Categorization and Reasoning in Relation to Culture and Expertise

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I. Introduction

Do culture and expertise affect how people conceptualize nature and reason about it? Intuitively, it seems that the answer to both questions must be "yes," but there is actually quite good evidence that there are universal principles governing the categorization of biological kinds (Atran, 1990; Berlin, Breedlove, & Raven, 1973; Malt, 1995). The question of how categories are used in reasoning shows considerably less unanimity (e.g., Lopez, Atran, Coley, Medin, & Smith, 1997). In this chapter our focus is on categorization and the use of categories in reasoning and a central question concerns the generality of results across populations.

Our study populations vary in both culture and expertise. It may not be immediately obvious why culture and expertise make a good pair when it comes to studying categorization and reasoning but we have found them to be excellent companions. In a minute we'll explain why but first we need to provide a bit more by way of background information.

A. The Issue of Participant Pools

Two bedrock cognitive processes are categorization (how do we decide what knowledge base applies to some entity we observe) and inductive reasoning (given that one object or class exhibits some property, how do we decide whether other related objects or classes also have that property). Although researchers have increasingly examined these issues in real world (as opposed to artificially contrived) domains, research participants are usually introductory psychology undergraduates. Attention to real-world domains, however, raises important questions concerning the way knowledge and culture may affect these processes - it is highly questionable whether undergraduate students are always the best participants in terms of their familiarity with such domains.

In the present chapter we focus on the domain of folkbiology for two reasons: There is a rich literature concerning how humans categorize and reason about plants and animals, and there is significant variability in folkbiological knowledge within and between cultures. If it should turn out that variations in knowledge systems, goals and activities differentially affect people's ways of conceptualizing the natural world, then lopsided attention to a single participant pool risks biasing interpretation and generalizations that do not generalize (Atran, 1995). Furthermore, the very questions that seem natural and interesting may depend on the population being studied to a much greater extent than cognitive psychologists realize. In the worst case, undergraduate performance becomes something of a standard and when comparisons are made with different populations, any differences may be wrongly interpreted as either 'failing' a given experimental task or being under the influence of 'extraneous' factors when performing it. As we shall see, in the domain of folkbiology, undergraduates are usually the "odd group out."

Although studies in social psychology and decision making have increasingly brought issues concerning populations and context to the forefront of the research agenda (Hsee & Weber, 1999; Markus & Kitayama, 1991; Nisbett, Peng, Choi, & Norenzayan, 2001; Weber & Hsee, 1998), there is no comparable cautionary perspective in categorization and reasoning studies. This is perhaps even more surprising given that Rosch's pioneering research on category structure was firmly rooted in cross-cultural comparisons (Heider, 1971, 1972; Rosch, 1973, 1977). In contrast to cognitive psychology, ethnobiology, one of the most relevant areas of anthropology, has by its very nature focused on cultural comparisons of classification systems (e.g., Atran, 1998; Berlin, 1992; Boster, 1988). These latter studies yield intriguing observations but generally lack the methodological rigor or direct comparative approach that we think is needed to advance theories of categorization and reasoning. Of course, it is challenging to perform cross-cultural comparisons on logistic, methodological and conceptual grounds. Let's take a look at some of the difficulties.

B. Hazards of Comparative Research

One reason that comparative research has not been popular is that it isn't always clear how to do it successfully. To put it bluntly, when one does a study comparing two cultures, there are two possible results and both spell trouble. If one compares two groups with respect to some process and finds no difference, then the generality of prior results is on firmer ground. But in this case one would have gone to a great deal of trouble to produce results that may not be considered particularly newsworthy. And that's the good news. The bad news comes when one compares two groups and finds clear differences. Why? Because interpretative problems quickly emerge. Which of the many ways in which the two groups differ are crucial? For example, Lopez, Atran, Coley, Medin, and Smith (1997) found that US undergraduates and Itza' Maya of Guatemala showed a different pattern of responding on a category-based inductive reasoning task involving mammals. Although this undermines the universality of the particular reasoning phenomenon, the two groups differ in myriad ways (e.g. age, education, literacy, livelihood, language, cosmology and so on). Which of these differences makes a difference? Practically speaking, it is very likely impossible to disentangle these various factors because (cultural) groups cannot be found that represent orthogonal combinations of these variables. In short, without a clear theory to guide interpretation, one may be confronted by the dilemma of findings that consist of either weakly informative similarities or uninterpretable differences.

A second and related problem is more conceptual in nature. Suppose we could control for age, education, literacy and the like in comparing Itza' Maya and undergraduates. How do we decide which variables represent "culture" and should not be controlled and which variables are not and should be controlled. The Itza' Maya practice agro-forestry and also hunt and collect plants in the forest. Is that what we mean by culture? It's not clear. If we rely on our intuitions, we'll probably agree that language is clearly cultural and should not be controlled but for almost any other variable it might be hard to achieve a consensus.

Some of the comparisons we'll describe involve people in different cultures who speak the same language (this is not uncommon given the widespread "languages of conquest" such as English, Spanish, and French). Now let's suppose that in this case we control for every variable we can think of except culture. If we still find differences, we will be more or less forced to reify or essentialize culture, because our only explanation of the cultural difference involves appealing to some abstract notion of "culture." In short, it seems that there are two possible outcomes: One is that we end up with a notion of culture that appeals to circular and mystical explanations of differences ("the Itza' are different because they are Itza"). The other option is to concede that cultural comparisons represent just a terribly confounded experiment and cultural differences will disappear as soon as properly controlled comparisons are made. This doesn't sound like good science.

The third problem or issue associated with comparative research seems almost mild in comparison to the other two, but for anyone trained in experimental design it has to be taken seriously. This is the issue of sampling. It seems that if we want to know how the Itza' Maya categorize and reason, we had better take a random sample of Itza', else our results may not generalize to the Itza' as a whole. But if we read the Lopez, et al, 1997, methods section in detail, it becomes clear that the sample was anything but random---it consisted of Itza' Maya elders who speak Itza' Maya. That fact alone makes the sample unusual and unrepresentative because Itza' Maya is a dying language; the "typical" Itza' speaks only Spanish. But given our bias to think that language is important to culture, we find ourselves wanting to endorse the practice of running Itza' who speak Itza.' If we do that, however, we'll have to give up one of our cherished principles of experimental design, random sampling. One might counter-argue that experimental psychology has always given random sampling lip service but the handy undergraduate participant pool leads researchers to never follow it in practice, so we shouldn't be all that nervous. Nonetheless, when one tries to compare two groups or cultures the issue of sampling comes to the fore and it can't be ignored.

Each of the above three problems stems from two related biases associated with culture comparisons (these hold for other group comparisons as well, but for now we'll stick with culture). One bias, already mentioned, is to essentialize culture and the other is to treat culture as if it were an independent variable. We believe that if progress is to be made in cultural comparisons, both biases must be explicitly addressed and overcome. In the next section we describe the strategy for cultural comparisons that our research group has developed and then illustrate it with a series of examples from ongoing research.

II. The Distribution View and an Approach to Comparative Research

There is no theoretically-neutral way to define culture. We have just suggested that the idea that culture is whatever is left when all potentially confounding variables are controlled is self-defeating. In some respects it may be akin to trying to determine which stick in a bundle of sticks makes the bundle strong. Granted, it may be useful to control for variables that are clearly irrelevant to culture (as long as one keeps in mind that each decision is a theoretical decision that commits one to a particular notion of culture).

Suppose that we start with the view that *culture is a distribution of ideas (broadly construed) in a group and that cultural differences in these distributions are what one seeks to understand*. We know from social psychologists that people tend to exaggerate between group differences and minimize within group differences and that some groups may self-consciously make decisions with the goal of preserving and introducing group differences as a means of promoting cultural identity. This approach is distinct in that it studies the distribution of ideas rather than simply assuming that cultures are homogeneous. Note also that for this approach to be meaningful, it has to make some theoretical commitments as to which ideas should be studied and which differences are candidates for interesting cultural differences (Hannerz, 1999). The distribution view rejects essentialism and the associated idea that culture is a form of explanation of differences. It treats cultural differences as something to be explained or as a beginning point, not an endpoint.

Treating culture as a beginning point serves to clarify three other issues associated with comparative research: First, it avoids the (often ethnocentric) straightjacket of considering "culture" a well-bounded system or cluster of practices and beliefs (see Bruman, 1999, for some examples) in favor of using a set of techniques for assessing group-wide patterns that statistically demonstrate, rather than assume, cultural consensus. In our work we have relied extensively on the cultural consensus model (CCM) of Romney et al. (1986), an important tool for analyzing commonalties and differences within and across cultural groups.

Before describing the cultural consensus model in detail we should add a general note of caution. The CCM does not prescribe which ideas should be studied any more than analysis of variance dictates which variables should be measured. It is not a theory of culture or a theory of the cultural transmission of information. Rather it is a tool that can be used to evaluate such theories. The CCM also does not provide a definition of culture. Although we would expect considerable agreement across individuals in a given culture, agreement is neither necessary nor sufficient to define a culture.

