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The Tree of Life: Universal and Cultural Features of Folkbiological Taxonomies and Inductions

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Two parallel studies were performed with members of very different cultures—industrialized American and traditional Itzaj-Mayan—to investigate potential universal and cultural features of folkbiological taxonomies and inductions. Specifically, we examined how individuals organize natural categories into taxonomies, and whether they readily use these taxonomies to make inductions about those categories. The results of the first study indicate that there is a cultural consensus both among Americans and the Itzaj in their taxonomies of local mammal species, and that these taxonomies resemble and depart from a corresponding scientific taxonomy in similar ways.

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However, cultural differences are also shown, such as a greater differentiation and more ecological considerations in Itzaj taxonomies. In a second study, Americans and the Itzaj used their taxonomies to guide similarity- and typicality-based inductions. These inductions converge and diverge crossculturally and regarding scientific inductions where their respective taxonomies do. These findings reveal some universal features of folkbiological inductions, but they also reveal some cultural features such as diversity-based inductions among Americans, and ecologically based inductions among the Itzaj. Overall, these studies suggest that while building folkbiological taxonomies and using them for folkbiological inductions is a universal competence of human cognition there are also important cultural constraints on that competence.

Humans evolved in a world where knowing whether an animal was an antelope or a lion was essential for their survival: they could eat the antelope, and they could be eaten by the lion. Accordingly, the human mind seems to have evolved to organize its knowledge of the natural world into sets of related categories (e.g., cheetahs and lions are kinds of felines, aardwolves and spotted hyenas are kinds of hyenas, and felines and hyenas are kinds of carnivores) and to use these relations to make inductions about those categories (e.g., if lions digest fast, then aardwolves probably digest fast, too). That is, humans appear to be innately prepared to build taxonomies which guide their inductions about the world.

The work presented here is an attempt to reveal people's knowledge of the tree of life by finding some universal and cultural features of folkbiological taxonomies and inductions. We intend to determine how humans organize natural categories into taxonomies, and whether they readily use these taxonomies to make inductions about those categories. Furthermore, we intend to determine whether these taxonomies and inductions are comparable across cultures, and whether they are also comparable to scientific taxonomies and inductions. In other words, we aim to assess some universal and cultural features of categorization, and how these features inform reasoning. To this end, we performed two parallel studies with members of very different cultures: industrialized American and traditional Itzaj-Mayan. We believe that by comparing the particular folkbiological taxonomies and inductions of Americans and the Itzaj makes it more likely that our findings will extend to humans in general.

Whereas there is a tradition in anthropology and psychology of studying universal versus cultural features of categorization (for a review, see Malt, 1995), studying how these features inform reasoning represents an original approach, which may be the main contribution of our work. In that same tradition, universal and cultural features are typically seen as respectively mirroring the influence of the world and the mind on categorization. On the one hand, there are those who view categories as universal reflections of the structure of the world (e.g., Berlin, 1973, 1992; Rosch & Mervis, 1975; Boster, 1991). In this view, categories correspond to the perceived discontinuities of the natural environment. On the other hand, there are those who view categories as cultural projections of the structure of the mind (e.g., Malinoski, 1954; Hunn, 1982; Murphy & Medin, 1985). In this view, categories correspond to conceptual distinctions in an underdetermined environment. In fact, both views acknowledge natural and conceptual influences on categorization but assert one over the other. Moreover, some would argue that the environmental discontinuities are the necessary input upon which innate mental presumptions necessarily operate to create categories (e.g., Carey, 1985; Atran, 1987; Keil, 1989; Medin & Ortony, 1989; Gelman & Wellman, 1991). In such a view, both the world and the mind result in universal features of categorization.

Our work reflects this last view. In our work, the universal-versus-cultural distinction simply refers to features of categorization and reasoning that are present across both cultures (all cultures) versus those that are present in one culture (some cultures), respectively. This distinction does not mirror the world-versus-mind dichotomy, because we believe that the world and the mind ontologically specify each other (Maturana & Varela, 1987): categorization and reasoning emerge from this mutual specification embodying both universal and cultural features. Therefore, our purpose in studying taxonomies and inductions is not to identify world-based versus mind-based features, but to identify universal versus cultural features, and thus distinguish what is essential for all human categorizers and reasoners (universal features) versus what is important for just some of them (cultural features). Moreover, our purpose is to determine how the universal and cultural features of categorization inform the universal and cultural features of reasoning.

Finally, our work is also an attempt to bring closer together the theories of mind developed in cognitive anthropology and cognitive psychology. Moreover, we intend to broaden the research methodology available to cognitive scientists by applying field methods in the laboratory, and laboratory methods in the field. Consequently, our work has been guided by two formal models developed by cognitive anthropologists and cognitive psychologists, respectively: the *cultural consensus* model (Rommey, Weller, & Batchelder, 1986), which accounts for the knowledge shared by different members of the same culture, and the *similarity-coverage* model (Osherson, Smith, Wilkie, López, & Shafir, 1990), which accounts for the category-based inductions that members of a culture make based on their shared knowledge of natural categories. What follows is a brief review of these two models (for details, see Rommey et al., 1986, and Osherson et al., 1990), including an overview of our present studies.

THE CULTURAL CONSENSUS MODEL

Some domains of knowledge are more widely distributed across cultures than others, and information pertaining to them are more likely to be widely shared within a culture than other kinds of information (Sperber, 1990; Tooby & Cosmides, 1992). There is evidence that knowledge associated with *core domains* of human cognition, such as folk biology, spreads within a population in rapid, extensive and lasting fashion owing to an affinity of such knowledge with basic (possibly innate) cognitive dispositions (Atran & Sperber, 1991; Wellman & Gelman, 1992). By contrast, where the distribution of opportunities to learn is patchy, then the amount of knowledge shared by randomly chosen pairs of individuals should be shaped more by their social relationship than by general cultural knowledge. For example, among the Aguaruna of Perú only a few women cultivate rare manioc varieties, so only they and their kin share knowledge of these particular varieties (Boster, 1986). The issue of whether the folk biology within a cultural group is affected by different belief systems and levels of knowledge or expertise can be examined by analyzing agreement and disagreement in judgments of taxonomic relatedness. A mathematical tool well-suited to this task is the *cultural consensus* model of Romney et al. (1986, 1987; Weller, 1987).

The cultural consensus model assumes that widely-shared information is reflected by a high, uniformly distributed agreement among individuals. The model is implemented by means of a factor analysis of a matrix of interparticipant agreement in a given domain. If the factor analysis results in a single factor solution, then, according to Romney et al. (1986), one can conclude that a single competence, or *cultural consensus,* underlies the responses of the participants in that domain. In other words, if a single dimension underlies patterns of agreement within a domain, then consensus can be assumed for that domain and the dimension can be thought of as reflecting the degree to which each participant shares in the consensual knowledge. To the extent that some individuals agree more often with the consensus than others, they are considered more *culturally competent* than others with respect to the domain in question. If the model fits, estimation of individual knowledge levels, or competencies, is given by each participant's first factor score. This represents the degree to which that participant's responses agree with the consensus.

The cultural consensus model has been widely applied to the classification of folkbiological species (e.g., Atran, 1994). Boster (1991) reviews several studies showing that there is a high cultural consensus among members of the same culture when classifying local flora and fauna. Furthermore, this consensus also exists between members of different cultures (e.g., Americans and Peruvian Jívaro), between novices and experts (e.g., undergraduates and ornithologists), and between children and adults (Coley, 1995; Johnson, Mervis, & Boster, 1992). According to Boster, high consensus is often apparent in domains, such as folk biology, where knowledge is freely available to and directly observable by all members of a culture.

We extend these findings in our first study by applying the cultural consensus model to the taxonomic classification of local mammal species by Americans and the Itzaj, and comparing these taxonomies with each other and science.[1] These comparisons reveal some universal and cultural features of folkbiological taxonomies. Significantly, we go beyond previous work by studying how these taxonomies of mammals are used to make inductions about those mammals. In short, our first study on folkbiological taxonomies lays the necessary foundation for our second study on folkbiological induction.

THE SIMILARITY-COVERAGE MODEL

An important function of taxonomic classification is enabling generalizations between categories. Osherson et al. (1990) have proposed a model—the *similarity-coverage* model—to account for such category-based inductions (see also Smith, López, & Osherson, 1992; Smith, Osherson, & Shafir, 1993). According to this model, inductions about categories can be expressed as categorical arguments in which the premises correspond to the known facts, and the conclusion correspond to the induction itself. For example, inducing that tigers have omyhoid muscles from the fact that cats and dogs do amounts to believing the following categorical argument is a strong one (where the premises are above the line and the conclusion is below the line):

Cats have omyhoid muscles.

Dogs have omyhoid muscles.

Tigers have omyhoid muscles.

This categorical argument is said to be strong to the extent that belief in its premises engenders belief in its conclusion. An argument is categorical if its premises and conclusion are of the form: All members of category *C* have property *P*. The similarity-coverage model applies to categorical arguments where *C* is a natural category like DOG or MAMMAL,[2] and *P* is a blank property like *have omyhoid muscles* which remains the same across premises and conclusion. A blank property is an unknown underlying biological property. Thus, to evaluate the strength of the above argument, one has to focus on its premise and conclusion categories (i.e., CAT, DOG, TIGER), and decide how strongly it follows that tigers have such an unknown property given that cats and dogs do. It is this process of category-based induction that the similarity-coverage model intends to account for.

[1] Henceforth, *mammal species* are simply referred to as ''mammals.'' Notice, however, that the mammals used in this study would be better thought of as *generic species* because the genus of most of them is monospecific. Thus, for these mammals, the scientific genus and species are coextensive and not distinguished perceptually by Americans and the Itzaj. Furthermore, a scientific distinction between species and genus was not conceptually motivated, and historically did not appear, until relatively modern times (Atran, 1990).

[2] Capitals are used to denote categories, and italics to denote properties.

TABLE 1
Three Inductive Phenomena Documented by Osherson et al. (1990)

Phenomenon	Schematic description and example
Similarity	The more similar the premise categories to the conclusion category, the stronger the argument. ROBIN, BLUEJAY/SPARROW > (is stronger than) ROBIN, BLUEJAY/GOOSE
Typicality	The more typical the premise categories, the stronger the argument. ROBIN/BIRD > PENGUIN/BIRD
Diversity	The more diverse the premise categories, the stronger the argument. HIPPOPOTAMUS, HAMSTER/MAMMAL > HIPPOPOTAMUS, RHINOCEROS/MAMMAL

Osherson et al. (1990) empirically documented a series of phenomena that characterize the evaluation of categorical arguments. Each phenomenon shows the effect of a given factor on argument strength (e.g., premise typicality), as illustrated by a contrasting pair of arguments where the first argument is stronger than the second according to that factor (i.e., the first argument has a more typical premise than the second). Examples include premise-conclusion similarity, premise typicality, and premise diversity, which are the focus of our work (see Table 1).[3] The similarity-coverage model accounts for all of the phenomena in terms of just two components which reflect reasoning processes based on similarity and category membership.

To illustrate, consider the argument CAT, DOG/TIGER. You may induce that tigers have omyhoid muscles because they are somewhat similar to cats (a similarity-based induction). But you may also induce that tigers have omyhoid muscles because all carnivores may have them given that cats and dogs do, and that tigers are carnivores (an induction based on category membership). Accordingly, the first component of the model—*similarity*—calculates the maximum similarity of the premise categories (CAT, DOG) to the conclusion category (TIGER). The higher this premise-conclusion similarity, the stronger the argument. Thus, the argument above is relatively strong because of the high similarity of CAT to TIGER.

The second or category membership component—*coverage*—calculates the average maximum similarity of the premise categories (CAT, DOG) to sampled instances (BEAR, LION, WOLF, etc.) of the lowest-level category that includes both the premise and conclusion categories as proper members (in this case, CARNIVORE). The higher the coverage of this *inclusive category* by the premise categories, the stronger the argument. Basically, coverage

[3] Henceforth, arguments are presented in the format ''Premise Categories/Conclusion Category.''

is high to the extent that the premise categories are each similar to different instances of the inclusive category. Thus, the argument above is also relatively strong because of the high coverage of the inclusive category CARNIVORE by CAT and DOG (i.e., they are similar to different instances of CARNIVORE such as LION and WOLF, respectively). While the coverage component of the similarity-coverage model of category-based induction is necessary to account for the premise diversity phenomenon, the similarity component is sufficient to account for the premise-conclusion similarity phenomenon (for alternative models, see Smith et al., 1992; Sloman, 1993).

We extend Osherson et al.'s (1990) findings in our second study by providing crosscultural evidence for category-based inductions about local mammals by Americans and the Itzaj. This evidence reveals some universal and cultural features of folkbiological inductions. Moreover, it reveals how folkbiological taxonomies are readily used to make such inductions. In short, our second study on folkbiological induction is founded on and validates the categories and relations obtained in our first study on folkbiological taxonomies.

