

---

# CHAPTER 10

## THE INFORMATION ECONOMY MODEL APPLIED TO BIOLOGICAL SIMILARITY JUDGMENT

JAMES S. BOSTER

One way cognitive anthropologists discover how cognition is socially shared is through examining how the product of cognition, knowledge, comes to have a patterned social distribution. The strategy is to study the process by examining its consequences. The process of socially shared cognition comprises the collective struggles of individuals to learn, interpret, and understand their world. In building their representations of the world, individuals learn both from what they directly experience and from what others teach them. Because they vary in their experiences and in their goals in interpreting experience, individuals vary in their understandings. Thus the consequence of the process of socially shared cognition is a patterned distribution of cultural knowledge through a community. We can use this pattern to make inferences about how people learn. The task is like that of economics: Instead of charting the pattern of the production, distribution, and consumption

---

I would like to acknowledge gratefully the collaboration of Carolyn Mervis and Kathy Johnson in the Amherst mammal data (the project was Johnson's undergraduate honors thesis project); Isaias Bello Perez for his help in collecting the Tlaxcalan mammal data; Jeffrey Johnson for sharing the data from the fish project; Michelene Chi for allowing me to analyze the data from her dinosaur projects; Brent Berlin and John O'Neill for collecting the Aguaruna and Huambisa bird identification data; John O'Neill for providing the scientific determinations of all specimens used in the Kentucky bird studies, as well as a successive pile sort of the birds himself; and Penny Beile for her assistance in the Kentucky bird study. I would also like to thank Leslie Clark, John Levine, Lauren Resnick, John Roberts, A Kimball Romney, and Sara Sturdevant for their helpful comments.

of wealth, one attempts to describe and explain how information is acquired, transmitted, and used. On the basis of this analogy, I have borrowed Roberts' term *information economy* (1964) to label the model I have been developing to describe and explain the social distribution of knowledge. This chapter has two objectives: to provide a preliminary sketch of the model and to illustrate how it applies to the interpretation of several recent studies of biological similarity judgment.

### **THE INFORMATION ECONOMY MODEL**

The information economy model (IEM) can be summarized as follows: Because culture is learned, both the degree of sharing and the pattern of sharing cultural knowledge reflect the quantity, quality, and distribution of individuals' opportunities to learn. The character and distribution of learning opportunities are, in turn, determined by the characteristics of the learners, the nature of the knowledge domain, and the ways in which the domain is learned.

### **Learning Opportunities and *Intracultural Variation***

The IEM proposes that the degree of agreement individuals can reach about a domain is largely determined by the quantity and quality of available information about the domain, whereas the "patchiness" of the social distribution of cultural knowledge is determined primarily by the patchiness of learning opportunities. Just as the degree of sharing of cultural knowledge ranges from the universal to the idiosyncratic, so learning opportunities may be either ubiquitous or rare, and may vary in quality. Similarly, just as the pattern of sharing of cultural knowledge ranges from even to patchy distributions across individuals, so may learning opportunities vary from being potentially available to all to being available to only a subset of individuals. By a patchy distribution of information across individuals, I mean one in which clusters of individuals share clumps of information not shared by others.

### **Quantity and Quality of *Information***

The world is by turns a straightforward and a confusing place: Domains vary in the quantity and quality of information available about them. At one end of the

---

<sup>1</sup>Here I am restricting use of the term *cultural knowledge* to propositions that members of the community would regard as matters of fact, cases in which one's beliefs are not significantly affected by one's calculation of self-interest. Matters of opinion, such as political dispute, are excluded from the range of beliefs treated by the model. Extension of the model to matters of opinions an important concern to be addressed in future work.

continuum are domains for which good quality information is freely available and there is a high degree of coherence and redundancy in the information. For such domains, learning will be easy, average individual knowledge great, and agreement between individuals high. Even in the early stages of learning the domain, novices should recognize the same underlying pattern of similarities among the items as do experts. For example, novices sort birds similarly to the way experts do, presumably because the basis for judgment is readily available by inspecting the birds (Boster, 1987). In this case, the coherence of the information is a consequence of the intercorrelation of relevant and irrelevant attributes. If attributes in a domain are strongly correlated, even if an individual chooses to attend to attributes that generally are considered irrelevant, he or she is likely to find the same pattern of similarities as do other individuals, because the attribute attended to is often correlated with the attributes generally considered relevant (but see Boster & D'Andrade, 1989). At the other end of the continuum are domains for which information is of poor quality, difficult to obtain, incoherent, or inconsistent. For such domains, learning will be difficult, average individual knowledge low, and overall agreement weak. During the early stages of learning, novices are considerably less likely to recognize the same pattern of similarities as do experts. In this type of domain, if a novice chooses to attend to irrelevant attributions, these are unlikely to be strongly correlated with the attributes that experts consider relevant. For example, it is relatively difficult without specialized equipment to monitor one's own blood pressure and to figure out the factors that raise or lower it; hence, there is a large gulf between folk and expert models of blood pressure (Garro, 1988).

### ***Distribution of Opportunities to Learn the Domain***

Although the quantity and quality of learning opportunities determine the overall level of sharing of knowledge, the relative evenness of the distribution of opportunities to learn the domain determines the social distribution of knowledge. At one end of a continuum are domains in which the opportunities to learn are equally available to members of the community. These are the domains considered by the *cultural consensus* model (Romney, Weller, & Batchelder, 1986). This model asserts that, if individuals share a common culture, give their answers independently, and have competences that are constant over all questions, the expected agreement between any pair of individuals is simply the product of their competences, when *competence* refers to an individual's degree of agreement with the culturally defined standard or "truth." For example, if Mary knows the truth 90% of the time and John knows the truth 80% of the time, they are expected to agree about (.9 x .8) or 72% of the time. As discussed below, variation in competence should be interpretable as the outcome of differences in the individuals' access

to information about the domain and their motivation and skills in accumulating and organizing that information.

At the other end of this continuum are domains for which opportunities to learn are more patchily distributed, both across individuals and across items in the domain. The cultural consensus model will fit not as well (or not at all) in such domains because there are likely to be many subsets of individuals who agree with each other more often than would be expected given the product of their competences. These subsets are composed of individuals who have shared opportunities to learn, either because they share direct observation of rare phenomena or because they communicate information through the social network.