The cultural consensus model assumes that widely-shared information is reflected by a high concordance among individuals. When there is a single cultural consensus, individuals may differ in their competence, e.g. the extent to which an individual shares in the common knowledge pool. Consensus can be assumed if the data conform to a single factor solution (the first latent root is large in relation to all other latent roots) and individual scores on the first factor are positive. If this is the case, individual competencies (the extent to which an individual agrees with the general model) is equal to the individuals' first factor score. Of course, general agreement may be coupled with systematic disagreement. Boster and Johnson (1989; Johnson et al., 1992) have shown how the CCM may uncover shared and unshared knowledge. Given that an individuals' first factor score reflects his/her agreement with the consensus, we can calculate the expected agreement between each pair of subjects as the product of their respective consensus parameters. If we subtract the resulting (and standardized) expected agreement matrix from the standardized raw agreement matrix we produce a matrix describing the residual agreement, e.g. agreement between individuals that is not captured by the individuals' participation in the general consensus (cf. Hubert & Schultz, 1976). If raw and residual agreement are significantly associated, then a significant portion of the agreement consists of deviations from the consensus. This means that pairs (or groups) of individuals agree with each other in a way not captured by the consensual model. This opens space to explore other factors (e.g. cultural subgroups, social network distance) which produce this unexplained, residual agreement. For example, Boster (1986) found that among the Aguaruna Jivaro people there was a shared cultural model for the identification of various varieties of manioc and that deviations from this shared model were related to membership in kin and residential groups (that is, agreement within these groups is higher than what one would predict on the basis of the overall cultural model). In our work in Guatemala we were able to use to CCM to demonstrate that one immigrant group is learning from the indigenous Itza' Maya group. Immigrant competence scores correlated reliably with social network distance from Itza' experts (Atran el al., 1999). In other cases the CCM provides suggestive evidence that knowledge is NOT being directly transmitted. Within our Itza' sample we consistently fail to find reliable residual agreement linked to social structure or distance from the most expert Itza'.

A second property of the distribution view of culture is that it leads one to employ sampling techniques most likely to reveal cultural differences rather than focusing on estimating population parameters. Consider our studies with the Itza' Maya. We assumed that younger Itza' Maya might have notions of biology that differed from those of Itza' elders and that these differences might reflect an assimilation to "western culture." Thus a random sample would tend to hide rather than emphasize some of the differences we were interested in. Instead of randomly sampling farmers, we restricted our initial sample to Itza' speaking Maya elders as the best representatives of Itza' Maya culture. It's not that we think that there was some pure Itza' culture in the past that nowadays is being degraded. In fact, Itza' Maya culture is a rich blend of ideas and habits stemming from different inputs, including a great deal of Spanish influence. Instead, we believe, that across time and outside influences (of varying nature) the knowledge base differs between individuals; in short, cultures are not at all static and that there is nothing essential about them. Nonetheless, it still seems sensible to look for sharp contrasts by means of selecting subpopulations that have retained more traditional knowledge. This view of change and the loss of knowledge (in specific domains) receives some support from studies documenting the erosion of knowledge across generations (Ross, in press; Zent, 2001) and even centuries (Wolff, Medin, & Pankratz, 1999).

In follow-up studies we are attempting to trace the flow of the knowledge from Itza' elders to younger Itza' farmers, again using the CCM. In related work Ross (in press) studied the neighboring Lacandon Maya of Mexico and found a strong consensual agreement on folkecological models among all male adults from a single community. Nonetheless, young and older Lacandon Maya showed differences in patterns of residual agreement that Ross was able to trace to changes in living arrangements that kept older men near their farms and led younger men away from their farms. Ross found that younger men were losing interest in and knowledge of the forest, relative to the older men.

Consider now a different example. Suppose we want to study Itza Maya farming methods. Again one could argue against using a random sample on much the same grounds. It is only when we want to make claims such as that the current Itza' farmers grow a greater variety of crops than the current farmers of from other cultural groups does it become mandatory to have an unbiased sample. In short, a random sample is only appropriate when one wants to make claims about population parameters, something that we believe is rarely relevant in cultural comparisons.

A third aspect of the distribution view is that once cultural differences are found it is natural to ask a series of more analytic questions about things like 1. when and how do these differences emerge in development 2. are these ideas spread by means of abstract schemas or models or is the information conveyed in quite literal form? 3. do factors like income or occupation or density of social networks or a variety of other input conditions moderate cultural differences (either within or between groups)? 4. Do social factors restrict access to certain types of information? Note that one may look for variations that would be welcome by the "control for everything but culture" people but within the present framework the goal is quite distinct. The goal is to have a theory about the distribution of ideas and flow of information, not to isolate some magical entity, "culture."

In addition to the cultural consensus model, our research group has often employed what we informally refer to as a "triangulation strategy." As we noted earlier, it may be in principle impossible to disentangle the various sources of variation among groups, because (cultural) groups cannot be found that represent orthogonal combinations of these variables. The general idea of triangulation is to use observations from a third group to get at least modest leverage for understanding initial group differences. The third group should resemble one group in some potentially important ways and the second group in other ways. If the third group performs very much like one of the groups and different from the other group, then the variables shared by the third group and the group it mimics become candidates for critical variables.

To illustrate this strategy, we will look at the Lopez et al. (1997) study in greater detail. They compared Itza' Maya elders and University of Michigan undergraduates on categorization and reasoning involving local mammals (local to Petén, Guatemala and Michigan, USA, respectively.) Participants performed both a sorting task and a category-based reasoning task and it is the latter, which is of current interest. In this task people were told that one or more mammals could get some novel disease and then asked about what other mammals also might get the disease. For example, when people are told that coyotes get some new disease they may be more sure that wolves also get this disease than that cows get this disease. In this case participants may be reasoning in terms of (taxonomic) similarity because coyotes are more like wolves than they are like cows. Both Itza' and USA undergraduates show reliable similarity effects.

Other arguments involved two premises. Suppose you are told that there is one new disease that we know affects coyotes and wolves and another new disease that affects coyotes and cows and now we ask which disease is more likely to affect all mammals. University of Michigan undergraduates overwhelmingly say the disease that coyotes and cows get is more likely to affect all mammals. They justify their answers by appealing to the converse of similarity, diversity. That is, they note that coyotes and cows are more different than coyotes and wolves and that if some disease affects such different mammals it is likely to affect all mammals. This reasoning strategy seems quite sensible and the Osherson et al. (1990) model for category-based reasoning predicts that people will prefer more diverse premises in drawing inductions to a category. What is surprising is that the Itza' Maya do not show a diversity effect. In some cases they are reliably below chance in picking the more diverse premises on these kinds of tests.

Why don't the Itza' show diversity effects? Obviously, there are any number of hypotheses one could conjure up. Perhaps the question wasn't asked quite the same way in Itza' Maya (back translation is no guarantee of equivalence) or perhaps formal education is a pre-requisite for this form of abstract thought or perhaps the Itza' have a very different conceptualization of disease. There was some evidence in the response justifications that the elders were reasoning in terms of causal and ecological relations (that is, they might choose the pair of premises that are more ecologically diverse rather than the pair that are more taxonomically diverse).

For the above puzzle a triangulation strategy proved to be very effective. In this case the third group was USA tree experts (e.g. landscapers, parks maintenance workers, taxonomists) who were asked to reason about novel tree diseases. USA tree experts resemble Michigan undergraduates in many respects (language, formal education, etc.) and resemble Itza' with respect to having considerable domain knowledge. A typical diversity probe might be as follows: "White pine and weeping willows get one new disease and river birch and paper birch get another. Which is more likely to affect all trees?" Using these kinds of probes Proffitt, Medin, and Coley (2000) found that diversity effects depended on type of expertise. Taxonomists showed robust diversity effects, landscapers were intermediate and parks maintenance workers showed reliably below chance diversity responding. For example, for the above probe 13 out of 14 parks workers picked the disease of the birches as more likely to affect all trees. A standard justification would go something like this: "Well, birches are highly susceptible to disease so that if one gets it they will all get it. Also they are very widely planted so there will be plenty of opportunities for the disease to spread." Actually all three types of experts used ecological/causal reasoning some of the time and the differences appear to be differences in the salience of alternative strategies. With respect to triangulation, the Proffitt et al study pinpoints domain knowledge as one key variable. We'll return to this point later on.

This so-called triangulation strategy obviously is not a cure-all. For example, it may be difficult to find third groups that share variables with the first two groups without introducing further extraneous variables. Even if used successfully, it is like playing "twenty questions" but only being able to ask two ("Are A and B different and if so, is C more like A or B?"). For the strategy to be effective one must either make good guesses about relevant variables or be able to collect data from additional groups to further clarify the pattern of similarities and differences.

At first glance, it might appear that our triangulation strategy is just a 2 × 2 design with one cell missing. But a 2 × 2 design presumes what the triangulation strategy is intended to discover, namely, which factors are crucial to group differences. In fact, the logic of triangulation implies compression of any number of possible 2 × 2 designs that together entail a host of possible explanations for group differences. Instead of running 2^Nth conventional controlled designs, each of which allows inference to a single factor, a carefully chosen third group, C, that resembles the first group, A, in a number of ways and the second group, B, in a number of other ways deliberately confounds a number of variables. This is to enable discovery of the relative importance of the set of culturally-confounded variables by which C differs from A versus those by which C differs from B.

A 2 × 2 design also implies more precise matching and control of variables than is feasible in cross-cultural comparisons. We view the triangulation strategy as having the potential to be applied iteratively at different levels of resolution. For example, suppose we were to find that US experts resembled Itza' experts in some ways but differed from them in other ways. Rather than attributing any differences to culture, one might well attempt to develop another triangular comparison involving Itza' experts, US experts with goals and activities resembling those of the Itza' and US experts with goals and activities distinct from the Itza'. Again, it would be unlikely that one could obtain a precise match on goals and activities but one might well be able to produce greater cross-cultural than within culture similarity in goals and activities.

We have spent a lot of time on methodology because these issues are inherent in comparative research. The remainder of this chapter is organized as follows. We first review some literature that serves to motivate several hypotheses concerning the role of expertise and culture in conceptual behavior. In doing so we will describe another set of studies where we have followed a triangulation logic. These studies undermine the practice of treating undergraduates as prototypical of human categorization and reasoning. Our focus will also be on the assumptions that underlie general models of categorization and category-based reasoning, in particular typicality and diversity. Then we will shift our attention to the question of providing an account of cultural differences. One attractive hypothesis is that differences, including differences associated with type of expertise, can be explained by differences in the characteristic practices and activities that different groups engage in. Attractive though this idea may be, we ultimately find it to be wanting. We conclude with some general observations on the place of expertise in understanding cultural differences.