STUDY 1: FOLKBIOLOGICAL TAXONOMIES

Study 1 was designed to explore and map out universal and cultural features of folkbiological taxonomies. Toward this end, we present a detailed comparison of how members of two very different cultures classify mammals. Earlier studies of folkbiological taxonomy (e.g., Diamond, 1966; Bulmer, 1970; Breedlove & Raven, 1973; Hunn, 1975) were groundbreaking in the degree to which they revealed the richness of traditional folkbiological thought and structural parallels in the classification systems of different cultures. However, these early studies are limited by the following factors: (1) the methods for eliciting vernacular names and identifications of flora and fauna are somewhat informal, with no clear sampling strategies for participants; (2) there is an implicit simplifying assumption that participants agree in their assignment of individual organisms to named categories; and (3) there is little systematic attempt to explain the ''residual'' variance between various folk and scientific classifications that does not owe to shared agreement. Later studies (e.g., Boster, Berlin, & O'Neill 1986; Boster & Johnson, 1989; Boster, 1991; Johnson, Mervis, & Boster, 1992) aimed at overcoming these limitations by introducing more formal methods into the analysis of folkbiological and scientific taxonomies. These include the application of correspondence correlations and the cultural consensus model to appropriate numbers of participants and fixed stimulus sets. Nevertheless, the following limitations persist: (1) pictorial stimuli may bias results towards agreement; (2) the stimuli often include organisms that are not locally present (e.g., for Americans, elephants and lions) and do not include organisms that are locally present (e.g., badgers and chipmunks); and (3) these later studies also tend to assume that agreement between folk and scientific classifications result from objective discontinuities in nature that represent an ‘‘observer-independent pattern of resemblance between organisms’’ (Boster et al., 1986, p. 580).

The stimulus sets of our first study are designed to overcome the first two limitations of the earlier studies and of the later studies (see Method, below). Moreover, we also aim at overcoming the third limitation of the earlier studies by performing analyses which go behind and beyond correspondence correlations, in order to explore the cognitive bases for agreement and disagreement in biological classifications. Not only do we seek to better understand classifications, but also how it happens that these correlations seldom account for even half of the variance. Finally, unlike previous studies, our use of the cultural consensus model is not merely to show that there is enough across-subject agreement to allow us to aggregate individual taxonomies into a cultural taxonomy, and thus to compare the structure and content of different cultural taxonomies. Rather, our integrated aim is to show how different groups of people use their cultural taxonomies to reason about nature. But in order to show this, we first need to demonstrate that there are cultural taxonomies. This is the rationale for the sorting and aggregating procedures employed in our first study. Finally, our assumption that environmental discontinuities are the necessary input upon which innate mental presumptions necessarily operate to create categories addresses the third limitation of the later studies.

More specifically, in our first study, we compare American and Itzaj taxonomies of mammals to each other and to a scientific taxonomy. The Itzaj are Mayan Amerindians living in the Petén rainforest region of Guatemala and devoting their time to shifting agriculture and hunting (males) and to household maintenance (females). They comprise the last independent native polity in Mesoamerica to be conquered by the Spaniards and have preserved virtually all ethnobiological knowledge recorded for Lowland Maya since the time of the initial Spanish conquest (Atran, 1993b). As for Americans, they are represented by Michigan students, who we assume to be fairly similar to Americans in general, particularly regarding their corresponding local ethnobiological knowledge.

We assume that ‘‘industrialized’’ Americans have less ecological knowledge about their local flora and fauna than the ‘‘traditional’’ Itzaj, basically because Americans’ subsistence does not directly depend on their knowledge of the natural environment anymore, while the Itzaj’s still does. However, we also assume that literate Americans have more scientific knowledge about nature than the illiterate Itzaj. We use a scientific taxonomy primarily as a metric for comparing the two folk taxonomies of overlapping but nonidentical mammals. To the extent that Americans and the Itzaj respectively represent distinct industrialized and traditional cultures, we assume that taxonomic features shared by both cultures may reflect universals of folkbiological thought, and that differences may reflect differences in cultural beliefs or perhaps differences in expertise.

Method

Participants. Twelve American undergraduates at the University of Michigan (6 female, 6 male) and 12 Itzaj adults (6 female, 6 male) were paid to take part in this study. American participants were all English native speakers who grew up in rural Michigan. We selected rural students to ensure they would know most local mammals. However, we did not expect their ecological knowledge to match that of the Itzaj. Itzaj participants were all Itzaj native speakers, who grew up in the Petén rainforest region of Guatemala. Half of them could read the Itzaj names of local mammals written in a newly standardized Mayan alphabet (Academia de las Lenguas Mayas de Guatemala, 1988), but none of them had more than a few years of elementary school education in Spanish. While American participants came from typical middle-class farmers' households, Itzaj participants came from subsistence households.

Design. This study had two conditions: the American condition, and the Itzaj condition. Both conditions tested for cultural consensus in the folkbiological taxonomies of local mammals among Americans and the Itzaj. These taxonomies were obtained by the participants' pile sortings of mammal name cards. The Appendix shows the 40 mammals that Americans and the 42 mammals that the Itzaj had to classify. For the American condition, the mammals were selected by the experimenters from local wildlife field guides (Baker, 1983; Burt, 1972), and included 30 extant native Michigan mammals (e.g., BADGER), the WOLVERINE (native to but extirpated from Michigan), and 9 local domestic mammals (e.g., CAT). Four other native mammals (i.e., ERMINE, FISHER, MARTEN, VOLE) were excluded because pretesting showed that most participants were unfamiliar with them. For the Itzaj condition, all 35 extant native Petén mammals (e.g., AGOUTI) and 7 local domestic mammals (e.g., DOG) were included (Emmons, 1990). These mammals were identified by the participants themselves in a pilot study.[4] The distributions of Petén and Michigan mammals we used in this study are quite similar. Whereas Michigan mammals comprise 40 species, 34 genera, 21 families, and 8 orders, Petén mammals comprise 42 species, 33 genera, 21 families, and 10 orders.

Materials. The different mammals used in the American and Itzaj conditions were each represented by their respective English or Itzaj names handwritten on separate 3'' × 5'' index cards. Each card served as a mnemonic icon representing a particular kind of mammal.

Name cards were used instead of drawings or pictures to avoid biasing participants toward visual attributes on their taxonomic judgments and to instead mobilize their overall knowledge of the mammals. Participants were constantly reminded by the experimenter of what particular mammal each card represented, by repeatedly pointing it out and reading it out loud for them. No differences between literate and illiterate participants were observed in their handling of the cards.

Procedure. American participants were tested in a university laboratory in Michigan, while Itzaj participants were tested in a field station in Petén. All participants were tested individually in their native language (English or Itzaj). In both conditions, they were simply told that we were interested in how people classify mammals. Then they were asked to perform a sorting task. Participants were shown the mammal cards one by one, and asked whether they knew the

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[4] In a pilot study with the Itzaj involving the classification of all Petén animals, OTTER was the only mammal crossclassified with another animal class (i.e., with water-dwelling reptiles). In addition, BAT was always classified as a bird. Nonetheless, we included BAT in the present study because: we wanted all extant native Petén mammals for comparing folk and scientific classifications of mammals; the isolation of BAT when classified along other mammals could confirm Itzaj verbalized animal classes (e.g., birds versus ''quadrupeds that walk'' or mammals); and the classification of BAT could highlight important commonalities and differences between Americans and the Itzaj concerning the role of education in folk biology (see General Discussion).

corresponding mammals. The cards they did not know were set aside, and were not used during the rest of the session. The remaining cards were placed in alphabetical order in front of them. Participants were then asked to ''put together those mammals that go together by nature into as many different groups as you want.'' The experimenter recorded the groupings, and then asked them to perform a successive pile sorting by ''putting together those groups of mammals that go together by nature into as many different groups as you want.'' The experimenter recorded the new groupings, and the successive pile sorting was then repeated. Participants were free to combine as many groups as they liked on any given round of sorting. The successive pile sorting was repeated until the participants indicated that the next grouping would include all the mammal cards. At this point, the experimenter restored the first groupings that participants made during the free pile sort, and asked them to perform a successive subpile sorting by ''subdividing the groups by putting those mammals that most closely go together by nature into as many different subgroups as you want.'' The experimenter recorded the subgroupings, and the successive subpile sorting was then repeated. Participants were free to divide as many groups as they liked on any given round of sorting. The successive subpile sorting was repeated until the participants indicated that there were no further subdivisions to be made.

Results and Discussion

First we discuss how performance on the sorting task was quantified. Then we consider, in turn, the degree to which performance within each culture reflected a consensual folk taxonomy, the correspondence of these folk taxonomies with science, and finally, similarities and differences between the American and Itzaj folk taxonomies.

Scoring. In both the American and the Itzaj conditions, participants did not have any problems in performing the sorting task, indicating that the pile-sorting paradigm with name cards is appropriate for obtaining the folkbiological taxonomies of people from different cultures. Most participants knew all mammals. In the American condition, only four participants set aside 1–3 unknown cards (2 on the average), with LEMMING being the least known mammal (unknown to three participants). In the Itzaj condition, six participants set aside 1–6 unknown cards (2.5 on the average), with CACOMISTLE and COYOTE being the least known mammals (unknown to three participants). It was mostly Itzaj women who did not know these two mammals. They were probably unfamiliar with the CACOMISTLE, because it is a nocturnal mammal that lives deep in the forest, and women seldom venture deep into the forest at night. Likewise, they were probably unfamiliar with the COYOTE, because it is a savanna mammal that lives mainly in southern Petén and women rarely venture to the savanna.

Each participant's taxonomy was obtained by translating the groupings the participant made during the free pile, successive pile and successive subpile sortings into a taxonomic tree. The bottom level nodes of this tree correspond to individual mammals that the participant sorted, and the top level node to all mammals together. Intermediate levels correspond to the groupings the participant made during the sortings. Each level includes all groupings made during a given round of sorting, and the levels are rank-ordered from the last successive subpile sorting to the last successive pile sorting.

Figure 1 depicts the folkbiological taxonomy of local mammals by an American participant. It shows that this participant's taxonomy has a total of six levels. Level 3 of the taxonomy corresponds to the participant's initial pile sorting of mammals. On this sorting, he combined all 40 mammals into ten different groups including, in his own words, ''dogs'' (WOLF, COYOTE, FOX, DOG), ''large rodents'' (RACCOON, BEAVER, PORCUPINE, SKUNK, BADGER, OPOSSUM, WOODCHUCK), and the isolated BAT, which ''flies.'' On the first successive pile sorting (level 4), he combined these ten groups of mammals into just four different groups. For example, he combined ''dogs'' with BEAR and ''cats'' into a ''carnivores'' group. On the next pile sorting (level 5), he left the ''carnivores'' alone, and combined the remaining three groups of mammals into a ''herbivores'' group. The ''carnivores'' and ''herbivores'' form a single group comprising all 40 mammals at level 6 of the taxonomy. Similarly, on the first successive subpile sorting (level 2), he divided four of the ten initial groups of mammals into subgroups. For example, he divided the ''large herbivores'' group (MOOSE, DEER, ELK, HORSE, DONKEY, GOAT, COW, SHEEP) into two subgroups: ''wild'' (MOOSE, DEER, ELK) and ''domesticated'' (HORSE, DONKEY, GOAT, COW, SHEEP). On the next subpile sorting (level 1), he just divided the ''domesticated'' subgroup into two further subgroups: ''horses'' (HORSE, DONKEY) and ''cows'' (GOAT, COW, SHEEP). Finally, level 0 of the taxonomy corresponds to each of the 40 mammals in a subgroup by itself.

Analogous taxonomic trees were constructed for each participant. From each taxonomy, we derived a pairwise mammal-by-mammal folk-taxonomic distance matrix by calculating the distance between all possible pairs of mammals in the taxonomy. The lowest level at which two given mammals go together in a folk taxonomy represents the folk-taxonomic distance between them. For example, for the participant above, GOAT and SHEEP go together at level 1; thus, the folk-taxonomic distance between them is 1. Similarly, the distance between GOAT and HORSE is 2, between GOAT and DEER is 3, between GOAT and PIG is 4, between GOAT and RABBIT is 5, and between GOAT and WOLF is 6. The folk-taxonomic distance between a mammal and itself is 0; thus, the distance between GOAT and GOAT is 0. Low folk-taxonomic distance corresponds to high folkbiological relatedness. Thus, for this participant, the folk-taxonomic distance between GOAT and SHEEP is small, the distance between GOAT and PIG is moderate, and the distance between GOAT and WOLF is large. In short, for each participant, we derived a mammal distance matrix in which rows and columns correspond to the sorted mammals and the cells to the distances among them.

