. The Itzaj Maya inhabit the Petén rainforest region of Guatemala. The Itzaj are Mayan Amerindians; their ancestors were the last independent native polity in Mesoamerica to be conquered by the Spaniards. The Itzaj of today have retained mastery of most of the ethnobiological knowledge that the Spaniards reported collecting from native people at the time of the initial conquest (Atran, 1993). Men divide their time between agriculture (agro-forestry) and hunting, while women are responsible for the myriad tasks required to run households that lack electricity and running water. In terms of age and (lack of) knowledge of the natural world, the Northwestern University students were fairly homogeneous.[1]

We asked members of both populations to rate the relative strength of inferences from taxa of one rank to taxa of the next higher rank. For example, a participant might be told that all members of a given folk-generic taxa have a certain property, and then asked how likely they thought it was that all members of the appropriate life-form taxa would also share that property (e.g., "All trout have enzyme X. How likely is it that all fish have enzyme x?"). For Northwestern undergraduates, properties involved unspecified enzymes, proteins, and disease. Students rated the likelihood of the arguments on a scale of 1 (not very likely) to 9 (extremely likely).

For the Maya participants, we used folkbiological taxa familiar to them, and we phrased the questions a bit differently. All properties involved were unfamiliar diseases; participants were given the premise, and then queried with possible conclusions (e.g., "All green agoutis are susceptible to a disease of the heart called eta. If all green agoutis are susceptible this disease, do you think all other agoutis are susceptible to this disease? [If the response is "No,"] Do you think some other agoutis are susceptible?").

By systematically presenting participants with a number of inferences at different levels of the folkbiological hierarchy, and varying the lifeforms presented in those inferences, we were able to get a good look at perceived strength of inductive inferences to different folkbiological ranks. The results are summarized in Figure 1. They clearly show that folk-generic categories (e.g., trout, oak) were inductively privileged for both the Itzaj and for American undergraduates. For both groups, inferences to folk-generic categories were consistently stronger than inferences to more general (life-form or folk-kingdom) categories, and no weaker than inferences to more specific (folk-specific) categories. For both groups, the gain in inductive strength was greatest moving from life-form to folk-generic categories, suggesting that folk-generic categories are psychologically privileged with respect to induction.

Insert Figure 1 about here.

We expected this pattern for the Itzaj; it is consistent with Berlin's characterization of the folk-generic rank as psychologically privileged for members of traditional societies. We did not expect it for the Americans. Indeed, this result is surprising given Rosch's findings that the basic level for American students is at the life-form level for biological categories, which would lead one to expect that American students would also show inductive privilege at the life-form level, not the folk-generic level. So, rather than resolving the discrepancy between Rosch's and Berlin's notions of privilege, we appear to have complicated it: Why do we find a discrepancy among American undergraduates between the level privileged for induction and that privileged for other cognitive measures? Why do members of two such different cultural groups--with such radically different knowledge about and experience with nature--show such similar patterns of reasoning about folkbiological categories, when their "basic" levels are presumably different?

The answer to these questions may lie in a distinction between knowledge and expectation. We suspect that Roschian tasks measuring the "basic level" and our induction task are tapping different competencies, resulting in the discrepancy between the level identified as privileged by the two sets of tasks.. Most of Rosch's tasks--and Berlin's too, for that matter--required knowledge (either in terms of generating information corresponding to labels, or identifying pictures on the basis of labels) or the ability to make perceptual discriminations. Thus, for biological categories, Rosch's results show that (1) the folk-generic level is not the locus of knowledge for urban Americans, and (2) the folk-generic is not the most perceptually differentiated level for Americans.

In contrast, rather than having participants list features that they knew to be true of categories, we asked them to project properties expressly designed to be unknown. Instead of testing participants' knowledge, we tested their expectations. Our results show that despite lack of knowledge and perceptual differentiation, Americans expect that the folk-generic level is most useful for inductive inference. Although both Itzaj and undergraduates are going beyond their knowledge to make inferences about novel properties, we suspect that they may be doing so for different reasons. Americans' expectation may be guided by implicit assumptions about the way that language constrains categories, whereas the same expectation on the part of the Itzaj may be bolstered by knowledge and personal experience.