Because the social transmission of information is a common source of the patchiness of learning opportunities, one can understand the difference between even and patchy learning opportunities as a contrast between psychological and social models of the distribution of cultural knowledge. The cultural consensus model is a psychological (or individual-based) model of knowledge distribution, because it explains the pattern of agreement among individuals in terms of their intrinsic competences. Thus, it applies to situations in which one need not know the pattern of social connections among individuals to predict their agreement. These are cases in which the domain information is relatively freely and evenly available to all and the only factors that determine the pattern of agreement are the individuals' abilities and motivations to learn. Of course, there are many cases in which individuals do share much more knowledge with each other than they would be expected to share given their pattern of agreement with others; spouses, collaborators, and other intimates often share large chunks of common understanding that others do not. One can explain the high agreement between these intimates in terms of their social relationship, not their individual competences.

My use of the cultural consensus model to reanalyze data on variation in Aguaruna Jivaro manioc identification (Boster, 1986b) illustrates the contrast between even and patchy domains. (The Aguaruna Jivaro are an Amerindian group living on the rim of the Amazon basin in Northern Peru; manioc [*Manihot esculenta*], a starchy root crop, is the mainstay of their diet.) In this case, the degree of fit to the cultural consensus model depended on the rarity of the manioc varieties. When common varieties were identified, virtually all the agreement between informants could be attributed to their general cultural knowledge, because learning opportunities were fairly evenly distributed and available to all. When rarer varieties were identified, however, the deviations from the general cultural consensus were significant. The pairs of women who agreed with each other more than would be expected given their general knowledge of manioc were typically closely related kinswomen (e.g., mothers and daughters or sisters). Here, because learning opportunities are patchy, kinswomen agree with each other because they learn from one another, sharing numerous privileged opportunities to agree on names for the rarer varieties.

## Explanations of Variation

By describing the pattern of intracultural variation as a consequence of the quantity, quality, and distribution of learning opportunities, the problem of explaining the distribution of knowledge in a community is transformed into one of explaining the distribution of learning opportunities. The next step is to relate the character and distribution of learning opportunities to the ways in which *individuals learn about the world*. The subject, verb, and object of the last clause (*individuals, learn, world*) indicate three complementary tactics in explaining variation. To explain variation one must ask: (a) Who does the learning? (b) How do they learn? and (c) What do they learn about?

### *Who does the learning?*

Both the inherent characteristics of individual learners and the interrelationships among these individuals may help explain the pattern of variation among them. By *inherent characteristics*, I mean those factors that globally affect individuals' chances, abilities, and motivations to learn. The outcome of this set of factors is the individual's cultural competence (Komney, Weller, & Batchelder, 1986) because these factors influence how closely an individual agrees with the cultural standard. Motivation may stem from the individual's response to expectations created by his or her social role (e.g., occupation, sex role, kin relationships, voluntary associations), whereas chances to learn may stem from the individual's age and experiences. For example, in the case of Aguaruna manioc identification described above, women generally know more about manioc than do men because women are the principal cultivators of the society; women are thus provided the motive and chance to learn more about manioc because of their social role. Learning can be viewed as an interaction between individuals and an information source, and, therefore, constraints on an individual's chances to learn may stem from characteristics of either the individual or the information source. Thus, an individual with greater talent or motivation to learn than another can be treated as having access to more and better information. Hence, I use the phrase *opportunities to learn* to refer to the cumulative result of an individual's motivation, talent, and luck.

Although the inherent characteristics of individuals affect the quantity and quality of information available to them, the pattern of relationships between individuals affects the distribution of learning opportunities. For example, if cultural information is transmitted through a social network, adjacent individuals in the network would be expected to agree more with each other than with more distant individuals. If the distribution of opportunities to learn has an extremely patchy distribution, one would expect the amount of knowledge shared by randomly chosen pairs of individuals to be shaped largely by their social relationship

rather than by their general cultural knowledge. This is illustrated by the Aguaruna's identification of rare manioc varieties. Because the rare varieties were cultivated by only a few women, usually only they and their close associates (e.g., daughters or sisters) had ample opportunities to visit the gardens and learn to recognize the variety. Thus, social relationships were a far more important determinant of agreement on the rare varieties than on the common ones.

### *How do people learn?*

As indicated earlier, one can relate the character and distribution of learning opportunities to modes of acquiring knowledge. There are various ways in which individuals acquire knowledge, including direct observation of the world, verbal transmission of information, and inference from other things they know. The relative importance of these modes of learning depends on the sources of structure in experience that give rise to shared understanding. The sources of structure vary in the degree to which they are available to individuals independently of one another. The following sources of structure are listed from low to high levels of social mediation. The first source of structure is that inherent in the natural world (e.g., the succession of the seasons and passages of planets, the form of plants, and the behavior of animals). The second source of structure is that imposed on human experience by our characteristics as perceiving, thinking, and feeling beings (e.g., the physiology of perception, the character of the human mind, and the nature of human emotions and drives). A third source stems from interaction with an environment structured by deliberate human action (e.g., the layout of cities and supermarkets and the forms of artifacts). A fourth source is regularities in human social interaction (e.g., patterns of dominance and submission, of solidarity and conflict, of deviance and conformity). Finally, the most socially mediated source of structure in experience is the social transmission of information through a symbol system (e.g., oral or written language).

Most conceptions of culture have focused almost entirely on this last source of structure as the source of cultural knowledge. This is understandable. Of all the sources of structure in experience, the social transmission of information is most likely to produce a pattern of interindividual variation that reflects individuals' affiliations in distinct social groups. In other words, social transmission of information most readily leads to systematic cultural differences among social groups. If one were only interested in ferreting out and documenting cultural differences among social groups, it would be appropriate to define culture so that the mode of learning cultural knowledge is limited to social transmission. The problem with this approach is that it is difficult to isolate rigorously learning through social transmission from learning through other sources. Although it is natural to emphasize social transmission of knowledge as the basis of culturally specific un-

derstandings of the world, it should not be done to the exclusion of other possible sources of structure in experience.