Taxonomic consensus within cultures. In each condition, participants' mammal distance matrices were correlated with each other, yielding a single pairwise participant-by-participant correlation matrix representing the degree to

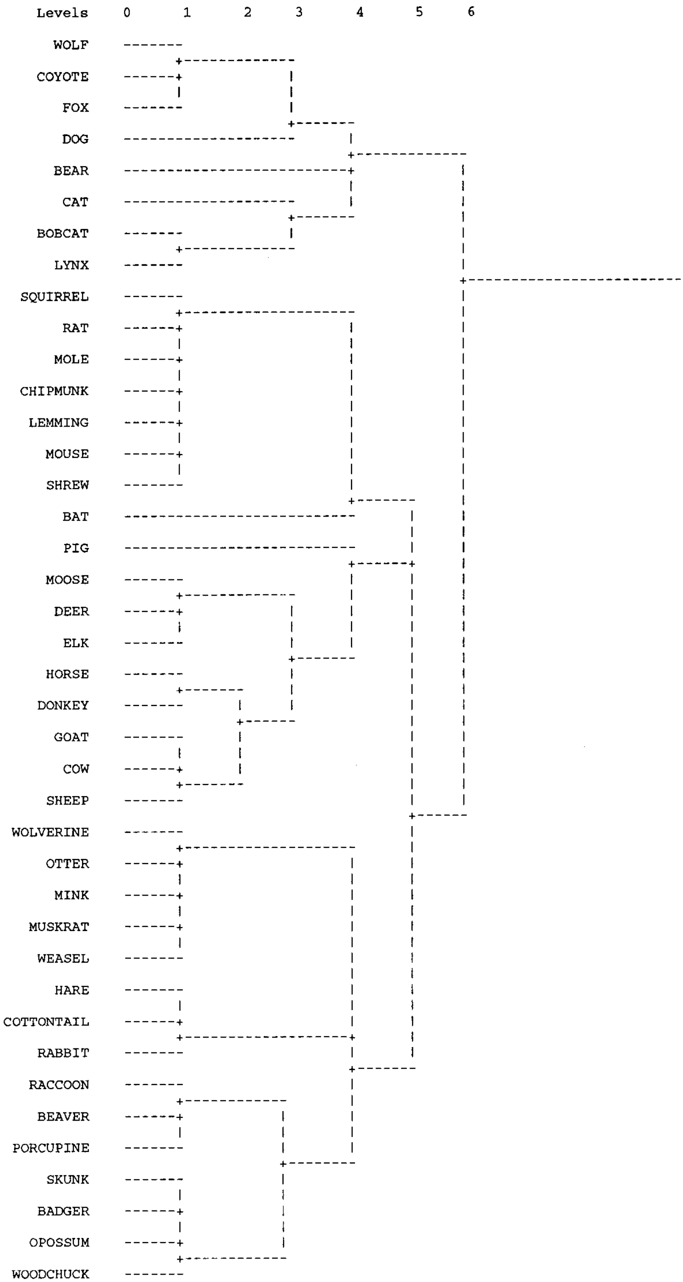

FIG. 1. Folk taxonomy of local mammals by an American participant.

which each participant's taxonomy agreed with each other participant's taxonomy. Principal components factor analyses were then performed separately on the American and Itzaj interparticipant correlation matrices to determine whether or not there was a ''cultural consensus'' in the participants taxonomies of each group.

According to the cultural consensus model (Romney, Batchelder, & Weller, 1986), a cultural consensus is plausible for such a data set if the factor analysis results in a single factor solution. If a single dimension underlies patterns of agreement within a domain, then consensus can be assumed for that domain, and the dimension can be thought of as reflecting the degree to which each participant shares in the consensual knowledge. Consensus is indicated by a strong single factor solution in which: (1) the first latent root (eigenvalue) is large compared to the rest; (2) all scores on the first factor are positive; and (3) the first factor accounts for most of the variance. To the extent that some individuals agree more often with the consensus than others, they may be considered more ''culturally competent'' than others with respect to the domain in question. Estimation of individual knowledge levels, or competencies, is given by each participant's first factor scores. This represents the degree to which that participant's responses agree with the consensus. That is, the pattern of correlations among participants should owe entirely to the extent to which each knows the common (culturally relative) ''truth.'' The mean taken from all first-factor scores provides an overall measure of consensus.

Thus, a fit to the cultural consensus model would provide a number of important indicators of within-group reliability and validity in mammal classification. For example, it would indicate (1) that there is sufficient justification for aggregating individual taxonomies into a cultural taxonomy; (2) how (much) each participant's taxonomy compares to the cultural taxonomy; (3) how (much) subsets of participants' taxonomies (men) compare to other subsets of participants' taxonomies (women); and (4) how (much) one cultural taxonomy (American) compares to another cultural taxonomy (Itzaj).[5]

Results show that both American and Itzaj interparticipant correlation matrices fit the cultural consensus model. For Americans, the factor analysis

[5] Although the cultural consensus model is a formal model designed for fixed-format responses (e.g., true or false), it can also be used as a ''data model'' for the more open-ended responses of our study (i.e., taxonomic distance). For interval data, the first factor loading in a principal components analysis becomes an estimate of how much a participant knows. In other words, our data model provides estimates of consensus as the correlation of the individual with the aggregate. This data model is similar to reliability theory with the role of individual and item reversed, and produces an insignificant reliability overestimation compared to the formal model. This is because an item in the formal model is supposedly correlated with a cultural ''truth,'' whereas an individual in our data model is correlated with an aggregate including that individual (see Romney, Batchelder, & Weller, 1987).

produced a single factor solution in which the first latent root (7.39) was seven times larger than the second (1.03), all scores on the first factor were positive, and this first factor accounted for most of the variance (61.5%). For the Itzaj, the factor analysis produced a single factor solution in which the first latent root (8.27) was twelve times larger than the second (0.69), all scores on the first factor were positive, and this first factor accounted for most of the variance (68.9%). This indicates that both Americans and the Itzaj show strong within-culture consensus in their classification of mammals. These findings are in line with other studies on folk taxonomies of local flora and fauna (for a review, see Boster, 1991).

According to the model, the degree to which a participant agrees with the consensus—the participant's *cultural competence*—is represented by her score on the first factor. These scores range from 0 to 1, and a high score indicates that the participant has great cultural competence; that is, she strongly agrees with the consensus. An examination of first-factor scores shows that both Americans and the Itzaj have high cultural competence in their classification of mammals. For Americans, participants' scores on the first factor ranged from .61 to .89, with a mean score of .78. For the Itzaj, participants' scores on the first factor ranged from .70 to .91, with a mean score of .83. On the average, Americans and the Itzaj were equally competent in their classification of mammals, $t(22) = 1.39$, n.s. This indicates that in each culture the members' performances reflect their cultural consensus to similarly high degrees.

Correspondence to scientific taxonomy. Figure 2 depicts the scientific taxonomy of all mammals used in this study.[6] Starting at the bottom, the levels of this taxonomy correspond to species (e.g., for GOAT, *hircus*), genus (*Capra*), family (Bovidae), suborder (Ruminata), order (Artiodactyla), subclass (Eutheria), and class (Mammalia). From this scientific taxonomy, we derived a pairwise mammal-by-mammal scientific taxonomic distance matrix in a manner analogous to that described above for the folk taxonomies. For example, for science, GOAT and SHEEP go together at the second or family level; thus, the scientific taxonomic distance between them is 2. Similarly, the distance between GOAT and PIG is 4, and between GOAT and WOLF is 5. Thus, for science, GOAT is somewhat closely related to SHEEP, moderately related to PIG, and somewhat remotely related to WOLF (compare to participant above). This procedure yielded a scientific distance matrix for both Michigan and Petén mammals.

[6] The conventional evolutionary taxonomy that we use as our scientific standard in this study is somewhat of a compromise between phenetic classifications, which are morphologically based, and cladistic classifications, which are chronologically based. We have opted for a conventional classification as our scientific taxonomy because, by and large, there is greater historical consensus over conventional classifications than over phenetic or cladistic classifications (Atran, 1993a; Stevens, 1994). This is especially the case for the range of mammals used here.

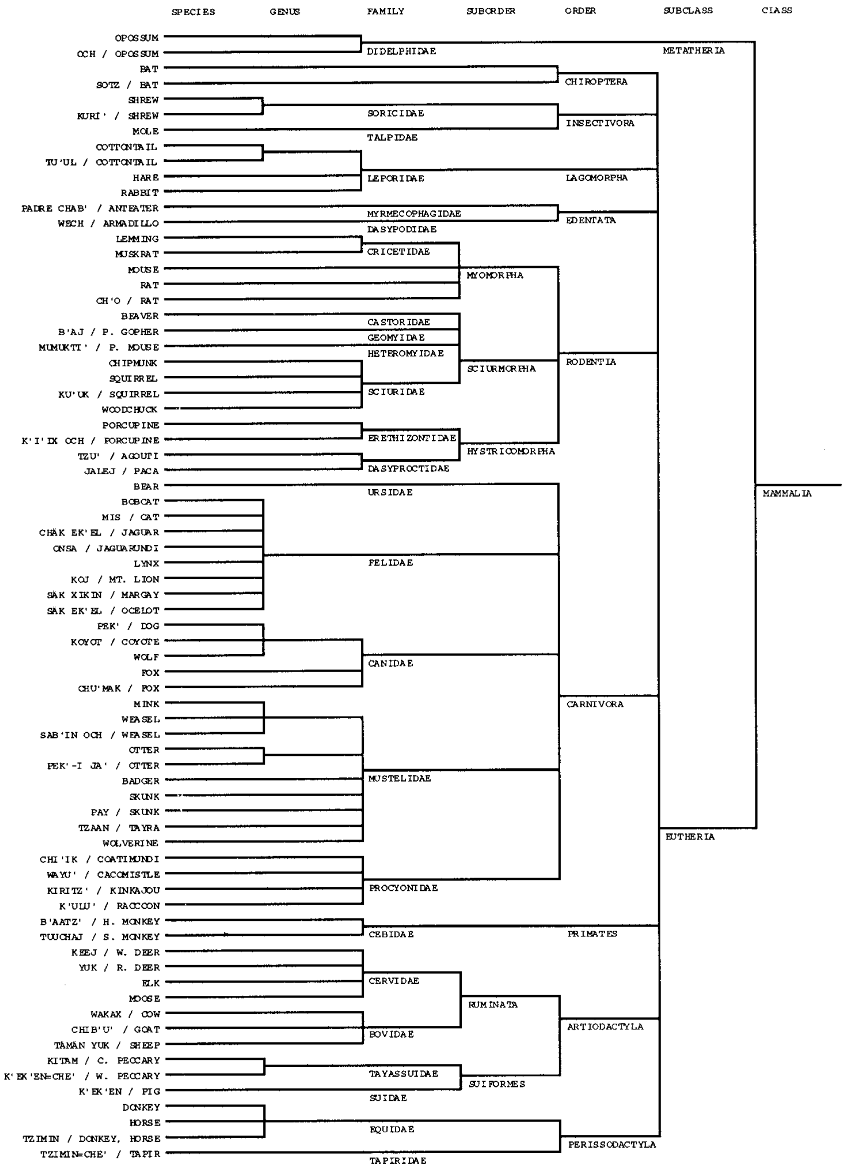

FIG. 2. Scientific taxonomy of all mammals used.

In order to assess the correspondence of folk taxonomies to the scientific taxonomy, we calculated American and Itzaj aggregate taxonomies by averaging over the respective participants' mammal distance matrices. Cluster analyses of these average matrices are depicted in Figs. 3 and 4. We then correlated

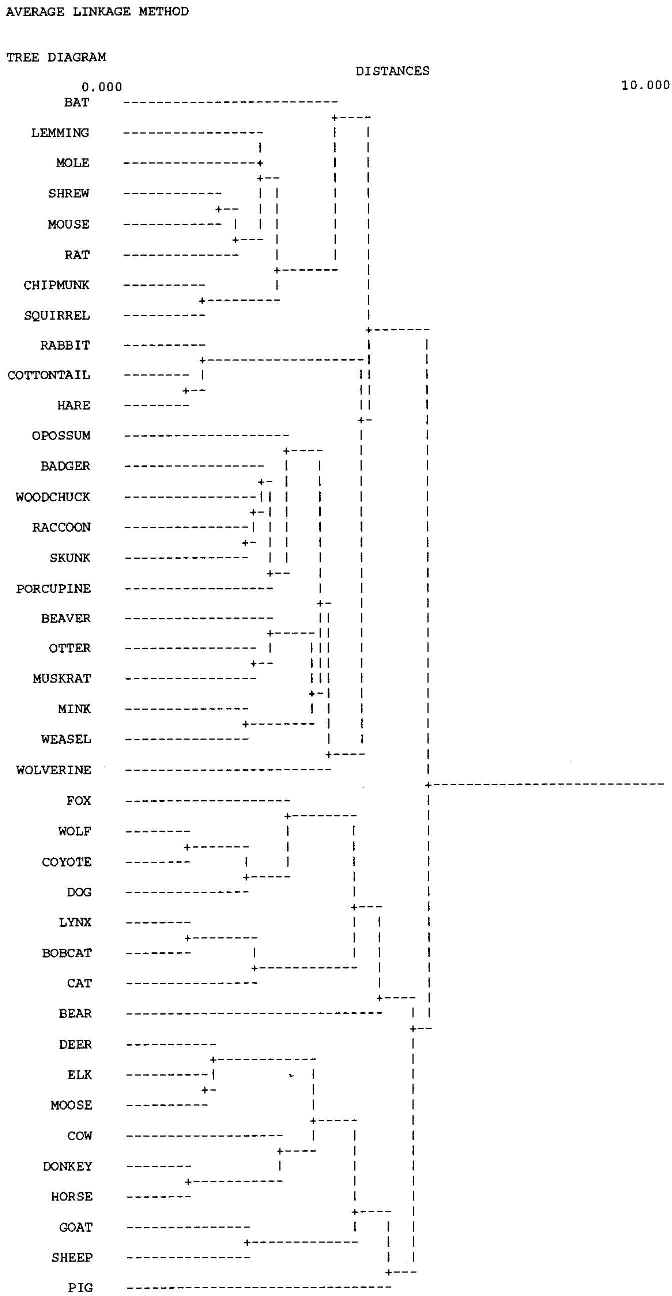

FIG. 3. Aggregate American taxonomy of local mammals.