Implicit assumptions that members of named categories share important properties and explicit knowledge about how language marks hierarchical taxonomic relations might drive the undergraduates' expectation that folk-generic taxa are inductively strong. As Berlin et al. document, below the level of folk-generic, the nomenclatural pattern tends to mark relative subordinate relationships (e.g., Oak, Red Oak, Northern Red Oak). Thus, knowing that an oak is a tree marks Oak as a folk-generic--the lowest level at which things have unique names--because subordinate relations are often given in the nomenclature. More generally, implicitly learning the logic of nomenclatural patterns of inclusion ("a Red Oak is a kind of Oak"), and explicitly learning inclusion relations of folk-generics under life-forms ("an Oak is a kind of Tree") may be enough to set up a semblance of a folk-biological taxonomy and to flag the folk-generic level despite little experience with members of the categories.

Sensitivity to such nomenclatural patterns begins early in development (Gelman, Wilcox & Clark, 1989). Moreover, developmental evidence shows that labels can be important indicators of taxonomic categories (Waxman 1991). Children take labels as signals to look for commonalities among otherwise disparate objects. Further, children as young as 2 years expect that members of the same category, despite perceptual dissimilarities, will share underlying properties. Thus, labels may "stake out" a category, despite lack of specific knowledge about members of that category (Gelman & Coley, 1990, 1991). This may include the assumptions that the category will be coherent, category members will share many underlying properties beyond what meets the eye, and that in effect, here is "where the conceptual action is." In other words, labels may signal categories which are believed to embody an essence (e.g., Gelman & Coley, 1991; Gelman, Coley & Gottfried, 1994, Medin & Ortony, 1989). These mechanisms are available early, and may represent underlying, basic assumptions about how language organizes experience. These assumptions may well have led to expectations of inductive privilege of folk-generic taxa despite little direct experience with those taxa. The notion of expectation is crucial here. Our task--inductive inference concerning virtually blank biological predicates--relies on expectations about the categories involved. We are not claiming that our American participants knew that maples or trout share important clusters of properties. On the contrary, we argue that in many cases, what little knowledge subjects possessed about maples and trout led them to expect that important property clusters would cohere at that level. Indeed, Rosch sums it up very well: "For humans, the major part of the classification system is probably neither biologically fixed nor created anew by each individual, but is provided by the culture and language into which the individual is born" (Rosch, 1975, p. 177).

Thus, perhaps we can characterize American performance as reflecting this divergence of knowledge and expectation. On one hand, Americans may know more features and perceptual affinities at the more abstract level of tree and fish. Nevertheless, they may expect the strongest clusters of properties to cohere at the folk-generic level, even if they have little specific knowledge about most folkbiological categories at that level.

This discrepancy may not characterize the folk-biological knowledge of the Itzaj. In situations where people are likely to be well-acquainted with local living kinds, as in "traditional" societies like the Itzaj, ethnobiological evidence argues that perceptual cues converge on folk-generics as being psychologically basic. In other words, for the Itzaj, knowledge may converge with expectations. This rests on the presumption that the Itzaj, and indeed the other groups that provided the basis for Berlin's system, would in fact show a "basic" level on Roschian tasks subordinate to that of American college students, due to relative folkbiological expertise. This presumption remains to be tested. Rosch et al. (1976, Mervis & Rosch, 1981) suggest that the basic level may change with expertise; Tanaka and Taylor (1991) and Johnson & Mervis (submitted) offer empirical support for this hypothesis, showing that experts may have basic levels subordinate to those of non-experts. If members of traditional societies can be considered folkbiological experts, they may indeed a basic level (folkgeneric) advantage for both perceptual and knowledge-based tasks.

Indeed, the Itzaj pattern may well represent the default case for human understanding of living kinds under normal (evolutionarily-attuned) environmental conditions, in which personal knowledge of the natural world converges with expectations derived from societal systems of nomenclature and cognitive expectations about the properties of named categories. The divergence for Americans may in turn represent a "devolved" or degenerate state of folkbiological knowledge, based on the poor environmental conditions of urbanized societies.

<u>Summary.</u> We examined the relation between privileged levels and inductive inference, expecting that the basic level in folkbiological taxonomy (life-forms for American undergraduates based on empirical work, folk-generics for the Itzaj, based on some anthropological data and presumption) would also be inductively privileged. The results present a much more complicated picture. The folk-generic level was inductively privileged for both the Itzaj and for American undergraduates. For the Itzaj, this is in accord with the location of the presumptive basic level for traditional societies. For the Americans, it does not correspond to the empirically-established basic level, suggesting a dissociation between knowledge, organized at the life-form rank (<u>fish</u>, <u>tree</u>), and expectations of shared properties, category coherence, and perhaps even essence, which is maximized at the folk-generic rank (<u>trout</u>, <u>oak</u>).

