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Cognition 99 (2006) 237–273
COGNITION
www.elsevier.com/locate/COGNIT

Folkbiology of freshwater fish

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Received 20 June 2003; accepted 15 December 2003

Abstract

Cross-cultural comparisons of categorization often confound cultural factors with expertise. This paper reports four experiments on the conceptual behavior of Native American and majority-culture fish experts. The two groups live in the same general area and engage in essentially the same set of fishing-related behaviors. Nonetheless, cultural differences were consistently observed. Majority-culture fish experts tended to sort fish into taxonomic and goal-related categories. They also showed an influence of goals on probes of ecological relations, tending to answer in terms of relations involving adult fish. Native American fish experts, in contrast, were more likely to sort ecologically. They were also more likely to see positive and reciprocal ecological relations, tending to answer in terms of relations involving the full life cycle of fish. Further experiments support the view that the cultural differences do not reflect different knowledge bases but rather differences in the organization and accessibility of knowledge. At a minimum the results suggest that similar activities within a well-structured domain do not necessarily lead to common conceptualizations.

Keywords: Taxonomic; Native American; Folkbiology; Ecology

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0022-2860/$ - see front matter
doi:10.1016/j.cognition.2003.12.005

One of the most striking observations in folkbiology is the high level of agreement both within and across cultures in the categorization of plants and animals (e.g. Atran, 1990; Berlin, 1992; Boster, 1987; Boster & D'Andrade, 1989; Lopez, Atran, Coley, Medin, & Smith, 1997; Malt, 1995; Shafto & Coley, 2003). This agreement has been attributed to the correlational structure of the environment (e.g. Rosch, 1978); the idea being that correlated features or properties create natural "chunks" or basic level categories that any well-adapted categorization system must acknowledge or exploit. Of course, the observation that the basic level may change as a function of expertise (e.g. Johnson & Mervis, 1997, 1998; Tanaka & Taylor, 1991; see also Coley, Medin, & Atran, 1997) forces nuances on the idea that the structure is in the environment. Furthermore, coherence may also be importantly driven by (universal) inference principles that, for example, allow tadpoles and frogs and even caterpillars and butterflies to be seen as different stages of the same kind of thing (Atran, 1998). Nonetheless, there is a broad agreement that the sort of perceptual and conceptual features associated with people's categorization schemes correspond much more closely with correlated features than with orthogonal distributions of them. Overall, there is considerable consensus in people's categorization of living things.

Agreement on categories does not necessitate agreement on the *basis* for categorization. The same categories can result from very different sources of information. For example, woodticks have categories that correspond very closely with the human concept, mammal, but the basis for woodtick categorization is not visual (morphological) features or abstract properties like bearing live young but rather the presence of butyric acid. In short, similar outcomes in categorization processes are no guarantee of similar underlying features. One consequence of the assumption of correlated features is that two people or two groups may have roughly the same categorization scheme but have very different underpinnings for it. For example, Lopez et al. (1997) noted that undergraduates in the USA and the Itza' Maya of Guatemala both sorted mammals into categories that corresponded fairly well with science. However, the justifications for sorting (and multi-dimensional scaling results) suggested that the USA students had relied heavily on size as the basis of sorting, whereas the Itza' used a broad range of morphological and ecological criteria and primarily used size to describe within category differences.

There is some evidence that expertise affects both the basis for categorization and categorization itself. Boster and Johnson (1989) observed that free sorting of ocean fish by commercial fisherman actually agreed *less* with scientific taxonomy than the free sorts of novices. One possibility is that the experts were using goal-related knowledge to structure their categories (e.g. Barsalou, 1985). Medin, Lynch, Coley, and Atran (1997) also used a free sorting task, in this case with different kinds of tree experts (landscapers, parks maintenance personnel, and taxonomists). They found that landscapers tended to sort trees into goal-related categories but that the free sorts of maintenance personnel (and taxonomists) corresponded more with scientific taxonomy. This finding suggests that kinds of expertise play a role in category organization.

One hypothesis that summarizes the current literature is that the correspondence of expert sorts to (general purpose) scientific taxonomy is driven by the relationship between that taxonomy and how expertise-related goals structure the domain. If the goals crosscut the taxonomy (as they do for landscapers), then the correlation with science will be reduced. If the goals are concordant with the taxonomy, then expertise should increase the correlation between expert sorts and science. For example, given that the goal of bird watching is to identify birds, one might expect higher agreement between the sorts of expert birders and science than between the sorts of novices and science. This is indeed the case (Bailenson, Shum, Atran, Medin, & Coley, 2002). A corollary of this hypothesis is that different groups that have the same goals and characteristic activities should converge as they become more expert.

Concept representations also include more than a set of features used in categorization (e.g. Smith and Medin, 1981). Sometimes cognitive scientists appeal to the contrast between a dictionary and an encyclopedia to make this distinction. Individuals and groups may have the same categories and use the same features to categorize but have very different conceptualizations of these categories. By conceptualization, we mean amount and types of knowledge as well as how that knowledge may be organized in memory.

There is suggestive to strong evidence that the bases for categorization and the conceptualization of categories may be affected by both cultural background and expertise. In a recent comparative study of three populations living in close proximity in the rainforest of Guatemala and engaged in more or less the same activities for at least 20 years (agro-forestry, hunting, gathering), our research team (Atran et al., 1999, 2002) has found striking differences in mental models of plant–animal interactions that were correlated with differences in agro-forestry practice. Although the three groups categorize the plants and animals in similar ways, they have very different understandings of ecological relations; one group has a reciprocal model where plants help animals and animals help plants, but the other two groups have asymmetrical models and deny that animals help plants. This suggests that previous studies showing similar patterns of sorting may mask large differences in how the respective categories are conceptualized and related to environmental behaviors.

To address these questions, one has to be careful not to confound culture with expertise (as was the case in the studies by Lopez et al., 1997). Although the populations studied by Atran et al. (1999, 2002), each had 20 or more years of experience in the area, one group was indigenous whereas the other two had immigrated to the area. Thus, at least some of the differences observed may be attributable to expertise, not culture. Indeed, there is evidence that expertise is associated with a greater propensity to think about biological kinds in terms of ecological relations (Proffitt, Coley, & Medin, 2000; Shafto & Coley, 2003).

In the present studies we examine the existence and nature of cultural differences in folkbiology between two populations closely matched for both expertise and characteristic goals and activities. We present four studies looking at several domains of folkbiological knowledge: (1) free sorting; (2) fish–fish interactions and (3) ecological sortings of fish (according to shared habitats).

Each of the above measures targets one or more of the questions motivating this research. The sorting tasks address the question of whether expertise leads to a convergence on the structure and relational facts inherent in nature? The sorting justification and fish–fish interaction tasks evaluates whether the hypothesized convergence extends to both the basis for categorization and the conceptualization of categories (the salient information associated with them)? Finally, all of the tasks bear on the question of whether cultural variables play any role beyond that reflected by characteristic practices and activities?

The participants for the present studies were (non-professional) experts in freshwater fish and fishing in north central Wisconsin. The experts were drawn from two populations, a Native American group (Menominee Indians) and a nearby majority-culture (European–Americans) group. Members of both groups engage in similar fishing activities, including fishing in both rivers and lakes in all seasons and using live bait, flies (that they frequently tie themselves) and other artificial lures to do so. In the following paragraphs, we describe these populations in some detail, noting their similarities and differences. We then provide further information concerning the comparability of goals and activities.

Menominee. The Menominee ("Wild Rice People") are the oldest continuous residents of Wisconsin. Historically, their lands covered much of Wisconsin but were reduced, treaty-by-treaty, until the present 95,000 ha was reached in 1856. There are 4–5000 Menominee living on tribal lands in and around three small communities. The 1990 census indicated that the mean family income was about $20,000 compared with $33,000 in adjacent Shawano County. Despite economic incentives to the contrary, the Menominee have preserved diversity and habitat types of their forest, which is managed by a tribal enterprise. Overall, sustainable coexistence with nature is a strong value among the members of this population (Hall & Pecore, 1995).

The reservation has a number of lakes, ponds, creeks and rivers. One of the major rivers is the Wolf River, which runs through the reservation into Shawano and continues to Lake Winnebago. Shawano is the closest majority-culture town and it lies south of the reservation. Historically, lake sturgeon migrated up to the river in the spring to spawn within the reservation, and sturgeon provided an important food-source for the Menominee. Early in the 20th century, however, a dam was built south of the reservation, preventing the sturgeon from migrating up to the Menominee reservation. Recently, the tribe has begun a program reintroducing sturgeon into reservation waters.

The tribe sets its own fishing regulations, which allow spear-fishing of some game fish (in contrast to Wisconsin state law which prohibits spear-fishing;[1] nonetheless, only a minority of Menominee fishermen spear-fish). Tribal fishing regulations prohibit the "wanton destruction" of any fish. For Menominee, a strong cultural value is respect for nature and the belief that one should only take what is needed from the environment. Recent surveys reveal that the fish population on the reservation shows above average health and abundance (Schmidt, 1995). Fish are stocked in only a minority of the reservation lakes. There is some evidence that fish stocking may reduce biodiversity (e.g. Radomski & Goeman, 1995).

Majority culture. Just south of the reservation is Shawano County, the other focal area for our study. The major sources of income in the town of Shawano are light manufacturing, small-scale farming, and tourist recreation, mainly in the form for hunting, fishing, boating, jet-skiing and snowmobiling. Shawano Lake is a major attraction and

[1] There are some exceptions to this Wisconsin state law.

there are also several smaller lakes in the county. The Wolf River runs through Shawano County and is connected by a channel to Shawano Lake.

Outdoor recreation is very important to many of the Shawano residents and many of them have fished since the time they were young children. Several fishing clubs (e.g. a "Muskie Club") provide a social dimension to fishing. These clubs also raise money to stock lakes and rivers with desired fish and encourage the practice of "catch and release" (for example, the Muskie Club rules are such that you will be dismissed from the club if you cause the death of even a single muskie). There are usually several local fishing contests each year, open to Shawano residents, tourists and professional fishermen. Considerable sums of money go to winners; for example, one of our informants had won $25,000 in a muskie contest.[2]

Comparison of populations. Based on the literature we have reviewed so far, there is little reason to expect differences between Menominee and majority-culture fishing experts. Both groups share the general goal of catching adult fish, both groups target essentially the same set of fish, and both use the same set of methods (using live bait, artificial lures, fly fishing, ice fishing, etc.). This common goal and common practices, coupled with their very extensive fishing experience (on average, several decades) should lead to a convergence of the two groups with respect to their conceptualizations of fish. In short, previous literature provides every reason to expect that we will not observe any substantial group differences.

Against this background of similarities, there are some group differences in orientation towards fish and fishing that are important to bear in mind. In addition to the experiments presented in this paper, we have conducted interviews with informants from both groups concerning goals associated with fishing and attitudes toward various fishing practices. One group difference is that fishing for food is a higher priority goal for the Menominee than it is for the majority-culture experts.[3] Furthermore, the range of species that are considered appropriate for eating typically is broader for the Menominee informants. For example, Menominee typically catch and eat largemouth and smallmouth bass, whereas majority-culture fishermen often practice catch and release for these bass, describing them mainly as sportfish. The Menominee are also more approving of someone with a large family catching more than the legal limit of fish in order to feed their family. Generally, it can be said that majority-culture informants focus relatively more on fishing for sport than on fishing for food.

It is important to bear in mind that many generalizations concerning goals, values and attitudes towards fishing practices are associated with substantial variability. For example,

[2] There are some small-scale fishing contests on one of the reservation lakes but the prizes are tiny by comparison and it is more a local, social event than a contest per se.