### *Nature of domains*

The next step in explaining patterns of intracultural variation is to relate modes of learning (i.e., direct observation, verbal transmission, and inference) and the sources of structure in experience to the objective nature of domains and the organization of cultural knowledge. The objective nature of a domain affects both the quality and the distribution of individuals' opportunities to learn about the domain. Domains vary from being directly observable and primarily defined on morphological attributes (e.g., biological organisms) to being directly observable and defined (by experts) primarily on functional attributes (e.g., artifacts), being observable only through their effects or symptoms (e.g., disease), and being essentially unobservable (e.g., spirits). Instances of categories in directly observable domains are likely to be recognized on the basis of family resemblances to prototypical members of the category (cf. Rosch & Mervis, 1976). In such domains, one would expect greater variability in attribute description than in item identification. Conversely, categories in indirectly observable domains or unobservable domains are likely to be learned primarily from other people's verbal descriptions and to be defined on the basis of the presence of a set of verbalizable attributes. In such domains, one would expect greater variability in item identification than in attribute description (cf. Frake, 1961). Furthermore, because such domains are learned primarily through verbal communication, the pattern of interindividual agreement should strongly reflect the pattern of social relations among the individuals. Thus, domains vary in the ways in which individuals typically learn about them. To the extent that a domain is learned through direct experience, the pattern of interindividual agreement should reflect the distribution of opportunities to experience various instances of the categories. On the other hand, to the extent learning comes through verbal transmission, the pattern of agreement should reflect the social distribution of knowledge and the social communication network. Regardless of the way in which the domain is learned, learning opportunities may be either evenly distributed or patchily distributed. However, information acquired through direct experience should generally be more evenly distributed than information dependent on verbal transmission or inferences from other knowledge.

One can also distinguish among several different kinds of domain information: (a) information about the morphological attributes of objects that allow them to be recognized as instances of particular categories; (b) information about the names of the categories at various hierarchical levels; (c) information about nonmorphological attributes (e.g., function and behavior) that can be learned only through sustained observation or from other people; (d) connotative meaning, or appropriate affect toward category; and (e) information about relationships to other categories (e.g., category inclusion and contrast, causal relations, and part-whole

relations). Just as domains may vary in the way people typically learn about them, these types of domain information differ in their accessibility and their order of acquisition. Although the exact order of acquisition is unknown, knowledge of morphological attributes should generally be the most accessible and should be learned before the other types of knowledge.

### *STUDIES OF BIOLOGICAL SIMILARITY JUDGMENT.*

To illustrate the application of the IEM, I will use it in the balance of this chapter to interpret the results of several recent studies of biological similarity judgment. Again, the IEM proposes that patterns of agreement among individuals depend on the availability of learning opportunities. It interprets instances of high agreement or consensus on a domain as resulting from the free availability of good quality domain information to all members of the community. This raises two related questions: (a) How is knowledge socially distributed within a group when the knowledge is not limited to that particular group? and (b) What is the pattern of intracultural variation in domains characterized by strong crosscultural universals?

Cultural universals represent cases in which independent groups of people have come to common understandings of the world. By and large, these commonalities are not mysterious. After all, human beings are members of the same species, live in the same real world (although in radically different social and natural environments), and confront many of the same problems in getting along in that world. It is, therefore, not surprising that independent human groups sometimes make common inferences from common experience. However, one expects these cultural universals only in domains with a sufficiently strong, salient, and unambiguous structure in experience. According to the IEM, if the structure in experience were sufficiently strong to allow independent human groups to come to a shared understanding, that structure should be strong and freely available enough to allow individual members of the same social group to reach a consensus. In other words, the patterns of intracultural variation in domains characterized by strong crosscultural universals should show high degrees of fit to the cultural consensus model and high levels of individual competence. (Conversely, if the domain structure is not sufficiently strong and salient to allow consensus within a community, cross-cultural agreement on the domain is unlikely.)

One of the better documented cases of crosscultural universals is in folk biological classification. At least four different types of universals have been described in this domain: (a) universals in the structure of folk taxonomic systems (Berlin, Breedlove, & Raven, 1973); (b) universals in mapping of categories onto biological species (Berlin, 1973; Hum, 1975); (c) universals in judgments of similarities among organisms (Boster, Berlin, & O'Neill, 1986; Boster, 1987); and (d) universals in choice of attributes of organisms (Boster & D'Andrade, 1989).

My own work has been directed toward documenting the last two types of universals. Boster, Berlin, and O'Neill (1986) established that Jivaroans and scientific ornithologists agree in their recognition of patterns of resemblance among a collection of South American bird specimens. Subsequently, I showed that this result is not limited to people with long experience with the birds; ornithologically naive college students substantially agreed with the Jivaroans and the scientists in judging the similarities among the same bird specimens (Boster, 1987). Finally, D'Andrade and I (1989) have argued that crosscultural agreement in biological classification is the outcome of a pan-human perceptual strategy that selects those characteristics of a collection of organisms that yield the most informative classification. In other words, crosscultural commonality has its source in the nature of individual cognition.

The final portion of this chapter will focus on a comparison of crosscultural and intracultural variation in biological similarity judgment. Biological similarity judgment readily lends itself to an examination of intracultural variation. In contrast to the first two types of universals described earlier, one can study biological similarity judgment without assuming that everyone agrees, and one can elicit similarity judgments from informants who lack an explicit linguistic classification scheme for the organisms or even from those who have never seen the organisms before. Given that the opportunities to learn biological domains are relatively freely available to all observers, one would expect high levels of agreement and a high degree of fit to the cultural consensus model, according to the IEM.

Each of the studies reviewed here elicited similarity judgments from informants using concrete (as opposed to verbal) stimuli representing different biological domains: mammals, dinosaurs, fish, and birds. Three distinct methods of eliciting similarity judgments were used in these studies: triad test, free pile sort (FPS), and the successive pile sort (SPS).<sup>2</sup> Different tasks elicited different amounts

<sup>2</sup>In the triad task, informants were presented with three stimuli at a time and were asked to judge which of the three was the most different from the other two. Lambda two balanced-incomplete-block designs were used in which each pair of stimuli only occurred twice in the set of triads (Burton & Nerlove, 1976). This greatly reduced the number of triads presented to informants; for 25 items, a complete design has 2,300 triads, whereas a lambda two design has only 200 triads. An informant's judgment of the similarity of each pair of stimuli was assessed by counting the number of triads (0, 1, or 2) in which the pair was judged most similar in the triad. In the free pile sort, informants were presented with a collection of stimuli and were asked to sort them into piles according to which they thought were most similar to one another. Informants were instructed to form as many piles as they wished and to base their judgments of similarity on any characteristic they chose. An informant's judgment of the similarity of each pair of stimuli was assessed by noting whether the informant had placed the pair in the same pile (1) or not (0). The successive pile sort began by asking informants to place the stimuli into piles as they would in an ordinary tree pile sort. Then, the informant was asked to merge the most similar pair of piles. The informant continued to merge piles until all piles of stimuli were merged. Next, the informant's initial piles were restored, and informants were asked to split the pile they thought was most heterogeneous into two subpiles. The informant continued to split piles until all stimuli were separated. An informant's judgment of the similarity of each pair of stimuli was assessed by counting the rank order in which they were split apart.

of information from each informant, with the successive pile sort eliciting the most and the free pile sort the least. The studies generally compared different groups of informants, including groups of domain experts and novices, different age groups (7-year-olds, 10-year-olds, and adults), different cultural groups (e.g., Jivaro, Tlaxcalan, and U.S.), different regional groups (North Carolina, Texas, and Florida), or some combination of these.

