

Toward a Theory of Culture as Shared Cognitive Structures

A. KIMBALL ROMNEY and
CARMELLA C. MOORE

ABSTRACT *A small but important aspect of culture consists of shared cognitive representations of semantic structures that reside as localized functional units in the minds of individuals. In this article we discuss the cognitive and biological foundations for a model of culture as shared cognitive representations and summarize empirical evidence for predictions derived from the model. The structure of semantic domains such as the names of colors, animals, or kinship terms is defined as the arrangement of the terms relative to each other in a spatial model. In this space, items that are judged as more similar are placed closer to each other than items judged as less similar. Measuring the extent to which “pictures” or cognitive representations in the mind of one person correspond to those in the mind of another, research on various semantic domains has demonstrated that typical members of a culture have similar “pictures” in their minds.*

What will happen next in the development of cognitive anthropology is unclear. Whatever the new directions, it is nice to look back at what has been done and realize that when this work was started we did not know how to do lots of the things we can do now. The things we know how to do—to work out a taxonomy, or scale terms in a domain, or find prototypic objects, or work out a cultural model, or show how reasoning or memory or other psychological processes are affected by cultural representations, or investigate the way in which cultural knowledge is distributed—are modest accomplishments. Though modest, if these accomplishments can be built on, the venture will have proven worthwhile.

—Roy G. D’Andrade, *The Development of Cognitive Anthropology*, p. 252

One important part of culture consists of the shared aspects of the structure of cognitive representations held by the individual members of

A. KIMBALL ROMNEY is a professor in the Department of Anthropology, University of California, Irvine.
CARMELLA C. MOORE is an assistant research anthropologist, Department of Cognitive Sciences, University of California, Irvine.

Ethos 26(3):314–337. Copyright © 1998, American Anthropological Association.

that culture. The locus of culture, in this view, resides in the minds of the members of the culture. It follows that culture is clearly subject to all the psychological and neurophysiological constraints of any other cognitive process: for example, memory or learning. In this article we construct a theory in which the “picture” inside the mind of a single individual may be thought of as a cognitive representation of the structure of the corresponding semantic domain.¹ We construct a model of culture by aggregating the individual cognitive representations, derived from judged-similarity tasks, into an optimal “composite picture.”

Recent advances in the measurement and scaling of the structure of semantic domains—for example, animal names or kinship terms (Brazill et al. 1995; Romney et al. 1995; Romney et al. 1996; Romney et al. 1998), as inferred from pair-wise judgments of similarity—have made possible precise comparisons among what is in the mind of different individuals. We are now in a position to measure the extent to which cognitive representations or “pictures” inside the mind of one person correspond to cognitive representations or “pictures” inside the mind of another. The extent to which pictures correspond or differ is subject to measurement, with specified confidence limits on the error of measurement. In addition we can express in a variety of ways the extent to which a large number of individuals “share” similar pictures.

A semantic domain may be defined as an organized set of words, all on the same level of contrast, that refer to a single conceptual sphere. The set of words are exemplars of a single superordinate category, such as animals, colors, or birds (cf. Romney et al. 1993:28). Note that a semantic domain does not include the superordinate term.

The structure of a semantic domain is defined as the arrangement of the terms relative to each other as represented in some metric system such as Euclidean space and described in terms of a set of interpoint distances. It is assumed that each individual has an internal cognitive representation of the semantic structure of the terms. The meaning of each term is defined by its location relative to all the other terms. We propose to use the idea of culture as shared cognitive representations as a model for this one aspect of culture. It provides us with a fully quantified structure for the measurement of every term relative to every other term. It allows the precise measurement of the overall degree of sharing among the members of a culture as well as the extent to which each individual participates in the common understanding.

We are aware that shared cognitive structures constitute only one small part of the concept of culture as used in the field of anthropology. Such a model, however, can provide powerful leverage for the understanding of cultural sharing as a general phenomena. Although we illustrate the model on the domains of animals and kinship, it is designed to

apply equally well to other semantic domains, many of which are present in all cultures.

DESCRIPTION AND MEASUREMENT OF SEMANTIC STRUCTURES

In this section we summarize the results of a series of research contributions that provide us with the results from fully quantified measurement methods applied to the semantic structures of animals and kinship. The results include graphic displays that offer a clear intuitive understanding of what constitutes a model of the semantic structures.

The choice of domains was the result of several considerations. The semantic domain of animals has appeared in numerous previous studies, including several discussed further on in this article. Studies that have used the domain of animals in published research include Baker and Young 1975, Caramazza et al. 1976, Chan et al. 1993a, Chan et al. 1993b, Cunningham 1978, Friendly 1979, Henley 1969, Howard and Howard 1977, Hutchison and Lockhead 1977, López et al. 1997, Rips 1975, Rips et al. 1973, Romney 1989, Rumelhart and Abrahamson 1973, Sattath and Tversky 1977, Shepard 1974, Shoben 1976, and Smith et al. 1974. Another reason for picking the domain of animals is that the items in the domain are concrete visible entities with clearly defined physical characteristics such as size, shape, color, and so on. Animals were also always present in the environment in which humans evolved so that the evolution of visual mechanisms for their detection and characterization can be assumed. It is clear, for example, what we mean when we say we can image an elephant in “our mind’s eye.”