[3] We asked 15 Menominee experts and 17 majority-culture experts to rank order six different goals associated with fishing. These goals were (a) fishing as a way of being close to nature; (b) fishing for the challenge of outsmarting the fish; (c) fishing for food; (d) fishing for trophy sized fish; (e) fishing as a source of relaxation, and (f) fishing as an activity to pass on knowledge to future generations. Members of both groups agree with each other on most goals. However, majority-culture experts are marginally more likely to rank the goal of "fishing as a challenge" higher than Menominee (average 4.4 versus 3.4; $t=1.89$, $P=0.066$), while Menominee placed higher importance on the "fishing as a food source" goal (average 2.7 versus 4.5; $t=3.4$; $P=0.002$).

a considerable number of Menominee—about half of our sample of experts—do not approve of spear-fishing walleyes (a game fish prized for its meat) because spearing is typically done in the spring when fish are spawning and they believe that it might hurt the fish population. The response by spear-fishers is that they ignore the larger females in favor of spearing the males.[4] Conversely, a fair number of majority-culture fishermen oppose fishing contests, citing high death rates from catch and release and expressing concerns about moving individual fish from their natural home range.

These between group differences in goals may lead to some minor differences in experience with particular species. For example, the muskie is the largest game fish found in this area and, for majority-culture informants, there is prestige associated with catching and releasing them—the bigger, the better. Majority-culture fishermen are more likely to target muskie than are the Menominee in part because there are fewer muskie in the reservation lakes than in Shawano Lake. Majority-culture fishermen also target two other gamefish as “large and prestigious.” These are the northern pike, belonging to the same genus as the muskie, and the walleye. Larger northerns and walleyes are typically released but majority-culture fishermen may eat smaller northerns and walleyes, the latter being considered one of the best tasting freshwater fish by both informant groups. Menominee fishermen also eat northerns and walleyes and both groups eat panfish (e.g. bluegills, sunfish, crappies, perch).

Menominee are somewhat more likely to target trout than are majority-culture informants. Trout are very good to eat, according to the informants, and trout streams are abundant on the reservation. When we asked 14 Menominee and 14 majority-culture fish experts to rank order the importance of 15 species of fish to themselves, we found that trout (brook trout and brown trout) were ranked reliably higher by Menominee fishermen and that muskie was ranked reliably higher by majority-culture fish experts. On another task we asked 13 Menominee and 15 majority-culture fish experts to generate names of local fish off the top of their heads. Majority-culture fishermen were reliably more likely than Menominees to mention northern, muskie and walleye in their first five names and Menominees ($t=2.21$, $P<0.05$) were reliably more likely to mention either “trout” or specific kinds of trout (e.g. brown, brook, rainbow) in their first five names ($t=2.28$, $P<0.05$).

We see two possibilities for how these more subtle differences may affect knowledge and conceptual organization. One is that catch and release gives fewer opportunities to observe what some fish has been eating than catching and cleaning fish. This seems like a very weak possibility, since experts who tend to practice catch and release with large northerns and walleyes nonetheless will have caught and cleaned hundreds if not thousands of smaller walleyes and northerns, and will have spent hundreds of hours in conversations about these fish. The second possibility is that differences in the species of fish targeted will lead to differences in knowledge. For example, we might expect majority-culture experts to know relatively more about the large species of gamefish

[4] Although speared walleyes are not sexed on the Menominee reservation, Wisconsin Department of Natural Resource records of another Native American group’s spearing (the Ojibwe) indicate that about 90% of walleyes speared are males.

(northern, muskie, walleye) and Menominee experts to know relatively more about trout. This possibility is more plausible than the first one. Note, however, that differential experience with particular species would be unlikely to lead to overall differences in conceptual organization.

In summary, it seems clear that what one might call a "practice account" leads one to expect that, at most, one would see second-order differences between experts in the two groups. On this view any effects of goals and attitudes would be mediated by the particular activities and practices associated with fishing. As we have seen, there are clear differences in attitudes but the only consequences for activities are that a few Menominee spearfish walleyes in the spring and majority-culture fishermen are more likely to practice catch and release. We turn now to an alternative view that is compatible with more substantial cultural differences.

A role for cultural factors? The view that the structure of nature- and goal-related activities drives conceptual structure leaves little if any room for cultural variables to influence folkbiology. On the other hand, one might argue that events in nature are complex and subject to construal. It may be that framework theories serve to guide the interpretation of experience (Keil, 1995; Keil, Levin, Richman, & Gutheil, 1999) and make accessible and highlight certain features over others. Cultural beliefs may act as a framework theory, either in the form of so-called "skeletal principles" (e.g. nature seeks a balance; every fish has a role to play, etc.) or in the form of more concrete stories and examples that might serve to guide reasoning by analogy (e.g. knowledge about cowbirds tricking other birds into caring for their young may lead one to be alert for the possibility that some species of fish might spawn on the bed of another species of fish with the same goal in mind). In short, cultural factors may produce different "habits of the mind" that have consequences for conceptualizing nature. This raises the possibility that shared activities and decades of experience may be insufficient to produce convergence in conceptual behaviors. In this view, we would predict certain levels of agreement (due to shared experience) with underlying differences in the ways cultural life shapes the interpretation of experience and attention to various aspects of nature.

Although we find the above ideas appealing on several grounds, we wish to explicitly reject the invited implication that "culture" represents a uniformly shared framework theory with causal potency. Instead, we believe that culture should be studied as a statistical distribution of mental representations and their public expressions among a given population in a given physical context (Medin & Atran, 2004). Cultural differences are a beginning point for analysis and "culture" is, at best, shorthand for a diverse set of (distributed) ideas, values and beliefs.

Cultural milieu may affect conceptual organization in at least two straightforward ways: (1) it may lead to different knowledge bases and (2) it may lead to differences in the *accessibility* of different types of knowledge (e.g. Hong, Morris, Chiu, & Martinez, 2000). Based on previous research in folkbiology by our research team (e.g. Atran et al., 1999, 2002; Shafto & Coley, 2003), a strong candidate for differences is in the conception of ecological relations. The two groups might differ in their propensities for noting ecological relations (different knowledge bases) or in the role that ecological relations play in organizing knowledge of fish. In the latter case, the two groups might have the same knowledge base but what is foreground for one group may be background for the other group. These possibilities are not mutually exclusive.

In the present studies, we aim to see if cultural background influences conceptual organization in a manner than cannot be accounted for in terms of habitual goals and activities. In order to make cross-group comparisons, we will rely heavily on the Romney, Weller, and Batchelder (1986) cultural consensus model (CCM). In the next few paragraphs, we describe the CCM and its application to our present studies.

Measuring agreement. To assess responding within and across groups, we apply the Cultural Consensus Model (CCM), as developed by Romney et al. (1986); (see also Atran et al., 1999; Weller, 1987 for examples). The CCM is a factor-analytic method for computing levels of agreement and disagreement in the structure and distribution of information within and across populations. The model assumes widely-shared information is reflected in a high concordance, or "cultural consensus," among individuals. Principal-components analysis is used to determine if a single underlying model holds for all informants from a given population: a strong group consensus exists if (1) the ratio of the latent root of the first to the second factor is high, (2) the first eigenvalue accounts for a large portion of the variance and (3) all individual first-factor scores are positive and relatively high. If this is the case, then the structure of the agreement can be explained by a single factor solution, the "consensual model." In this case, first-factor scores represent the agreement of an individual with this consensual model.

The CCM is also useful for analyzing within and across group differences. These differences can be explored by (1) comparing first-and second-factor scores of each individual and (2) analyzing patterns of residual agreement. Residual agreement is calculated by subtracting predicted agreement (equal to the product of first-factor scores) from the observed agreement (Boster, 1986; Coley, 1995; Lopez et al., 1997). To the extent that within group residual agreement is larger than across group residual agreement, one has evidence of reliable group differences.

1. Experiment 1: spontaneous sorting

The first study examined spontaneous, hierarchical sorting of fish species by majority culture and Menominee Indian fish experts. Although we have provided some rationale for expecting cultural differences, there is previous literature that would support the expectation of striking similarities. The "correlational structure" of information in the environment would seem to enforce cross-group agreement, as researchers such as Berlin (1992) have noted (see Malt, 1995 for a review). Although Medin et al. (1997), (see also Proffitt et al., 2000) found that different types of tree experts differed from each other on a free sorting task, these different types of experts characteristically engage in different types of activities. Majority culture and Menominee fish experts, in contrast, engage in essentially the same activities at both an abstract (fishing) and more specific level (methods of fishing). In short, there is good reason to expect an overall consensus in sorting. As mentioned earlier, however, the same sorts may be conceptualized in different ways. Therefore, based on the different goals associated with fishing (e.g. fishing for sport versus fishing for food) we might expect to observe at least modest cultural differences in the basis or justification for the sorts.

1.1. Methods

Participants. The participants were 16 majority culture and 16 Menominee Indian fish experts. Participants of the two groups do not differ with respect to age (mean: 44.8 years for majority-culture experts and 48.8 for Menominee experts; $t=1.0$, $P>0.25$), fishing experience (mean: 37.5 years for majority-culture experts and 44 years for Menominee experts, $t=1.44$; $P>0.15$) or education. All informants had English as their native language and all interviews were conducted in English. Expertise was defined by a combination of peer nomination and familiarity with the sample of fish found in this general area of Wisconsin. None of our informants had any formal training in ichthyology and all informants had experience fishing streams, rivers, ponds and lakes in all seasons. Although the participants in the different experiments are not completely the same, there is an extensive overlap and for none of the tasks do any of the features mentioned differ significantly across groups. Therefore, we avoid further mention of these attributes in the descriptions of the individual experiments. Informants were paid for their participation.

Stimulus materials. The common and scientific names of the 44 species of fish employed are listed in Table 1. We initially included two more fish (jumping jack and mully) but they were excluded when we determined that almost none of the Menominee and only a few of the majority-culture experts were familiar with these common names. For the few fish that had more than one common name, both names were listed on the stimulus card (e.g. American eel, lawyer). For the 44 fish used in the task, there were no group differences in common names. The fish were selected to be broadly representative of the fish genera and families found in this part of Wisconsin. Our sample was somewhat biased toward larger fish. For example, instead of presenting individual species of dace and darters we used the folk generic terms, darter and dace. Experts confirmed that all these species of fish are found in this general area, although some species are less common locally. Specifically, smelt are mainly found in Lake Michigan and the rivers feeding into it, white bass are more common slightly south of the research area and flathead catfish, sheephead (drum), and sauger are not locally common. Carp are not found on the lakes or rivers on the reservation but they are common in nearby lakes and rivers.

Procedure. For each informant, each fish name was presented one at a time on a small card. Informants were asked to indicate their general familiarity with the fish by saying a sentence or two about it. This familiarity task was relatively unconstrained both with respect to how long informants talked and with respect to content. For example, the expert might mention the physical appearance of the fish, where it is found, its habits, how to fish for it or simply tell a story about it. Fish names that the informant was unfamiliar with were set aside and not used in the sorting task. If the informant indicated familiarity with the folk genus (e.g. crappie) but expressed uncertainty about distinguishing the specific kind (black crappie versus white crappie), then the fish name was kept. The exception to this rule was that if an expert indicated familiarity with one specific kind of a generic (e.g. golden shiner), then other specific kinds associated with that generic (e.g. spottail shiner) were included only if the informant indicated familiarity with that specific kind.