These results suggest that characterizing cultural differences in terms of expertise-driven differences in the location of a single, monolithic "basic level" is an oversimplification. Americans and Itzaj appear to differ in the level at which knowledge is most readily organized and accessed, but not in the level at which expectations about inductive strength are strongest. Thus, it may be more accurate to characterize cultural differences in terms of the degree to which knowledge and experience correspond than as differences in the location of a single privileged level. This research also demonstrates the more general point of how combining anthropological insight with psychological methodology can lead to discoveries which enhance our understanding of the complexity of folkbiological thought. We now turn to another such example.

Diversity-based Reasoning

An important function of taxonomic classification is enabling generalizations between categories. Osherson et al. (1990) identify a set of phenomena that characterize category-based inferences in adults, and formalize a model that predicts the strength of those inferences. Osherson et al. discuss inductive “arguments,” in which facts used to generate the inference play the role of premises, and the inference itself plays the role of conclusion.

(i) Hyenas have an ileal vein

Cows have an ileal vein

Wolves have an ileal vein.

This argument is strong to the extent that belief in the premises leads to belief in the conclusion. To promote reasoning based solely on the categories, the properties (e.g., have ulnar arteries) are "blank," that is, plausible but unfamiliar biological properties. There are two components to Osherson et al's (1990) similarity-coverage model (SCM). Subjects may infer that wolves have an ileal vein because they are similar to hyenas, or they may infer it because they have inferred that all mammals share the property given that hyenas and cows do. Thus, the first component of the model, similarity, calculates the maximum similarity of the premise categories to the conclusion category; the greater this similarity, the stronger the argument. In this example, hyenas are more similar to wolves than cows are, hence similarity is calculated for hyenas. The second component - coverage - calculates the average maximum similarity of premise categories to members of the "inclusive category" - the lowest category that includes both premise and conclusion categories. For argument (i), the inclusive category is presumably mammal. In our research, the inclusive category is simply the conclusion category. The greater the coverage of the inclusive category by the premise categories, the stronger the argument. Sloman (1993) presents an alternative model, but for our purposes his computation of coverage makes the same predictions as Osherson et al.

We use the SCM to compare patterns of inference based on taxonomic categories by testing for three category-based induction phenomena: Similarity, Typicality and Diversity. These phenomena can be accounted for in terms of the two main features of the SCM: the similarity component and the coverage component. Not surprisingly, the similarity component drives the Similarity phenomenon, which predicts that the stronger inference is the one whose the premise is most similar to the conclusion.

In contrast, Typicality and Diversity hinge on coverage. The Typicality phenomenon predicts that a more typical instance promotes stronger inferences than a less typical instance. Typicality in this case is computed in terms of central tendency; the typicality of an item is the average taxonomic distance of that item to all other items in the inclusive category. The higher the average similarity of that item to other members of the category, the more typical it is. Thus, more typical items provide greater coverage than less typical ones.

Like Typicality, Diversity is a measure of category coverage. The Diversity phenomenon predicts that an argument will be inductively strong to the degree that categories mentioned in its premises are similar to different instances of the conclusion category. For example, consider arguments in (ii):

(iia). Jaguars have protein Y
Leopards have protein Y
All mammals have protein Y.

(iib). Jaguars have protein Y
Mice have protein Y
All mammals have protein Y.

The SCM predicts that that the categories mentioned in the premise of (iib) provide greater coverage of the conclusion category mammal--i.e., are more similar to more mammals--than the categories mentioned in the premises of (iia), thus making (iib) the stronger argument. Indeed, most subjects agree that the (iib) is stronger than (iia) (López, 1995; Osherson, Smith, Wilkie, López & Shafir, 1990, Smith, López, & Osherson, 1992). In general, diversity predicts that an argument with more diverse premises will be evaluated as stronger than an argument with more similar premises.

For the purposes of this chapter, we focus on our findings regarding diversity. This phenomenon has been well-documented among American college student subjects, but has received no cross-cultural validation. As part of a larger, comprehensive comparison of categorization and reasoning about mammals (López, Atran, Coley, Medin & Smith, in press), we compared diversity-based reasoning among two groups: the Itzaj Maya natives of Peten, Guatemala, and University of Michigan undergraduates. To generate sets of premises that informants would judge to differ in diversity, we first need a measure of similarity. To this end, we asked each participant to sort cards corresponding to local mammal species into categories by "putting the things together that go together by nature." We then asked participants to successively lump and split categories to produce a hierarchical taxonomy. Each group showed a high consensus on sorting, and we therefore used group patterns of sorting to establish similarity relations among the mammals of each locale. Specifically, our measure of similarity was the folktaxonomic distance derived from these sortings. One advantage of the sorting measure of similarity is that it directly links folktaxonomies with patterns of reasoning.