## Data Analysis

For each study, a correlation matrix was produced by correlating the similarity matrices derived from informants' responses. This interinformant correlation matrix was then assessed for its fit to the cultural consensus model (Romney, Weller, & Batchelder, 1986).<sup>3</sup> Minimum residual factor analysis was used to check whether an interinformant correlation matrix fits the model. If it does, there should be a single factor solution so that there are no negative scores on the first factor, and the first latent root (the largest eigenvalue) should be large compared with all other latent roots. In other words, the pattern of correlations among individual informants should be entirely due to the extent to which each knows the common (culturally relative) "truth." In its application to the results of these studies, a fit to the cultural consensus model would indicate that there is an overall agreement on the pattern of similarity among the organisms. The cultural consensus model also allows the estimation of individual knowledge levels from interinformant agreement: If an interinformant correlation matrix fits the model, one is justified in using the informants' scores on the first factor of the minimum residual factor analysis as an estimate of the informants' cultural competences. The competences of the diverse informant groups can then be compared. In addition, each informant's similarity judgments are correlated with aggregate similarity judgments based on either his or her own group's or another informant group's judgments. Each informant's similarity matrix is also correlated with the matrix of *taxonomic distances* (Boster, Berlin, & O'Neill, 1986) among the specimens. This measure is calculated by counting the nodes one has to ascend in the scientific taxonomic tree to arrive at one that includes both species. Because biological systematists base their reconstructions of phylogeny primarily on the sharing of morphological characters,

<sup>3</sup>The application of the cultural consensus model to similarity judgment data represents an extension of the method beyond the scope of the *formal process model* developed by Romney, Weller, and Batchelder (1986), because the original model applies only to dichotomous data. When Romney, Batchelder, and Weller (1987) and Weller (1987) generalized the consensus model to accommodate rank order and interval scale data, respectively, they referred to these extensions as *data models* to distinguish them from the more fully developed formal process model. My use of the consensus model to analyze interinformant correlations on similarity judgments would also be termed a data model and was suggested to me by Romney.

Table 1  
DIMENSIONS OF DIFFERENCE AMONG THE STUDIES

Location	Oomain	Method	N of stimuli	Nature of stimuli	Scientific authority
Amherst & Tlaxcala	Mammals	Triad test	25	Line drawmgs	Eisenberg (1981)
Pennsylvania	Dinosaurs	FPS	20	Color plates	Lambert (1983)
South East (United States)	Fish	FPS	43	Line drawings	Nelson (1984)
Kentucky & Amazonas, Peru	Birds	FPS	40 × 2	Prepared specimens	Meyer Deschaensee (1970)
Kentucky & Amazonas, Peru	Birds	SPS	15 × 2	Prepared specimens	Meyer Deschaensee (1970)

Note: FPS = free pile son; SPS = successive pile son

taxonomic distance is an easily computed proxy measure of the similarities of form among species. Pearson correlation is used here as a measure of similarity among alternative classifications rather than as an inferential statistic.

## Description of the Studies

There were several dimensions of difference among the studies. First, there was variation in the type of similarity judgment task performed (i.e., triad test, free pile sort, or successive pile sort). Second, there were different kinds of contrasts among the subgroups of informants examined in each study, including expertise, age, region of the country, and society. A third dimension of difference among the studies involved the nature (and the number) of stimulus items; organisms were variously represented by line drawings, color plates, and stuffed specimens. These various stimulus materials differed in their realism and complexity. A fourth dimension of difference involved the class of organisms used; these included mammals, reptiles (dinosaurs), birds, and fish. Table 1 summarizes these differences among the studies.

In the mammal study, 25 color drawings of mammals were used as stimuli in a triad test. The informants were 20 Amherst adults, 20 Amherst 10-year-olds, 20 Amherst 7-year-olds, 20 Tlaxcalan (Mexican) mature adults (ages 43 to 71), and 20 Tlaxcalan young adults (ages 20 to 45). For further details of

the Amherst mammal study, see Johnson (1988) and Johnson, Mervis, and Boster (1988).

In the dinosaur study, 20 color plates of dinosaurs were used as stimuli in a free pile sort. The informants were 15 dinosaur novices, 8 intermediates, and 15 dinosaur experts, ages 4 to 7. Further details of the design of the study are given in Chi and Koeske (1983), Gobbo and Chi (1986), and Chi, Hutchinson, and Robin (1989).

In the fish study, 43 line drawings of salt water fish species were used as stimuli in a free pile sort. The informants were 15 East Florida expert fishermen, 15 West Florida expert fishermen, 15 Texas expert fishermen, 15 North Carolina expert fishermen, and 15 North Carolina novice fishermen. For further details, see Boster and Johnson (1989).

The bird study consisted of two separate experiments. In the first, two sets of 40 stuffed specimens of South American birds (40 nonpasserine and 40 passerine species) were used as stimuli in a free pile sort. The informants were 37 University of Kentucky ornithologically naive undergraduates who had been screened to ensure that they had no formal training in zoology and no familiarity with these South American birds. In addition, results of identification tasks with the birds among the Aguaruna and Huambisa Jivaro (Berlin, Boster, & O'Neill, 1981; Boster, Berlin, & O'Neill, 1986) were used to generate similarity matrices among the birds. In the second experiment, two sets of 15 stuffed specimens of South American birds (15 nonpasserine and 15 passerine species) were used as stimuli in a successive pile sort. These subsets of the birds used in the first experiment were chosen so that each had the same underlying taxonomic structure as the other. The informants were 45 University of Kentucky ornithologically naive undergraduates. Again, the results of identification tasks with the birds among the Aguaruna and Huambisa Jivaro (Berlin, Boster, & O'Neill, 1981; Boster, Berlin, & O'Neill, 1986), as well as the results of free pile sort experiments, were used to generate similarity matrices among the subsets of the birds. See Boster (1987) for additional details.