III. Studies of Culture and Expertise in Folkbiology

The theoretical framework for this project grows out of prior work in anthropology and cognitive psychology, which supports the view that key aspects of folk biology are culturally universal and probably domain-specific. As we shall see in our brief review, these include at least ranked taxonomic hierarchies, a privileged (basic) level, and very likely the presumption of underlying causal structure, or psychological essentialism (Atran, 1998; Berlin, 1992; Medin & Ortony, 1989; Rosch, 1975a, 1975b, 1975c, 1975d). [Footnote 1] In short, cultural differences emerge against a backdrop of universal skeletal principles of conceptual development.

A. Expertise

Boster and Johnson (1989) examined knowledge and sorting patterns among expert and novice fishermen. They note that morphological information (the stimuli were pictures of fish) is available to any observer, but cultural knowledge of functional and utilitarian properties of fish requires experience. Therefore, experts and non-experts should differ not only in the amount of information they possess, but also in the kinds of information. If this information is used in classification, then experts should be more likely to classify along functional and utilitarian lines. As expected, Boster and Johnson found that non-experts relied more on morphological information than did experts. Although similarity judgments of all groups correlated with scientific taxonomy; non-experts correlated more highly than experts. Experts' similarity judgments in turn were more highly correlated with functional similarity. In further support of these differences, 98% of novice justifications were based on morphology whereas only 30% of experts' justifications cited morphology. Based on these results, Boster and Johnson argue that expertise consists, in part, of mastering functional information that goes beyond morphological similarity, and that acquisition of domain knowledge consists of moving not from random to consistent responses, but from readily available default models to newly acquired ones.

Medin, Lynch, Coley, and Atran (1997) addressed the question of inter-expert differences. Instead of comparing the conceptual structure of experts and non-experts, they examined similarities and differences among experts with different specialties within a single domain. They looked at how different types of tree experts (maintenance workers, landscapers, and taxonomists) categorized and reasoned about familiar tree species. Their analysis revealed some common conceptual organization between different types of experts, but also that expert groups differed with respect to the structure of their taxonomies and how they justified or explained the categories they formed. In sorting, parks workers relied on morphological features, while the landscape workers structured their sorts around goal-derived categories based on practical interests (e.g. good shade trees, nice specimen tree that looks nice by itself, etc.) Taxonomists, not surprisingly, sorted largely in accordance with scientific taxonomy. The reasoning of taxonomists and maintenance workers accorded well with the similarity relationships revealed on the sorting task. Landscapers' reasoning could not be predicted from their (goal-derived) sorting; instead, like the parks workers they relied on morphological similarity. Thus, the acquisition of expertise in a particular domain does not necessarily lead to a standardized conceptual organization of information in that domain, though reasoning tasks may reveal more agreement (see Proffitt, Coley, & Medin, 2000, for further similarities and differences among tree experts as a function of type of expertise).

The above studies of expertise clearly indicate an influence of experience in a domain with respect to reasoning and sorting about members of that domain. The way in which people structure their concepts about particular domains depends on both their level of knowledge and the <u>kind</u> of knowledge they possess by virtue of their characteristic goals and activities. In the following section we discuss the ways in which an individual's cultural experience may affect the way he or she reasons.

B. Cross-Cultural Comparisons of Folkbiology

In general, cross-cultural research in folkbiology has pointed to similarities between different cultural groups in their categorization and reasoning about natural kinds. Ethnobiologists studying systems of classification in small-scale societies (e.g., Atran, 1990, 1999; Berlin, 1978, 1992; Berlin, Breedlove, & Raven, 1973, 1974; Brown, 1984; Bulmer, 1974; Hunn, 1977; Hays, 1983) have argued that taxonomies of living kinds are organized into ranked systems. Not only are categories related to each other via class inclusion, but categories (taxa) at a given level in the system also share taxonomic, linguistic, biological, and psychological properties with other categories at that level. Moreover, these regularities in folkbiological classification and nomenclature can be seen in disparate cultures throughout the world. Indeed, these common principles observed in culturally diverse populations are often taken as evidence for universal cognitive constraints on folkbiological thought. Berlin (1992) argues:

> The striking similarities in both structure and content of systems of biological classification in traditional societies from many distinct parts of the world are most plausibly accounted for on the basis of human beings' inescapable and largely unconscious appreciation of the inherent structure of biological reality-- human beings everywhere are constrained in essentially the same ways--by nature's basic plan--in their conceptual recognition of the biological diversity of their natural environment. (p. 8)

These claims are supported by research that extends beyond the cataloging of folk taxonomies. For example, Boster, Berlin, and O'Neil (1986) examined disagreement between Aguaruna and Huambisa Jivaro natives by having the groups identify prepared bird specimens. Although the groups are both from the same region in Peru, their cultures are distinct in the sense that members of the communities are not in direct contact and speak different (but related) languages. Boster et al. found that the two groups exhibit similar disagreement patterns during identification that can be predicted by taxonomic relatedness (both groups are more likely to confuse species that are more closely related scientifically).

Boster (1987) extended the results of these experiments to include a condition where USA undergraduates sorted unfamiliar birds. He presented a subset of the birds used in the Boster et al. in a sorting task and compared sorting distance with Jivaro identification errors to US undergraduates. Specimens that the college students found perceptually similar corresponded with closely related birds according to scientific taxonomy, and also tended to be the ones confused by Peruvian natives. This finding is impressive in that it shows two completely distinct cultures performing quite similarly with the same biological kinds (albeit with somewhat different tasks).

Boster’s findings support Berlin’s claim that diverse groups discern the same sorts of biological kinds in the same ways because of the inter-correlated structure of the biological world (see also Hunn, 1976). There may be universal classificatory principles that interact with the world’s correlational structure with the result that diverse groups of informants choose the same salient features of specimens to construct and distinguish biological kinds. However, there is an alternative view that is also consistent with universal principles. If features are highly inter-correlated, then two individuals (or groups) may attend to different features but produce more or less the same sorts. That is, universal cognitive capacities may be analogous to a mountain river valley, so that no matter where the rain comes it ends up in pretty much the same place. Just so, different experiences may lead to convergence on a common categorization scheme. In short, a shared categorization scheme does not guarantee that different groups conceptualize the kinds in question in the same way. Either alternative of the above possibilities is consistent with findings by Medin et al. (1997) that when different groups of tree experts produce similar sortings of species they may justify them differently (e.g., See also Boster & D'Andrade, 1989).

C. Integrating Culture and Expertise

Combining the studies of expertise with work in ethnobiology suggests the following hypothesis: there is a natural or default categorization scheme sensitive to the structure of nature (relative to the human perceptual system) but experts may develop special-purpose classification schemes as a function of characteristic activities and the additional goal-related knowledge they acquire. Whether experts develop special-purpose categorization schemes may depend on the variety of goals they have with respect to some domain and the degree to which their goals are compatible with the correlational structure of that domain. For example, Medin et al's finding that landscapers but not parks workers developed goal-related categories may reflect the fact that 1. the goals associated with aesthetic appeal and size constraints violate the natural organization of trees so much that landscapers develop a special-purpose scheme whereas the maintenance workers' goal of dealing with disease is compatible enough with natural taxonomic relations that the default organization suffices or 2. landscapers tend to have a single goal (finding the right trees for the right setting) whereas maintenance personnel have multiple goals and the default organization which works pretty well most of the time is overall more efficient than a special-purpose organization for each separate goal. As we shall see, the studies to be described have clear implications for models of categorization and reasoning.

D. Similarity-Based Models of Categorization and Reasoning in Folkbiology

The cross-cultural findings on conceptual organization reported thus far in this brief review are all interpretable in terms of ‘similarity-based models’ (Smith & Medin, 1981), which organize perceptually identifiable categories on the basis of correlation or covariation of stimulus attributes. Category-based induction models of taxonomic reasoning in folkbiology also rely on computations over similarity judgments or their presumed underlying features (Osherson et al., 1990; Sloman, 1993). As we shall see, these models predict diversity effects in reasoning. As was noted earlier, diversity responding is observed with undergraduates and some experts but is not observed in Itza’ Maya elders or in many tree experts.

Lopez et al. (1997) tested for three category-based induction phenomena as defined by Osherson et al. (1990): similarity, typicality, and diversity. We have already discussed similarity and diversity. Lopez et al also derived a metric for typicality from the sorting data. Items that were more "typical" by virtue of having higher central tendency (i.e., high average similarity to other mammals) supported inferences better than items that were less typical (i.e., less similar on average to other mammals). Items that are more typical thus provide greater “coverage” of the category than items that are less typical. Both the undergraduates and Maya showed reliable typicality effects in reasoning. Note that this creates a certain logical tension in that diversity and typicality seem to tap into similar reasoning strategies – “coverage,” at least according to current models of induction. Thus we are faced with the puzzle of why Itza' show typicality effects but not diversity effects.

Subsequent work on direct typicality judgments among Itza' (Atran, 1999) shows that inductively useful notions of typicality may be driven more by notions of idealness than central tendency. For the mammals used by Lopez, et al, central tendency and idealness were positively correlated and the dimensions of perceptual, ecological and cultural salience all appear necessary to a determination of judged typicality. Therefore, it isn't clear whether the typicality effects in reasoning observed by Lopez et al among the Itza' reflect "true" typicality effects rather than ecological reasoning. Proffitt, et al (2000) also examined typicality effects in reasoning among different tree experts. They failed to find any overall typicality effects. There was some tendency to use "local coverage" based on family size (e.g. "the oak family is bigger that the pine family") but direct appeals to typicality were rare in one experiment and totally absent in another. In short, there are no clear-cut demonstrations of typicality effects in reasoning for populations other than USA undergraduates.

So far our analysis has drawn on cross-experimental comparisons and has not been free of speculation. We now turn to a set of studies that revisit our triangulation strategy with the same stimuli and procedures.