Using these similarity ratings--based on the participants' own folk taxonomies--we created pairs of arguments where the categories mentioned in the premise of one argument were more similar than the categories mentioned in the corresponding argument. Participants were then asked which pair provided a better basis for a generalization. Questions concerned hypothetical diseases among populations of familiar mammals "on an island in Ontario" for Michigan students
sland in Yucatan" for Itzaj participants. For example, one item for the Michigan

participants was: "Wolves and deer have a disease. Wolves and coyotes have another disease. Do you think all other mammals on this island have the disease of wolves and deer or the disease of wolves and coyotes?" In this case, since Michigan students deem wolves and deer to be more diverse than wolves and coyotes (based on their sorting data), they cover the conclusion category mammal better. Therefore, the diversity principle predicts that Michigan students should choose the disease of wolves and deer. Structurally identical items were derived for the Itzaj participants from their sortings of Peten mammals. It should be emphasized that there is no obviously correct answer to the diversity problems; preference for the more diverse argument is simply a phenomenon predicted by the SCM and validated empirically with American undergraduate populations (e.g., Osherson et al., 1991).

Each participant was given four diversity problems, along with other reasoning problems. We were interested in how often participants in each group would favor the argument with the more diverse premise. The results were striking: Michigan participants overwhelmingly favored the more diverse premise, choosing it on 96% of trials. In contrast, Itzaj participants chose the more diverse premise on only 35% of trials. Both groups were reliably different from chance performance. Why did this significant difference in performance emerge?

Two possibilities can be ruled out immediately. First, the difference did not stem from an unwillingness on the part of the Itzaj to reason hypothetically. On the other reasoning problems included with the task--those involving similarity and typicality--the Itzaj performed identically to the Michigan students. Second, the Itzaj do not lack the ability to use diversity as a reasoning strategy. On other real-world reasoning problems where a diverse sample would lead to a more robust conclusion, (e.g., “Imagine you want to buy several bags of corn from a given person. Before buying them, this person will show you only two cobs of corn to check whether all the corn is good. Do you prefer him to show you two cobs from one and the same bag, or do you prefer him to show you one cob from one bag and another cob from another bag?”), the Itzaj showed a reliable preference for the more diverse sampling strategy. Of course, it is not entirely clear that this sort of "spatial" diversity is the same kind of process as category-based diversity;

nevertheless, performance on these problems indicates that the Itzaj do have an understanding of sampling.

Although we can safely rule out these two potential explanations, a myriad of differences remain between the Itzaj and Michigan students which might explain or contribute to an explanation of the differences in diversity-based reasoning. Chief among these is expertise. The Itzaj have a great deal of contact, and a correspondingly vast store of knowledge about the mammals of the forest, including ecological relationships that exist among species (See Atran, 1994; Lopéz et al., in press). In contrast, Michigan students have little contact and little knowledge about native mammals. To get a better idea about why the Itzaj show negative category-based diversity, we turn a more detailed analysis of the justifications they provided for their judgments and how these might reflect differences in the kind of knowledge possessed by the Itzaj.

The Itzaj justified their responses to the reasoning items on the basis of specific ecological knowledge, often leading them to conclude that the more diverse premise was the weaker of the two choices. For example, given the argument that rats and mice have one disease and tapirs and squirrels have another, one Itzaj participant favored the rats and mice argument, which is less diverse. She explained that tapirs and squirrels are less likely to pass on the disease because they probably required an ecological agent (a bat biting them) to get the disease in the first place, whereas rats and pocket mice are close enough “companions” that they need no such intervention. In other cases the more similar pair had a more different range and habitat (according to the justifications) than the other pair such that using diversity based on ecology would yield negative diversity according to categorical similarity. This suggests that the Itzaj may be using a diversity-based reasoning process, but using different kinds of categories (i.e., ecological ones). A follow-up study testing the Itzaj on different palms also failed to show (category-based) diversity and produced justifications that again were causal/ecological in character. Informants appealed to range, abundance, and causal potency (e.g. tall palms can affect short palms more readily than the converse) as well as other ecological factors to reason about the hypothetical disease. In short, the

Itzaj justifications revealed that the novel disease may not in fact function as a blank property, but rather as a trigger for ecologically-based inductions.