## Results

The first result was that, in all five studies, the interinformant correlation matrices appeared to fit the cultural consensus model. As shown in Table 2, for all studies the ratio of the first to second eigenvalue was high (range = 4.2 to 14.3) and there were no strongly negative scores on the first factor. (The lowest value in any of the studies was  $-.02$ , effectively zero.) This indicates that, in all five studies, there was a good deal of agreement on biological similarity judgment, and any subgroup differentiation did not obscure that overall consensus. This fit

Table 2  
FIT TO THE CULTURAL CONSENSUS MODEL

Study	First Eigenvalue	Second Eigenvalue	Ratio of Eigenvalues	Lowest first factor score
Mammals triad				
Amherst	23.36	3.30	7.06	.26
Tlaxcala	7.27	1.52	4.70	.02
Both	26.93	3.99	7.25	.00
Dinosaurs FPS				
All data	15.10	2.54	5.94	.02
No pairs	14.64	1.71	0.56	.37
Fish FPS	12.15	2.63	4.60	.06
Birds FPS				
Nonpasserine	17.45	1.22	14.30	.17
Passerine	7.30	1.75	4.17	.11
Birds SPS				
Nonpasserine	29.56	2.27	13.03	.33
Passerine	16.34	2.09	8.78	.04

Note: FPS = free pile sort; SPS = successive pile sort

justified the use of the first factor score as a measure of the agreement of each informant with other informants or informants' competence (Romney, Weller, & Batchelder, 1986).

Second, the relationship between expertise and competence (as just defined) was variable. Most applications of the cultural consensus model have documented cases in which experts have significantly higher competence than novices; that is, they agree more than novices (Boster, 1985; D'Andrade, 1987; Garro, 1986; Romney, Weller, & Batchelder, 1986). In at least one of the studies reviewed here, however, experts did not have higher competences in similarity judgment than novices (Table 3, Part C, Fish,  $t = .71$ ,  $p > .05$ ). In two other studies, judgment about the relationship between expertise and competence depended on how the data were treated. In the dinosaur study, if informants making only two piles were eliminated (Table 3, Part B, No Pairs), there was a significant difference between novices and experts ( $t = 2.11$ ,  $p < .05$ ). If all the data were included (Table 3, Part B, All Data), however, there was no significant difference between

Table 3  
COMPETENCE ESTIMATES AND CORRELATIONS WITH TAXONOMIC MODEL

Study	Competence		$r^a$		<i>n</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
<b>Mammals triad</b>					
Amherst (AM)					
7-year-olds	.61	.12	.23	.08	20
10-year-olds	.63	.13	.26	.10	20
Adults	.59	.14	.31	.14	20
Tlaxcala (TL)					
Young adults	.37	.21	.13	.11	20
Mature adults	.38	.21	.16	.13	20
AM and TL					
7-year-olds	.61	.12	.23	.08	20
10-year-olds	.63	.13	.26	.10	20
AM adults	.58	.14	.31	.14	20
TL young adults	.32	.19	.13	.11	20
TL mature adults	.35	.20	.16	.13	20
<b>Dinosaurs FPS</b>					
All data					
Novices	.55	.28	.41	.18	15
Intermediates	.61	.23	.50	.27	8
Experts	.54	.36	.42	.25	15
No pairs					
Novices	.62	.22	.45	.17	13
Intermediates	.71	.11	.60	.22	6
Experts	.80	.17	.58	.13	9
<b>Fish FPS</b>					
Novice	.36	.11	.24	.09	15
All experts	.39	.13	.16	.08	60
EF experts	.42	.11	.18	.06	15
WF experts	.39	.10	.16	.08	15
TX experts	.35	.17	.15	.11	15
NC experts	.39	.12	.17	.08	15

Table 3 (continued)

Study	Competence		$r^a$		<i>n</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
<b>Birds FPS</b>					
Nonpassenne	.67	.15	.49	.11	37
Passerine	.43	.13	.20	.06	37
<b>Birds SPS</b>					
Nonpassenne	.80	.12	.73	.14	45
Passerine	.61	.19	.28	.12	45

Note: FPS = free pile sort; SPS = successive pile sort; EF = East Florida fishermen; WF = West Florida fishermen. TX = Texas fishermen; and NC = North Carolina fishermen  
\* $r$  = Correlation between informants' responses and the taxonomic model

the novices and experts ( $t = .06, p > .05$ ).<sup>4</sup> Similarly, in the mammal study, if Tlaxcalan informants were treated as novices in triad judgments of world mammals vis-a-vis Amherst informants (Table 3, Part A), there were significant differences between the novices and experts ( $t = 8.49, p < .001$ ). However, in the mammal study, if the Amherst 7- and 10-year-olds were treated as novices in triad judgments of world mammals vis-a-vis adults (Table 3, Part A), there were no significant differences in competence by expertise ( $F = .54, p > .05$ ).

In those cases in which one group (nominally experts) had significantly higher competences than another (nominally novices), they generally also had significantly higher correlations to the taxonomic model (Table 3, Part A, Mammals, Amherst vs. Tlaxcala,  $t = 5.20, p < .001$ ; Table 3, Part B, Dinosaurs, No Pairs,  $t = 1.96, p < .05$  if treated as a one-tailed test). The reverse was not true; the novices in the fish study were closer to the taxonomic model than the expert fishermen ( $t = 3.07, p < .01$ ) (Boster & Johnson, 1989).

<sup>4</sup>The inclusion of extreme lumpers also worsens the fit of the dinosaur FPS data to the cultural consensus model. If the responses of informants making only two piles are removed, the fit to the cultural consensus model is substantially improved (Table 2, Part B, No Pairs). The lumpers-splitter problem is a major drawback of using results of the free pile sort to assess individual differences. Boorman and Arable (1972; Arable & Boorman, 1973) have shown that often the pattern of individual variation on the free pile sort is swamped by differences between such lumpers and splitters. They concluded that free pile sort is useless for making inferences about individual differences. However, some recent studies (Boster, Johnson, & Weller, 1987; Boster & Johnson, 1989) have suggested a qualification of their finding: For those domains offering various possible levels of making splits among stimuli, individual differences in pile sorting will probably only reflect differences in aesthetic preferences for the number of piles. However, for those domains with a salient cutpoint (analogous to Berlin's notion of the generic or Rosch's notion of the basic level object), the differences among individuals' responses are more likely to be independent of the lumpers-splitter contrast. For example, when the extreme lumpers are removed from the dinosaur sample, there is negligible residual correlation between lumping and competence ( $r = .03$ ). Nevertheless, the lumpers-splitter problem is a major reason for preferring the successive pile sort to the free pile sort.