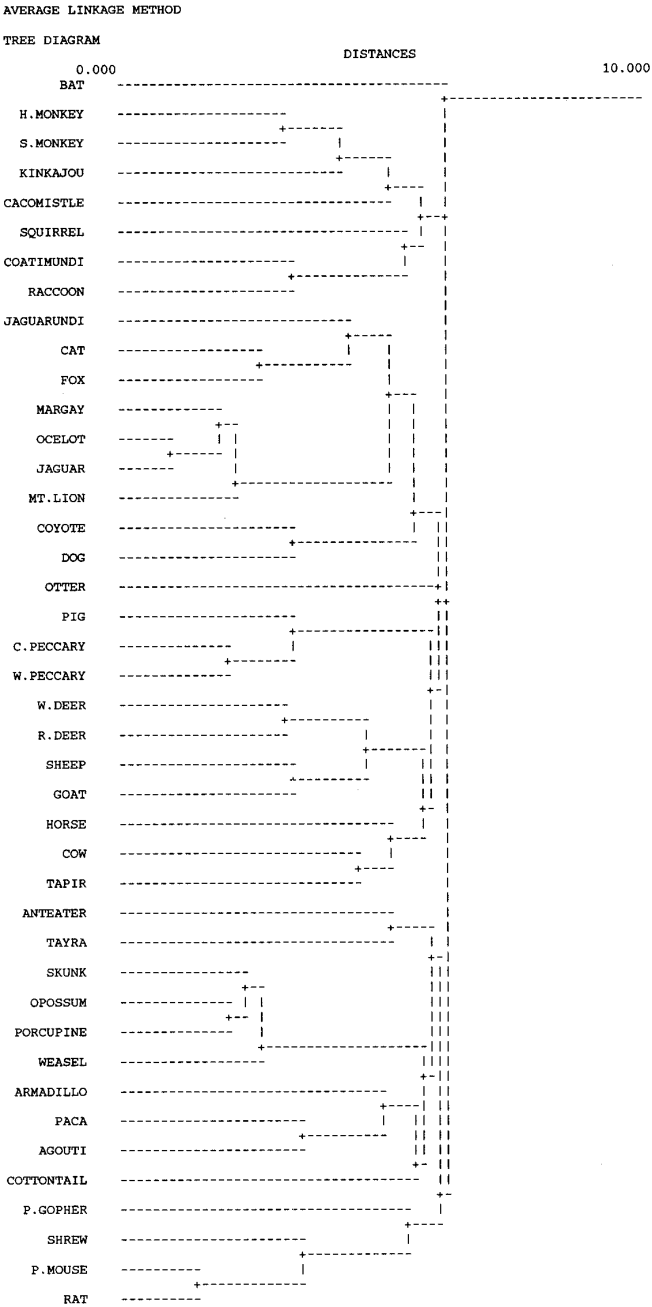

FIG. 4. Aggregate Itzaj taxonomy of local mammals.

the American and Itzaj aggregate folkbiological taxonomies with the scientific taxonomy of Michigan and Petén mammals, respectively.[7]

Results show that both the American and Itzaj taxonomies correlate positively and significantly with the scientific taxonomy when the folk and scientific species levels are included ($r = .75$ and .81, $p < .01$, respectively); and that both taxonomies correlate with science equally well ($z = .33$, n.s.). Furthermore, this correlation is also apparent when the folk and scientific species levels are excluded ($r = .48$ and .51, $p < .01$, respectively).[8] These results indicate that both Americans and the Itzaj tend to agree with science in their classification of mammals. Of course, positive correlations may conceal systematic differences and more refined analyses are needed.

In order to examine the correspondence between scientific and folk classification more closely, we computed the mean folk distance between pairs of mammals related at each scientific level (genus, family, order, subclass, and class) for each participant.[9] These were analyzed using a 2 (Condition: American, Itzaj) $\times$ 5 (Level: Genus, Family, Order, Subclass, Class) mixed ANOVA. To the degree that folk distance corresponds to scientific distance, mean folk distance should be low for lower levels and higher for higher levels. Indeed, this is supported by a main effect of level ($F[4,88] = 283.61$, $MS_e = .122$, $p < .01$). Separate Scheffé tests reveal the same patterns for Americans and the Itzaj (see Fig. 5). Specifically, pairs related at the levels of genus and family are closer than pairs at all higher levels (genus pairs were also closer than family pairs). No reliable differences in folk distance

[7] The use of matrix correlations of node counts to compare the *topological* distances of different taxonomic trees should be interpreted cautiously because: the elements in the matrices are treated as if they were independent (Phipps, 1971); the most weight is attached to matches at the highest taxonomic level because they are represented by more elements in the matrices (e.g., the extension of a family is greater than that of a genus) (Farris, 1973); and the computation of internodal distance as an interval scale assumes that the differences between levels are the same (e.g., between species and genus, genus and family, etc.) (Boster et al., 1986). Still, supposing that hierarchical levels are important and broadly reflect staggered aspects of the same underlying biological pattern, then matrix correlations of node counts remain fairly reliable and convenient tools for assessing congruence between taxonomies (Hunn, 1977; Rohlf, 1982).

[8] Including the folk and scientific species yields a higher correlation because it involves filling in the respective matrices' diagonal cells (e.g., BAT–BAT). For the folk matrices, the diagonal cells are always 0 because the folk distance between a mammal and itself is 0. For the corresponding scientific matrix, the diagonal cells are usually 0, but not always so. When the scientific distance between a given mammal and itself is not 0, it is because the scientific extension of that given mammal crosses one or more scientific levels. For instance, in Michigan, BAT exemplars extend over several genera of the same family (second level). Hence, the most conservative estimate of the scientific distance between any two BAT exemplars is 2 rather than 0. Similarly, in Petén, BAT exemplars extend over two suborders of the same order (fourth level). Accordingly, the most conservative estimate of the scientific distance between any two BAT exemplars is 4 rather than 0.

[9] The level of *suborder* was excluded from this analysis because only two orders under consideration—*Artiodactyla* and *Rodentia*—are divided into suborders.

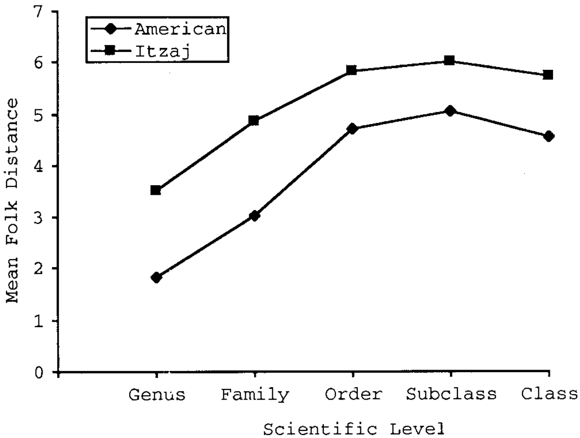

FIG. 5. Mean folk distance between pairs of mammals at each scientific level in American and Itzaj aggregate taxonomies.

emerge between pairs related at the order, subclass, and class levels. Thus, folk distance corresponds to scientific distance to the extent that lower-level scientific relations are reflected in folk classification. However, folk classification does not correspond nearly so closely to higher-order scientific levels. Moreover, the patterns of correspondence are essentially the same for Americans and the Itzaj. Interestingly, there was a main effect of condition ($F[1,22] = 36.07$, $MS_e = 1.55$, $p < .01$), suggesting that overall, Americans perceive less folk distance among mammals ($M = 3.83$) than the Itzaj ($M = 5.20$). This is consistent with the Itzaj having a more differentiated knowledge of mammals than Americans. Finally, there was a significant level × condition interaction ($F[4,88] = 7.68$, $MS_e = .122$, $p < .01$). This simply reflects the fact that the main effect of distance becomes smaller at higher taxonomic ranks.

Correspondence between American and Itzaj taxonomies. To sum up results so far, both Americans and the Itzaj show strong within-culture consensus in their folk taxonomies of local mammals. They also show reliable correlations with scientific taxonomy, which are driven mainly by the salience of scientific genus and family groups. Below, we show that both Americans and the Itzaj classify mammals on largely morphological and behavioral grounds and show considerable agreement in the content of some mammal groups. However, the Itzaj differentiate among smaller mammals more than Americans, are less likely to cluster mammals together into broad groups, and give considerably greater weight to ecological considerations to make distinctions among mammals. Americans, in turn, appear to give greater weight to size as a basis for categorization.

First of all, both Americans and the Itzaj seem to base their classifications

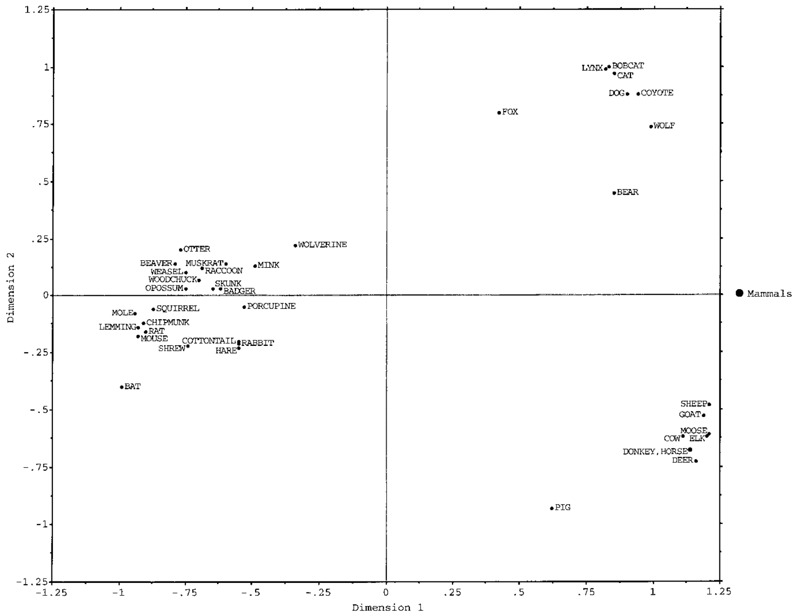

FIG. 6. Multidimensional scaling of the American taxonomy of local mammals (actual values were multiplied by −1 to make higher numbers roughly indicate higher degrees of ferocity (dimension 1) and size (dimension 2)).

on morphology and behavior. Figure 6 depicts a multidimensional scaling analysis of the American aggregate taxonomy. This analysis revealed that a two-dimensional solution explained 98% of the variance in mean folktaxonomic distance. Like previous scalings of mammals (e.g., Rips, Shoben, & Smith, 1973), this solution shows that Americans classify mammals largely on two dimensions: a morphological dimension of *size*, and a behavioral dimension of *ferocity*. Indeed, further analysis of the American responses suggest that size alone may be the primary determinant of their classification. A one-dimensional solution explained 93% of the variance in American responses. In order to test whether this dimension mapped onto size, mean size (weight in grams) was computed for each mammal kind in the stimulus set.[10] The log weight in grams was then regressed on the dimension scores for the one-dimensional MDS solution, using second-order polynomial regression.

[10] Size information was obtained from field guides. For folk terms that correspond to biological species (e.g., ''raccoon''), the average weight was used. In cases of sexual dimorphism, the sizes of males and females were averaged. For folk terms that correspond to broader scientific taxa (e.g., ''bat''), the weights for all species covered under that term native to the region were averaged. Thus, this should be considered a rough, but not wholly inaccurate, index of size.

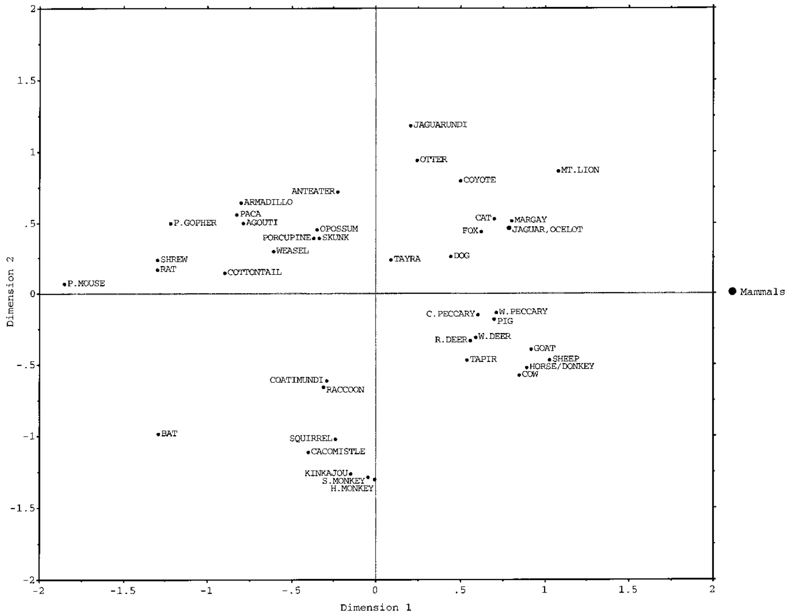

FIG. 7. Multidimensional scaling of the Itzaj taxonomy of local mammals.

The size measure explains 71% of the variance in the dimension scores for Michigan mammals. In other words, almost all the variance in the folk distance among Michigan mammals is explained by a single dimension, and almost 75% of the variance in that dimension is explained by size alone.

The Itzaj present a different picture. Figure 7 depicts a multidimensional scaling analysis of the Itzaj aggregate taxonomy. This analysis revealed that a two-dimensional solution was less adequate than for Americans, explaining only 81% of the variance in mean folk-taxonomic distance (recall that the corresponding figure for Americans was 98%). In fact, the Itzaj classification is not nearly as size-driven as that of Americans. For the Itzaj, a one-dimensional solution explains only 56% of the variance and size explains only 16% of the variance in this dimension. A look at sorting justifications reinforces this differential attention to size. All of the Americans mentioned size similarity as a justification for at least one category on their initial sorts, whereas only half of the Itzaj mentioned it. Even more striking, 10 of the 12 Itzaj participants mentioned size *difference* within a category as part of their initial sorting justifications.