Results from the sorting task provide converging evidence for the role of ecology. Many of the Itzaj groupings had an explicitly ecological nature. For example, many Itzaj classified the spider monkey, howler monkey, kinkajou, coatimundi, and other climbing mammals together as arboreal mammals, based on habitat and behavior. Likewise, the otter--the only aquatic mammal in our set--was isolated because of habitat instead of being classified with other morphologically similar mustelids. In contrast, the undergraduate sorts were based almost entirely on morphology, and more specifically, on size. In addition, sorting justifications were much more likely to include detailed ecological information for the Itzaj than for the undergraduates (López, et al., in press). Whereas the Itzaj sort mammals into relational (ecological) categories and justify their diversity responses using relational (ecological) information, the undergraduates do neither.

In addition, the density of the Itzaj's ecological knowledge about individual folk genera may block the salience of more abstract categories like mammal as the basis for induction. It's possible that given their knowledge of individual species, the Itzaj find higher-order groups of mammals--a necessary component of diversity-based reasoning--less salient than do the Michigan students, who have little knowledge of individual species but have some ideas about taxonomic relations at higher levels. Indeed, consistent with this interpretation, Michigan students were more likely to sort mammals into a few, higher-order groups than were Itzaj participants; thus, higher-order classes seem more salient for the Michigan participants.

Thus is appears that differences in patterns of reasoning may be attributable to the higher levels of ecological knowledge possessed by the Itzaj. Of course, there are myriad of other differences between Maya elders and University of Michigan undergraduates that could account for these differences. Here's where our triangulation research comes into play: if knowledge blocks the use of diversity-based reasoning, then American experts may also fail to show diversity.

To address this question, we are exploring the impact of different kinds of expertise on categorization and reasoning about trees (See Medin, Lynch, Coley, & Atran, in press). We have recently collected data on diversity-based reasoning from Chicago-area tree experts. Their educational backgrounds are diverse; some never completed high school, while others have earned advanced degrees. They are ethnically diverse, predominantly male, and range in age from twenty-nine to seventy-six years old. For present purposes we focus on three types of tree experts: maintenance personnel, landscapers, and taxonomists. Parks maintenance personnel are primarily involved with removing damaged and diseased trees, planting new trees. and pruning and treating trees in public parks and along streets. Landscapers tend to be concerned with utilitarian aspects of trees and with placing suitable (low-maintenance, disease-resistant) trees in appropriate, aesthetically pleasing settings. Taxonomists tend to be involved in research, consulting, and a variety of educational activities. Members of each group have had ten or more years of experience working with trees, which qualifies each participant as a knowledgeable expert.

Each of these experts was given a number of diversity-based reasoning problems. As with the mammal problems, diversity was computed based on the aggregated sortings of the experts themselves. Problems involved two newly discovered tree diseases. The only information available to the expert was that one disease affected one pair of trees, while the other disease affected a different pair. For example, in one item, experts were told that "Disease A affects Eastern White Pine and Weeping Willow; Disease B affects White Birch and River Birch." The expert was then asked which disease would be more likely to affect more other kinds of trees. In this case, the first pair is more dissimilar, and therefore provides better coverage of the conclusion category <u>tree</u>, than the second, so a diversity-based response would be that Disease A was more likely to affect more other kinds of trees.

Insert Figure 2 about here.

The results are presented in Figure 2, along with the responses of the UM students and Itzaj to the mammal diversity items mentioned above. (The horizontal line at 50% represents chance responding across all items.) As can be seen in Figure 2, there were clear differences in diversity-based reasoning among the three expert groups. Specifically, taxonomists and landscapers chose the more diverse pair at levels that were reliably above chance (86% and 71%, respectively) and reliably more often than maintenance workers. Maintenance workers' responses, like the Itzaj, were significantly below chance (27%), indicating that they showed a reliable preference for the more similar pair. Thus, expert groups clearly differed in their use of diversity as a basis for induction.

These results from tree experts allow us to rule out several possible explanations for the discrepancy in the use of diversity between the Itzaj and the Michigan students. First, general differences between Maya and Americans cannot explain the result; results from the tree experts show that some Americans use diversity, and some do not. Second, expertise or quantity of knowledge does not necessarily block the use of diversity. All of our tree experts have a good deal of knowledge about trees, but some used diversity and some did not.