Table 1
Fish names used in the different experiments

Common names	Scientific names	Exp1	Exp2	Exp3	Exp4
American Eel (lawyer)	*Anguilla rostrata*	×		×	
Black (hog) sucker	*Hypentelium nigricans*	×	×	×	×
Black bullhead	*Ameiurus melas*	×		×	
Black crappie	*Pomoxis nigromaculatus*	×	×	×	×
Blacktail (hornyhead) chub	*Nocomis biguttatus*	×		×	
Bluegill	*Lepomis macrochirus*	×	×	×	
Bluntnose minnow	*Pimephales notatus*	×		×	
Brook trout	*Salvelinus fontinalis*	×	×	×	×
Brown trout	*Salmo trutta*	×	×	×	
Carp	*Cyprinus carpio*	×	×	×	×
Channel catfish	*Ictalurus punctatus*	×		×	
Dace	*Phoxinus* sp. or *Rhinochthys* sp.	×		×	
Darter	*Etheostoma* sp.	×		×	
Dogfish (bowfin)	*Amia calva*	×	×	×	×
Emerald shiner	*Notropis atherinoides*	×		×	
Fathead minnow	*Pimephales promelas*	×	×	×	
Flathead (Missis-sippi) catfish	*Pylodictis olivaris*	×			
Gar (billfish)	*Lepisosteus* sp.	×	×	×	
Golden shiner	*Notemigonus crysoleucas*	×	×	×	
Green sunfish	*Lepomis cyanellus*	×		×	
Lamprey eel	*Ichthyomyzon* sp.	×			
Largemouth bass	*Micropterus notius*	×	×	×	×
Mudminnow	*Umbra limi*	×		×	
Musky	*Esox masquinongy*	×		×	
Northern pike	*Esox lucius*	×	×	×	×
Pumpkinseed	*Lepomis gibbosus*	×		×	
Rainbow trout	*Oncorhynchus mykiss*	×		×	
Redhorse	*Moxostoma* sp.	×	×	×	×
Redtail chub	*Nocomis effusus*	×	×	×	
River (blackback) shiner	*Notropis blennius*	×	×	×	
Rock bass	*Ambloplites rupestris*	×	×	×	×
Sauger	*Stizostedion canadense*	×			
Sheephead (drum)	*Aplodinotus grunniens*	×		×	
Smallmouth bass	*Micropterus dolomieu*	×	×	×	×
Smelt	*Osmerus mordax*	×			
Spottail shiner	*Notropis hudsonius*	×		×	
Stickleback	*Culaea inconstans*	×		×	
Sturgeon	*Acipenser fulvescens*	×	×	×	
Walleye	*Stizostedion vitreum*	×	×	×	×
White (brown) sucker	*Catostomus insignis*	×		×	
White bass	*Morone chrysops*	×		×	
White crappie	*Pomoxis annularis*	×		×	
Yellow bullhead	*Ameiurus natalis*	×	×	×	×
Yellow perch	*Perca flavescens*	×	×	×	×

While testing the first few informants we observed that some of our common names were more specific than those used locally. For example, we used green sunfish on the card but this fish is normally referred to simply as sunfish. After an expert denied familiarity with green sunfish, we changed the procedure by saying “What if we just said sunfish?” This procedure was followed for each folk generic represented by a single species in this area (e.g. northern pike could be described as pike or northern).

Sorting. Immediately after the familiarity task, informants were asked to sort the fish names into meaningful categories. The specific instructions were to “put the fish that go together by nature into as many groups as you want.” In previous work (e.g. Lopez et al., 1997), we have found that the instruction to sort on the basis of similarity is typically met with the question “similar in what respects?” and yields large cross-informant inconsistency (except in undergraduate populations). The above instruction, in contrast, yields coherent patterns of sorting in all of the populations we have studied. Informants were told that there were no right or wrong answers and that we wanted to know how they thought about fish. After the sorting was completed, the informant was asked to explain the basis for each of the categories created.

Next, the informants were invited to combine groups to create larger categories. Again the instruction was to “place the fish that go together by nature into larger groups.” This successful lumping continued until the informant no longer found it meaningful to create larger groups. At this point the initial sorting was restored and informants were invited to examine each group and ask themselves whether there were meaningful subgroups of fish that go together by nature. This splitting continued until the informant no longer found it meaningful to create smaller groups. At each point in the lumping and splitting participants were asked to justify their sorts (for each group we asked “why do these go together?”). In brief, the full sorting procedure created a hierarchical taxonomy for each informant.

1.2. Results

Because of the richness of information provided by the sortings and justifications, we present a variety of measures of category organization. First, we describe how the data were coded, then turn to the questions of within- and across-group agreement and the relation between folk taxonomy and scientific taxonomy. Next, we illustrate the folk taxonomies in terms of both multi-dimensional scaling and cluster analysis. This provides the basis for more fine-grained analyses, which we supplement by looking at the sorting justifications.

Each informant’s fish taxonomy was obtained by translating the groupings created during the initial free sorting, successive super-ordinate sorts, and successive sub-ordinate sorts into a taxonomic hierarchy. For each taxonomy, we derived a pairwise fish-by-fish folk–taxonomic distance by calculating the distance between all possible pairs of fish in the taxonomy. The lowest level at which two given fish go together represents the distance between them. The distance between any species and itself is zero. If two species were placed together in the most specific (lowest) level, their distance was 1. Two species combined at the second most specific level would have a distance of two and so on. The result was a 44 by 44 distance matrix with symmetrical upper and lower diagonals (because distance is symmetrical). Unfamiliar fish were scored as missing data for all pairs involving the unfamiliar fish.

Familiarity with the species. On average experts indicated considerable familiarity with the 44 fish. There were no reliable between group differences (majority-culture mean number left out = 3.3, Menominee left out = 4.7, $t = 1.60$, $P > 0.10$). As a group, experts were least likely to be familiar with three small fish not used in fishing: stickleback, dace and darter. They were also somewhat unfamiliar with the bluntnose minnow. The Menominee experts were less familiar with sauger and sheephead, which are rarely found on the reservation. Majority-culture experts were somewhat less familiar with mudminnow and Menominee less familiar with the spottail shiner. Overall, the pattern of unfamiliarity is consistent with Hunn's (1999) observation that characteristic size is correlated with psychological salience.

Sorts. All of the majority-culture experts produced a hierarchy with at least two levels. Four of the 16 Menominee informants declined to produce either super-ordinate or sub-ordinate sorts. In most of these cases, the initial sort had been on the basis of characteristic habitat which often crosscuts taxonomic relations. In that situation it may not be sensible to create super-ordinate or sub-ordinate groups. One consequence of sorting only at a single level is that there will be a very diminished range of distances for the 44 by 44 matrix.

Consensus analysis. A key finding revolves around the pattern of within- and across-group agreement. As we shall see, it suggests that the two groups share a common model but that, in addition, the Menominee fishermen have a distinct ecological component to their consensual model.

Each informant's fish–distance matrix was correlated with that of every other expert, yielding a 32×32 matrix in which entries correspond to observed agreement among experts on pairwise fish distances associated with the individual sorts. As described above, a principal components analysis was then performed on the inter-subject correlation matrix to see how well it fit the Romney et al. (1986) cultural consensus model.

The results show a clear overall consensus. The first three eigenvalues were 18.4, 2.4 and 1.6. The first latent root is large relative to the second (ratio = 7.6–1) and accounts for just over 57% of the variance. Furthermore, every informant had a positive loading on the first factor. The first-factor scores ranged from 0.67 to 0.94 for the majority informants and from 0.15 to 0.89 for the Menominee experts. The Menominee informants showed less agreement with the overall consensus than the majority-culture experts [mean first-factor score = 0.68 versus 0.82 for majority-culture experts; $t(30) = 2.55$, $P < 0.05$].

The Menominee informants also showed more within group variability. A separate CCM for the Menominee experts yielded a first factor that accounts for 51.5% of the variance, a ratio of the first to the second latent root of 5.9–1, and a range of first-factor scores of −0.02 to 0.91 (mean first-factor score = 0.66). In part, this greater variability reflects clustering on the basis of ecological relations (habitat) and the associated tendency to have a single level of sorting. The corresponding figures for the majority-culture informants were 60.0% of the variance, 6.9–1 and 0.60–0.91 (mean first-factor score = 0.77).

In order to test for group differences in sorting patterns, an informant-by-informant residual agreement matrix was prepared, as described above (see also Nakao & Romney, 1984).

This residual agreement matrix was standardized and then we compared within-versus between-group residual agreement for the two groups. An analysis of variance on residual agreement revealed greater within-than between-group agreement [$F(1,30)=4.96$, MSe = 0.082, $P<0.05$] and a significant population by within versus between interaction [$F(1,30)=8.32$, $P<0.01$].

The form of this interaction is that only the Menominee informants displayed reliably greater within-than between-group residual agreement. In short, *it appears that the Menominee and majority-culture informants share a common cultural model of fish but that the Menominee, in addition, share a somewhat distinct conceptual organization of fish.* We will further explore these similarities and differences by looking at multi-dimensional scaling and clustering of each group's consensual model. In order to illuminate these additional analyses, we first turn to the sorting justifications.

Sorting justifications. The sorting justifications reinforce and expand the differences noted so far. For an initial analysis, each justification was categorized as involving taxonomic or morphological properties (e.g. bass family), ecological properties (e.g. river fish, bottom feeders) or goal-related properties (e.g. game fish, garbage fish). These categories were not mutually exclusive—the justification, "pond-dwelling baitfish" would be scored as both ecological and goal-related.

The majority-culture expert justifications were primarily taxonomic or morphological (62%), followed by goal-related (32%). Ecological justifications were rare (6%). Menominee experts were much more likely to provide ecological justifications (40%), less likely to give taxonomic justifications (33%) about as likely as the majority-culture informants to give a goal-related justification (27%). Separate ANOVAs on number of the different types of justifications showed that the differences in ecological [$F(1,30)=18.7$, MSe = 3.39, $P<0.001$] and morphological/taxonomic [$F(1,30)=12.27$, MSe = 6.12, $P<0.001$] justifications were highly reliable.

A finer level of analysis reveals more detail concerning these cultural differences. Eleven of the Menominee informants mentioned rivers, streams, lakes or ponds for at least one justification, compared with only two majority-culture informants (chi-square with 1 d.f. = 9.63, $P<0.01$). All but one majority-culture informant had a category described as "panfish," compared with only five Menominee (chi-square with 1 d.f. = 16.62, $P<0.01$). We scored "panfish" as a taxonomic justification, though one might argue that it is goal-related. Panfish (e.g. bluegill, sunfish, crappie and sometimes perch) are so-called because they are said to be shaped like a pan or to readily fit into a frying pan. The majority-culture and Menominee informants were about equally likely to mention "baitfish" (11 and 7 out of 16, respectively) and food or eating value (7 and 5, respectively). Majority-culture informants were more likely to describe a group as undesirable or "garbage fish" than were Menominee (12 versus 5 informants, chi-square with 1 d.f. = 4.52, $P<0.05$). Majority-culture informants were also more likely to describe a group as being game fish or sport fish (8 versus 2, respectively; chi-square with 1 d.f. = 3.84, $P<0.05$). In short, majority-culture experts are somewhat more likely to give evaluative (garbage, sport) justifications for fish sorts.

Multi-dimensional scaling. The consensual sorting distances (averaged across all informants of one group) were analyzed using MDS and the results are shown separately for the two groups in Figs. 1 and 2. For the majority-culture experts, a one-dimensional

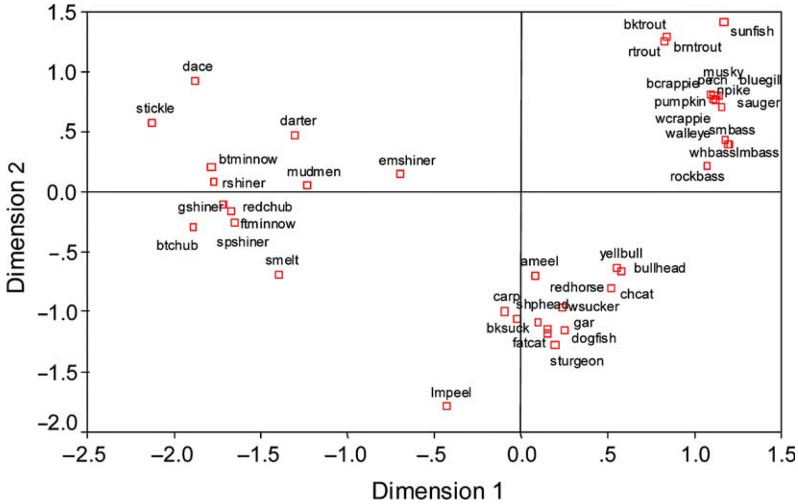

Fig. 1. Majority culture MDS; Euclidean distance model.