IV. Culture and Expertise in Categorization and Reasoning About Birds

Bailensen et al. (2001) studied three populations categorizing and reasoning about birds. The populations were 1. Itza' Maya elders of Guatemala, 2. USA bird experts (bird watchers), and 3. USA novices recruited through ads placed on campus. The experts were ten men and ten women (mean age=51 years) having either occupations or extensive experience related to birds. The average number of years spent watching and studying birds (termed 'birding' hereafter) was 22 years. On a 7-point continuous scale with 1 indicating 'very little knowledge about birds' and 7 indicating 'total expertise', the mean self-reported rating for experts was 5.1. Most of them viewed birding as an extremely involving hobby, often dedicating their vacation time to traveling to places where they could find birds that they had never seen before. The novices were eight men and eight women (mean age=21 years, range: 18-40) who were recruited through the university and paid for their participation. On the 7 point rating scale mentioned above, the mean self-reported rating for our novices was 2.33.   The Itza' informants were eight men and two women (mean age = 66). All were bilingual in Itza' and Spanish, although experimental instructions and responses were in the Itza' language. It was assumed that all Maya elders would be experts given their continuous and extensive experience with forest plants and animals. All Itza' were well acquainted with the experimenters, and at relative ease in the session.

The stimulus materials were pictures of Chicago-area USA birds as well as pictures of birds of lowland Guatemala. The idea was to see if the experts responded differently to local versus exotic species. Itza' can be thought of as novices with respect to USA birds but they have extensive experience with birds that they may bring to bear with novel bird species. Each set consisted of full-color illustrations of 104 bird species laminated onto index cards. For the USA set, illustrations were taken from the Golden and National Geographic field guides, books designed to aid bird identification. The other set ('Tikal birds') was taken from the book The Birds of Tikal (Smithe, 1966). The specific selection of birds was based on the inventory list carried out by the University of San Carlos (Guatemala) for the UN-sponsored Maya Biosphere Reserve.

The structure of the scientific taxonomy representing the US bird was designed to correspond maximally with that representing the Tikal bird set. The Tikal bird set consisted of 30 families and 17 orders, while the US bird set consisted of 33 families and 17 orders. One notable difference was in the number of passerines (songbirds) in the two sets. Although passerines are the numerically dominant group both in Chicagoland and Mayaland, they are somewhat more prevalent in Chicagoland. There were some birds and taxonomic groups that were common to both sets (18 shared orders, 12 shared families, 12 shared genera, and 5 shared species).

In the first study we asked participants to sort pictures of local and exotic birds into groups that “go together by nature.” In our experience this instruction is more useful in eliciting taxonomies than more abstract instructions to sort things into groups based on their similarities. Especially for non-undergraduate populations the latter instruction is often met with puzzlement and questions such as “similar in what way?”.

The main goal of this study was to compare within and across group patterns of sorting. In that regard there are two important questions: 1. Do people within a group agree sufficiently in their sorting that it is sensible to claim that there is a consensual cultural or group model? 2. Are the patterns of sorting reliably different across groups. To address these questions we use the cultural consensus model (CCM), allowing us to compare one cultural taxonomy to the other ones. To do this we look at patterns of residual agreement. If there is a single consensus across groups then the CCM should provide a good fit to the aggregate data. If the groups differ, however, then individuals within a group should agree with each other to a greater extent than is predicted by the overall consensus analysis.

What should we predict concerning agreement across groups and agreement with scientific taxonomy? Based on the work of Boster and his associates, we might expect that novice sortings would correlate highly with scientific taxonomy. Whether the two experts groups show a strong correlation with science hinges on whether or not they have specialized goals. Given that the primary goal of birders is to identify birds, we see no reason for expecting that their goals violate the correlational structure of bird taxonomy. Both bird identification and traditional taxonomic systems are based on morphological similarities and differences. If this analysis is correct then both US experts and US novices should base their categorization of both US and Mesoamerican birds on the natural or default taxonomy and show good agreement with scientific taxonomy.

It is less clear what to predict for the Itza' experts. On the one hand, they do have specialized goals with respect to some birds (e.g., hunting them for their meat) but, on the other, our prior work suggests that they have rich ecological knowledge concerning relationships between particular kinds of birds and both plants and other animals (Atran, Medin, Ross, et al, 1999). The latter observation suggests a general purpose (default) representation. If the Itza' have both special-purpose and general purpose representations, then we would expect that the special-purpose representation would be much more evident in their sorting of familiar Mesoamerican birds than the unfamiliar US birds.

All participants were tested individually. They were told that we were interested in how they organized their knowledge about birds. First, we showed them all 104 bird cards one at a time and asked them to name them 'as specifically as possible.' Next, all

104 cards were placed in front of the participant, who was asked to 'put together the birds that go together by nature into as many different groups as you'd like.' The experimenters recorded these initial categories and asked the informant to explain their basis for each category. Subjects were then asked to combine the initial categories by 'putting together those groups of birds that go together by nature into as many larger groups as you'd like.' Successive compiling was repeated until the informant indicated no further grouping seemed to be natural. At this point the initial sort was restored and participants were invited to 'split as many of the groups as you'd like into smaller groups of birds that go together by nature.' The subpile sorting was repeated until participants indicated that no further subdivisions seemed sensible.

A. Naming Accuracy

The naming data are useful in providing an independent index of expertise and relative familiarity with the two picture sets. We scored each naming response on a three-point scale, with a 3 representing an exact species match, a 2 representing a correct genus match, and a 1 representing a match at order or higher (i.e., a 'bird' response was scored a 1). For the Itza' this measure is somewhat conservative in that, unlike novices, they rarely said "bird" and instead often used intermediate categories such as "flesh-eating bird." The three groups named all the birds from both stimulus sets except the Itza', who only named birds from the Tikal set. Experts were more accurate at naming US birds (<u>M</u> = 2.55) than Tikal birds (<u>M</u> = 1.66), but novices showed little difference (<u>M</u> = 1.25 for US birds versus 1.14 for Tikal birds. These results establish that the US experts were more familiar with the US birds than the Tikal birds and that their naming skills were superior to those of novices for both sets of birds. The Itza' averaged 1.92 for Tikal birds and were less accurate at naming passerines (M = 1.39) than other birds (M = 2.11). Notably, USA experts were equally good on passerines and non-passerines.

B. Sorting

We used each informant's hierarchical sorting to derive a bird-bird distance matrix. First, a hierarchy was derived from each informant's initial sort, successive compilings, and successive splittings. Then, the lowest level at which any two birds were joined in a single node was taken as the distance between those birds. The distances corresponding to all possible pairs of birds were then combined as elements in a (symmetric) bird-bird distance matrix. (This yielded one such matrix for each informant.) We then computed the correlations between each informant's matrix and every other informant's matrix, which yielded a single informant-by-informant pairwise correlation matrix, representing degree of agreement for all possible pairs of informants.

1. Combined Consensus

We first applied the CCM to the full set of data to see if there was an overall consensus. There was: the ratio of the first factor to other factors was high and accounted for a large proportion of the variance. Although we observed robust overall agreement, this was coupled with reliable group differences. For the US birds all three groups showed significant residual agreement. That is, in sorting US birds, each group's sorts show internal consistency beyond that captured by the consensus across groups. For Tikal birds, there was significant residual agreement for novices and Itza' experts. Apparently, the first factor accounted for almost all of the consensus for experts. These results point to differences in the taxonomies produced by each group, which we will take up in detail shortly.

2. Correspondence to Scientific Taxonomy

In order to compare performance from each group to science, we used the scientific taxonomy to derive a pair-wise bird-by-bird folk taxonomic distance matrix by calculating the distance between all possible pairs of birds in the taxonomy. We used classical evolutionary taxonomy because it represents a reasonable compromise between similarity-based, phenetic, or numerical taxonomy and theory-based, cladistic, or phylogenetic taxonomy (see Lopez et al, 1997, for further discussion). We then compared the average matrix from each group to the science matrix. The mean correlations for each of the groups on the US birds were .38, .60, and .45 for novices, USA experts, and Itza' experts, respectively. Note that Itza' sorts agreed more with science than did novice sorts. The mean correlations for each of the groups on the Guatemalan birds were .34, .70, and .61 for novices, USA experts, and Itza', respectively. Again, Itza' sorts corresponded more closely with science than did novice sorts. This result is the opposite of the Boster and Johnson (1989) findings for commercial fishermen.

In summary, the data on correspondence with science reveal no evidence that expert sorts deviate more from science than novices. For USA experts this result is not surprising in that their primary goal is identifying birds and they often use guides that are organized in a manner concordant with scientific taxonomy. But what accounts for the relatively high Itza correlation with science? There are three potential explanations that await further research. One is that Itza' interact with birds using multiple goals which makes a general purpose representation fairly efficient. The second possibility is that that it just happens that the special purpose (goal-related) representation that the Itza' develop of birds corresponds more closely with scientific taxonomy than the special purpose representation of commercial fishermen corresponds to fish taxonomy. In short, the comparisons of Itza' and commercial fishermen may confound goals with domain. What is needed is a study where the domain is held constant and goals are varied across groups.

The third explanation focuses not on the Itza' but on the novices. Their correlations with science are reliable but quite low, in no case accounting for more than 16% of the variance. We take this as evidence that the structure of nature is not nearly so transparent as previous researchers have suggested (or perhaps that the structure of nature is not as transparent in pictures of birds as it is in pictures of fish). It may be that our novices have had so little by way of meaningful interactions with birds that they have failed to learn which aspects, features, or dimensions are most relevant to organizing and classifying birds.