Table 4

RELATIONSHIP BETWEEN COMPETENCE AND CORRELATION WITH THE TAXONOMIC MODEL

Study	Mean <i>r</i> and SDs between INs' responses and the TM		<i>r</i> between aggregate of INs' responses and the TM	<i>r</i> between competence and INs' approach to TM
	M	SD		
<b>Mammals triad</b>				
Amherst	.27	.11	.43	.66
Tlaxcala	.14	.12	.39	.80
Both	.22	.13	.44	.81
<b>Dinosaurs FPS</b>				
All data	.43	.22	.75	.88
No pairs	.52	.18	.73	.80
Fish FPS	.18	.09	.46	.41
<b>Birds FPS</b>				
Nonpasserine	.49	.11	.71	.91
Passerine	.20	.06	.45	.73
<b>Birds SPS</b>				
Nonpasserine	.73	.14	.91	.92
Passerine	.28	.12	.46	.64

Note: TM = taxonomic model; INs = informants; FPS = free pile sort; and SPS = successive pile sort.

The third result, shown in Table 4, was that in all cases the correlation of the aggregate of informant responses to the taxonomic model was higher than the mean individual correlation to the taxonomic model. In other words, the aggregated similarity judgments are always closer to the scientific system of classification than is the average individual.

Fourth, also shown in Table 4, competence tended to be highly correlated with approach to the taxonomic model. That is, the higher an informant's agreement with other informants, the closer his or her similarity judgments will be to the scientific classification of the organisms. It would appear that often the scientific classification is close to what the target informants aim at in making their similarity judgments.

Fifth, from the crosscultural studies (mammals and birds), it appeared that competence is correlated not only with approach to the taxonomic model but also

Table 5

CORRELATION BETWEEN COMPETENCE AND APPROACH TO ALTERNATIVE STANDARDS: MAMMAL TRIAD STUDY ALTERNATIVE STANDARDS

Informants	Taxonomic model	Amherst			Tlaxcala	
		Adults	10-year-olds	7-year-olds	Mature adults	Young adults
Amherst	.66	.70	.97	.89	.73	.90
Tlaxcalan	.80	.86	.93	.94	.92	.96

with approach to aggregate structures derived from the responses of other groups of informants. For example, Tables 5 and 6 show the correlations between competence and various possible aggregate standards for the mammal and bird studies. It can be seen that competence strongly correlates with approach to all of the standards: The more one agrees with the members of one's own group in biological similarity judgment, the more likely one will agree with members of culturally different groups.

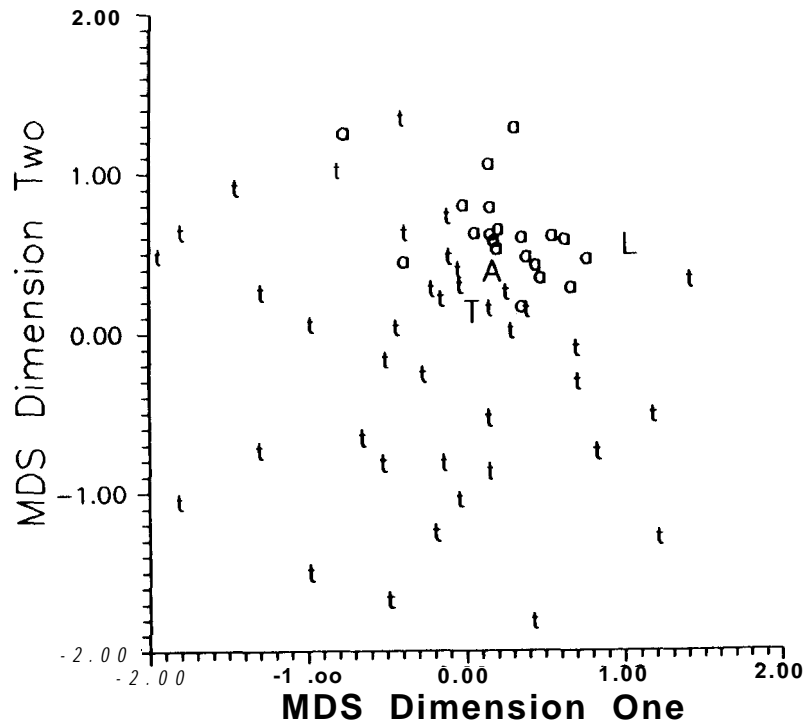
Finally, in the crosscultural studies, aggregates tended to be closer than individuals were; the level of intracultural variation was much larger than the level of crosscultural variation. It appears that all groups of informants are aiming at similar targets; the aggregates are much more tightly clustered around the shared target than are the individuals. This is illustrated in Figure 1. The figure shows a multidimensional scaling of the intercorrelations among Tlaxcalan adult and Amherst 7-year-old informants' responses to the mammal triad task, along with various aggregate structures. The aggregates (in caps) are clustered tightly in the

Table 6

CORRELATION BETWEEN COMPETENCE AND APPROACH TO ALTERNATIVE STANDARDS: BIRD FPS AND SPS STUDIES

Subtaska	Taxonomic model	Aguaruna Jivaro	Huambisa Jivaro	FPS -- aggregate
Bird FPS study alternative standards				
Nonpasserines	.91	.70	.73	
Passerines	.73	.71	.89	
Bird SPS study alternative standards				
Nonpasserines	.92	.72	.82	.92
Passerines	.64	.78	.94	.94

Note: The Aguaruna Jivaro and Huambisa Jivaro aggregate structures were derived from an analysis of their "confusion" in a bird identification task (Berlin, Boster, & O'Neill, 1981; Boster, Berlin & O'Neill, 1986) FPS = free pile sort; SPS = successive pile sort



**Figure 1** Multidimensional scaling of triad similarity judgments among mammals. a = Individual Amherst 7-year-olds; t = Individual Tlaxcala adults; A = Aggregate of Amherst information; T = Aggregate of Tlaxcala informants; L = Linnaean taxonomic model.

center of the space; the individual informants (in lower case) are scattered more widely. Subject groups may differ slightly in their targets but mainly vary in their degree of scatter around the shared targets.

if informant groups share a common target but differ in their degree of approach to it, certain interesting anomalies may result. For example, the Amherst informants were closer on average to the Tlaxcalan aggregate than the Tlaxcalans were (Table 7).