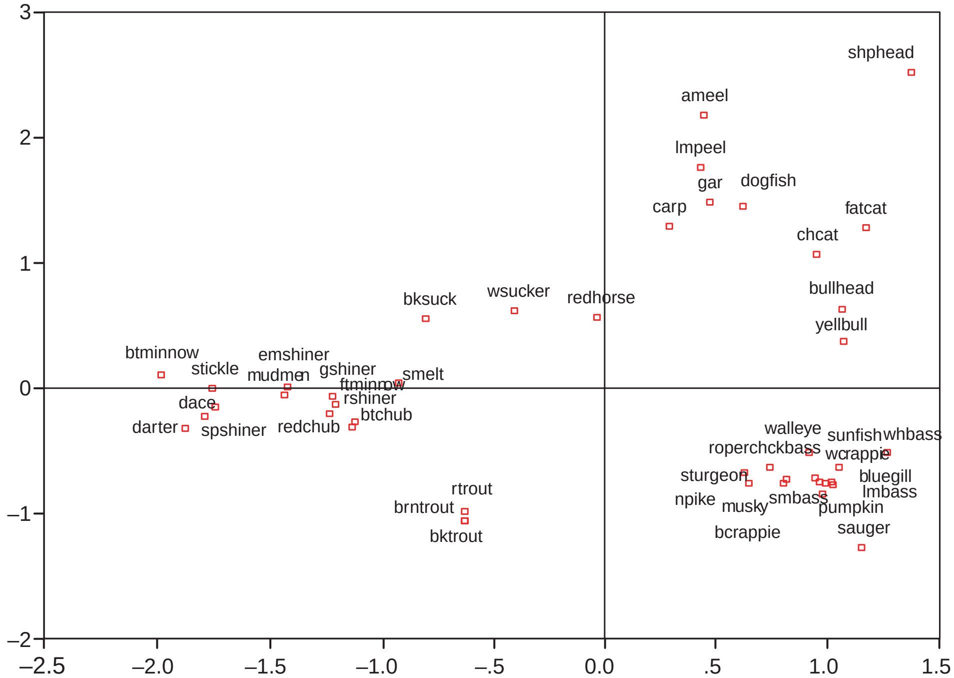

Fig. 2. Menominee MDS; Euclidean distance model.

solution accounted for 86% of the variance and a two-dimensional solution accounted for 96% of the variance. The corresponding figures for the Menominee were 62 and 86%, with a three-dimensional solution covering 94% of the variance. As shown in Fig. 1, the majority-culture solution appears to consist of four clusters, corresponding to baitfish, garbage fish, trout, and (other) desirable sport fish, as one moves from left to right. Within a cluster, folk–generics (e.g. bass, catfish, sucker, chub) are closer to each other than to other members.

Although we fail to see any obvious interpretation of the two dimensions in Fig. 1, we did uncover some reliable correlates of them. Using the sorting justifications to categorize a fish as desirable (+1), undesirable (−1), or neutral (0), there is a +0.67 correlation between the first dimension and desirability. The second dimension correlates reliably (−0.54) with characteristic adult size (as determined by consulting fish guidebooks).

The picture is more complex for the Menominee informants, as shown in Fig. 2. First of all, there is no grouping corresponding to garbage fish. Second the trout are closer to suckers and to baitfish than they are to more desirable fish. This probably reflects ecological sorting in that trout, shiners, and suckers are often found in the same water. Shortly, we describe evidence consistent with this hypothesis. In general, there is more dispersion in the MDS solution for the Menominee fish experts.

Although this greater dispersion may partly reflect greater within-group disagreement, we were able to uncover factors that correlate with position on each of the three dimensions. Using the sorting justifications, we categorized each fish as mainly associated with in lakes and ponds (+1), mainly in rivers and streams (−1), or about equally in rivers and lakes (0). To be scored as mainly in one habitat, more than 75% of the assignments or descriptions by informants had to be with that location. For example in this area, trout, dace, darter, stickleback, black sucker, redhorse, chubs, white bass, and sturgeon are mainly associated with rivers, while sunfish, crappie, perch, dogfish, bluegill, and largemouth bass are mainly associated with lakes, and bullhead, gar, musky, northern, carp, walleye, fathead minnows, and smallmouth bass are associated with both. This habitat factor correlated +0.72 with values on the first dimension. Desirability, again determined by the sorting justifications (different for Menominee than for majority-culture informants), correlated +0.82 with value on the second dimension, and size correlated +0.60 with value on the third dimension.

Overall, the MDS solutions yielded values that correlate with size and desirability for each of the groups. However, the Menominee informant solution had a third salient dimension that correlated highly with habitat. As noted earlier, desirability was mentioned by many informants (though Menominee were less likely to do so) and Menominee fish experts were very likely to mention habitat. In short, the correlates of the dimensions seem to correspond fairly well with the sorting justifications. A notable exception is the correlation with size, which is never mentioned as a justification. This observation suggests that the correlation involving size is an artifact of the correlation of size with other categorization schemes such as baitfish versus sport fish or taxonomic relatedness.

Clustering. Hierarchical clustering provides a complementary perspective on the consensual sorts. Fig. 3 shows the hierarchical clustering that reflects the consensual sorting of majority-culture informants and Fig. 4 is the corresponding clustering

```
                       Rescaled Distance Cluster Combine

  C A S E      0         5        10        15        20        25
Label     Num  +---------+---------+---------+---------+---------+

BULLHEAD    3   -+-----+
YELLBULL   43   -+     +---------------+
CHCAT      11   -+-----+               I
FATCAT     16   -+                     I
BKSUCK      2   -+-+                   +-----------+
WSUCKER    39   -+ +-+                 I           I
REDHORSE   28   ---+ +-------------+   I           I
CARP       10   -----+             I   I           I
SHPHEAD    33   -----+             +---+           I
AMEEL       1   ---+---------+     I               I
LMPEEL     21   ---+         +---+ I               I
DOGFISH    14   -----+-------+   +-+               +-------------+
GAR        18   -----+           I                 I             I
STURGEON   37   -----------------+                 I             I
BKTROUT     8   -+                                 I             I
BRNTROUT    9   -+-------------------------------+ I             I
RTROUT     42   -+                               I I             I
BCRAPPIE    4   -+---+                           I I             I
WCRAPPIE   41   -+   +---------------+           +-+             I
SUNFISH    20   -+   I               I           I               I
PUMPKIN    26   -+---+               I           I               I
BLUEGILL    6   -+                   +-----------+               I
LMBASS     22   -+-------+           I                           I
SMBASS     34   -+       +-------+   I                           I
ROCKBASS   31   ---+-----+       I   I                           I
WHBASS     40   ---+             +---+                           I
MUSKY      24   -+-------------+ I                               I
NPIKE      25   -+             +-+                               I
SAUGER     32   -+-----+       I                                 I
WALLEYE    38   -+     +-------+                                 I
PERCH      44   -------+                                         I
BTCHUB      5   -+-+                                             I
REDCHUB    29   -+ +-+                                           I
BTMINNOW    7   ---+ I                                           I
FTMINNOW   17   -+---+---+                                       I
MUDMEN     23   -+   I   I                                       I
GSHINER    19   -+   I   I                                       I
RSHINER    30   -+   I   +-----------+                           I
SPSHINER   35   -+---+   I           I                           I
EMSHINER   15   -+       I           I                           I
DACE       12   ---+-+   I           +---------------------------+
DARTER     13   ---+ +---+           I
STICKLE    36   -----+               I
SMELT      27   ---------------------+
```

Fig. 3. Majority culture consensual sorting; hierarchical clustering.

solution for the Menominee informants. These clusters are consistent with the idea that majority-culture sorts are both more taxonomic and more goal-derived than Menominee sorts. For example, the majority-culture consensual clustering has three main clusters corresponding to (from bottom to top) small, mostly baitfish, desirable fish, and other, mostly undesirable fish. The desirable fish are further broken down into trout, panfish,

```
                       Rescaled Distance Cluster Combine

  C A S E      0         5        10        15        20        25
Label     Num  +---------+---------+---------+---------+---------+

BRNTROUT    9   -+
RTROUT     42   -+---------------------------+
BKTROUT     8   -+                           I
BKSUCK      2   -+-----+                     I
WSUCKER    39   -+     +-----------+         I
REDHORSE   28   -------+           +-+       +-+
SMELT      27   -------------+-----+ I       I I
STURGEON   37   -------------+       I       I I
CHCAT      11   -+-+                 I       I I
FATCAT     16   -+ +-+               +-------+ I
BULLHEAD    3   ---+ +-----+         I         I
YELLBULL   43   -----+     +-------+ I         I
CARP       10   -----------+       I I         I
DOGFISH    14   -+-----+           +-+         I
GAR        18   -+     +-----+     I           I
AMEEL       1   ---+---+     +-----+           +-----------------+
LMPEEL     21   ---+         I                 I                 I
SHPHEAD    33   -------------+                 I                 I
BLUEGILL    6   -+                             I                 I
PUMPKIN    26   -+-+                           I                 I
SUNFISH    20   -+ +-----+                     I                 I
BCRAPPIE    4   -+-+     I                     I                 I
PERCH      44   -+ I     I                     I                 I
WCRAPPIE   41   ---+     +-----+               I                 I
LMBASS     22   ---+-+   I     I               I                 I
ROCKBASS   31   ---+ I   I     I               I                 I
SMBASS     34   -----+---+     +---------------+                 I
WHBASS     40   -----+         I                                 I
MUSKY      24   ---+-+         I                                 I
NPIKE      25   ---+ +---+     I                                 I
WALLEYE    38   -----+   +-----+                                 I
SAUGER     32   ---------+                                       I
BTCHUB      5   -+                                               I
REDCHUB    29   -+-+                                             I
RSHINER    30   -+ I                                             I
BTMINNOW    7   -+ I                                             I
FTMINNOW   17   -+ I                                             I
DACE       12   -+-+                                             I
MUDMEN     23   -+ I                                             I
EMSHINER   15   -+ +-------+                                     I
GSHINER    19   -+ I       I                                     I
DARTER     13   ---+       +-------------------------------------+
SPSHINER   35   ---+       I
STICKLE    36   -----------+
```

Fig. 4. Menominee consensual sorting; hierarchical clustering.

and sport fish. Catfish and bullheads, less desirable but edible fish, are separated from truly undesirable or “garbage” fish.

The most obvious difference in the Menominee super-ordinate clusters, is that the trout are near other fish that are more likely to be found in rivers and streams than in lakes. The second cluster has less desirable fish, again with catfish and bullheads separated from the “true” undesirable fish. Note that the cluster of undesirable fish for the Menominee does not include the suckers and redhorse. The third cluster consists of mostly desirable fish with a further separation of larger game fish from panfish. In the consensual clustering perch are included with panfish. Several majority-culture experts also placed the perch with panfish but their overall consensus grouped perch with walleye and sauger, its taxonomic cousins (Percidae family). There is also a cluster that consists of small fish (mostly baitfish). Smelt are placed with other fish that are mainly river fish (or at least caught when they are in rivers). In short, the cluster analyses reinforce the view of overall similarities coupled with differences associated with the tendency of Menominee to pay more attention to ecological relations.