There is some evidence that provides clear support for the third interpretation. Johnson and Mervis (1998) tested bird experts, fish experts and novices on a triads task where participants were asked to pick out the two animals that were "most like the same kinds of thing." Some triads pitted overall morphological similarity against taxonomic membership. Not only were birds experts more likely to make the taxonomic choice for birds and fish experts to make the taxonomic choice for fish but also these two types of expert were substantially more likely than novices to pick the taxonomic choice for the domain where they lacked expertise. Johnson and Mervis suggested that experts had learned to weight modified parts as much as features more related to overall similarity in contrast with novices who apparently gave the latter type of feature more weight. In short, the Johnson and Mervis findings support the idea that some combination of perceptual learning and what they referred to as “intuitive theories” (e.g. understandings of the functional significance for the animal of different features) leads experts to organize biological kinds in a manner closer to scientific taxonomy. Our results are consistent with this general interpretation in that the two groups of experts were clearly using information not reflected in the novice sorts. In short, expertise appears to involve more than a passive reception of real world structure---it includes learning to attend to the features and relationships that are most informative (see also Boster & D’Andrade, 1989, which does not necessarily correspond with overall similarity).

3. Cluster Analysis

A matrix representing mean pair-wise distance between all birds was subjected to cluster analysis, using the average link method (Sokal & Sneath, 1973). On both sets of birds, the three groups showed overall similarly coupled with systematic group differences. In all the taxonomies there were groups of predators, game birds, water birds, hummingbirds, woodpeckers, to name a few. Some notable differences in the taxonomies are as follows. Whereas US novices and US experts generally kept Passerines (small songbirds) together in a large single group, the Itza’ experts had them spread out more across the taxonomy in a few different clusters.

We also found a difference in subjects’ sorting of ‘water birds.’ On the USA bird set, USA experts had a large "water birds" cluster, featuring ducks, grebes, geese, "shore birds" and herons/egrets. This cluster was fairly isolated from the rest of the taxonomy. Although novices also had a water bird category, it was more spread out, was not as isolated from other birds, and was interrupted by non-water birds, such as gamebirds, nightjars (birds that eat insects while they are flying), the pigeon, and the turkey vulture. This also reduced the correspondence of novice sorts to scientific taxonomy.

C. Category-Based Induction

We used the data from the sorting study to develop typicality and diversity probes to see how participants use bird categories and salient examples of birds in reasoning. We focused on two phenomena: typicality and diversity. According the category-based induction model of Osherson, et al ,1990), both of these phenomena hinge on coverage. The typicality phenomenon predicts that a more typical instance promotes stronger inferences to a category 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.

Given the results from Lopez et al. (1997) and Proffitt et al. (2000), we expected that US novices should exhibit more diversity responding than either of the other two groups. It would not be surprising if the US bird experts showed some modest amount of diversity responding given that they are quite familiar with the scientific taxonomy. Overall, however, our hypothesis is that domain knowledge makes it less likely that a person will employ abstract reasoning strategies. Instead we expect to observe more concrete justifications such as the ecological/causal reasoning.

1. Properties for Induction

Based on previous work we decided against using identical properties for the Itza' and US induction probes. Half of the probes involved disease and this was constant across groups. For the other half we used "enzyme" for North American subjects and "little things inside" for Mesoamerican subjects. We piloted both terms with both groups. We found that North American adult participants are confused by "little things inside" but not "enzyme," "protein" or "disease X", whereas Maya subjects were confused by "enzyme" and "protein" but not by "little things inside" or "disease X." Earlier studies show that the patterns of results on different kinds of biological induction tasks for American undergraduates were statistically the same for "enzyme" and "disease," whereas the Itza' showed the same patterns of results for "little things inside" and "disease" (Atran et al.1997, Coley et al. 1999). As in the sorting study we used probes involving both USA birds and birds of Tikal.

For both kinds of probes we presented two pairs of birds and then asked about the property in question (disease, enzyme, or little things inside). For example, for the typicality trials, we displayed both birds in each pair and said:

> "Let's assume that we discovered two new diseases. All we know about these diseases is that Disease A is found in these types of birds and

Disease B is found in these. Which disease do you think is more likely to be found in all birds? "

Similarly, for the diversity trials, we placed one pair of birds on the left-hand side and one pair of birds on the right hand side, and asked the same question.

2. Typicality Results

There were no differences as a function of property so we collapsed across this variable. Only the undergraduates (novices) showed any indication of a typicality effect, making typicality-consistent choices on 78% of trials. The experts and the Itzaj' showed no reliable preference for high-typicality probes (57% & 50% typicality-consistent choices, respectively).

A look at the justifications for choices confirms this pattern. The most striking difference is that novices use typicality as a reason for the choice more than half of the time, while experts and Itza' *never* indicate typicality. Both Itza' and US experts tended to use range or ecological factors as justifications.

3. The Passerine Effect

We also analyzed the responses to the probes not simply in terms of typicality but also in terms of whether one of the birds in a pair was or was not a passerine. The US experts and novices chose the passerine over the non-passerine (66% and 86%, respectively) more than the Itza' (40%). In short, the Itza' experts tended to avoid passerines in their choices while the USA participants tended to choose them. As we will see, this difference probably derives from the salient role of nonpasserines in Itza' Maya folkbiology.

4. Diversity

Again there were no differences as a function of property so we collapsed across this variable. Across conditions, US experts chose the more diverse pair on 60% of the trials, the novices 58%, and the Itza' 45%. None of these percentages differed reliably from each other or from chance (50%). The diversity pattern for the experts was largely driven by two experts. The justifications are once again informative. The novices tended to use either typicality or diversity as a justification. Interestingly, they appeared to show something of a "learning effect" in that diversity justifications increased from 17% to 43% from the first to the second half of probes. It was as if once they hit upon this strategy, they thought it was a good one and tended to continue using it. Two experts gave almost exclusively diversity justifications but the other USA experts and Itza' predominantly responded in terms of ecological/causal relations. (Experts and Itza' showed no changes in patterns of justifications between the first and second half of probes).

5. The Passerine Effect Again

The US populations tended to choose probe pairs involving passerines while the Itza' tended to avoid them. This passerine effect suggests that the idealness of the birds may be driving our results more than coverage. To the Itza', passerines are not considered "true birds" to the same extent as other birds in the environment. Even though 'passerine' was rarely cited as a justification, American subjects tended to pick small songbirds as generalizing to the population of all birds while the Itza' preferred larger, more perceptually striking birds. Given the prominent role of the larger game birds in the behavioral ecology of Mayaland, and the more interactive goals of Itza' in monitoring their ecology, then the information provided by their ideal birds would be more relevant to environmental understanding and management than information provided by songbirds. Itza' preferentially monitor those species in their ecosystem (e.g., game birds as opposed to passerines) that provide the most relevant information about the interaction of human needs with the needs of the forest: for example, Itza' tend to have the most detailed knowledge of, and to best protect, those species that are perceived to have the most interactions both with other species and with humans (Atran et al., 1999). For the Americans, whose interest in and interaction with the behavioral ecology is of a much reduced and altogether different order (game birds are not considered palpably crucial to survival of the human habitat), correlated perceptual information may be more relevant by default.

D. Summary of Bird Studies

Our triangulation strategy once again proved to be quite useful. For a number of important phenomena US and Itza' experts clustered together and contrasted with US novices. First of all, the expert groups sorted in closer correspondence with scientific taxonomy than did novices. This difference is particularly striking for the Itza' for US birds because they were unfamiliar with western science, scientific taxonomy and the birds employed. US novices had prior exposure to the birds and to western science but their sorts corresponded less well with scientific taxonomy than those of the Itza'. This finding gives no comfort at all to relativists who see each culture as the single most important factor in conceptual organization. For that matter it also is inconsistent with the opposite extreme view that everyone naturally perceives the structure of nature unless goals and activities foster a special purpose categorization scheme. Instead our data suggest that expertise confers benefits in abstracting important relationships in nature and, as a consequence, may lead to greater correspondence with scientific taxonomy. In that regard our results are well-anticipated by the findings mentioned earlier by Johnson and Mervis (1998) who showed that bird and fish experts were better able to apprehend relational features tied to function and ecology than novices.

The category-based induction findings also reinforce the view that the novices were the 'odd group out.' Novices relied very heavily on familiarity or typicality as the basis of their choices on both the typicality and diversity trials. Neither the Itza' nor the US experts *ever* gave typicality as a justification for either type of probe. Instead, they used knowledge about birds that the novices did not possess. For example, both the Itza' and US experts frequently mentioned the geographical range of birds, an explanation that the novices rarely produced. This is a truly striking qualitative difference.

In our reasoning studies, typicality strategies are reliably used only by US novices (undergraduates). Consequently, models invoking these principles may apply solely to situations where novices are reasoning about stimuli with which they have limited knowledge. Most work on the role of typicality judgments in natural categorization and reasoning stems from studies with college students. Those studies tend to support the view that similarity-based structures (e.g., central tendency, family resemblance) are the primary predictors for typicality in taxonomic categories, in general, and folkbiological categories, in particular (Rosch & Mervis, 1975; Barsalou, 1985). In this view, the mind's similarity judgments about typicality and the world's correlational structure are closely linked: typical members of categories capture the correlational structure of identifiable features in the world better than do atypical members. But for Itza' Maya, passerines are not very typical at all. One way to follow up these findings would be to study US hunters who target gamebirds such a turkeys, grouse, partridges, ducks and geese. They might look more like the Itza' with respect to the passerine effects than other US groups.

Both US experts and novices used 'diversity' as a justification for a modest minority of probes. Itza' did not. But even in this case the differences with expertise loom larger than the similarities. Two bird experts produced virtually all the expert diversity justifications and this pattern did not change across the test session. Novices, in contrast, gave more than twice as many diversity justifications in the second half of the tests as in the first. Apparently, once they thought of it, novices found the diversity justification intuitively appealing.

No doubt similarity structures and similarity-based typicality and diversity are important determinants in natural categorization and reasoning. Our findings suggest that, at least for American undergraduates, these may be dominant factors. But for our relative experts (US experts and Itza'), who have substantial knowledge, goals and activities about the items they classify and reason with, information other than that derived from perceptual clustering and similarity judgment is relevant to understanding natural biodiversity. Behavior and ecology, for example, appear to be crucial to the deeper and broader understanding of nature that birdwatchers seek. Such concerns also may be critical to the way the Maya and perhaps other peoples in small-scale societies manage to live and survive with nature. If so, then it is practically impossible to isolate folkecological orientation from other aspects of cultural knowledge.