Both the Amherst and the Tlaxcalan informants were aiming at similar targets (the aggregate structures are highly correlated), but the Amherst subjects converged much more tightly than the Tlaxcalans, and by approaching their own consensus they also approached the Tlaxcalan one. This is also illustrated

**Table 7**  
MEANS AND STANDARD DEVIATIONS WITH ALTERNATIVE STANDARDS  
FOR MAMMAL TRIAD

Informants	TM		Amherst subjects						Tlaxcala subjects			
			Adults		Age 10		Age 7		Mature adults		Young adults	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Amherst	.27	.11	.57	.13	.60	.13	.59	.14	.46	.11	.47	.12
Tlaxcala	.14	.12	.27	.17	.30	.18	.30	.19	.37	.19	.36	.18
<i>t</i>	5.20		9.81		9.88		8.90		2.96		3.85	

**Note:** TM = taxonomic model. All differences were significant at the 01 level

in Figure 1, which shows that the Amherst 7-year-olds were more tightly clustered around all aggregates (including the Tlaxcalan one) than the Tlaxcalan informants were.

### Discussion

The results of these studies of biological similarity judgment closely corresponded to what would be expected, given the IEM, in a domain in which learning opportunities are of relatively high quality and are relatively freely available to all observers. To review, the patterns of variation among informants showed a high degree of fit to Romney, Weller, and Batchelder's (1986) cultural consensus model: Expertise sometimes (but not always) leads to higher competence, aggregate structures are more highly correlated than individuals are, and competence correlates with approach to all informant groups' aggregate structures.

The correlation of individual competence with approach to the aggregate is a feature of those domains that fit the cultural consensus model and, more generally, an outcome of averaging noisy measures of the same phenomenon. Epstein (1979) noted, "When measures of behavior are averaged over an increasing number of events, stability coefficients increase to high levels for all kinds of data, including objective behavior, self-ratings, and ratings by others." One would expect that, when populations of individuals are aiming at the same target, aggregates will more stably and reliably hit the target than will individuals.

These patterns of intracultural and crosscultural variation in biological similarity judgment appear similar to the pattern described by Berlin and Kay (1969) in discussing the focal points of basic color categories. Berlin and Kay found that, for a given basic color category, there was much higher agreement on the focal

chip across aggregates from different societies than there was among informants within a single society. In other words, there was large within-group variation and little between-group variation.

Color, like biological organisms, is another example of a domain in which there is a strong structure in experience that is not dependent on social transmission of information: We learn the best examples of color categories from our lateral geniculate nuclei (Kay & McDaniel, 1976) not through ostensive definition. This strong structure, shared by different human groups by virtue of their common phylogeny, forms the target around which individuals vary. Individuals may vary at how well they approximate the target, but aggregates of individuals will tend to cancel out the “noise” and reinforce the “signal.” Because of this shared structure, it is possible to construct tasks in which individuals recapitulate the evolutionary development of color lexicons (Boster, 1986a); crosscultural universals in color classification can be explained by shared cognitive strategies used by individuals.

Of course, the source of structure in biological similarity judgment is in the world, not in the brain, and so the results of an investigation of biological similarity judgment are much more dependent on factors other than the inherent structure in the domain, such as the amount of individuals’ experience with the organisms, the other kinds of knowledge they have about them, the representativeness or realism of the stimulus materials, and the design of the similarity judgment task. The inherent structure in biological domains appears robust enough to emerge relatively clearly in all these studies, but it is not as tidy a picture as in the case of color.

The contrast between experts and novices illustrates the effect that prior experience can have on the performance of the task. One might say that, for experts, the stimuli were treated as a “sign”; the specimen or stimulus item “refers” to a category with which the expert has other rich experience (e.g., photographs of fish for recreational fishermen, specimens of birds for Aguaruna and Huambisa hunters, pictures of dinosaurs for avid 7-year-olds). For novices with little previous experience or knowledge of the domain, the same stimulus item is a token only of a vague superordinate category, (e.g., South American bird specimens or salt water fish for ornithologically and ichthyologically naive college students). The novices are much more dependent on the structure inherent in the stimulus item itself to guide their judgments than are the experts.

If the other experience that experts have of the domain largely reinforces the judgments one would make on morphological grounds (as represented in the stimuli), one would expect experts to agree much more highly—both with each other and with the scientific classification—than novices. This appeared to be the case in the Amherst (Johnson, Mervis, & Boster, 1988) and Tlaxcala mammal experiments. It seems that, by the time a middle-class Amherst child is seven, he or she has been exposed through picture books, television, or trips to the zoo to

sufficient examples of giraffes, gorillas, and chipmunks to judge similarities among mammals more or less along the lines that his or her parents would. It seems likely that the Tlaxcalan corn farmers, in addition to potentially having greater difficulty with the experimental task itself, had not had nearly as much exposure to these world mammals and so had a much harder time supplying for the interpretation of the pictures the proper scale and other attributes of the animals. Thus the Tlaxcalans tended to judge *bear* and *beaver* as similar because both were represented as roundish and black. If the task were performed with a stimulus set of mammals local to the Tlaxcalans, I am confident that this picture would be substantially changed.

In contrast, if the experts’ other experience leads to sorting on alternative criteria, experts would not be expected to agree highly either with each other or with the scientific classification. This appeared to be the case in the fish study. Boster and Johnson (1989) showed that the novices sorted fish solely according to morphological features of the fish, whereas experts relied about equally on morphological and functional or behavioral information. Consequently, novices approached the scientific classification of fish more closely than expert fishermen.

Chi’s dinosaur work (1983) provides an interesting intermediate case. Many (6 out of 15) of Chi’s dinosaur experts chose to divide the dinosaurs into two piles on the behavioral criteria of plant eating and meat eating. These examples of extreme lumping were not well correlated with either the aggregate response or the taxonomic model. However, if we eliminate from consideration those informants who only made two piles and hunt for higher competence and correlation with the taxonomic model on the part of Chi’s experts, we find it.

## CONCLUSIONS

This chapter presents a sketch of the Information Economy Model and an illustration of its application to the interpretation of five recent studies of biological similarity judgment. Consistent with the expectations of the IEM, I found that (a) the patterns of variation among informants showed a high degree of fit to Romney, Weller, and Batchelder’s (1986) cultural consensus model; (b) expertise sometimes, but not always, led to higher competence; (c) aggregate structures were more highly correlated than individuals were; and (d) competence correlated with approach to all informant groups’ aggregate structures.