Correlation with scientific taxonomy. We used conventional evolutionary taxonomy as our scientific standard in this study (rather than phenetic or cladistic classifications over which there is less historical consensus). Overall, there was fair agreement between taxonomic distance and distance in each group’s consensual sorting. The correlation was +0.62 for the majority-culture experts and +0.60 for the Menominee experts. This is in the same range reported by Lopez et al. (1997) for Itzá Maya and undergraduates sorting mammals (about 0.50) and by Medin et al. (1997) for different types of tree experts (range = 0.37–0.85) and almost the same as birds experts sorting birds of the Chicago area (Bailensen et al., 2002).

Note that although the correlation is strongly positive, it accounts for less than half the variance. Several factors work to reduce the correlation. For example, folk generics usually correspond to genera but there are notable exceptions—the American eel and the lamprey eel belong to different classes and the mudminnow and the bluntnose minnow belong to different orders. Relative to science, folk classifications tend to under-differentiate small organisms (Hunn, 1999) and that appears to be true in our data as well. Note also, the fish that experts were most likely to be unfamiliar with are small fish such as darter, dace, stickleback, and mudminnow. Another difference between science and folk schemes is that science gives little weight to size, but folk schemes do. For example, the darter, which is quite small, belongs to the perch family along with walleye and perch, yet rarely is sorted together with its larger cousins. Similarly, the carp, which grows to be quite large, is a member of the minnow family, yet rarely is grouped with minnows by our fish experts.

1.3. Discussion

Although the two groups of experts showed a strong overall consensus, perhaps the most striking results are the cultural differences. The differences are most readily seen in the sorting justifications but they also appear in the consensus analysis and in the scaling results. The majority-culture experts are more likely to mention taxonomic or morphological justifications than are the Menominee informants and they, in turn, are much more likely to organize categories in terms of ecological relations than the majority-culture informants. In the multi-dimensional scaling only the Menominee have a dimension corresponding to habitat. In hierarchical clustering, the Menominee clustering places the trout near other river fish but the majority-culture clustering places the trout near other desirable game fish. The justification data also suggest that the majority-culture experts are somewhat more likely to have categories organized around evaluative dimensions (e.g. prestigious sport fish, garbage fish) than the Menominee. Both groups, however, showed a dimension correlated with desirability in their MDS solutions. Overall then, the Menominee consensual model has an ecological component not seen in the majority-culture sorting.

In follow-up work, we have also given less expert Menominee and majority-culture fishermen the same sorting task (Medin, Ross, Atran, Burnett, & Blok, 2002). Relative to experts, non-expert majority-culture fishermen were significantly less likely to give taxonomic justifications (41%) and more likely to give goal-related justifications (43%). Menominee non-experts did not differ from Menominee experts in their propensity for giving ecological justifications.

A significant potential source of cross-group agreement and a potential challenge to understanding differences are correlated values or features. Baitfish tend to be small and game fish large, so it is not surprising that the MDS solution revealed a reliable correlation with size, despite the fact that no expert mentioned size as the basis for sorting. Similarly, there is a correlation between game fish categories and taxonomic relatedness such that the clustering data can be interpreted either in terms of taxonomy or goal-derived categories. This underlines the importance of looking at the justifications for sorting.

The overall consensual agreement was coupled with the Menominee showing reliable within-group residual agreement. Interestingly, the majority-culture informants did not show reliably greater within-group than across-group residual agreement. These two observations suggest that the majority-culture and Menominee experts have a shared cultural model of fish but that the Menominee informants, in addition, have a specific and distinct cultural model. Other analyses suggest that the difference derives from the Menominee having a greater tendency to take an ecological orientation. This ecological orientation parallels differences in folk–ecological models between indigenous and immigrant farmers in Guatemala (Atran et al., 1999). We will examine expert ecological knowledge in greater detail in the remaining experiments.

2. Experiment 2: ecological sorting

Experiment 1 indicated that experts of the two cultural groups share a general model with respect to certain features of freshwater fish, but that the two groups have also distinct cultural models. Within these different cultural themes, Menominee fish experts are more concerned with ecological relationships than their majority-culture counterparts. In turn, majority-culture experts are more influenced by goal orientation and morphological features of the species.

Experiment 2 was conducted to establish that our two groups of experts are equally knowledgeable concerning where fish are found and which fish are found together. Knowledge of habitat is important whether one has the goal of simply observing fish or trying to catch them. To be successful in fishing, one needs to know where certain species are found and what they are eating (and what they are eating often consists of other fish). From this perspective one might expect cultural differences in the salience of some forms of knowledge over others, but not any difference in the knowledge base involving habitat per se.

2.1. Method

Participants. The informants were 14 majority culture and 14 Menominee fish experts. Their demographic characteristics were essentially the same as for the Experiment 1.

Stimuli. Forty of the original set of 44 local species of fish used in Experiment 1 were again employed. We dropped four species that tend not to be found locally (lamprey, smelt, flathead catfish, sauger). Each species was represented with a name card.

Procedure. Instructions for the task were as follows: "Please put those fish together that live together, that share a common habitat." We also told the informants that a given species could appear in more than one group. If an informant noted that some fish lived in two different habitats (such as river and lake) a copy of the name card was made, so that this species could be included in different piles. There was no limit on the number of groups a given species could be placed into and name cards were added as needed. After the initial sorts were constructed, the informant was asked if he would like to further divide these piles into coherent sub-piles (e.g. making finer differentiations with respect to the habitats). If an informant was not familiar with a given species, the name card was dropped for that informant.

Informants were asked to ignore seasonal differences in habitats (spawning season, etc.) , and to give their general assessment over the whole year (dominant habitats). Once all the groups were established, we asked each informant to give a short description of the type of habitat (e.g. clear, fast running water). It took an informant about 20 min to complete this task.

2.2. Results

Informant agreement and cultural models. Again, the cultural consensus model was used to explore the existence of an overall model as well as culture-specific models of fish habitat sharing. For each informant the data consisted of an ordering of all fish species according to the habitats, permitting the calculation of distances between any pair of fish. Based on the sorts, for each informant a fish-by-fish distance matrix was calculated. For example, two species were scored as having distance one, if they shared a habitat at the lowest level of the informants sorting. Of course, a given fish might appear in more than one group. In the event that a fish appeared in more than one pile, the shortest distance to the other species was entered into the matrix.

Agreement between two informants was calculated by correlating the respective distance matrices. Factor analysis was performed over the resulting inter-subject agreement matrix to see how well the data fit the consensus model. In our analyses we first looked for consensus at the overall level (both groups together) and then examined patterns of residual agreement. As described earlier, residual agreement is calculated by subtracting predicted agreement (product of first-factors scores) from observed agreement.

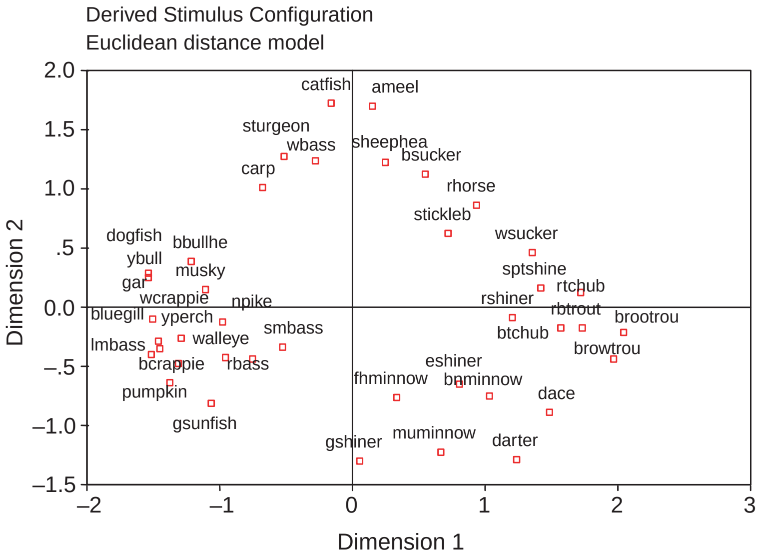

Fig. 5. Fish habitat relations, MDS (both groups).

The principal components analysis showed a strong consensus across the experts: The ratio of first/second factor eigenvalues was 9.52, with the first factor explaining 72% of the variance. First-factor scores were positive for all informants and averaged 0.85. This means that a great deal of the experts' knowledge is shared across the two cultural groups. No group difference was found with respect to the distribution of first- and second-factor scores. In addition, an analysis of the pattern of residual agreement also failed to reveal any cultural difference (for both groups, within-group residual agreement did not differ reliably from cross-group residual agreement). In short, both groups share essentially the same model and knowledge base for fish habitat. Fig. 5 presents the MDS for average sort over both groups and Fig. 6 shows a cluster analysis of these same relationships. In both representations trout and other river fish are clearly separated from fish found in lakes and, at a finer, level of detail, fish found in clear running water (e.g. trout, chubs) are separated from fish found in slower, more stagnant water (e.g. mudminnow).

2.3. Discussion

As expected, Experiment 2 produced no reliable group differences in the sorting of the fish species by habitat. This finding is important on two accounts. First, it provides converging evidence that our experts do not differ in knowledge per se. Second, the data support the idea that the differences noted in Experiment 1 are linked to the differential salience of ecological information in the two groups. In the next experiment we probe ecological information in the form of fish–fish interactions. Given that a large number of pairs are used and the task demands are considerable, we expect differences in the accessibility of ecological information to yield cultural differences.

```
                         Rescaled Distance Cluster Combine
  C A S E      0         5        10        15        20        25
Label     Num  +---------+---------+---------+---------+---------+

BROOTROU    8   -+-----+
BROWTROU    9   -+     +---------------------------------+
RBTROUT    25   -------+                                 I
CATFISH    11   -----------------------------+---+       I
WBASS      36   -----------------------------+   I       I
AMEEL       1   ---------------------------------+       +-+
CARP       10   ---------------------------------+-----+ I I
SHEEPHEA   30   ---------------------------------+     I I I
BTCHUB      5   -----------------+-------------------+ I I I
RTCHUB     27   -----------------+                   I I I I
DACE       12   ---------------------+-----+         I +-+ I
DARTER     13   ---------------------+     +-------+ I I   I
MUMINNOW   21   ---------------------------+       I I I   I
BNMINNOW    7   -------------+---------------+     +-+ I   +-+
FHMINNOW   16   -------------+               +-+   I I I   I I
RSHINER    28   -----------------------------+ +---+ +-+   I I
ESHINER    15   -------------------------+-----+     I     I I
GSHINER    18   -------------------------+     I     I     I I
SPTSHINE   32   -------------------------------+     I     I +---+
RHORSE     26   ---------------------------+---------+     I I   I
WSUCKER    38   ---------------------------+         I     I I   I
BSUCKER     4   -------------------------------------+     I I   I
STICKLEB   33   -------------------------------------------+ I   I
STURGEON   34   ---------------------------------------------+   I
DOGFISH    14   ---------------------+-+                         I
YBULL      39   ---------------------+ +-+                       I
BBULLHE     2   -----------------------+ +-+                     I
GAR        17   -------------------------+ I                     I
MUSKY      22   -----------+-----+         I                     I
NPIKE      23   -----------+     I         I                     I
BLUEGILL    6   -------+---+     +-+       I                     I
PUMPKIN    24   -------+   I     I I       I                     I
GSUNFISH   19   -----------+-----+ I       I                     I
LMBASS     20   -----------+       +-----+ I                     I
YPERCH     40   -------------------+     +-+                     I
WCRAPPIE   37   -------------------+     I +---------------------+
SMBASS     31   ---------------------+---+ I
WALLEYE    35   ---------------------+     I
BCRAPPIE    3   ---------------------------+
RBASS      29   ---------------------------+
```

Fig. 6. Fish habitat relations, cluster analysis single linkage (both groups).