In other words, the conditions that lead one to use diversity as an inductive reasoning heuristic are not as straightforward as we might have thought. To get some better insights into the basis of performance we again turn to the justifications given for judgments, which reveal distinct strategies. Many of the taxonomists and some of the landscapers explicitly mentioned diversity as the basis for their choice. But some of the taxonomists and many of the landscapers employed causal/ecological justifications on at least some of the tests. For example, they might mention range, numbers or frequency of a kind, and susceptibility to disease. In short, for these experts, diversity was one strategy among several.

In contrast, maintenance personnel rarely mentioned anything that could be construed as diversity or, in terms of the SCM, coverage, and instead revealed predominately causal/ecological strategies.[2] For example, on the item contrasting two birches with a pine and a willow, almost all maintenance personnel responded that more other trees were likely to get the disease associated with the birches (the less diverse pair), often arguing that birches are very susceptible and widely planted so that there would be more opportunities for the disease to spread. Generally, the justifications were remarkably parallel to those of the Itzaj on mammals and palms, including in a few cases the idea that a disease will spread more readily from a big tree to a small than from a small tree to a big one.

Although it appears that diversity is one strategy among many and that it may be blocked by alternative patterns of reasoning, we still do not have a good understanding of the differences associated with type of expertise. In general, our landscapers and taxonomists have had more formal education than our maintenance workers. There are exceptions, however, and our sample includes both landscapers and taxonomists who have do not have college degrees, and maintenance workers who do. This allowed us to compare diversity-based reasoning among those experts who have a college degree or more with those who have less than a college degree without duplicating our previous analysis. Were education the major determinant in the use of diversity in induction, the more educated group should show more use of diversity. Results suggest that this is not the case; there were no reliable differences in the use of diversity as a function of education. Indeed, this also makes it unlikely that differences between Michigan students and Itzaj are attributable to disparities in formal education.

What, then, drives the differences in the use of diversity-based reasoning? What do the Itzaj and tree maintenance workers have in common that differs from landscapers, taxonomists, and university undergraduates? One speculation is that it may relate to how knowledge that is specifically relevant to our questions is acquired. Taxonomists and landscapers are probably more likely to learn about trees formally than are maintenance workers, who may well received the bulk of their training on the job. Similarly, the Itzaj acquire their knowledge of mammals through first-hand experience or orally-transmitted lore, whereas what UM students know about local mammals is probably picked up in school, at the zoo, or on TV, rather than in local woods and fields. Perhaps it is the way that domain-specific knowledge is acquired, rather than the level of education in general, that predicts diversity-based reasoning. A related possibility is that the diversity-users may have had more experience--at least in educational settings--with taxonomic categories superordinate to the genus level. This may also contribute to diversity-based induction.

It may be that the use of ecological knowledge versus "coverage" depends on the relative accessibility of taxonomic versus ecological information. One observation consistent with this competing strategy view (noted earlier) is that some of the maintenance personnel did use coverage as a justification on other reasoning trials that were not tests of diversity. Obviously this is a puzzle that awaits further exploration.

Summary. In comparing category-based induction across cultures, we found that Itzaj Maya and Michigan undergraduates both showed similarity and typicality phenomenon, but that whereas the Michigan participants showed diversity-based reasoning, the Itzaj did not, and indeed, showed reliable anti-diversity. This seems attributable in part to the Itzaj's relatively large store of ecological knowledge, but is viewed very differently when one notes that American tree maintenance personnel--but not landscapers or taxonomists--also show negative diversity. Thus, our "triangulation" strategy allows us to rule out several potential explanations for our findings.

Together, our studies of diversity-based reasoning provide an intriguing perspective on the similarity-coverage model (and associated models). First of all, diversity is not a universal--there are alternative reasoning strategies that may be triggered by what are nominally "blank" properties. We believe that ecological reasoning is important in and of itself and we have launched a separate line of research aimed at analyzing folkecology (e.g. Atran and Medin, in press). Secondly, the apparent competition of strategies raises new questions about the memory organization and the role of hierarchical taxonomies in retrieval which we are also aiming to pursue. Finally, our results are leading us to take a closer look at the notion of diversity itself. Should it be equated with coverage? We suspect, for example, that undergraduates might show diversity-based reasoning even when they know too little about the referents of folkbiological terms to assess something like coverage (similarity). Answers to these sorts of questions await further investigation.