Figure 1 is from a study (Romney et al. 1995:278) that presents the detailed methods for scaling judged-similarity data for a large number of individuals into a common Euclidean space. It represents a two dimensional representation of the semantic structure of animals. We note that the third and fourth dimensions carry additional information about the structure of the domain but for ease of exposition and graphing we present only two dimensions. The ellipses in Figure 1 are 95% confidence ellipses of the location of the mean position for 125 individuals scaled in the experiment. The center of the ellipse, for each animal, is the best estimate of the cultural definition of the animal name. The whole figure is a representation of a metric space in which animals judged more similar are placed closer to each other than animals judged as less similar. The figure represents a model of the semantic structure of the semantic domain of animals. It is also a representation of the culture and is assumed to reside in some second-order isomorphic form in the brain of an individual as a cognitive representation (as outlined below in the discussion of theory).

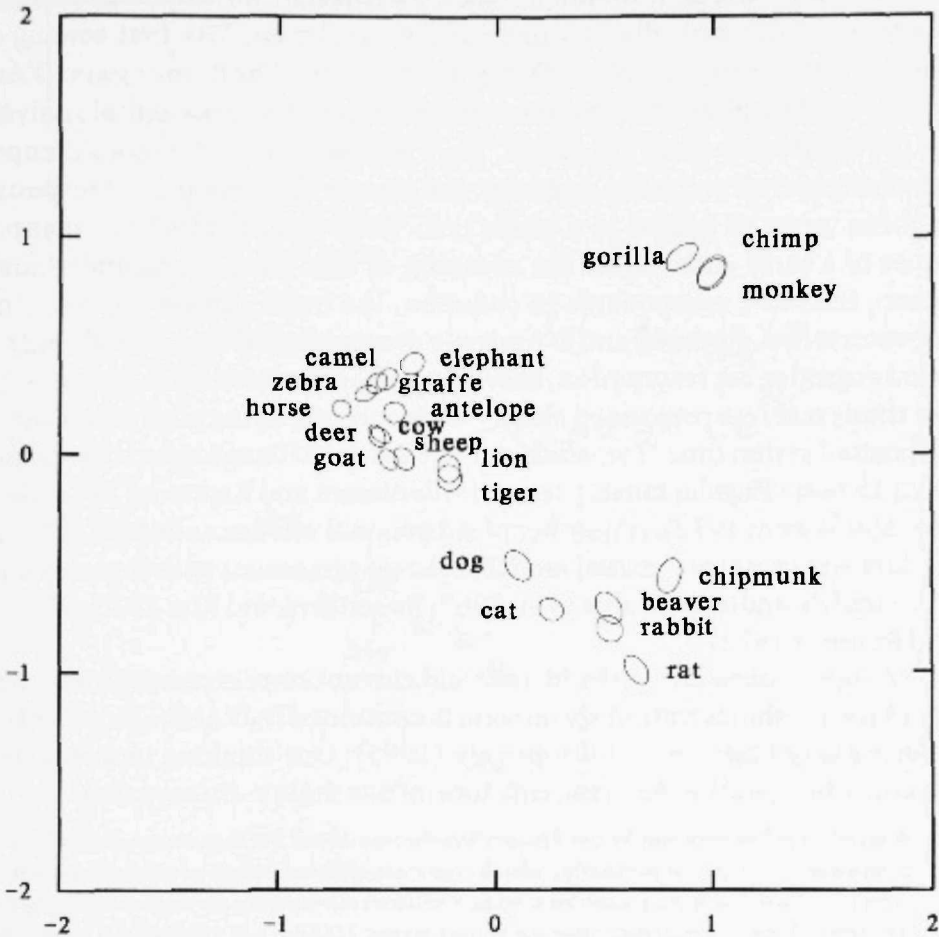


Figure 1. Semantic structure of 21 English animal terms with 95% confidence ellipses of the mean cultural position (adapted from Romney et al. 1995:278).

A similar structure was presented in a study by Brazill et al. (1995), a replication that supports the validity of the findings. These two studies, together with one by Kumbasar, Romney, and Batchelder (1994), established the methods for scaling a large number of individuals into a common picture.