3. Experiment 3: species interaction

In Experiment 1 we presented data indicating a shared model for both the Menominee and majority-culture experts, with the Menominee having a specific and distinct consensual model based on ecological relationships. In Experiment 2 we found no differences in knowledge of fish habitats. In Experiment 3 we explicitly targeted expert ecological knowledge in the form of understandings of fish–fish interactions.

On many grounds one would not expect to observe group differences in perceived fish–fish interactions. As we noted earlier, informants from the two groups engage in more or less the same activities in terms of when and how they fish (e.g. hook and line, artificial lures, etc.). (A small minority of the informants in each group trap and seine baitfish for retail purposes, but the groups do not differ in this regard.) Secondly, goals and activities associated with fishing are intimately intertwined with fish–fish interactions. To be successful in fishing, one needs to know where fish are found and what they are eating. Food chains are an important component of fish–fish interactions. Third, our experts have been fishing on average for several decades and one might expect a convergence of knowledge, especially when that knowledge is relevant to certain activities. From this perspective one might expect cultural differences in the salience of some forms of knowledge over others (they might know more about the fish that they target more often) but not any difference in the knowledge base per se. For example, we might expect that majority-culture fishermen might report more relations involving northern pike and walleyes and that Menominee fishermen might report more relations involving brook trout and brown trout but that there would be no overall differences.

On the other hand, one should not underestimate the possible role of cultural factors on folk–ecological systems. In previous work on forest ecology in Guatemala we observed striking group differences in both the amount and organization of ecological knowledge among the three groups of informants (Atran et al., 1999, 2002). Cultural background may influence both what people attend to and how they interpret it. As an example of the latter, woodpeckers may be seen as helping trees in a culture oriented toward reciprocity or as hurting trees in a culture that tends to view relations more asymmetrically.

If we were to observe cultural differences, what form might they take? One normative expression of Menominee culture is to take from nature only what is needed. As mentioned before, Menominee fishing regulations outlaw the "wanton destruction" of any fish.[5] Some Menominee pray before taking fish or game to apologize to and thank the animal for giving its life. Menominee may also offer tobacco to the spirits as a sign of respect and as a token of reciprocity. It is possible that notions of balance and reciprocity may affect Menominee notions of fish–fish interactions (e.g. they might report more reciprocal relations).

Majority-culture sportsmen also express appreciation of nature; however, they also tend to view fish in terms of specific goals, such as the challenge of catching a large fish or providing food. As a result, majority-culture fish experts may be less inclined to spontaneously report relations that are not pertinent to their goals. These differences may be expressed in terms of: (a) the number of relations, and (b) the kind of relations the members of each group perceive. For example, if one has the goal of catching the biggest fish, then that person might be more likely to reason in terms of adult fish if asked about fish–fish interactions. To offer a somewhat loose analogy with research on object perception, the majority-culture ecological model might correspond more with a viewer-centered representation, whereas the Menominee model would correspond with a more object-centered representation.

[5] This is in stark contrast to some majority-culture fish experts who may go out bow hunting for carp, which, according to their model, is a "garbage fish." Any carp taken are then left dead in the water or tossed up on the shore.

3.1. Method

Participants. Our informants in this experiment were 15 majority culture and 15 Menominee fish experts. Their demographic characteristics were essentially the same as for earlier studies and there was about an 80% overlap in participants across studies.

Stimuli. Because it would not be practical to probe each of the nearly 1000 pairwise relations of 44 local species of fish, we narrowed the set to 21 species (indicated in Table 1). We selected familiar species varying in range of habitat, desirability and status in food chains. A name card represented each species.

Procedure. This experiment was run in a separate interview. In the few cases when an informant was not familiar with a given species, the name card was dropped. After assuring that the informant was familiar with all the remaining items of the set, the informant was presented with a short description of the task as follows:

"The following task is about relations between different kinds of fishes. For each single pair of fish we want you to think about whether the two species involved have any relations with each other. If so, please tell us about the kind of relation they have. By relation we mean whether one kind of fish affects the other kind or vice versa."

The experimenter then randomly picked one fish as a base-card and compared it with every other species (presented in random order). For each informant, this procedure yielded 210 pairs and 420 potential fish–fish relationships. For each fish–fish pair, the informant was asked if the base species affects the target species and vice versa (e.g. "Does the northern affect the river shiner?" and "Does the river shiner affect the northern?"). Informants were then asked whether the species affect each other in other ways and so on until no more relations were mentioned. The task was presented at a fairly rapid pace and took about an hour.

Responses were initially coded into one of 19 categories. Examples include: A eats B, A eats the spawn of B, A helps clean the bottom that helps B when it spawns, and so forth. Food-chain relations (A eats B) comprised the most frequent response. Table 2 shows the categories in the coding scheme. We report results only for coding categories that had sufficient frequency across informants to make group comparisons meaningful. In addition, we collapsed over categories in various ways to examine responses at different levels of granularity.

3.2. Results

Informant agreement and cultural models. As in the first two experiments, we used the cultural consensus model to probe for a single, general cross-group model for fish–fish interactions, as well as for each group's particular cultural model. For each informant the data consisted of a 21 by 21 matrix (minus the main diagonal) of reported fish–fish interactions. Agreement between two informants was calculated as the average agreement over all 420 cells. For any given pair of fish, agreement between any two informants was assessed on four levels: (1) both informants reported some kind of relation (no matter what the specific relation was), (2) both agreed on either a positive or a negative relation (no matter what the specific relation was), (3) both agreed on a food-chain relation and (4) both agreed on a reciprocal relation (no matter what the specific relations were).

Table 2
Categories as applied in the coding scheme for Experiment 3

No.	Impact	Type of interaction
1	Negative	Eating other fish
2	Negative	Eating spawn/eggs of the other fish
3	Negative	Compete for food
4	Negative	Compete for habitat
5	Negative	Destroy habitat of other fish
6	Negative	Taking over spawning area of other fish
7	Negative	Overpopulation stunts the growth of other fish
8	Negative	Attacks the other fish
9	Positive	Providing food as prey
10	Positive	Providing eggs as food
11	Positive	Providing food as when dead
12	Positive	Clean habitat for other fish
13	Positive	Create food by stirring up the bottom
14	Positive	Leaving scraps that help other fish
15	Positive	Prepare spawning beds for other fish that spawn later
16	Reciprocal	Eats other fish and is also a food source for it
17	Reciprocal	Help each other by schooling together
18	Reciprocal	Eats spawn of other fish and vice versa

Calculations of average agreement between each pair of informants yielded a total of four (symmetrical) informant by informant agreement matrices (30×30), one for each of the four levels of analysis. Each cell of these matrices represents the observed percentage agreement between two individuals.

It is important to note that observed agreement may owe in part to chance and might be further affected by response criteria (e.g. how often must a relation occur in nature for it to be reported) or biases. Response bias is interesting in itself in that it may reflect cultural values. We were, however, further interested in differences of agreement pattern (and the existence of cultural models) that are based on actual knowledge differences,[6] rather than response criteria or biases alone. To explore both possibilities (differences in knowledge as well as in response biases), we conducted two separate sets of consensus analyses, one using raw observed agreement[7] and another using adjusted agreement.

To adjust for guessing or different base rates of mentioning a relation, for each person we calculated the overall probability of giving a certain response and then used this to predict agreement between any two individuals (the product of their response probabilities). This procedure not only adjusts for chance agreement, but also agreement owing to cultural or individual response biases. If cultural differences are found using the observed agreement as the basis for analysis but not the adjusted agreement, we can

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

[7] One could argue, that the procedure does not allow for guessing, as for example in a yes/no or a multiple-choice format. However, guessing may occur, and may show a bias toward a specific kind of relation.

Table 3
Consensus analysis over raw observed agreement in Experiment 3

Coding	Both groups	Menominee	Majority culture
Binary	$R=6.4$; $V=64\%$; $A=0.79$	$R=7.8$; $V=66\%$; $A=0.81$	$R=6.2$; $V=67\%$; $A=0.82$
Help/hurt	$R=12.8$;$V=61\%$; $A=0.78$	$R=10.3$; $V=58\%$; $A=0.76$	$R=10.3$; $V=67\%$; $A=0.82$
Food-chain	$R=26.1$; $V=85\%$; $A=0.92$	$R=21.8$; $V=84\%$; $A=0.92$	$R=26.0$; $V=87\%$; $A=0.93$
Reciprocal relations	$R=15.1$; $V=82\%$; $A=0.89$	$R=14.4$; $V=78\%$; $A=0.88$	$R=12.9$; $V=89\%$; $A=0.92$

R, ratio of first- and second-factor eigen-values; *V*, percentage of variance explained by first factor; *A*, average of first-factor scores.

reasonably assume that these differences stem from a cultural bias in guessing and not actual differences in consensual knowledge.[8]

To adjust the observed agreement for response biases, we used the following formula. For any pair of informants *i*, *j*:

$$\mathrm{RA}_{i,j} = \mathrm{AA}_{i,j} + (1 - \mathrm{AA}_{i,j})(P_{\mathrm{p}i}P_{\mathrm{p}j} + P_{\mathrm{n}i}P_{\mathrm{n}j}),$$

where

RA raw agreement
AA (for guessing) adjusted agreement
P_{p} probability of giving a positive answer
P_{n} probability of negative answer (no relation)

In general, there is a high correlation between raw and adjusted agreement ($0.69 < r < 0.90$, $P < 0.01$). This indicates that the patterns of agreement are rather stable and depend little if at all on response tendencies alone. The only exception is the set of agreement matrices for reciprocal relations. Although still highly significant, the correlation coefficient between raw and adjusted agreement is low ($r = 0.134$, $P < 0.01$).

Principal components analysis was performed over both the raw observed matrix and the adjusted inter-subject agreement matrix to see how well the data fit the cultural consensus model (Romney et al., 1986). As noted earlier, it is possible to observe both an overall consensus and between group differences. First we report the overall and group consensus analyses and then focus on group differences. For both raw and adjusted agreement, we found consensus for the combined meta-cultural model as well as for separate cultural models on three levels: (1) existence of a relation, (2) helping/hurting relations, and (3) food chain relations. Helping and hurting were defined at the individual level; that is, northern eating perch was coded as hurting regardless of the fact that northerns may indirectly help perch by keeping their population in check. We found consensus for reported reciprocal relations only with respect to raw observed agreement. Tables 3 and 4 summarize these results.

As expected, for each coding scheme consensus is considerably stronger for the analysis over observed agreement than over adjusted agreement. This difference is

[8] Of course, one could argue that a "cultural bias" represents a special kind of knowledge in a given domain.

Table 4
Consensus analysis over adjusted agreement in Experiment 3

Coding	Both groups	Menominee	Majority culture
Binary	$R=4.2$; $V=30\%$; $A=0.52$	$R=3.1$; $V=30\%$; $A=0.52$	$R=3.5$; $V=37\%$; $A=0.59$
Help/hurt	$R=7.6$; $V=40\%$; $A=0.62$	$R=5.1$; $V=41\%$; $A=0.62$	$R=5.1$; $V=45\%$; $A=0.66$
Food-chain	$R=9.6$; $V=49\%$; $A=0.67$	$R=5.7$; $V=49\%$; $A=0.66$	$R=7.0$; $V=53\%$; $A=0.71$
Reciprocal relations[a]	$R=1.21$; $V=10\%$; $A=0.2$	$R=1.33$; $V=18\%$; $A=0.35$	$R=1.56$; $V=14\%$; $A=0.17$

R, ratio of first- and second-factor eigen-values; *V*, percentage of variance explained by first factor; *A*, average of first-factor scores.