Summary, Conclusions, Further Questions

In this chapter, we've discussed two cases in which examining the use of folkbiological categories in inductive inference has yielded insights that mere description of folk taxonomy might have missed. The first set of findings involved a surprising cross-cultural convergence. Previous research leads to the prediction that Northwestern undergraduates would privilege more general categories for induction than the Itzaj. Instead, we found that despite large disparities in experience and knowledge of the natural world, folk-generic taxa were inductively privileged for both groups. Indeed, superimposed data from the two groups are nearly identical.

Second, we related findings that University of Michigan undergraduates, but not Itzaj Maya, evaluated arguments in accord with the principle of diversity. This initial divergence seemed strange; to us, the argument with the more diverse premises seems intuitively much stronger. However, after further research, it turns out that this anti-diversity pattern is not peculiar to the lowland rainforests of Guatemala. Illinois tree maintenance workers showed the same patterns of reasoning, and landscapers and taxonomists displayed similar strategies at least some of the time.

Taken together, what do these results tell us about the nature of folkbiological thought? First, we find group convergences and divergences that are not simply a function of culture or experience. Itzaj folkbiological "experts" resemble American "novices" in some respects (privileged levels) but not in others (diversity-based reasoning); with respect to diversity-based reasoning, they resemble some American experts (maintenance workers) but not others (landscapers, taxonomists). In other words, when reasoning is examined, a broad construal of "culture" seems not to be the largest predictor of performance.

Second, experience may have a differential impact on different aspects of folkbiological reasoning. On one hand, folk-generic taxa appear to be inductively privileged for individuals whether or not those individuals have had much experience with the organisms so classified or not. For the Itzaj, experience may converge with language and expectation to privilege the folk-generic. For American college students, language and expectations appear to be enough to overcome lack of experience and similarly mark the folk-generic as privileged. Thus, different experiences appear to lead to similar outcomes.

On the other hand, diversity-based reasoning seems quite susceptible to the effects of experience. Itzaj and American college students show radically different patterns of performance on diversity-based reasoning items. Taxonomists and landscapers show a pattern of reasoning intermediate to that of undergraduates and Maya, while the behavior of American maintenance experts is strikingly similar to that of the Itzaj. Clearly, in this case, experience has a large impact on reasoning patterns; it remains to be seen exactly what aspects of experience have this effect.

Finally, this sampling of results yields important avenues of future research. First, although we do find many cross-cultural similarities with respect to folkbiological reasoning, we are in no position to claim that members of different cultures do not differ fundamentally with respect to other aspects of folkbiological thought. The abilities that we've measured may well be the very ones that are most likely to show universality. Moreover, constraints inherent to our methods may reinforce this apparent finding. In this light, it is vital to look at beliefs, naive theories, and the explanatory networks in which folkbiological categories are embedded (e.g., Carey, Keil, Hatano). Further exploration of these issues may well reveal deep cultural differences. Another important future direction is to look at less "taxonomic" ways of organizing folkbiological knowledge (e.g., ecological webs). Again, it may be that by focusing on taxonomies we are overlooking important sources of cultural differences in folkbiological thought.

In addition, further research is needed regarding the development of folkbiological thought. Our findings point to salient differences in patterns of reasoning, and also to unexpected commonalities. In either case, we are left wondering how different learning conditions might contribute to the differences in patterns of reasoning, or how developmental patterns result in similar outcomes despite marked differences in environment and experience. These are essentially developmental questions, and research on the changes in folkbiological reasoning and thought over time is needed to answer them.

Apart from expanding and challenging our knowledge about folkbiology, these results make a methodological point about the investigation of folkbiology in general: investigations of inductive reasoning complement, expand, and enrich studies of categorization. It is important to describe folk taxonomy, but it is equally important to document how folk taxa are used in everyday thought and interaction with the world. Moreover, this research demonstrates the value of a multidisciplinary approach to the study of folkbiological thought. Without a detailed analysis of the systems in which these categories are situated, or the justifications that our informants provide along with their responses to our items, we could not have made the progress that we have to date. Moreover, our cross-cultural and cross-experiential evidence provides a clear challenge for existing models of inductive reasoning. Our work on folkbiological induction is far from complete, but the fragmentary evidence we have gathered adds depth and complexity to our understanding of folkbiological thought.

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Notes

[1]In a recent survey of Northwestern undergraduates, we presented the names of 80 trees and asked the students to circle the trees that they had heard of before, regardless of whether they knew anything about them. More than 90% said they had heard of Birch, Cedar, Chestnut, Fig, Hickory, Maple, Oak, Pine, and Spruce, but fewer than half indicated any familiarity with Alder, Buckeye (despite the fact that the Ohio State Buckeyes are in the Big Ten conference along with Northwestern), Catalpa, Hackberry, Hawthorn, Honeylocust, Horsechestnut, Larch, Linden, Mountain Ash, Sweetgum, or Tuliptree--all of which are common to the Evanston area, and many of which they see nearly every day on the Northwestern campus.