In further contrast to Americans, more detailed knowledge of morphological and behavioral properties, and a variety of ecological considerations (e.g., habitat) lead the Itzaj to make distinctions among smaller mammals to a degree not seen among Americans (see Fig. 4). For example, ANTEATER and TAYRA are clustered closer together because they share distinctive black and tan markings. Also, POCKET MOUSE and RAT are clustered closer together because they are both village animals. However, OTTER, a distinct water mammal, and BAT, the only flying mammal, are kept relatively isolated. Note also that FOX is in a group with CAT and other felines rather than with COYOTE and DOG. Among the Itzaj, foxes are sometimes called ''forest cats'' and, at first glance, they look and act like cats (''like cats, they eat chicken, opossums and pigeons,'' as one Itzaj participant put it).

Thus, beyond reliance on size, another difference between American and Itzaj taxonomies is that they seem to differ in the degree to which smaller mammals are differentiated. Americans drastically underdifferentiate smaller mammals, relative to the Itzaj. The Itzaj's greater differentiation of smaller mammals may be due to their greater knowledge of mammals in general, and their greater direct experience with the mammals in question. It could be hypothesized that this difference stems from the presence of two orders of mammals in Petén not found in Michigan, namely, Edentata (anteaters and armadillos) and Primates (howler and spider monkeys). The idea is that the Itzaj look more differentiated because there are legitimately more kinds of smaller mammals in their environment to classify. In order to rule out this possibility, we first analyzed the American ''small mammal cluster.'' This cluster corresponded to the scientific orders Rodentia, Lagomorpha, Insectivora, Chiroptera, the Mustelidae and Procyonidae families of Carnivora, and the subclass Metatheria. We then identified just the Petén mammals that fell into these scientific groups, to control for the presence of other mammal groups in Petén. For these subsets of mammals, we computed mean pairwise folk distance for each participant. The mean folk distance among this subset of mammals was greater for the Itzaj ($M = 5.78$) than for Americans ($M = 3.96$), $t(22) = 6.52$, $p < .01$, indicating greater differentiation among the Itzaj. Note that on this analysis the groups found in Petén but not in Michigan cannot be driving differences in differentiation. Indeed, the presence of salient, unique mammals such as anteaters, armadillos, and monkeys in Petén but not Michigan should contribute to less—rather than more—differentiation among other mammals by the Itzaj, according to models relating density to psychological distance (Krumhansl, 1978). In short, greater differentiation among the Itzaj is not an artifact of local distribution of mammals.

Interestingly, domesticity as a criterion for the classification of mammals is secondary for Americans and minimal for the Itzaj. Taking HORSE and DONKEY as an example, an American participant paying attention to domesticity could conceivably classify them with COW, GOAT, SHEEP, and/or PIG as domestic (farm) mammals, excluding DEER, ELK, and MOOSE from the group. Alternatively, she could classify HORSE and DONKEY with DEER, ELK, and/or MOOSE on morphological considerations of size and overall appearance. On initial sortings, of twelve participants, only one showed a domesticity pattern, while six showed a morphology pattern. The remaining five participants isolated HORSE and DONKEY initially, but subsequently sorted them into higher-order groups based on morphology rather than domesticity.

However, Americans did show some influence of domesticity at more specific levels of classification. In fact, participants overdifferentiated some scientific genera (*Canis* and *Felis*) on the basis of domesticity: of 12 participants, 10 split both DOG away from COYOTE and WOLF and CAT away from BOBCAT and LYNX. Likewise, one-fourth of Americans kept COW, GOAT, and SHEEP separate on initial sortings, even though they belong to the same scientific family. For Americans, then, domesticity appears to play a secondary role in the classification of mammals. For the Itzaj, however, domesticity plays only a minimal role as just another consideration along many entering into folkbiological classification. For example, one participant grouped TAPIR with COW rather than HORSE, because tapirs' meat is eaten just like cows' meat (a utility consideration) and tapirs' hoofprints are more like cows' hoofprints (a morphological consideration).

The salience of ecological knowledge for the Itzaj has implications for the degree to which folk taxonomic groups crosscut scientific taxonomic groups in both cultures. For this comparison, considering the scientific order level is most informative. On folk grounds such as size and ferocity, Americans combine seven distinct scientific orders and one subclass into just three broad folk groups: large predators (Carnivora), large nonpredators (Artiodactyla, Perissodactyla), and smaller undifferentiated mammals (Carnivora, Rodentia, Lagomorpha, Insectivora, Chiroptera, Metatheria). However, Carnivora is the only scientific order crosscut by two folk groups; that is, carnivores such as WOLF and SKUNK are crossclassified as large predators and smaller undifferentiated mammals, respectively. Interestingly, this crossclassification is made cleanly along scientific family lines: while mustelines (SKUNK and others) and procyonines (RACCOON) are grouped with smaller undifferentiated mammals, canines (WOLF and others), felines (LYNX and others), and ursines (BEAR) are grouped as large predators.

In comparison, Itzaj taxonomic groups are more likely to crosscut scientific taxonomic groups due to the Itzaj's greater differentiation of smaller mammals. The Itzaj combine nine distinct scientific orders and one subclass into basically six folk groups: large predators (Carnivora), large nonpredators (Artiodactyla, Perissodactyla), arboreal mammals (Primates, Carnivora, Rodentia), medium-size mammals (Carnivora, Rodentia, Edentata, Lagomorpha, Metatheria), small-size mammals (Rodentia and Insectivora), and the isolated BAT (Chiroptera). Thus, the scientific orders Carnivora and Rodentia are crosscut by three folk groups each. For example, rodents such as SQUIRREL, PORCUPINE, and RAT are crossclassified as arboreal, medium-size and small-size mammals, respectively. Still, like Americans, the Itzaj mostly crossclassify along scientific family or suborder lines. For example, all procyonines (RACCOON and others) are grouped with arboreal mammals. The only exception are the mustelines (OTTER and others): smaller carnivores widely adapted to diverse ecological niches, and consequently crossclassified with diverse folk groups. Thus, the reason for the Itzaj's crosscuttings of scientific groups is probably that the scientific taxonomy is not based on the ecological knowledge the Itzaj use for their further differentiation of smaller mammals.[11]

Justifications for initial sorts are consistent with greater attention to ecological factors among the Itzaj. For purposes of this analysis we counted comments about behavior, habitat, and diet as ecological. For Americans there was a mean total of 2.8 (median = 2.5) ecological justifications compared with a mean of 5.5 (median = 4.5) for the Itzaj. These overall numbers likely represent an underestimate in that the justifications tended to differ systematically in their specificity. For example, a typical behavioral justification for Americans might be ''flies,'' whereas Itzaj descriptions might be as specific as ''sleeps in the hollows of trees during the day and snores loudly.''

Overall, Americans and Itzaj taxonomic differences show a manner that is consistent with greater knowledge of mammals on the part of the Itzaj. The average number of levels in Itzaj taxonomies (6.25) does not differ significantly from the average number of levels in American taxonomies (5.66), $t(22) = 1.74$, n.s. However, Americans appear much more likely to form broader groups of mammals. In order to quantify this, the number of groups formed immediately before the level at which all mammals were combined into a single class was computed for each participant. The mean number of groups for the Itzaj (10.67) is much greater than the mean number of groups for Americans (3.83), $t(22) = 3.52$, $p < .002$. This suggests that whereas both Americans and the Itzaj construct taxonomies with comparable numbers of levels, the Itzaj are much less willing to lump mammals into broader groups than Americans.

Finally, to further examine crosscultural taxonomic correspondence, we directly compared American and Itzaj aggregate taxonomies. There are two problems in such a comparison. First, only a modest number of mammal species are actually common to the two locales. Second, even where there are common species, the corresponding folk terms may not map onto them in an identical way. Thus, most Americans consider HORSE and DONKEY to comprise separate species, but the Itzaj include both species under the single term ''tzimin.'' To address these problems, we have established a

[11] The ecological nature of Itzaj taxonomic groups was independently confirmed by Atran and Medin (in press) for arboreal mammals. They asked participants to indicate which plants are the most important for the forest to live. Then, they aggregated the answers into a cultural model, and for each plant in the aggregate they asked which animals interacted with it (without ever asking directly which animals interact with one another). The same group of arboreal mammals obtained here emerged as a stable cluster in interactions with plants.

method for determining corresponding *chunks* of biological reality captured by different folk taxonomies. To compare folk taxonomies directly, one culture's (mammal) category is deemed topologically equivalent to the other's if (1) each category shares a common species (e.g., the American HORSE and the Itzaj TZIMIN both share *Equus caballus*) or (2) each category represents a different species which is the sole local representative of the same genus (e.g., the American OTTER, *Lutra canadensis,* and the Itzaj PEK'-IJA', *Lutra annectens*). By this definition, two comparable partial taxonomies were derived from the American and Itzaj aggregate taxonomies. Each partial taxonomy included the 17 mammals with topological equivalents in both Michigan and Petén (see starred mammals in the Appendix). The American and Itzaj partial taxonomies were then correlated by means of their corresponding distance matrices. Results show that there is a significant positive correlation between these partial taxonomies ($r = .61$, $p < .01$). This indicates that Americans and the Itzaj tend to agree in their classification of topologically equivalent mammals; that is, these mammals tend to be seen similarly close or distant among themselves by both cultures. However, this correlation accounts for only 37% of the variance, suggesting that this crosscultural agreement is coupled with enough unexplained variance to accommodate considerable cultural differences in knowledge and differentiation.

In sum, the findings of Study 1 suggest some universal features of folkbiological taxonomies. Both Americans and the Itzaj show high within-culture consensus and high correlations to science in their taxonomies of mammals. The folk distance at different levels of scientific taxonomy shows identical patterns in the two cultures, despite overall differences in differentiation. Moreover, they both create taxonomies of similar depth (six levels), by similar overall criteria (morphological and behavioral properties), and with similar taxonomic groups (large predatory mammals and large nonpredatory mammals). Finally, their taxonomies of equivalent mammals correlate highly.

These findings also revealed differences between American and Itzaj folkbiological taxonomies. The Itzaj make fewer broad higher-order groups of mammals, and make more distinctions among smaller mammals than Americans. These distinctions often crosscut scientific taxonomic groups in favor of ecological considerations not captured by science. Also, whereas Americans rely twice as often as the Itzaj on a general size criterion for their taxonomies, the Itzaj rely twice as often as Americans on more specific ecological criteria. Finally, domesticity is a secondary taxonomic criterion for Americans but not for the Itzaj and science.

In our next study, we examine the degree to which these common and distinct features of folkbiological taxonomies drive folkbiological inductions. We believe that the basis for folkbiological inductions is a built-in feature of folkbiological taxonomies. In other words, categorization of nature predicts reasoning about nature.

STUDY 2: FOLKBIOLOGICAL INDUCTIONS

Study 2 was designed to find some universal and cultural features of folkbiological inductions. Specifically, our aim was to determine whether Americans and the Itzaj readily use their taxonomies of mammals to make inductions about those mammals, whether these inductions are comparable across both cultures, and whether they are also comparable to scientific inductions. To this end, we tested for the Similarity, Typicality, and Diversity phenomena of category-based induction among Americans and the Itzaj. More significantly, we used their respective folk taxonomies to simultaneously verify the presence of the phenomena and link their presence to those taxonomies.

Method

Participants

Twelve American undergraduates at the University of Michigan (6 female, 6 male) and twelve Itzaj adults (6 female, 6 male) were paid to take part in this study. Of these participants, 8 Americans and 10 Itzaj also took part in Study 1. The new participants had basically the same characteristics as the old ones.

Design

This study had two conditions: the American condition and the Itzaj condition. Both conditions tested for the following three category-based induction phenomena among Americans and the Itzaj: Similarity, Typicality, and Diversity. Each phenomenon was tested with a block of four items. Each item consisted of a pair of contrasting arguments: one supposedly strong and one supposedly weak. The stronger argument in each case was the one that maximized the factor that the corresponding phenomenon represents (e.g., for Typicality, the stronger argument had a more typical premise than the weaker). The aggregate folk taxonomic distances among mammals obtained in Study 1 were used to determine the similarity between premise and conclusion categories, and the typicality and diversity of the premise categories for both Americans and the Itzaj. The more distant two mammals are in the corresponding folk taxonomy, the more diverse they are. The less distant two mammals are in the taxonomy, the more similar they are. The typicality of a mammal is given by its average distance to the rest of the mammals in the taxonomy (see Osherson et al., 1990). The lower its average distance to the rest of the mammals, the more typical a mammal is. Although the items included Michigan mammals for the Americans and Petén mammals for the Itzaj, the similarity, typicality, and diversity of the corresponding items was the same for both group.

Four items were used to test each phenomenon; two presenting the stronger argument first, and the other two presenting the weaker argument first. The order of items within each block was randomized anew for each participant. Blocks were presented in the same order for all participants: Similarity, Typicality, and Diversity. This order supposedly represents the developmental course of the phenomena (López, Gelman, Gutheil, & Smith, 1992), and might represent a difficulty gradient as well. A single familiarization item was also included at the beginning of the test.

Each item compared the relative strength of two arguments by asking participants a question of the following generic form: ‘‘[Mammal 1] has a disease. [Mammal 2] has another disease. Do you think [Mammal 3] has the disease of [Mammal 1] or the disease of [Mammal 2]?’’ Blank properties were used to make participants focus on the premise and conclusion categories of the arguments for their judgments. *Has a disease* and *has another disease* were the two blank properties used across all items, because pre-testing showed that the Itzaj had difficulties understanding previously used blank properties like *have omyhoid muscles.* For example, one of the Similarity items in the American condition was: ‘‘Mice have a disease. Foxes have another disease. Do you think rats have the disease of mice or the disease of foxes?’’ This question contrasts the relative strength of the arguments MOUSE/RAT and FOX/RAT. Items used for Americans and the Itzaj were structurally identical in terms of the relations among the categories used, but employed only local mammals.