E. A Practice Account?

So far almost all of the data we have reviewed could be captured in a general framework where categorization and reasoning are driven by the amount and type of experience. Although we have referred to bird watchers and Itza' as experts, which implies that they deviate from the norm, it may be useful to consider the possibility that undergraduates deviate from the norm in having very few meaningful interactions with plants and animals. A lack of adequate input and cultural support may lead to a devolutionary pattern (Ross, in press; Wolff et al., 1999). For example, a devolutionary shift of the basic level from oak, trout, and bluejay to tree, fish, and bird strongly limits the possibilities for input about ecological relationships. In other work we have evidence that children's understanding of biology is heavily influenced by opportunities for direct experience (compare Carey [1985] with Atran et al. [2001] and Ross, Medin, Coley, and Atran [2001]). So *amount* of experience matters. *Type* of experience or practices may determine whether people develop general-purpose versus special-purpose (goal-derived) taxonomies (again see Barsalou, 1985). Differences in activities, practices, and goals may lead to differing conceptions of nature (Hatano & Inagaki, in press, Vygotsky, 1978, Wertsch, 1991, 1998, Medin, et al., 1997).

Although the practice account is a useful research heuristic and general framework, we see two major limitations of it. First, for an examination of cultural practices to be useful, a theory is needed about which practices are relevant and how these practices affect mental representations. Second, there is suggestive evidence that shared practices do not guarantee shared mental representations. In related work we have found that Itza' share with other cultural groups (e.g., Spanish-speaking Ladino immigrants, Highland Q'eqchi' Maya immigrants) an identical habitat, a similar taxonomic understanding of its flora and fauna; and common agro-forestry and hunting and gathering practices. Nevertheless, these different cultural groups cognitively model species relationships (including humans) and socially interact with the same local ecology in fundamentally different ways (Atran et al. 1999). Unfortunately, the Atran et al, 1999 comparisons do not fully control for amount of experience as the Itza' are indigenous to the Lowlands whereas the other two groups have immigrated to the area (albeit more than 20 years ago). (Note, however, that we also find clear differences between the two migrant groups that cannot be explained by a difference in years of residence). We now turn to some recent studies we have been conducting with two cultural groups where the practice account would predict no differences but we nonetheless find differences. In the remainder of this chapter we describe these differences and how they may be modulated by expertise and then turn to theoretical accounts of such differences.

V. The Role of Culture and Expertise in Freshwater Folk Ecology

Medin et al. (2001) studied the freshwater folk ecology of non-professional fish experts of two populations in rural north central Wisconsin. The two populations were 1. Menominee Native American Indians and 2. majority-culture individuals living in a community next to the Menominee reservation. (Note: Compared to the previous study, this research includes a common environment for the two populations with equal familiarity with the species under examination.)

The Menominee are Native American residents living on their reservation in north central Wisconsin. They are well known for their sustainable forestry practices (Hall & Pecore, 1995) and most adults engage in outdoor activities such as hunting and fishing. As with the Itza' Maya only (a few) older people speak Menominee and English is used in the daily interactions among the tribal members.

Just south of the Menominee reservation is Shawano County, the other focal area for our study. Again, many people engage in hunting and fishing as outdoor activities. Members of the community are mostly of the majority culture.

From each group about 15 expert fishermen were individually interviewed on a series of tasks. Participants were selected based on peer nomination ("who are the experts in your community?") and a species familiarity task to establish a common level of expertise. Overall, there were no reliable between group differences with respect to numbers of fish correctly identified and on average experts were familiar with about 90% of the 44 species of fish we used. Participants in both groups were male and did not differ in age (mean: 45 years for majority culture experts and 49 for Menominee experts), fishing experience (mean: 38 years for majority culture experts and 44 years for Menominee experts) or formal education.

Although further interviews revealed differences with respect to goals (sport fishing for majority culture members versus fishing as a food source for Menominee) with consequential differences in certain activities (catch and release for the majority culture individuals versus consumption of the fish for the Menominee) the primary goal of members of both groups is catching fish and they target the same fish species. (Obviously these general descriptions gloss over within group differences. Often majority culture individuals eat fish and many Menominee perform catch and release at least some of the time). Given these similarities, a practice account would predict the members of the two groups to be similar with respect to their categorization of fish species. However, we do find striking differences on several levels.

A. Sorting

In a task similar to the ones described in the López, et al study (1997) and the Bailenson, et al (n.d.) we asked each informant to sort name cards of 44 fish species that broadly represent the fish genera and families found in this part of Wisconsin. Our sample was somewhat biased toward larger fish. Both the actual sorting as well as the justifications were recorded and analyzed. Analyses were conducted as described previously, using individual species distances to calculate agreement and the CCM to test for patterns of agreement and disagreement.

1. Consensus

A CCM across all informants showed clear cross-cultural agreement as would be expected from previous accounts of the universality of taxonomical sorting. However, an analysis of residual agreement (see Nakao & Romney 1984) revealed clear group differences. Menominee informants but not majority culture informants displayed greater within-group than between group agreement. This suggests that the Menominee and majority culture informants share a common cultural model of fish categorization but that the Menominee, in addition, share a somewhat distinct conceptual organization of fish.

2. Justifications

To analyze justifications, we categorized responses as involving taxonomic or morphological properties (e.g., bass family), ecological properties (e.g., river fish, bottom feeders) or goal-related properties (e.g. game fish, garbage fish). Menominee informants were more likely to give ecological justifications than were majority-culture informants (40% versus 6%). Majority-culture informants were more likely to base their sorts on morphological/taxonomic features (62% versus 33%). Members of the two cultures were about equally likely to give goal-related justifications (27% and 32% for Menominee and majority-culture informants, respectively).

To further explore these differences we applied multidimensional scaling to the consensual sorts of each of the two groups. For the majority culture experts a one-dimensional solution accounted for 86% of the variance and a two-dimensional solution accounted for 96% of the variance. The corresponding figures for the Menominee were 62% and 86%, with a three–dimensional solution covering 94% of the variance. Using the sorting justifications to categorize a fish as desirable (+1), undesirable (-1), or neutral (0), we found a +0.67 correlation between the first dimension and desirability for the majority culture sorts. The second dimension correlates reliably (-0.54) with characteristic adult size (as determined by consulting fish guidebooks).

For the Menominee we used the sorting justifications to categorize each fish as mainly associated with lakes and ponds (+1), mainly in rivers and streams (-1), or about equally in rivers and lakes (0) (assignment was made only if at least 75% of the informants named the particular location). This habitat factor correlated +0.72 with values on the first dimension. Desirability, again determined by the sorting justifications (different for Menominee than for majority culture informants), correlated +0.82 with value on the second dimension, and size correlated +0.60 with value on the third dimension.

These data indicate that levels of expertise (knowledge of a domain) and kinds of expertise (practice and goals) cannot fully account for how individuals categorize living kinds.

3. Correlation With Scientific Taxonomy

Not surprising, scientific taxonomic distance and the distance in each group's consensual sorting overlap extensively. The correlation was +0.62 for the majority culture experts and +0.60 for the Menominee experts. This is in the same range reported as documented in the studies mentioned before. The justification data also suggest that the majority culture experts are somewhat more likely to have categories organized around evaluative dimensions (e.g. prestigious sport fish, garbage fish) than the Menominee. Both groups, however, showed a dimension correlated with desirability in their MDS solutions. In general we believe it is important to look beyond the actual sortings by analyzing the "why" of the specific sorts, the individuals' justifications. Obviously, correlated values or features represent a significant potential source of cross-group agreement and a potential challenge to understanding differences. For example, baitfish tend to be small and gamefish large, so it is not surprising that the MDS solution revealed a reliable correlation with size, despite the fact that no expert mentioned size as the basis for sorting. Similarly, there is a correlation between game fish categories and taxonomic relatedness such that the clustering data can be interpreted either in terms of taxonomy or goal-derived categories. In sum, even if we control for levels and kinds of expertise we still detect differences in how members of different cultural groups sort living kinds.

B. Species Interactions

In order to explore these differences further we conducted two more tasks. In the first we explored the perception of species interactions. This task was designed after a task used with forest species in Guatemala (Atran et al., 1999). Again, on many grounds one would not expect to observe group differences in perceived fish-fish interactions. First of all, informants from the two groups engage in more or less the same activities in terms of when and how they fish (hook and line). Secondly, goals and activities associated with fishing are intimately intertwined with fish-fish interactions. To be successful in fishing, one needs to know where fish are found and what they are eating. Food chains are an important component of fish-fish interactions. Third, our experts have been fishing on average for several decades and one might expect a convergence of knowledge, especially when that knowledge is relevant to certain activities.

Twenty-one familiar species were selected from the larger set of 44 species and represented on name cards. To the informants the task was described as follows: "The following task is about relations between different kinds of fish. For each single pair of fish we want you to think about whether the two species involved have any relations with each other. If so, please tell us about the kind of relation they have. By relation we mean whether one kind of fish affects the other kind or vice versa.“

The experimenter then randomly picked one fish as a base-card and compared it with every other species (presented in random order). For each informant, this procedure yielded 420 potential fish-fish relationships. For each fish-fish pair, the informant was asked if the base species affects the target species and vice versa (e.g., “Does the northern affect the river shiner?” and “Does the river shiner affect the northern?”). Informants were then asked whether the species affect each other in other ways. Responses were coded into 19 categories such as A eats B, A eats the spawn of B, A helps clean the bottom that helps B when it spawns, and so forth. Food-chain relations (A eats B) comprised the most frequent response.