[a] No consensus found.

particularly strong for reciprocal relations, where we find no consensus for adjusted agreement (neither for both groups taken together nor for each group considered individually). For the raw observed agreement the high number of "no reciprocal relation reported" drives the consensus, an effect that is removed by the adjustment for guessing. Nevertheless, the Menominee still show above chance agreement for the adjusted reciprocal relations: 69% of the agreement pairs are positive (by chance, half should be positive, $z=5.55$, $P<0.0001$). Cross-group agreement is very close to chance (48% of agreements). Surprisingly, agreement for majority-culture experts is actually slightly below chance (only 40.5% of the agreement pairs were positive; $z=2.2$, $P<0.05$). We have no ready explanation for this finding; at a minimum, it should be replicated before we engage in further speculation on it.

Overall, the data indicate high agreement within and across groups for the different levels of coding the data. Nevertheless, analysis of agreement on reciprocal relations shows significant differences in the elaboration of cultural models (as opposed to the general meta-cultural model that encompasses both groups).

For analyses conducted over adjusted agreement, we find significant group differences for the coding of binary relations with respect to the distribution of second-factor scores ($F=4.827$, $\text{MSe}=0.306$; $P<0.05$). This indicates reliable differences in cultural knowledge of the members of the two groups that cannot be attributed to response biases. Much the same pattern results from analyses of raw observed agreement ($F=5.2$; $\text{MSe}=0.468$; $P<0.05$). Here, we also observe significant differences on first-factor scores for the encoding of "help/hurt relations" ($F=6.34$; $\text{MSe}=0.027$; $P<0.05$). These data show that although the Menominee and the majority-culture experts share a common model, there are reliable cultural differences in the respective folk–ecological models. We now turn to a content analysis of these differences.

3.2.1. Content analysis of the different models

Binary relations. The most abstract level of coding distinguishes only between the existence and non-existence of a reported relation (without differentiating the type or impact of the relation). For binary coding we find the strongest cross-group consensus. Within-group agreement for both groups correlates highly ($r=0.78$, $P=0.000$); that is, whenever Menominee experts agree that a relation is present, majority-culture experts also tend to agree on this relation being present.

The distribution of the second-factor scores, however, also indicates a significant difference between Menominee and majority-culture experts. Specifically, Menominee report more relations than the majority-culture informants. If we focus on the relations reported by at least 70% of the group members, we find that Menominee experts agree on 39.8% of all possible relations compared to 25.5% for majority-culture experts. For all relations cited by at least 70% of the members of one group, we further find that: (1) 84.5% are reported by both groups; (2) 14% (45 relations) are reported by Menominee but not majority culture; and (3) 1% (four relations) are reported by majority-culture but not Menominee experts. Overall, Menominee report reliably more relations than their majority-culture counterparts (62 versus 46% of the possible relations, $F=4.832$; MSe = 0.179; $P<0.05$). In short, *the majority-culture ecological model appears to be subset of the Menominee model*, a finding that parallels our results from Experiment 1. Shortly, we will examine these differences in greater detail.

Helping/hurting relationships. Although we find a general consensus for helping and hurting across groups, the groups differ according to the distribution of the first-factor scores. Members of both groups describe the same number of negative relations. However, *Menominee experts report significantly more positive relations than majority-culture experts* (average 108 versus 78; $F=7.07$; MSe = 7022; $P<0.05$).

To further explore the content of these pairwise relations (the pairs involved), we examined cross-group agreement on specific helping or hurting relations. For each pair of fish ($n=420$), we counted the number of individuals for each group that agreed on either (1) or (−1) as a response. This produced two data columns for each group (percent agreement on positive relations from fish A to B, agreement on negative relations from fish A to B). Percent agreement is a rough indicator of consensus with respect to species A as helping or harming species B. In fact, we find strong correlations between the agreement patterns of the two groups (negative relations $r=0.874$, $P<0.01$; positive relations $r=0.906$, $P<0.01$). Members of both groups strongly agree on particular species being harmful or helpful to other particular species. Furthermore, for both groups positive and negative fish indices correlate negatively (Menominee: $r=-0.589$, $P<0.01$; Shawano: $r=-0.568$, $P<0.01$). In other words, both groups clearly distinguish between helpful and harmful relations (as opposed to a more general model that distinguishes only differences in number of relations).

Food-chain relations. If we count only food-chain relations that are not embedded in reciprocal relations, then there are no group differences in the number of relations mentioned. Note that the presence of a high cultural consensus across the two groups undermines the possibility that each group reports the same number of relations but attributes them to different species. This indicates that the two groups basically share knowledge of the food chain ($r=0.932$, $P=0.01$). This accords with the prediction that shared activity and goals (catching fish) should lead to converging knowledge about food chain relations.

Reciprocal relations. A reciprocal relation between two species was coded whenever there was at least one helping relation reported in each direction (each fish helps the other fish). For each informant, a matrix was calculated that had as entries 1 for reciprocal relations and 0 for all others. Recall that only the Menominee informants showed above chance agreement on reciprocal relations. On average, Menominee informants mention

59.5 reciprocal relations compared to 34.6 for majority-culture fish experts. Two individuals (one in each group) mentioned considerably more relations than anyone else (one Menominee, 195; one majority culture, 337). Accordingly, we applied a log transformation to the data. The difference between groups proved to be statistically reliable ($t=2.16$, d.f.$=28$, $P<0.02$). These reciprocal relationships tended to be reciprocal predation or feeding habits (including eating spawn or fry). The majority-culture experts differ in that they are likely to report the prototypical adult relation. For example, majority-culture experts are likely to report that northerns eat walleyes and not mention that a large walleye may eat a small northern. Similarly, majority-culture experts are likely to mention that brown trout and walleyes eat black suckers but not report that suckers eat the spawn of brown trout and walleyes (see Table 5 for the most prominent pairs of reciprocal relations and a summary of the group differences).

The above difference in reciprocal relations suggests that majority-culture fish experts tended to think in terms of adult fish. As another test of this idea we looked at relationships involving eating spawn. The median number of reports of one fish eating the spawn of another was 1.0 for majority-culture informants and 12.0 for the Menominee. However, the data were highly skewed by the fact that one majority-culture fish expert mentioned eating spawn a large majority of the time (290 times). To correct for this we used a square-root transformation but the difference still fell short of statistical reliability ($P>0.20$).

Cross-group specialization? Recall that walleyes and northerns appear to be relatively more salient and trout relatively less salient for majority-culture fishermen compared with Menominee experts. Are there corresponding differences in reported relations involving trout versus walleyes and northerns? The data are only weakly consistent with this idea. Menominee informants report more relations involving trout than do majority-culture fishermen (mean$=24.7$ versus 15.7, $t=3.03$, d.f.$=28$, $P<0.01$, after a log transformation). But Menominees also report more relations involving walleyes and northerns than do majority-culture fishermen (mean$=35.7$ versus 30.2), though this difference is nowhere near reliable, even after a log transformation ($P>0.20$). It is also the case that

Table 5
Most prominent reciprocal relations as elicited in Experiment 3

Shawano	Menominee	Species A	Species B
0.13	0.67	Walleye	Smallmouth bass
0.07	0.60	Northern pike	Walleye
0.07	0.53	Yellow perch	Black crappie
0.07	0.50	Carp	Black (Hog) sucker
0.21	0.50	Northern pike	Dogfish (Bowfin)
0.00	0.47	Brown trout	Black (Hog) sucker
0.00	0.47	Walleye	Black (Hog) sucker
0.33	0.47	Brown trout	Brook trout
0.20	0.47	Walleye	Largemouth bass
0.20	0.47	Black crappie	Rock bass
0.13	0.47	Smallmouth bass	Rock bass
0.20	0.47	Largemouth bass	Smallmouth bass

Numbers in the table indicate the percentage of members of each group agreeing on a reciprocal relation between a pair of species.

many of the relations reported for brook and brown trout are reciprocal and/or involve eating spawn. In short, we do not see the clear sort of interaction that one would expect if one group were expert with respect to one subset and the other expert with respect to the other.

3.3. Discussion

The results indicate that experts of both cultural groups share a substantial amount of knowledge concerning interactions among freshwater fish. This should not come as a surprise; much of expert knowledge stems from actual observation while looking for fish, fishing, and even from cleaning the catch (e.g. stomach contents usually tell what the fish had been eating recently). Despite this common knowledge we also find reliable group differences. The key findings are as follows: (1) In addition to a shared model with majority-culture experts, Menominee fishermen have a distinct consensual understanding of fish–fish interactions and (2) Menominee experts see many more positive fish–fish interactions (e.g. one fish helping another) as well as more reciprocal relations (two species affecting each other) than their majority-culture counterparts.

These results parallel our work in Guatemala where, in addition to an overall consensus, we find that the Itza' Maya see more reciprocal relations than the other two groups. It may also be the case that the Ladinos and Q'eqchi' may have a greater tendency to conceptualize the forest solely in terms of satisfying their goals. As we mentioned earlier, however, these differences may involve differences in expertise because the Itza' Maya have practiced agro-forestry in the Peten lowlands for a longer time than members of the other two groups.

What is the origin of the differences between majority culture and Menominee fishermen? The only obvious difference in fishing practices is that majority-culture informants practice "catch and release" somewhat more often. If this practice were the main source of differences, we might possibly observe differences tied to what could be learned from the stomach contents of fish. There is no evidence to support this view—there were no group differences in reported food chain relations. Furthermore, stomach contents would not provide useful information about which fish have their spawn eaten by suckers and other fish.

Our speculation is that cultural attitudes and beliefs reinforce certain "habits of mind" or characteristic ways of thinking about some domain. Specifically, responses of majority-culture informants concerning ecological relations may be filtered through a goal-related framework, whereas the responses of the Menominee informants appear to be less "viewer-centered." Goals may influence reports of ecological relations focusing on ecological relations that apply to adult fish rather than those associated with the entire life cycle. Many of the relations reported by Menominee experts but not majority-culture experts involve spawn, fry, or immature fish.

It is often difficult to distinguish between knowledge and "highly accessible knowledge." Nonetheless, despite the cultural differences noted, the majority-culture experts had very extensive ecological knowledge (as noted in Experiment 2), knowledge that was not recruited for the sorting task of Experiment 1 and perhaps not in response to the direct probes of Experiment 3. Overall, we believe that the major source of cultural differences is in the accessibility of knowledge as a consequence of different cultural models of fish as a resource. Experiment 4 bears directly on this conjecture.

4. Experiment 4

One way to examine the role of knowledge versus access is to compare speeded versus unspeeded probes. In Experiment 3 we probed for over 400 relations in less than an hour, which means that experts were answering questions at the rate of about 6–10 per minute (6–10 s per item). In the course of related interviews conducted about a year after Experiment 3, we used 34 pairs of fish–fish interactions as a filler task. This filler task went at a leisurely pace (typically this part lasted 15–20 min or about 30 s per item) and, in retrospect, can be used to evaluate speeded versus unspeeded testing. We describe this follow-up as Experiment 4.

Our sample of 34 pairs was a subset of the probes from Experiment 3 and they are given in Table 6. For this follow-up to be meaningful, we need to verify that the group difference in reported relations in Experiment 3 was reliable for this subset. That proved to be the case (as we report below). Although it would have been desirable to select probes where the differences in Experiment 3 were maximized, the probes that were (more or less randomly) selected (minnows and shiners were not included) for the filler task yielded a clear picture.