For the Typicality and Diversity items the conclusion category was always MAMMAL. For example, one of the Typicality items in the Itzaj condition was: ‘‘Porcupines have a disease. Squirrels have another disease. Do you think all other mammals on this island have the disease of porcupines or the disease of squirrels?’’ This question contrasts the relative strength of the arguments PORCUPINE/MAMMAL and SQUIRREL/MAMMAL. An example of one of the Diversity items in the American condition was: ‘‘Wolves and deer have a disease. Wolves and coyotes have another disease. Do you think all other mammals on this island have the disease of wolves and deer or the disease of wolves and coyotes?’’ This question contrasts the relative strength of the arguments WOLF, DEER/MAMMAL and WOLF, COYOTE/MAMMAL.

The familiarization item in both conditions had the following generic form: ‘‘[Mammal 1] has a disease. [Bird 1] has another disease. Do you think [Mammal 2] has the disease of [Mammal 1] or the disease of [Bird 1]?’’ We thought it would be easy for participants to answer this question correctly, making familiarization with the choice paradigm also easier. For example, the familiarization item in the Itzaj condition was: ‘‘Ocelots have a disease. Hummingbirds have another disease. Do you think mountain lions have the disease of ocelots or the disease of hummingbirds?’’ This question contrasts the relative strength of the arguments OCELOT/MOUNTAIN LION and HUMMINGBIRD/MOUNTAIN LION.

Materials

Again the different mammals used in the American and Itzaj conditions were each represented by their respective English or Itzaj names handwritten on separate 3’’ × 5’’ index cards. Each card served as a mnemonic icon representing a particular mammal. No card was used for the category MAMMAL. Participants were constantly reminded by the experimenter of what particular mammal each card represented, by repeatedly pointing it out and reading it out loud for them. No differences between literate and illiterate participants were observed in their handling of the cards.

Procedure.

American participants were tested in a university laboratory in Michigan, and Itzaj participants were tested in a field station in Petén. All participants were tested individually in their native language. In both conditions, participants were simply told the following: ‘‘In Ontario (Yucatán), there is a lake with an island inhabited only by animals. The mammals that live there are the same that live here in Michigan (Petén). We know that some of the mammals on the island have a disease. We would like you to tell us what other mammals on the island you think also have this disease.’’ They were then shown the mammal cards one by one, and asked whether they knew the corresponding mammals. The cards they did not know were set aside, and were not used during the rest of the session. They were then tested on the familiarization item. For example, in the American condition, the experimenter placed the OTTER card to the participant’s left (or right) saying, ‘‘This is an otter,’’ placed the HUMMINGBIRD card to the participant’s right (or left) saying, ‘‘This is a hummingbird’’ and placed the BEAVER card in the middle below saying, ‘‘This is a beaver.’’ Then, pointing to the corresponding cards, the experimenter said: ‘‘Otters have a disease. Hummingbirds have another disease. Do you think beavers have the disease of otters or the disease of hummingbirds?’’ The experimenter wrote down the participant’s answer, collected the cards, and repeated the procedure with the next item.

The same procedure was followed for all three phenomena in both conditions. For Typicality and Diversity, no card was used for the conclusion category MAMMAL. For Diversity, the two

TABLE 2
Study 2: Mean Number of Responses in Accord with the Phenomena by Condition

Phenomenon	(%)	M^a	*SD*	*t*
American condition				
Similarity	(92)	3.67	0.65	8.86**
Typicality	(94)	3.75	0.45	13.40**
Diversity	(96)	3.83	0.39	16.32**
Itzaj condition				
Similarity	(85)	3.42	0.79	6.19**
Typicality	(79)	3.17	1.03	3.93**
Diversity	(38)	1.50	0.91	−1.92

Note. The percentage of responses in accord with the phenomena is provided in parentheses.
[a] Maximum score = 4.00; expected value = 2.00; $n = 12$.
** $p < .01$.

cards corresponding to the two premise categories were placed one on top of the other, with the first premise category at the top.

Results and Discussion

In both the American and Itzaj conditions, most participants (100% and 92%, respectively) answered the familiarization item correctly, indicating that the choice paradigm with name cards is appropriate for testing folkbiological inductions in different cultures, and that the use of diseases as blank properties and of taxonomic distance as a measure of similarity is appropriate for testing Osherson et al.'s (1990) category-based induction phenomena.

Table 2 shows participants' mean responses for the experimental items by phenomenon and condition. Responses in accord with the phenomena were scored as 1, and there was a maximum score of 4 since four items were used to test each phenomenon. A two-tailed *t* test against chance was performed on the mean scores for each phenomenon across participants, with the expected score by chance being 2. Results show that the Similarity and Typicality phenomena were significant for both Americans and the Itzaj: they both judge an argument to be stronger the more similar its premise category to its conclusion category and the more typical its premise category. Results also show that the Diversity phenomenon was significant for Americans but not for the Itzaj: whereas Americans judge an argument to be stronger the more diverse its premise categories, Itzaj judgments seem to be insensitive to the diversity of the premise categories. Although three *t* tests were performed on the same small sample of participants and limited range of scores in each condition, the condition-wise α level did not exceed .05.

The Similarity and Typicality phenomena provide a crosscultural replication of the findings of Osherson et al. (1990) and López et al. (1992) with American adults and children, respectively. This replication indicates that both Americans and the Itzaj use their taxonomies of mammals to make similarity- and typicality-based inductions about those mammals. These findings suggest that similarity- and typicality-based inductions are a universal feature of folkbiological inductions. Moreover, they suggest that the basis for similarity- and typicality-based inductions is a built-in feature of folkbiological taxonomies: the taxonomic arrangement of natural categories entails the similarity matrix from which similarity- and typicality-based inductions are readily derived (remember that the typicality of a given category corresponds to its average similarity to the rest of the categories). The only assumption needed to trigger these similarity- and typicality-based inductions is that the distribution of underlying biological properties follows the distribution of those morphological properties according to which natural categories are taxonomically arranged.

Contrary to the Similarity and Typicality phenomena, the Diversity phenomenon does not provide a crosscultural replication of the findings of Osherson et al. (1990) and López (1995). The present findings indicate that whereas Americans use their taxonomies of mammals to make diversity-based inductions about those mammals, the Itzaj do not. Although alien task demands could possibly explain the Itzaj's nonsignificant performance on the Diversity items, it is unlikely given their significant performance on the analogous Similarity and Typicality items. These findings suggest that diversity-based inductions are not a universal feature of folkbiological inductions. Moreover, they suggest that whereas the basis for diversity-based inductions may also be a built-in feature of folkbiological taxonomies (i.e., the taxonomic arrangement of natural categories also entails the diversity matrix from which diversity-based inductions are derived), an extra assumption seems to be needed to trigger them. This assumption represents the basic principle of scientific induction in systematics: any underlying biological property shared by two natural categories is probably shared by the lowest taxonomic group including those two categories regardless of their morphological differences (Warburton, 1967). This seems to be the assumption that Americans make. The Itzaj, however, either do not make this assumption, or this assumption is blocked by cultural beliefs and expertise. We believe that the latter is the more likely possibility. The apparent cultural character of diversity-based inductions and the universal character of similarity-based inductions were more closely examined in a series of follow-up studies.

Follow-Up Studies

Similarity-Based Inductions

If, as suggested by the findings of Study 2, the basis for similarity-based inductions is actually a built-in feature of folkbiological taxonomies, then American and Itzaj inductions should converge and diverge where their taxonomies do. Furthermore, they should resemble and depart from scientific inductions where their taxonomies do regarding the scientific taxonomy. These predictions were tested in an American and Itzaj follow-up. Twelve Itzaj adults and 32 University of Michigan undergraduates were paid to take part in this follow-up (most Itzaj but no American had taken part in the original study). They were respectively tested on four critical items where the inductions of Americans, the Itzaj, and science were predicted to distinctively differ because their taxonomies distinctively differ on these same items. The methodological aspects of this follow-up were exactly like the ones of the original study (see above for details). Given their distinctive predictions, each item will be analyzed separately below (for all results, $p < .02$ by a one-tail binomial test, unless otherwise indicated).

The first prediction was that American and Itzaj inductions should converge and diverge where their taxonomies do. This was tested with the following two items: GOAT/SHEEP versus GOAT/COW and FOX/DOG versus FOX/CAT. For the first item, both Americans and the Itzaj classify goats with sheep instead of cows (for all items, see Figs. 2–4). Thus, they should both prefer the former over the latter argument. Results show that most Americans (92%) and Itzaj (67%, $p = .07$) do prefer the former argument. These findings suggest that folk inductions crossculturally converge where folk taxonomies do. For the second item, Americans classify foxes with dogs, whereas the Itzaj classify foxes with cats (see General Discussion). Thus, Americans should prefer the former and the Itzaj the latter argument. Results show that most Americans (79%) prefer the former and most Itzaj (75%) the latter argument. These findings suggest that folk inductions crossculturally diverge where folk taxonomies do.

The second prediction was that American and Itzaj inductions should resemble and depart from scientific inductions where their taxonomies do regarding the scientific taxonomy. This was the case of the second item in which American taxonomies and inductions coincide with, and Itzaj taxonomies and inductions deviate from science: scientifically, the first argument is inductively stronger because foxes are taxonomically closer to dogs (both canines) than to cats (felines). In the case of the first item, both American and Itzaj taxonomies and inductions deviate from science: scientifically, both arguments are inductively equivalent because goats are taxonomically equidistant from sheep and cows (all bovids). These findings suggest that folk inductions resemble and depart from scientific inductions where folk taxonomies do regarding the scientific taxonomy.

This predicted departure from science was further tested with the following two items: PORCUPINE/OPOSSUM versus PORCUPINE/SQUIRREL and BAT/RAT versus BAT/CAT. For the third item, both Americans and the Itzaj classify porcupines with opossums instead of squirrels, because of their appearances (see General Discussion). Thus, they should both prefer the former over the latter argument. Scientifically, however, the latter argument is inductively stronger because porcupines are taxonomically closer to squirrels (both rodents) than to opossums (marsupials), despite of their appearances. Nonetheless, results show that most Americans (91%) and Itzaj (100%) do prefer the former argument. For the fourth item, both Americans and the Itzaj classify bats with rats instead of cats, because of their appearances (see General Discussion). Thus, they should both prefer the former over the latter argument. Scientifically, however both arguments are inductively equivalent because bats are taxonomically equidistant from rats (rodents) and cats (felines), despite of their appearances. Nonetheless, results show that most Americans (87%) and Itzaj (75%) do prefer the former argument. These findings further suggest that folk inductions crossculturally converge where folk taxonomies do, and that they depart from scientific inductions where folk taxonomies do regarding the scientific taxonomy. Moreover, the overall findings of this follow-up suggest that the basis for similarity-based inductions is actually a built-in feature of folkbiological taxonomies.

Diversity-Based Inductions

Itzaj follow-up 2. Unlike similarity-based inductions, the findings of Study 2 suggest that diversity-based inductions are not a universal feature of folkbiological inductions. We tested this suggestion by devising a second Itzaj follow-up to control for two differences between the Diversity items and the Similarity and Typicality items of that study. First, the Diversity task might be more demanding given that its items consist of pairs of two-premise as opposed to one-premise arguments. This was now controlled by also having two-premise Typicality items. Second, the Diversity task might be more confusing given that its items contain overlapping as opposed to nonoverlapping categories. In other words, the Diversity items consist of pairs of two-premise arguments where one of the premises is the same in both arguments. This was now controlled by having nonoverlapping categories for the Diversity items.

Twelve Itzaj adults were paid to take part in this follow-up (most had also taken part in the original study). They were tested on a single Familiarization item, four Typicality items, and four Diversity items. All items consisted of pairs of two-premise arguments with non-overlapping categories. For example, one of the Typicality items was OCELOT, OPOSSUM/MAMMAL versus SQUIRREL, HORSE/MAMMAL, where the first pair is more typical but equally diverse relative to the second. An example of one of the Diversity items was SHREW, OTTER/MAMMAL versus COATIMUNDI, RACCOON/MAMMAL, where the first pair is more diverse but equally typical than the second. The single familiarization item was JAGUARUNDI, PACA/MAMMAL versus HUMMINGBIRD, PARROT/MAMMAL. All other methodological aspects were exactly like the ones of the original study (see above for details).

In this Itzaj follow-up, most participants (83%) answered the familiarization item correctly. Results show that most of the Itzaj responses were in accord with the Typicality phenomenon (75%, $t = 4.06$, $p < .01$), but not with the

Diversity phenomenon (33%, $t = -2.35$, $p < .05$). In fact, the Diversity phenomenon was significant in the opposite direction indicating that the Itzaj preferred arguments with similar instead of diverse premises. In short, the present findings replicate the original findings under a better-controlled design. These findings further suggest that diversity-based inductions are not a universal feature of folkbiological inductions.