In another survey, we presented names of 56 plants (trees, bushes, flowers), and 56 animals (mammals, birds, fish) with distractors to Northwestern undergraduates. Their task was to indicate which of the items belonged to which categories (i.e., is a tapir a mammal, fish, bird, or none of the above? Is a catalpa a tree, bush, flower, or none of the above?). Mean performance (51% correct) was just different from chance, but obviously left a great deal to be desired.

[2]Interestingly, the large majority of maintenance personnel did employ coverage-like justifications on some reasoning tasks. However, these tended to appear on typicality tests, not diversity tests. Thus on a trial involving Silver Maple getting one disease and Kentucky Coffee tree another, the disease of the Silver Maple might be selected by maintenance because "the maple family is bigger" (maintenance personnel tend to use "family" to refer to scientific genera). Assuming that "coverage" mediates diversity, maintenance personnel should have diversity available as a strategy but it appears to be blocked by other factors such as causal/ecological reasoning.

Figure 1: Induction Patterns from Northwestern Students and Itzaj Maya Compared

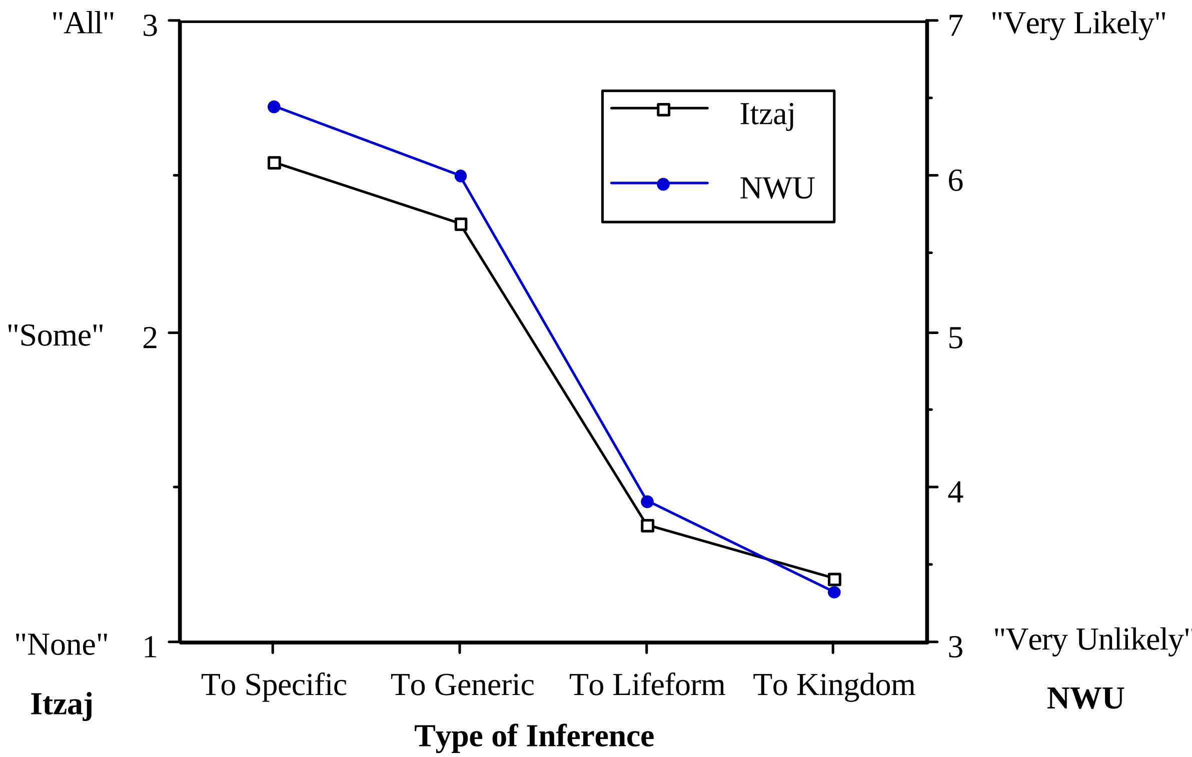

Figure 2: Percentage of Diversity-based Responses