These results suggest that, when learning opportunities are freely available, culturally diverse groups of informants can converge on a single consensus; they can agree (share *culture*) without the benefit of social information transmission. It is ironic that the cultural consensus model may work best when informants are not culturally transmitted, when individuals agree by virtue of their independent insights into the task rather than by virtue of their social contacts.

Experience and expertise, however, can make a difference. It is as though the phenomenal world is sometimes available at different levels; one picture presents itself without close study, another after long experience. The existence of differences between experts and novices depends on the amount of difference between these two pictures. If what experts learn reinforces the judgments one would make on the basis of morphological criteria, experts will agree more than novices. If expertise leads to acquisition of numerous alternate bases of judgment, the truth can set the experts free, and they will have responses to the similarity judgment task that are as variable as novices' responses.

## References

- Arabie, P., & Boorman, S. A. (1973). Multidimensional scaling of measures of distances between partitions. *Journal of Mathematical Psychology*, *10*, 148-203.
- Berlin, B. (1973). Folk systematics in relation to biological classification and nomenclature. *Annual Review of Ecology and Systematics*, *4*, 259-271.
- Berlin, B., Boster, J., & O'Neill, J. P. (1981). The perceptual bases of ethno-biological classification: Evidence from Aguaruna Jivaro ornithology. *Journal of Ethnobiology*, *1*(1), 95-108.
- Berlin, B., Breedlove, D., & Raven, P. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist*, *75*, 214-242.
- Berlin, B., & Kay, P. (1969). *Basic color terms: Their universality and evolution*. Berkeley: University of California Press.
- Boorman, S. A., & Arabie, P. (1972). Structural measures and the method of sorting in R. N. Shepard, A. K. Romney, & S. B. Nerlove (Eds.), *Multidimensional scaling: Theory and applications in the behavioral sciences* (Vol. 1, pp. 225-249). New York: Seminar Press.
- Boster, J. (1985). Requiem for the omniscient informant: There's life in the old girl yet. In J. Dougherty (Ed.), *Directions in cognitive anthropology* (pp. 177-197). Urbana: University of Illinois Press.
- Boster, J. (1986a). Can individuals recapitulate the evolutionary development of color lexicons? *Ethnology*, *25*(1), 61-74.
- Boster, J. (1986b). Exchange of varieties and information between Aguaruna manioc cultivators. *American Anthropologist*, *88*(2), 429-436.
- Boster, J. (1987). Agreement between biological classification systems is not dependent on cultural transmission. *American Anthropologist*, *89*(4), 914-920.
- Boster, J., Berlin, B., & O'Neill, J. P. (1986). The correspondence of Jivaroan to scientific ornithology. *American Anthropologist*, *88*(3), 569-583.
- Boster, J., & D'Andrade, R. G. (1989). Natural and human sources of cross-cultural agreement in ornithological classification. *American Anthropologist*, *91*(1), 132-142.
- Boster, J., & Johnson, J. C. (1989). Form or function: A comparison of expert and novice judgments of similarity among fish. *American Anthropologist*, *91*(4), 866-889.
- Boster, J., Johnson, J. C., & Weller, S. (1987). Social position and shared knowledge: Actors' perceptions of status, role, and social structure. *Social Networks*, *9*, 375-387.
- Burton, M., & Nerlove, S. B. (1976). Balanced designs for triad tests: Two examples from English. *Social Science Research*, *5*, 247-267.

- Chi, M. T. H., Hutchinson, J., & Robin, A. (1989). How inferences about novel domain-related concepts can be constrained by structured knowledge. *Merrill-Palmer Quarterly*, *35*(1), 27-62.
- Chi, M. T. H., & Koeske, R. (1983). Network representation of a child's dinosaur knowledge. *Developmental Psychology*, *19*, 29-39.
- D'Andrade, R. G. (1987). Modal responses and cultural expertise. *American Behavioral Scientist*, *31*(2), 194-202.
- Eisenberg, J. F. (1981). *The mammalian radiations: An analysis in trends in evolution, adaptation, and behavior*. Chicago: University of Chicago Press.
- Epstein, S. (1979). The stability of behavior: I. On predicting most of the people much of the time. *Journal of Personality and Social Psychology*, *37*(7), 1097-1126.
- Frake, C. (1961). The diagnosis of disease among the Subanon of Mindanao. *American Anthropologist*, *63*, 113-132.
- Garro, L. (1986). Intracultural variation in folk medical knowledge: A comparison between curers and non-curers. *American Anthropologist*, *88*(2), 351-370.
- Garro, L. (1988). Explaining high blood pressure: Variation in knowledge about illness. *American Ethnologist*, *15*(1), 98-119.
- Gobbo, C., & Chi, M. T. (1986). How knowledge is structured and used by expert and novice children. *Cognitive Development*, *1*, 221-237.
- Hunn, E. S. (1975). A measure of the degree of correspondence of folk to scientific biological classification. *American Ethnologist*, *2*, 309-327.
- Johnson, K. (1988). *Developmental changes in the structure of the mammal domain*. Honors thesis, University of Massachusetts, Amherst.
- Johnson, K., Mervis, C., & Boster, J. (1988). *Developmental changes in the structure of the mammal domain*. Unpublished manuscript.
- Kay, P., & McDaniell, C. K. (1976). The linguistic significance of the meanings of basic color terms. *Language*, *54*, 610-646.
- Lambert, D. (1983). *A field guide to dinosaurs*. New York: Avon.
- Meyer DeSchaenec, R. (1970). *A guide to the birds of South America*. Wynncwood, PA: Livingston Publishing Company.
- Nelson, J. S. (1984). *Fishes of the world* (2nd ed.). New York: Wiley.
- Roberts, J. (1964). The self-management of cultures. In W. H. Goodenough (Ed.), *Explorations in cultural anthropology* (pp. 433-454). New York: McGraw Hill.
- Romney, A. K., Weller, S. C., & Batchelder, W. H. (1986). Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist*, *88*, 313-338.
- Romney, A. K., Batchelder, W. H., & Weller, S. C. (1987). Recent applications of cultural consensus theory. *American Behavioral Scientist*, *31*(2), 163-177.
- Rosch, E., & Mervis, C. (1976). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology*, *7*, 573-605.
- Weller, S. C. (1987). Shared knowledge, intracultural variation, and knowledge aggregation. *American Behavioral Scientist*, *31*(2), 178-193.

THIS MATERIAL IS COPYRIGHTED