However, Itzaj's justifications reveal that diseases did not function as blank properties for the Diversity items but rather as triggers for ecologically based inductions. In most cases, ecological considerations led participants to conclude that the argument with more diverse premises was actually the weaker. For example, one participant favored the argument RAT, POCKET MOUSE/MAMMAL over TAPIR, SQUIRREL/MAMMAL. She argued that tapirs and squirrels are less likely to pass on the disease because they probably required an ecological agent (a bat biting them) to get the disease in the first place, whereas rats and pocket mice are close enough ''companions'' that they do not need an ecological agent (a bat biting them) to get the disease. In other cases, ecological considerations led participants to reject the premises of the more diverse argument. For example, for the argument SHEEP, AGOUTI/MAMMAL, one participant said that sheep and agouties cannot possibly have the same disease because sheep live in the village and agouties inhabit the forest. The participant went on to say that agouties could only catch the disease of sheep if they were enclosed together but that then agouties would no longer go into the forest where other animals may catch their disease, because they had become accustomed to the village. Finally, ecological considerations also led to diversity-based inductions in some few cases. For example, one participant accepted the argument TAPIR, SQUIRREL/MAMMAL as being stronger than RAT, POCKET MOUSE/MAMMAL, and offered the rationale that rats and pocket mice live only where there is corn, sleep above ground, and do not travel into parts of the forest where other animals may catch their disease. Overall, these justifications suggest that the Itzaj's performance on the Diversity items reflect ecologically based inductions, which are not reflected in Americans' performance.

Itzaj follow-up 3. In a third Itzaj follow-up, we controlled for possible category effects by testing Itzaj's category-based inductions about palms. Fourteen Itzaj adults were paid to take part in this follow-up (nine had also taken part in the original study). They were tested on three Similarity, Typicality, and Diversity items. Aggregate folk taxonomic distances among palms (obtained by Atran, in press) were used to determine the diversity of the premise categories. For example, one of the Diversity items was COCONUT, BASKET WHIST/PALM versus COCONUT, ROYAL PALM/PALM, where the first pair is more diverse (but equally typical) than the second. All other methodological aspects were exactly like the ones of the original study (see above for details).

Results show that most of the Itzaj responses were in accord with the Similarity (82%, $t = 3.41$, $p < .01$) and Typicality (73%, $t = 2.38$, $p < .05$) phenomena, but not with the Diversity phenomenon (47%, $t = -.29$, n.s.). These findings replicate the original findings with a different category. These findings again suggest that whereas similarity- and typicality-based inductions are a universal feature of folkbiological inductions, diversity-based inductions are not.

However, as with Itzaj's justifications for inductions about mammals, justifications for inductions about palms reveal that diseases did not function as blank predicates for the Diversity items but rather as triggers for ecologically based inductions. Again, in many cases, ecological considerations led participants to conclude that the arguments with more diverse premises was actually the weaker. For example, one participant favored the argument COCONUT, ROYAL PALM/PALM over COCONUT, BASKET WHIST/PALM arguing that because the coconut and the royal palm are tall and tree-like, their disease is more able to spread to all other palms. In this case, as in many others, size is indicative of the broader ecological coverage of the forest's tree canopy.

In other cases, ecological considerations again led participants to diversity-based inductions. For example, one participant accepted the argument COCONUT, BASKET WHIST/PALM as being stronger than COCONUT, ROYAL PALM/PALM by saying: ''Don't you see that the coconut is a big tree and the basket whist clings to it worse than a vine, isn't that so? It can encounter the coconut, climb it and catch the same disease the other has [and give it to the other palms].'' In other words, the vine-like basket whist can help spread the disease of the tree-like coconut to all of the other palms, whereas the tree-like royal palm would presumably contribute little more to the spread of the disease than would the coconut alone. In this case, as in others, the focus seems to be on broader ecological coverage in terms of the vertical, or storied, relationships between forest species rather than in terms of the horizontal relationships of broad spatial coverage.

Finally, in some cases, ecological considerations of range and frequency led participants to reject premises again. For example, one participant argued that because the royal palm is seldom found anymore in the forest, then any disease it might have would not likely affect other palms. He accepted the more diverse argument, COCONUT, BASKET WHIST/PALM, as being stronger only because he rejected one of the premises of the less diverse argument. But similar considerations for rejecting premises could also lead to acceptance of less diverse arguments. For example, one participant accepted the less diverse argument XATE, COW'S FOOT/PALM over the more diverse argument XATE, BROOM PALM/PALM. Here the premises of the less diverse argument are two herb-like species of the genus *Chamaedorea,* whereas a premise of the more diverse argument is the tree-like broom palm. He offered the following rationale: ''The disease of xate with cow's foot because there are so many of them in the forest; the other [palms] catch their disease anywhere; not so broom palm.'' Overall, these justifications again suggest that the Itzaj's performance on the Diversity items reflect ecologically based inductions, which are not reflected in Americans' performance.

Itzaj follow-up 4. Finally, in a fourth Itzaj follow-up, we controlled for possible context effects by testing Itzaj's reasoning about real-world scenarios which favor a resource diversification strategy. Twelve Itzaj adults were paid to take part in this follow-up (most had also taken part in the original study). They were tested on four items like the following: ''Imagine you want to buy several bags of corn from a given person. Before buying them, this person will show you only two cobs of corn to check whether all the corn is good. Do you prefer him to show you two cobs from one and the same bag (nondiversification response), or do you prefer him to show you one cob from one bag and another cob from another bag (diversification response)?'' Another item concerned safeguarding money, and the other two concerned inspecting farmland. Results show that most of the Itzaj responses on these items were diversification responses (75%, $t = 3.63$, $p < .01$), indicating that the Itzaj use a resource diversification strategy when reasoning about real-world scenarios which favor such a strategy. These findings suggest that the Itzaj reason based on diversity in certain contexts but not in others (see General Discussion).

Conclusions

In sum, the results of Study 2 and its four follow-up studies indicate that both Americans and the Itzaj use their taxonomies of mammals (and palms) to make similarity- and typicality-based inductions about those mammals (and palms). These findings suggest that similarity- and typicality-based inductions are a universal feature of folkbiological inductions. Moreover, that the basis for similarity-based inductions is a built-in feature of folk taxonomies: inductions converge and diverge crossculturally and regarding science where taxonomies do. Results also indicate that whereas Americans use their taxonomies of mammals (and palms) to make diversity-based inductions about those mammals (and palms), the Itzaj make ecologically based inductions instead. Moreover, they indicate that the Itzaj can reason based on diversity in real-world contexts. These findings suggest that diversity- and ecologically based inductions are not universal features of folkbiological inductions and may instead be based on cultural beliefs and expertise.

GENERAL DISCUSSION

Our purpose in this paper was to examine how features of categorization in two very different cultures inform patterns of reasoning in those cultures. Our findings reveal striking similarities in how Americans and the Itzaj-Maya form folkbiological taxonomies and use them for category-based inductions. They also reveal important differences. Below we review these, and then consider the implications for universal and culturally-specific aspects of folkbiological thought. We argue that similarities reveal a universal tendency to create a folkbiological conceptual system based on morphological and behavioral similarity, and to use this system to guide induction. Differences emerge in the degree to which specific knowledge effects both the structure of the taxonomy and, in turn, inferences based on the taxonomy.

Folkbiological Categorization

On an initial level of analysis, the taxonomies of Americans and the Itzaj were remarkably similar. Members of both cultures formed folk taxonomies involving highly consensual similarity relations among mammals. Both created taxonomies of similar depth (six levels), based on similar criteria (morphological and behavioral properties), containing similar groups (e.g., large predatory and nonpredatory mammals). Also, taxonomies of equivalent mammals correlated highly. Using the scientific taxonomy as a metric for comparison also reveals similarities. American and Itzaj taxonomies correlate with the scientific taxonomy to the same degree. In both cultures, folk distance maps onto scientific distance in the same way: mammals related at the scientific level of genus and family are perceived as more similar than more distantly related species. Indeed, Americans and Itzaj even depart from science in systematic and comparable ways. To illustrate, consider the case of the opossum, the only marsupial native to North and Central America. Unlike placental mammals, marsupials carry their young in an external pouch. For the purposes of biological science, this fact about reproduction gives a strong indication that opossums are evolutionarily quite distinct from other placental mammals. Science therefore sets opossums (and other marsupials) in a subclass of their own (Metatheria). However, this scientific classification does not prevent both Americans and the Itzaj from classifying opossums with porcupines (rodents)—on the basis of morphology and behavior—despite the fact that, evolutionarily, porcupines are more closely related to squirrels, or even to horses or wolves, than they are to opossums.

Despite these striking similarities, equally striking differences also emerged between American and Itzaj taxonomies. First of all, on a surface level, there were simple differences in perceived similarity. For instance, the Itzaj consider foxes more similar to smaller cats than to dogs, whereas Americans classify foxes with dogs. On a deeper level, several results suggest that the Itzaj have richer knowledge about local mammals than Americans. The Itzaj are more likely to differentiate intermediate groups of mammals on the basis of behavioral and ecological properties such as typical habitat, hunting patterns, and so on. Likewise, the Itzaj are less likely to lump mammals together into broad superordinate groups. Perhaps their more detailed knowledge of individual species renders broad groups of mammals less salient. Finally, some of the Itzaj groupings evident in Fig. 4 are based on knowledge of behavioral or ecological properties. Otters, for instance, are relatively isolated on ecological grounds (they are the only aquatic mammal), and monkeys, kinkajous, and squirrels are classified together because they all share the same ecological niche: they all live in trees. It must be noted, however, that whereas the Itzaj probably have a much richer body of ecological knowledge about local mammals than Americans, the latter were not confined solely to morphological properties in their classifications. American taxonomies show the influence of both domesticity (e.g., in the subordinate distinctions between dogs versus coyotes and wolves) and behavior (e.g., in the distinctions between large predators and large nonpredators). Thus, factors beyond morphology inform American and Itzaj folkbiological taxonomies, but to very differing degrees.

Category-Based Induction

Results for category-based induction also revealed cross-cultural similarities and differences. For both Americans and Itzaj, similarity and typicality predicted patterns of induction. For example, in agreement with their folk taxonomies, both Americans and Itzaj favored an inference from porcupines to opossums over one from porcupines to squirrels, whereas science favors the latter. Moreover, in the case of foxes, the same principle—similarity—guided Americans and Itzaj to different conclusions. For members of the two cultures, foxes occupy a different place within the folkbiological taxonomy, and participate in different similarity relations. Americans classify foxes with other canines like dogs, wolves and coyotes, whereas the Itzaj classify foxes with small felines like cats and jaguarundies. Accordingly, Americans preferred an inference from foxes to dogs, whereas the Itzaj preferred an inference from foxes to cats. Note that these different choices are based on the same underlying structural constraint: for both Americans and the Itzaj, similarity relations embodied in the folk taxonomy drive patterns of induction. Likewise for typicality relations, which were derived directly from each culture's respective taxonomies. Very different mammals qualified as typical in Petén versus Michigan; nevertheless, members of each culture perceived arguments with typical premises as stronger.

Alongside the common patterns of similarity- and typicality-based reasoning, we found a striking difference between Americans and Itzaj with respect to diversity-based reasoning. As in previous research (e.g., Osherson et al., 1991; López, 1995), Americans overwhelmingly preferred arguments with more diverse premises. In sharp contrast, the Itzaj did not, and sometimes showed below chance responding on diversity items. This could not be attributable to the general lack of a diversity-like reasoning mechanism; responses on several ''diversification'' reasoning problems clearly showed that in certain cases, Itzaj informants used a diversity-based reasoning strategy. It seems likely that diversity-based reasoning about disease was ''blocked'' by specific ecological knowledge and associated reasoning processes. In some cases Itzaj participants rejected the diverse premise as implausible based on their own specific knowledge of the ecology of the species in question. More often their reasoning could be characterized as using ''ecological coverage'' where likelihood of contact with other animals was assumed to be critical. In a follow-up study involving reasoning about palms, ecological coverage was expressed in terms of range, commonness, and the idea that big palms (from the upper canopy) are more likely to affect small trees (from the lower canopy) than vice versa.

One might wonder whether the difference between Americans and the Itzaj reflect culture or amount of knowledge or expertise. We do not find this distinction to be solid because knowledge is part of culture. (Recall that we did not find any difference in the mean consensus parameters for the two groups in the first study, suggesting that individuals were equally expert with respect to their own cultural consensus.) Still, we have some additional observations from a related line of work looking at American tree experts that bear on the interpretation of our findings). The experts consist of taxonomists, landscapers, and parks maintenance personnel (for details, see Medin, Lynch, Coley, & Atran, 1997) and, in work in progress, they have been tested for diversity-based reasoning involving local trees and novel diseases. Overall, they show diversity-based reasoning that is barely above chance. Taxonomists show the strongest diversity effect, landscapers produce an intermediate diversity effect, and maintenance personnel are below chance on diversity.

The taxonomists sorted and reasoned in close accordance with scientific taxonomy (although TREE is not a phylogenetically unitary category it can be taxonomically structured as a conjunction of evolutionarily-valid categories). These results directly confirm scientific (i.e., diversity-based) reasoning patterns that were only inferred from the scientific classification in the mammal studies. For the landscapers, inference was not directly based on the taxonomy produced from their sortings (for reasons discussed in Medin et al., 1997), and so cannot be directly compared to our present studies. The third group, parks maintenance personnel, sorted and reasoned pretty much as did the Itzaj; that is, they reasoned on the basis of the taxonomy produced by their sortings, and their performance on Diversity was below chance.

As with Itzaj palm sortings, the parks maintenance workers produced tree sortings that diverged from science in placing inordinate weight on stem strength and leaf shape (Medin et al., 1997; Atran, in press). They also diverged from the taxonomists and converged with the Itzaj in rejecting the diversity principle in favor of ecology-based reasoning (Medin, et al., 1997). Their justifications are remarkably parallel to those of the Itzaj. Commonness, range, and susceptibility to disease are the most prominent nondiversity strategies. Two experts even offered the argument that big trees are more potent disease spreaders than small trees. In short ecological/causal knowledge appears to compete with or block the use of a diversity strategy.