Again the cultural consensus model was used to probe for a single, general cross-group model for fish-fish interactions, as well as for each group's particular cultural model. Agreement between two informants was calculated as the average agreement over all 420 cells (21*21 species, without diagonal values). Agreement was assessed on four levels: (1) both informants reported some kind of relation (no matter what the specific relation was), (2) both agreed on either a positive or a negative relation (no matter what the specific relation was), (3) both agreed on a food-chain relation and (4) both agreed on a reciprocal relation (no matter what the specific relations were).

Agreement was adjusted for guessing and for individual response biases (see Medin et al., 2001, for the specific calculations) in order to explore differences of agreement pattern (and the existence of cultural models) that are based on actual knowledge differences[i], rather than response criteria or biases alone. CCMs were performed both on raw agreement as well as on the adjusted agreement. For both raw and adjusted agreement we found consensus for the combined meta-cultural model as well as for separate cultural models on three levels: (1) existence of a relation, (2) helping /hurting relations, and (3) food chain relations. We found consensus for reported reciprocal relations only with respect to raw observed agreement.

As expected, for each coding scheme consensus is considerably stronger for the analysis over observed agreement than over adjusted agreement. This difference is particularly strong for reciprocal relations, where we find no consensus for adjusted agreement (neither for both groups taken together nor for each group considered individually). For the raw observed agreement the high number of “no reciprocal relations reported” drives the consensus, an effect that is removed by the adjustment for guessing and response bias. Nevertheless, the Menominee still show above chance agreement for the adjusted reciprocal relations: 69% of the agreement pairs are positive (by chance, half should be positive). Cross-group agreement is very close to chance (48% of agreements).

Overall, the data indicate high agreement within and across groups for the different levels of encoding the data. Nevertheless, analyses of agreement on reciprocal relations show significant differences in the elaboration of cultural models. For all relations cited by at least 70% of the members of one group, we further find that: (1) 84.5% are reported by both groups; (2) 14% (45 relations) are reported by Menominee but not majority culture; and (3) 1% (4 relations) are reported by majority-culture but not Menominee experts. Overall, Menominee report reliably-more relations than their majority-culture counterparts (62% vs. 46% of the possible relations). In short, the majority-culture ecological model appears to be subset of the Menominee model, a finding that parallels our results from the sorting task. On a more specific level Menominee experts report significantly more positive relations (one species helping another) than their majority culture counterparts do while members of both groups mention about the same number of negative relations. As we anticipated, there were no reliable differences in reported food-chain relations.

The groups differ substantially with respect to reciprocal relations. On average, Menominee informants mention 59.5 reciprocal relations compared to 34.6 for majority-culture fish experts. Majority culture experts differ from their Menominee counterparts in that they are likely to report the prototypical adult-species relation. For example, majority culture experts are likely to report that northerns eat walleyes and not mention that a large walleye may eat a small northern.

In summary, the two cultures share a substantial amount of knowledge of species interaction. This should come as no surprise. Much of expert knowledge stems from actual observation while looking for fish, fishing, and even from cleaning the catch (e.g. stomach contents usually tell what the fish had been eating recently). However, the task also reveals clear cultural differences in the models of the individuals. These differences may be caused by the fact that the responses of majority culture informants concerning ecological relations seemed to be filtered through a goal-related framework. Goals may influence reports of ecological relations in at least two ways. One is to focus on ecological relations that apply to adult fish rather than those associated with the entire life cycle. And indeed, many of the relations reported by Menominee experts but not majority culture experts involve spawn, fry, or immature fish. The second difference is that relations present in pursuing goals may be "over-generalized" in the sense that they may be reported where they do not apply. Majority culture experts tend to report baitfish being affected by predator fish, even when the particular baitfish and predator tend not to be found in the same waters.

This suggests that some of the differences observed are more the effect of "habits of the mind," e.g. the higher saliency or accessibility of some knowledge over other knowledge. If this is correct, we might expect that the cultural differences in ecological knowledge would disappear if we used an unspeeded task directly probing for ecological information. In a final experiment we asked the experts to sort local fish species according to where they are found.

C. Ecological Sorting

Name cards of 40 local species were used with the following instructions given to each informants: "Please put those fish together that live together, that share a common habitat." We also told the informants that a given species could appear in more than one group. If an informant noted that some fish lived in two different habitats (such as river and lake) a copy of the name card was made, so that this species could be included in different piles. There was no limit on the number of groups a given species could be placed into and name cards were added as needed. After the initial sorts were constructed, the informant was asked if he would like to further divide these piles into coherent sub-piles (e.g., making finer differentiations with respect to the habitats).

Informants were asked to ignore seasonal differences in habitats (spawning season etc.), and to give their general assessment over the whole year (dominant habitats). Once all the groups were established, we asked each informant to give a short description of the type of habitat (e.g., clear, fast running water).

As in the above analyses, CCMs were performed both across groups and within each group. The principal components analysis showed a strong consensus across the experts. This means that a great deal of the experts' knowledge is shared across the two cultural groups. No group differences were found in first or second factor scores. In addition, an analysis of the pattern of residual agreement also failed to reveal any cultural difference (for both groups within-group residual agreement did not differ reliably from cross-group residual agreement). In short, both groups share essentially the same model and knowledge base. This finding is important on two accounts. First, it provides converging evidence that our informants do not differ in expertise per se. Second, the data support the idea that the cultural differences lie in accessibility of knowledge or "habits of mind" rather than knowledge per se.

VI. Revisiting a Theory of Culture: Experts and Non-Experts

Compared to the cross-cultural studies previously reviewed the studies with fish experts have the advantage that they compare individuals of different cultures, controlling not only for expertise but also for practices and environmental input. Therefore the cultural differences found cannot be explained by either experience alone (a possibility not ruled out for the comparison of Itza' Maya with Michigan students) or practice related experience (as found among tree experts in the USA). We labeled these differences cultural, a fact that brings us back to the issue of a theory of culture. Where do these differences come from and what are the factors causing them? What is "cultural" about these differences? In a sense our use of culture is similar to most of cross-cultural research, in that it targets more or less well-bounded entities that correspond with our folk notion of culture (e.g. Itza' Maya, Menominee, majority culture).

In the course of this paper we have drawn some distinctions that should make it clear that by culture we do not mean a simple pattern of agreement on any fact, belief or issue as suggested for example by Strauss and Quinn (1997) or Brumann (1999). What then is culture and how does it emerge? Obviously, there has to be something shared about culture that allows us to detect and predict patterns of agreement based on group assignments. Using these group assignments as causal factor, however, doesn't really help us. If we exclude the notion of genetically-transmitted cultures (an argument that is often not excluded in folk concepts of culture!), we are only left with an explanation of these differences as part of a learning process. Looking at it this way, it seems sensible to start with clearly defined (and often self-defined) social groups because the developmental processes take place (at least in part) within these groups. This is not to say that no other sources or factors are present [Footnote 2]. However, access to particular information is often confined to these social groups. We have to understand the input and output conditions of ideas in order to understand their development and change. These conditions can be both physical and social in nature and may include established norms and values, but also behaviors and the physical environment. Having identified differences across experts of two different groups does not necessarily mean that we should expect to find the same kinds of differences among non-experts. Underlying processes associated with becoming an expert may not be the same in different cultures. This leads to the question of how Menominee and Majority Culture non-experts fare on the tasks described above. In general three possibilities exist: (1) Experts of two cultures agree more with each other than non-experts do. (2) Experts of two cultures agree to the same extent as non-experts do. (3) Experts from two cultures agree less with each other than non-experts.

Possibility 1 is more or less in accordance with the view that universal phenomena are basically due to converging observations of differences in the real world. In this view the more observant individuals should agree with each other more (across culture) as an effect of their common observations. Possibility 2 would suggest that some kind of cultural knowledge prevails throughout the process of becoming an expert, while Possibility 3 would indicate that the process of becoming an expert includes not only "neutral" observation, but actually the development and elaboration of more specific cultural models and ideas. This line of reasoning suggests the usefulness of varying degree of expertise in studies of cultural differences in (biological) cognition. In the final section of this chapter we present preliminary findings of studies undertaken with Menominee and majority culture non-experts, again within the domain of freshwater ecology. Individuals were selected from the same locale as described above. To foreshadow the results: We find differences between non-experts that parallel differences between the experts, indicating in a sense, that "habits of mind" are involved in the folk ecological reasoning of both experts and non-experts.

So far we have held expertise constant at a high level and noted differences between cultures. But separating culture from expertise experimentally does not mean expertise is independent of culture. We have recently begun to explore this issue with Menominee and majority-culture non-expert fishermen. So far we only have data on unconstrained sorting. We'll describe these data and then examine their implications for understanding the role of culture and expertise in the people's conceptual organization of fish.

Participants came from the same communities as the experts of the above studies, but were not regarded as experts by other members of their community. Again peer nomination and by a species recognition task was used to identify non-experts. These non-experts tended to be familiar with about 75% of the fish, compared with 90% for the experts. This difference is robust and there are no cultural differences in familiarity.

A. Consensus Analyses

A principal-components analysis showed an overall consensus among non-experts. The two groups did not differ in how strongly they loaded on the first factor; that is, neither group seems to agree with the overall consensus more strongly than the other. Recall that Menominee expert informants showed within-group residual agreement that indicated they had a distinctive model not shared by majority-culture experts. Among non-experts, we found distinct submodels for both groups. An analysis of residual agreement among non-experts indicated that each cultural group showed reliably greater within group than across group residual agreement. In short, we see cultural differences among non-expert fishermen.

The next question then is how these non-experts compare to the experts. To answer it, we submitted all of the experts' and non-experts' sorts to a single principal-components analysis. This analysis revealed a fairly strong overall consensus. The first root is large relative to the second and accounts for 49% of the variance. All informants had positive loadings on the first factor. Majority-culture informants (mean loading = .74) agreed more strongly with the overall consensus than did Menominee informants (mean loading = .62). There was no reliable effect of expertise on first factor scores. In short, there is an overall consensus along with cultural differences in the level of agreement with this overall model.