We had two general predictions. One was that the group differences noted in Experiment 3 would no longer be observed and the other was that majority-culture fish experts would now start mentioning more relations other than those involving adult fish (e.g. reciprocal relations and relations involving immature fish such as eating spawn). The absence of differences would support the idea that the group difference involves knowledge accessibility rather than knowledge per se.

4.1. Method

Participants. Our informants in this experiment were 14 majority culture and 14 Menominee fish experts. Their demographic characteristics were essentially the same as for the earlier experiments

Stimuli and procedure. The probes consisted of 34 cards, each containing a pair of fish. The instructions were exactly as in Experiment 3, except that we explicitly told informants that there would be many fewer probes than before. The probes were given as part of a longer interview on attitudes with respect to different fishing practices.

Results. In general the results were as predicted. First consider overall relations reported. For these 34 probes majority culture and Menominee informants had reported and average of 17.3 and 28.3 relations, respectively, in Experiment 3. These numbers were subjected to a log transformation and the difference was found to be statistically reliable ($t=2.98$, d.f. $=26$, $P<0.01$). For these same pairs in Experiment 4, majority culture and Menominee informants reported an average of 29.3 and 32.6 relations, respectively. This difference is nowhere near reliable ($P>0.25$). The only comparison that proved to be reliable was the number of relations reported by majority-culture experts in Experiment 4

Table 6
The fish–fish relations used in Experiment 4

Black Crappie	Small Mouth Bass
Black Crappie	Rock Bass
Black Crappie	Large Mouth Bass
Black Crappie	Brown Trout
Black Crappie	Walleye
Black Crappie	Perch
Black Sucker	Walleye
Black Sucker	Dogfish
Bluegill	Northern
Brook Trout	Black Sucker
Brook Trout	Carp
Brook Trout	Black crappie
Brook Trout	Sturgeon
Brown Trout	Yellow Bullhead
Brown Trout	Large Mouth Bass
Carp	River Shiner
Carp	Bluegill
Gar	Bluegill
Golden Shiner	Northern
Golden Shiner	Black Sucker
Large Mouth Bass	Brook Trout
Northern	Redtail Chub
Northern	Walleye
Perch	Brown Trout
Redhorse	Yellow Perch
Redhorse	Rock Bass
Redtail Chub	Sturgeon
Redtail Chub	Dogfish
River Shiner	Walleye
Rock Bass	Black Sucker
Sturgeon	Perch
Yellow Bullhead	Walleye
Yellow Bullhead	Black Sucker
Yellow Bullhead	Brook Trout

versus Experiment 3. Since there was not complete overlap between informants in the two studies, for purposes of analysis we used an independent samples *t*-test ($t = 2.79$, d.f. $= 27$, $P < 0.01$). (The same pattern is observed if one only uses majority-culture informants who participated in both studies.) In short, the more relaxed pace led to more relations being reported by majority-culture fish experts but not by Menominee fish experts.

Moving to specific relations, the data were broken down into relations involving eating spawn, basic food chain relations and reciprocal or mutual relations. We included competing for food in the latter category, which was much more prominent for both groups in Experiment 4 (median frequency of 6 and 5.5 for majority and Menominee informants compared with a median of zero for both groups for these items in Experiment 3). For eating spawn the median for majority-culture informants shifted from 0 in Experiment 3–5 in Experiment 4 (the means were 3.8 and 6.2, respectively, with one expert reporting an unusually large number of relations in Experiment 3). The corresponding medians and means for the Menominee were 3 and 4.2 in Experiment 3 (for the subset of 34 relations) and 3 and 4.3 in Experiment 4. The majority-culture experts reported reliably more relations involving eating spawn in Experiment 4 than they did in Experiment 3. After a square-root transformation to reduce skewness, a *t*-test was statistically significant ($t=2.61$, d.f. $=27$, $P<0.05$). No other difference, including the group difference on these 34 relations in Experiment 3 approached reliability (P's >10).

There were also no group differences in simple food chain relations (e.g. those not involved in reciprocal or mutual relations). The means for the majority-culture experts were 10.1 and 8.9 for Experiments 3 and 4, respectively, compared with 9.1 and 7.8 for Menominee fish experts. This pattern is as expected.

For mutual relations the majority-culture informants showed a large increase between Experiments 3 and 4 (the median went from 1 to 5 and the mean from 4.0 to 8.1). After a square-root transformation a *t*-test indicated a reliable change ($t=2.60$, d.f. $=27$, $P<0.05$). Menominee informants showed essentially no change from Experiments 3 to 4 (medians of 9 and 8, respectively, and means of 8.9 and 8.5). The only cross-group comparison that was significant was the Menominee, majority culture difference in Experiment 3 on these 34 pairs ($t=2.91$, d.f. $=28$, $P<0.01$, after a square-root transformation).

In summary, the more leisurely pace of Experiment 4 produced two related shifts. One is that the group difference in total reported relations essentially disappeared. The second is that this change was concentrated in reciprocal relations and relations involving eating spawn. This pattern is consistent with a reduced focus on adult fish on the part of the majority-culture fishermen.

4.2. Discussion

The results were essentially as predicted. Under the slower pace the group differences in reported relations almost completely disappeared and were no longer reliable. In addition, we saw the expected changes in the type of relations reported. It appears as if the extra time allowed majority-culture experts to retrieve more reciprocal relations and relations involving spawn than they had in Experiment 3. Both reciprocal relations and relations involving spawn go beyond the simple food chain associations involving adult fish. These data fit with the hypothesis that the difference between majority and Menominee informants is in the accessibility of knowledge rather than in the knowledge base per se. Although cross-experiment comparisons have their limitations, the pattern of findings is consistent with the time pressure in Experiment 3 leading majority-culture experts to largely retrieve relations involving adult fish in unidirectional food chain relations, and the lack of time pressure in Experiment 4 leading to a more complete picture including immature fish and the dissolution of group differences at both a gross level and in detail.

5. General discussion

We began this paper with three related questions concerning culture, expertise and the folkbiology of freshwater fish. Does expertise lead to a convergence on the structure and relational facts inherent in nature? Does this hypothesized convergence extend to both categories and their conceptualization (the salient information associated with them)? Do culture variables play any role beyond that reflected by characteristic practices and activities? Previous work has shown that different kinds of expertise that are associated with different practices may lead to differences in free sorting and category-based reasoning (e.g. Medin et al., 1997; Proffitt et al., 2000). Our expert groups, in contrast, engage in more or less identical practices. Furthermore, other studies suggest that shared expertise may be more important than large cultural differences in mediating categorization and category-based reasoning. For example, USA experts perform more like Itzá-Maya silviculturalists than USA novices (Atran, 1998; Bailenson et al., 2002; Coley, Medin, Proffitt, Lynch, & Atran, 1999). In short, prior to the present studies there was some reason to think that the answers to these three questions would be yes, yes, and no, respectively.

Our data are more consistent with precisely the opposite pattern. First of all, Menominee experts differed from majority-culture experts on a free sorting task in that they were much more likely to sort ecologically. This was evident in the MDS scaling solution of Menominee consensual sorts, which revealed a dimension correlated with habitat. No such dimension emerged from the majority-culture sorts. Justifications for sorts provide further evidence of this and other cultural differences. Majority-culture informants were more likely to use evaluative descriptions (garbage fish versus desirable, prestigious fish) than Menominee informants. Interestingly, this difference in ecological orientation is paralleled by a corresponding difference between young Menominee and majority-culture children on an inductive reasoning task (Ross, Medin, Coley, & Atran, 2003).

The cultural difference in sorting by habitat was not produced by differences in knowledge about habitat. In Experiment 2 we probed directly for habitat information by asking experts to sort by where fish are found. We found a strong cross-group consensus and no group differences.

These cultural differences were again emerged on the fish–fish interaction task associated with Experiment 3. Menominee experts reported more positive (fish helping other fish) and more reciprocal relations than did majority-culture experts. In addition, there was evidence that majority-culture responses were influenced by characteristic goals. It is as if they answered the questions from the perspective of adult fish (the ones fishermen seek). Over-generalizations were made such that fish not found in the same waters were seen as linked if one fish tended to be used a bait to catch the other fish.

The second and fourth studies support the idea that the cultural differences represent differences in knowledge organization, which, in turn, are associated with differences in the accessibility of ecological information. Experiment 4 was like Experiment 3 except that we used less than a tenth of the number of probes and worked at a slower pace. Under these conditions the group differences disappeared. An analysis of the particular relations nominated supports the idea that the slower pace made mutual relations and relations involving spawn more accessible to the majority-culture experts. In short, the group differences appear to be differences in the salience of different kinds of information rather than differences in knowledge per se. In this respect our findings parallel research in cultural psychology which uses priming manipulations to support the idea that group differences are differences in accessibility (e.g. Gardner, Gabriel, & Lee, 1999; Hong et al., 2000).

This difference between knowledge versus knowledge organization parallels the findings of Medin et al. (1997) with different types of tree experts. Although landscapers differed from other experts in sorting trees in relation to goals, on a different (and unspeeded) task assessing the use of categories in reasoning, the difference between landscapers and parks maintenance personnel disappeared. Specifically, the best predictor of landscaper reasoning was *parks maintenance* consensual sorting. Landscaper sorting did not correlate with landscaper reasoning. In short, sorting in terms of goals did not leave landscapers unable to reason in terms of taxonomic relatedness.

Overall, we find systematic differences and similarities in our experiments. Cultural factors clearly play quite an important role, even when the typical practices and activities do not differ across groups. Of course, the results are not wholly surprising. In Guatemala we have found striking differences in folk–ecological models of the forest among three cultural groups that engage in common agro-forestry practices (Atran et al., 1999, 2002). Furthermore, these differences were in the form of reported positive and reciprocal relations, just as we have observed here. It remains to be seen whether these differences would be significantly reduced if ecological relations among plants and animals were probed at a slower pace, as in our Experiment 4. We suspect, however, that the differences are genuine knowledge differences and that they often are based on different interpretations of the same nominal event (e.g. a hummingbird common into contact with banana plants flowers can be seen as helping with pollination or as the hummingbirds simply knocking the petals off flowers). What does seem clear is that relative to the stability and agreement in how different groups partition examples into categories, the salience of ecological relations varies dramatically across cultures and expertise (see also Shafto and Coley, 2003).

Despite the appearance of marked cultural differences, our data provide no comfort to the radical constructivist position. In all experiments we find a robust cross-group consensus and no differences at all in the last two studies. Thus, differences emerge against a backdrop of similarities. In the first experiment, majority-culture informants showed no greater within-than between-group residual agreement. This suggests that the Menominee model is comprised of model shared with majority-culture experts, coupled with a distinct ecological focus not seen in the other population.

The Menominee appear to approach freshwater fish from the perspective of multiple goals and expectations or cultural frameworks (each fish has a role, notions of balance and reciprocity) that leads them to develop a more nature-centered biology of fish. In contrast, majority-culture experts may be more likely to approach fish from the perspective of a smaller set of goals and with a cultural model that focuses more on intrinsic than relational properties. Recent laboratory work in the psychology of concepts (e.g. Ross, 1997) is consistent with the idea that how categories are used may affect how they are represented and our study provides some real world evidence consistent with this general view. Researchers are starting to model the influence of use on category representations and in future work we hope to apply formal models to the present observations.

Just as theories are responsive to data, it is necessary for goals and models to adjust to the affordances of the environment. But theories also help determine what data are relevant and worthy of attention. Perhaps, the best summary is to say what is often said of good defenses on sports teams—"They bend but they don't break." In the present case, we believe that cultural models and biological reality both "bend" a bit in answering one another's demands, and so determining folk conceptions of freshwater fish. But this bending may be more consequential than implied by this analogy–ecological conceptions may be linked to environmental behaviors in ways that promote (or undermine) sustainability.

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