It would be premature to draw conclusions concerning why type of expertise is associated with differential patterns of diversity-based reasoning, but we offer a speculation. It may be that categories at a higher rank than genus (and family) are more salient and inductively useful to taxonomists than to maintenance personnel. Although tree was explicitly given as the target category, the abstract level of tree (or intermediate ranks like subclass and order) may not be as meaningful for maintenance personnel. By the same token the category, mammal, may have been more meaningful for the Michigan students than for the Itzaj. American participants were generally acquainted with the mammals used, but beyond that had little specific knowledge other than perceived taxonomic relations. In contrast, Itzaj participants had a great deal of knowledge about the habits, characteristics, and ecological proclivities of Petén mammals; this knowledge appears to have blocked diversity-based reasoning by rendering premises implausible on the basis of what the Itzaj know to be true. Thus, cultural knowledge available to the Itzaj may have rendered the diversity strategy irrelevant.

At the very least our observations dispel any notion that the absence of diversity-based reasoning is confined to traditional, nontechnologically oriented cultures. Moreover, our observations suggest that within-culture differences in expertise may correspond in interesting ways to cross-cultural differences. If so, then there may be no absolute distinction between ''culture,'' on the one hand, and ''expertise,'' on the other. This suggests that the hitherto largely separate fields of expert–novice studies in cognitive psychology and comparative cultural studies in cognitive anthropology may be quite complementary.

Role of Science

One source of cultural knowledge that should be available to Americans is science itself (cf. Carey, 1985). Our evidence indicates that such influence, if any, is far from pervasive. We found little evidence that Americans were more ''scientific'' than the Itzaj: both show similar correlations with science and similar relations of folk distance with scientific rank, and both diverge from science in similar ways. Nevertheless, the fact that Americans tend to preserve scientific families more than the Itzaj do may indicate some influence of science.

Alternatively, it may be that Americans and science tend to ignore ecological relationships more than the Itzaj do, but for different reasons. The early development of the scientific taxonomy involved an explicit decision to ignore the ecological setting of the organisms to be classified, as well as the more sense-intimate channels that the Itzaj and other traditional cultures rely strongly on for recognition, such as color, texture, taste, and smell (Atran 1990). This was to enable a worldwide distribution of easily reproducible representations of organisms for ready comparison regardless of an organism's original locale. Thus, science ignores ecology to maximize generality across local environments. On the other hand, Americans—even those raised in the countryside—may simply have a less necessary and intimate awareness of local ecology than do people—like the Itzaj—who depend on that awareness for their daily survival. Thus, American folk may have little ecological knowledge to use.

Another possible indication of the influence of science on American folk concerns the taxonomic position of bats. Americans group bats with insectivores and rodents; the Itzaj leave them unaffiliated. In fact, the Itzaj classify bats with birds. Itzaj participants acknowledge in interviews that bats do resemble shrews and small rodents; however, because the Itzaj *know* that bats are birds, they deem any relation to the other mammals to be superficial. By contrast, Americans *know* from education that bats are mammals. But this knowledge can hardly be taken as evidence for the influence of scientific theory on folk taxonomy. Despite learning that bats are mammals, Americans go on to relate bats to rats and shrews just as the Itzaj might if they did not already *know* that bats are birds. As shown, both Americans and the Itzaj think it is more likely that rats rather than cats will share a property of bats. From an evolutionary vantage, however, bats are taxonomically no closer to rats than to cats, and thus equally likely to share a property of bats. It seems that Americans are not aware of, or pay little heed to, the deeper biological relationships that scientific taxonomies are designed to represent. In other words, the primary influence of education on folkbiological knowledge may be to fix category labels.[12] Beyond this,

[12] A further issue related to the role of science that has not been addressed in the literature is whether or not the correlations between folk and scientific taxonomies result from a fundamental accord between human perception and *objective* discontinuities in the perceptible world, as some authors claim (Hunn, 1977; Berlin & Berlin, 1983; Boster et al., 1986). An answer requires separate assessment of the correlation between folk taxonomy and (at a minimum) three different kinds of competing scientific classification: cladistics, phenetics, and conventional evolutionary taxonomy. Cladists ideally analyze only those characters that reveal strict branching sequences in phylogeny (Hennig, 1966). Pheneticists ideally attempt to base classifications on as many observable characters as possible without any prior weighting of characters in terms of their relative importance in evolution (Sneath & Sokal, 1973). Conventional taxonomists ideally use as many observable characteristics as possible, but weight them according to their likely evolutionary role in the process of natural selection (Mayr, 1969). Because conventional taxonomy deals with the joint effects of phylogenetic descent and adaptive radiation, it uses both *cladistic* and *phenetic* perspectives to reconstruct limited patterns of evolutionary relationships among many morphological, behavioral and ecological characters. For example, birds are phylogenetically close to reptiles; however, their novel adaptation to life in the air renders them a class apart.

Folk taxonomy, as we have seen, is heavily based on perceptual assessments of local phenotypic relationships between phenomenally salient biological species. It should thus most closely approximate phenetic taxonomy, followed by conventional taxonomy, and then cladistic taxonomy. For example, some cladistic analyses of the felines indicate that jaguars actually constitute a distinct phylogenetic branch that merits its own genus (*Panthera onca*), rather than belonging to the genus *Felis* which encompasses all of the other felines in our study. Considerations of chronological origin and blood chemistry might tend to support the cladistic alternative, whereas criteria of morphology, behavior and adaptive radiation might weigh in favor of the conventional alternative. Thus, using cladistic analyses to determine scientific distance could slightly lower the overall correlation between Itzaj folk taxonomy and science.

In contrast to many cladistic schemes and an increasing number of conventional classifications, most phenetic analyses use a multitude of observable characteristics to place the orders Chiroptera (e.g., bats) and Insectivora (e.g., moles and shrews) closer to one another than to the other mammalian orders. Thus, using phenetic analyses to determine scientific distance could slightly raise the overall correlation between American folk taxonomy and science. Should the correlation between the cultural consensus on folk taxonomies and phenetic taxonomies prove to be the stronger one (cf., Sokal & Rohlf 1980), then continued preference for phenetic, and perhaps also conventional, taxonomies may reflect the continuing hold of common sense on science. In other words, rather than reflecting the *objective world* as such, the correlation between folk and conventional scientific taxonomies may reflect universal ways in which humans spontaneously apprehend the phenomenally bounded world that they evolved in and for whose representation their cognitive apparatus evolved.

science seems to have little impact on American students' folkbiological taxonomy or reasoning.

Conclusions

Our evidence supports the view that folkbiological taxonomy universally informs category-based induction. Americans and Itzaj Maya built taxonomies of mammal categories which were comparable in many ways. Moreover, predictions for induction, based on similarity and typicality relations derived from these taxonomies, were also supported. We also found evidence for differences in folkbiological taxonomy, based largely on the Itzaj's greater knowledge of the kinds in question and greater weighting of ecological factors. These differences may be further reflected in our failure to find diversity-based reasoning among the Itzaj's inductions; more specific knowledge may trigger strategies that, in effect, block diversity.

In sum, although cultures may differ somewhat in their knowledge, they may nonetheless converge on roughly the same taxonomic structure. What is universal in our apprehension of folk biology appears to be an ability to construct taxonomies of living kinds and to use those taxonomies in reasoning. What varies is the knowledge that individuals, as members of different cultures, bring to the process—different paths to more or less the same destination.

APPENDIX

Mammals for American and Itzaj Conditions

Michigan mammals:[a]
Common English name (Family: *Genus species*)

Badger (Mustelidae: *Taxidea taxus*)
*Bat (Vespertilionidae)
Bear (Ursidae: *Ursus americanus*)
Beaver (Castoridae: *Castor canadensis*)
Bobcat (Felidae: *Felis rufus*)
*Cat (Felidae: *Felis cattus*)
Chipmunk (Sciuridae: *Eutamias minimus, Tamias striatus*)
*Cottontail (Leporidae: *Sylvilagus floridanus*)
*Cow (Bovidae: *Bos taurus*)
*Coyote (Canidae: *Canis latrans*)
*Deer (Cervidae: *Odocoileus virginianus*)
*Dog (Canidae: *Canis familaris*)
Donkey (Equidae: *Equus asinus*)
Elk (Cervidae: *Cervus canadensis*)
*Fox (Canidae: *Urocyon cinereoargenteus, Vulpes vulpes*)
*Goat (Bovidae: *Capra hircus*)
Hare (Leporidae: *Lepus* sp.)
*Horse (Equidae: *Equus caballus*)
Lemming (Cricetidae: *Synaptomis cooperi*)
Lynx (Felidae: *Felis canadensis*)
Mink (Mustelidae: *Mustela vison*)
Mole (Talpidae: *Condylura cristada, Scalopus acquaticus*)
Moose (Cervidae: *Alces alces*)
Mouse (Cricetidae-part, Muridae-part, Zapodidae)
Muskrat (Cricetidae: *Ondatra zibethica*)
*Opossum (Didelphidae: *Didelphis marsupialis*)
*Otter (Mustelidae: *Lutra canadensis*)
*Pig (Suidae: *Sus scrofa*)
Porcupine (Erethizontidae: *Erethizon dorsatum*)
Rabbit (Leporidae: *Oryctolagus cuniculus*)
*Raccoon (Procyonidae: *Procyon lotor*)
*Rat (Cricetidae-part, Muridae-part)
*Sheep (Bovidae: *Ovis aries*)
Shrew (Soricidae: *Cryptotis parva, Sorex* sp.)
Skunk (Mustelidae: *Mephitis mephitis*)
Squirrel (Sciuridae: *Cittelus* sp., *Glaucomys* sp., *Sciurus* sp., *Tamiasciurus hudsonicus*)
*Weasel (Mustelidae: *Mustela frenta*, *M. nivalis*)
Wolf (Canidae: *Canis lupus*)
Wolverine (Mustelidae: *Gulo luscus*)
Woodchuck (Sciuridae: *Marmota monax*)

APPENDIX—*continued*

Petén mammals/b'a'al~che':[b] English gloss/Itzaj name (Family: *Genus species*)
Agouti/tzu' (Dasyproctidae: *Dasyprocta punctata*)
Anteater/padre chab' (Myrmecophagidae: *Tamandua tetradactyla*)
Armadillo/wech (Dasypoaidae: *Dasypus novemcinctus*)
*Bat/sotz (Desmontidae, Emballonuridae, Molossidae, Phyllostomidae, Vespertilionidae)
Cacomistle/wayu' (Procyonidae: *Bassariscus sumichrasti*)
*Cat/mis (Felidae: *Felis cattus*)
Coatimundi/chi'ik (Procyonidae: *Nasua narica*)
*Cottontail/tu'ul (Leporidae: *Sylvilagus brasiliensis*)
*Cow/wakax (Bovidae: *Bos taurus*)
*Coyote/koyot (Canidae: *Canis latrans*)
Deer Red Brocket/yuk (Cervidae: *Mazama americana*)
*Deer White-Tailed/keej (Cervidae: *Odocoileus virginianus*)
*Dog/peek' (Canidae: *Canis familiaris*)
*Fox/ch'umak (Canidae: *Urocyon cinereoargenteus*)
*Goat/chib'u (Bovidae: *Capra hircus*)
*Horse/tzimin (Equidae: *Equus caballus, Equus asinus*)
Jaguar/chäk ek'el (Felidae: *Felis onca*)
Jaguarundi/onsa (Felidae: *Felis yagouaroundi*)
Kinkajou/kiritz' (Procyonidae: *Potos flavus*)
Margay/säk xikin (Felidae: *Felis wiedii*)
Monkey Howler/b'aatz' (Cebidae: *Allouatta palliata, A. pigra*)
Monkey Spider/tuuchaj (Cebidae: *Ateles geoffroyi*)
Mountain Lion/koj (Felidae: *Felis concolor*)
Ocelot/säk ek'el (Felidae: *Felis pardalis*)
*Opossum/och (Didelphidae: *Didelphis marsupialis, D. virginiana, Philander Opossum*)
*Otter/pek'-i ja' (Mustelidae: *Lutra annectens*)
Paca/jalej (Dasyproctidae: *Cuniculus paca*)
Peccary Collared/kitam (Tayassuidae: *Tayassu tajacu*)
Peccary White-Lipped/k'ek'en=che' (Tayassuidae: *Tayassu pecari*)
*Pig/k'ek'en (Suidae: *Sus scrofa*)
Pocket Gopher/b'aj (Geomyidae: *Orthogeomys hispidus*)
Pocket Mouse/mumukti' (Heteromyidae: *Heteromys desmarestianus*)
Porcupine/k'i'ix och (Erethizontidae: *Coendou mexicanus*)
*Raccoon/k'ulu' (Procyonidae: *Procyon lotor*)
*Rat/ch'o (Cricetidae-part, Muridae-part)
*Sheep/tämän yuk (Bovidae: *Ovis aries*)
Shrew/kuri' (Soricidae: *Cryptotis micrurus*)
Skunk/pay (Mustelidae: *Conepatus semistriatus, Mephitis macroura*)
Squirrel/ku'uk (Sciuridae: *Sciurus deppei, S. aureogaster*)
Tapir/tzimin=che' (Tapiridae: *Tapirus bairdii*)
Tayra/tzaan jo'ol (Mustelidae: *Eira barbara*)
*Weasel/sab'in och (Mustelidae: *Mustela frenanta*)

[a] Asterisks indicate Michigan mammals with topological equivalents in Petén.
[b] Asterisks indicate Petén mammals with topological equivalents in Michigan.

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