An analysis of residual agreement reinforces this picture of cultural differences. Each of the four culture-expertise groups was evaluated for its within-group residual agreement, and this within-group agreement was compared to the group's average residual agreement with each of the other three groups. This revealed that Menominee experts and non-experts agreed more highly with each other than with either of the majority-culture groups. Likewise, majority-culture non-experts agreed more highly with each other than with either of the Menominee groups. In neither cultural group did experts differ reliably from non-experts, nor did majority-culture experts show reliably more within-group than between-group residual agreement. This suggests that the majority-culture experts drive the overall consensus, that majority-culture non-experts share in this consensus, and that Menominee experts and non-experts both (a) share in this consensus and (b) depart from it in a culture-specific way. In other words, this pattern of residual agreement points to an overall cultural difference. For converging evidence of this difference we turn now to sorting justifications.

B. Sorting Justifications

Recall that we found a clear cultural difference in the experts' justifications for their sorts in that Menominee informants were more likely to give ecological justifications like “river fish” and majority-culture informants were more likely to give taxonomic-morphological justifications like “bass family.” Not surprisingly, we found similar differences among non-experts. Menominee non-experts tended to give relatively more ecological justifications (40%), and fewer goal-related (29%) and taxonomic-morphological (31%) justifications. The majority-culture non-experts, by contrast, gave fewer ecological justifications (16%) and more goal-related (43%) and taxonomic-morphological (41%) justifications.

Menominee non-expert informants were much more likely to mention rivers, streams, lakes, or ponds than were majority-culture informants; 11 of the 16 Menominee informants, but only 4 of the 16 majority-culture informants, did this for at least one of their justifications. Like their more expert counterparts, majority-culture non-experts were more likely than Menominee non-experts to give markers of goal-relatedness (e.g. “panfish,” “garbage fish,” “gamefish”) as justifications. For example, “panfish” was given by 56% of majority-culture informants but only 27% of Menominee informants. Likewise, “garbage fish” was given by 69% of majority-culture but only 20% of Menominee informants. “Gamefish” was given by 50% of majority-culture but only 27% of Menominee informants. In short, majority-culture non-experts were more likely than Menominee non-experts to give evaluative or goal-related justifications.

In addition to confirming an overall cultural difference, the justifications reveal an interesting interaction between culture and expertise. Whereas the pattern of justifications given by Menominee informants is robust across the two levels of expertise, the pattern given by majority-culture informants changes, such that, with expertise, majority-culture informants come to give more taxonomic-morphological and fewer ecological and goal-related justifications. At a minimum these data should make one point clear: Becoming a fish expert among the Menominee takes place within a very different cultural model than becoming a fish expert among majority culture people. This observation reinforces the view that studying expertise cannot be separated from studying culture.

C. Correlation With Scientific Taxonomy

Each group's consensual sort can be evaluated for its correlation with the scientific taxonomy. This reveals an interaction between culture and expertise that is consistent with the patterns in justifications just described. Menominee informants' justifications didn't change much with expertise, and neither did their correlation with the scientific taxonomy; nonexperts correlated .52 with science, and experts correlated .56. By contrast, majority-culture informants' justifications shifted toward taxonomic-morphological with expertise, and their correlation with the scientific taxonomy went from .40 to .61. The results are in strong contrast to the findings of Boster and Johnson (1989), who report the opposite pattern. They studied complete novices who had to rely on the physical features depicted on the stimuli cards. Our stimuli were name cards, and our non-experts were quite familiar with the species involved in the study and had goals with respect to them.

D. Clustering

We used a hierarchical clustering method to gain an additional perspective on the consensual sorts generated by our two non-expert groups. Figures 1 and 2 present the tree diagrams for the two sorts. It seems that goals play a major role in the majority-culture category structure; the most abstract cut is the three-way distinction between prized game fish, nonprized fish, and bait. Prized game fish are further divided on morphological grounds into large game fish, panfish, and trout. Habitat appears to play a role in finer-level cuts made among the nonprized fish. Garbage fish like the Redhorse and the Gar are separated from bottom feeders like the Catfish and the Bullheads.

Insert Figures 1 and 2 about here

Menominee clustering provides a contrasting category organization. The top level cut divides the species according to habitat (river and lake vs. just river). Finer-grained cuts made to the river/lake group reflect goal-related concerns. Desirable game fish are separated from bottom feeders and rough fish. A closer analysis of the desirable cluster reveals that it is further subdivided on the basis of taxonomic/morphological relatedness. The panfish are separated from the bass and the larger fish. A specific instance of taxonomic grouping involves the placement of Perch, a typical panfish, with its taxonomic neighbor Walleye.

In summary, cluster analysis, like consensus analysis, reveals substantial differences between cultural groups as well as strong similarities within cultural groups across levels of expertise. For the majority culture, both experts and non-experts appear to sort according to goals, with some influence of morphological and taxonomic strategies such as size and folk-generic linguistic markings. By contrast, Menominee informants, across levels of expertise, appear to rely primarily on ecological closeness such as shared habitat.

E. Culture and Expertise in Categorization and Reasoning

The last set of studies showed that Menominee have a propensity to organize categories in terms of ecological relations regardless of their level of expertise. Expert Menominee are familiar with more fish than the non-experts of their group but they are equally likely to sort ecologically. This is different from the trend among majority culture individuals. Not only do they report fewer ecological justifications but expertise is associated with a less of a focus on goals and a greater tendency to sort in terms of taxonomic relations. It is not completely clear what triggers this shift. Some majority culture experts explicitly mentioned how their orientation towards fishing had changed over the years, moving away from the stereotypic sportsman's model that targets fishing contests of going for the "big-fish."

Looking across cultures, our data with fishermen show no tendency for expertise to be associated with cross-cultural convergence. Instead, the pattern is at least parallel and perhaps diverging. The increasing knowledge of experts of the two cultures does not lead them to agree more with each other than the non-experts of the two cultures do. This undermines the idea that human beings are only observing differences presented to us by nature; otherwise we would expect the more observant individuals to agree more with each other (across cultures) as an effect of their common observations. Increase in knowledge seems not to come unfiltered but is rather assimilated into different conceptual frameworks.

VII. Summary and Conclusions

At the beginning of this paper we indicated that expertise and culture make good companions in our endeavors to study categorization and reasoning. We presented several studies that showed that knowledge and expertise affect how individuals reason about biological categories. These studies indicate that experts apply more specific reasoning strategies than novices. The latter seem to use more abstract principles (typicality, taxonomic diversity) when they reason about biological species. The strategies applied by our undergraduate participants seem to be a consequence of the lack of knowledge and hence the lack of access to concrete (causal) chains of reasoning. Although this is interesting in itself, it should also caution us not to use student participants as the norm when establishing general principles of categorization and reasoning. As we have seen, the basic notion of typicality and the use of categories in reasoning differ strikingly as a function of knowledge.

We also reported similar reasoning strategies for experts across cultures and different domains (see Medin et al. 1997; Bailenson et al. 2001.). While these similarities indicate a general effect of expertise, the data also show that experts across cultures differ in the saliency of certain types of knowledge over others. Further studies are needed that look at the complex process of becoming an expert. Simply labeling the two points on the acquisition curve “novice” and “expert” may only lead to confusion. As we noted, our “non-expert” fishermen would be experts relative to undergraduates and in ongoing research on the use of categories in reasoning we find that neither non-expert nor expert fishermen show typicality or diversity effects in reasoning (presumably because they have ready access to causal/ecological reasoning strategies).

Our data show that expertise cannot be separated from culture, even when people engage in more or less the same activities. In that respect, culture (in the sense of a reliable distribution of conceptual representations in a population of minds) appears to provide something of a framework theory for interpreting experience. By framework theory we mean only a more or less consistently linked set of conceptually compatible (inferentially connected) background assumptions that are rarely, if ever, explicitly articulated or fully represented in a single mind. This is seen, for example, in the Itza' Maya tendency to see reciprocal relations (animals helping plants as well as being helped by them) and in Menominee fishermen's ecological orientation. The parallels between the Itza' and Menominee are striking, especially when one notes that both groups also have sustainable forestry practices.

As we have stressed, cultural differences are a beginning point, not an endpoint. One way to try to understand the roots of an ecological orientation is to perform studies with Menominee (and Maya) children. In related developmental work we have found that the youngest Menominee children we have been able to test tend to reason ecologically (Ross, Medin, Coley & Atran, n.d.). We are currently trying to examine within-culture differences for clues to the origins of ecological thought.

Although knowledge plays a major role in reasoning strategies, we find clear differences between experts across cultures as well as across different kinds of expertise. We have suggested that these group differences may arise from differences in abstract schemata (again noting that we are talking about a distribution of representations across individuals not some core feature affecting all and only group members) or cultural lenses through which objects and events are interpreted (e.g. Tharp, 1994), such as the extent to which nature is seen as a relational entity (Atran, et al, 1999) versus a natural resource. It is still not clear how these different cultural models are acquired (Cohen, 2001), and how they may guide interpretation of experience. That's a challenge for future work.

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Footnotes

Footnote 1.

Exactly how detailed such causal notions may be, and the manner in which these evolve over development, is a matter of ongoing research (Springer 1992, Hatano & Inagaki 1994, Solomon et al. 1996, Gelman & Hirschfeld , 1999, Strevens 2000, Atran et al. 2001).

Footnote 2.

Such factors may include the physical environment or cross-cultural transmission of information, as in the case of the Ladinos learning from the Itza' in one of our studies (Atran et al, 1999).

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[i] To be sure, to refer to differences in “actual knowledge” does not mean that we infer that either of the two groups knows more or that the consensus of a group on some relation is necessarily factually correct, but rather that there are many possibilities in which the respective knowledge systems of the two groups differ.