To maximize contrast with animals we wanted an abstract domain. As described in Romney et al.,

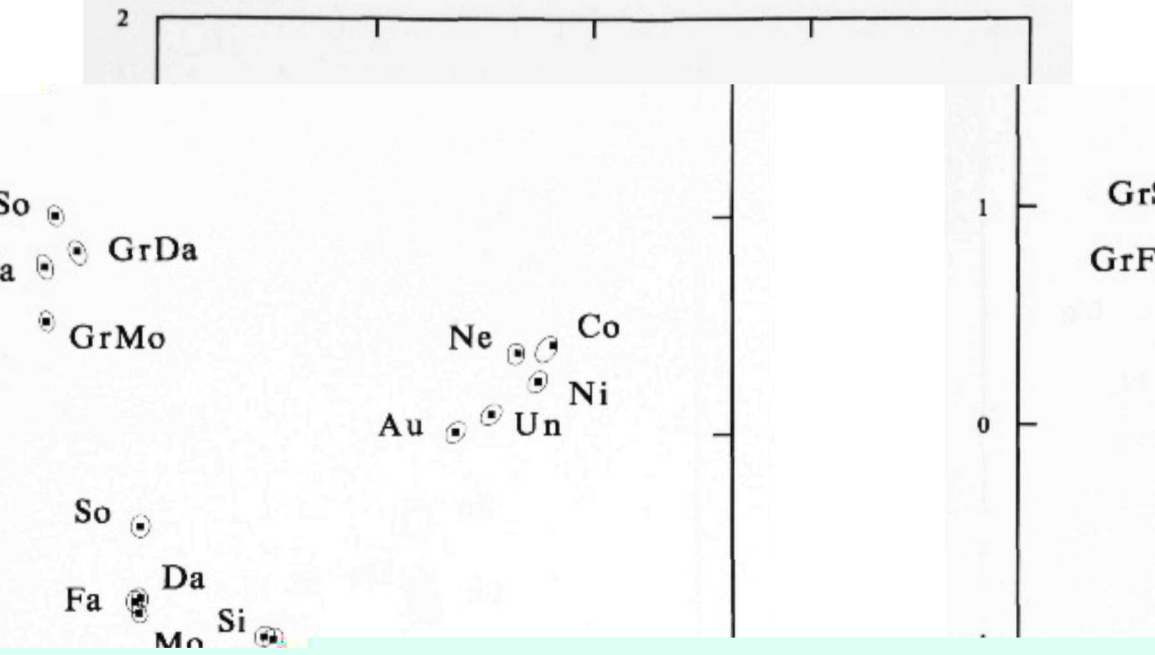
Kinship was chosen as the semantic domain for analysis because it is purely cultural in content. Kin terms are abstract concepts; they cannot be characterized in terms of obvious external physical characteristics or as occupying a single visible location. Kin terms have no "concrete" referents, such as size or color, in the way an animal such as "dog" or "cat" has. Different societies have very different ways of categorizing relatives; the English system is only one of many. For example, in English the categories of "mother" and "mother's sister" are distinguished by separate terms (i.e., mother and aunt) whereas in many societies "mother's sister" is called by the same term as "mother." [1996:4699]

Kinship is one of the domains studied earliest in anthropology and one of the more theoretically and technically developed. The first scaling of kinship terms using judged similarity was performed by Romney and D'Andrade (1964), who related the semantic structure to componential analysis for the eight basic male kin terms. They predicted that the more components any two terms had in common, the greater the similarity of response to these terms as judged in a triads test. They assumed that the components of a term constituted the meaning of that term for an individual; hence, the more components in common, the more similar the meaning between terms. Romney and D'Andrade demonstrated that a single aggregated cognitive representation, based on judged similarities collected with the triads task, corresponded closely with only one of the alternative models posited at that time. Two studies in the early 1970s extended the scaling to all 15 basic English kinship terms (Fillenbaum and Rapoport 1971; Nerlove and Burton 1972). A number of subsequent studies collected similarity data and presented spatial models in basic agreement with Romney and D'Andrade's findings (Arabie et al. 1987; Rosenberg and Kim 1975; Wexler and Romney 1972).

A superb summary of the history and current state of research and theory of the kinship terminology domain is contained in D'Andrade's *The Development of Cognitive Anthropology* (1995). Our thinking incorporates his contributions that form the capstone of our theory. He says that

similarity judgments can be used to test hypotheses about the feature arrangements of a set of terms. Most importantly, where there are different ways of analyzing a set of terms, similarity judgments can be used to decide which analysis corresponds best to the way individuals actually discriminate among terms. [D'Andrade 1995:49–50, emphasis in original]

A recent study (Romney et al. 1996) applies the newly developed methodology on measurement and scaling to the domain of kinship. This study provides strong validation of the results. The authors collected six independent sets of measurements of judged-similarity data from each of 122 individuals. Correspondence analysis was used to represent the data in a single multidimensional spatial representation. A variety of statistical procedures were employed to demonstrate that individuals share similar cognitive representations of the semantic structure of English kinship terms. The model accounted for between 70 and 90 percent of the total variability in the data. Figure 2 (Romney et al. 1996:4702) presents the overall results where the ellipses represent 95% confidence limits on the mean of the 732 (six measures times 122 subjects) scores for each term. That mean is considered the cultural definition of the term and is represented by solid squares. The ellipses give a visual idea of the precision and resolution of the methods.



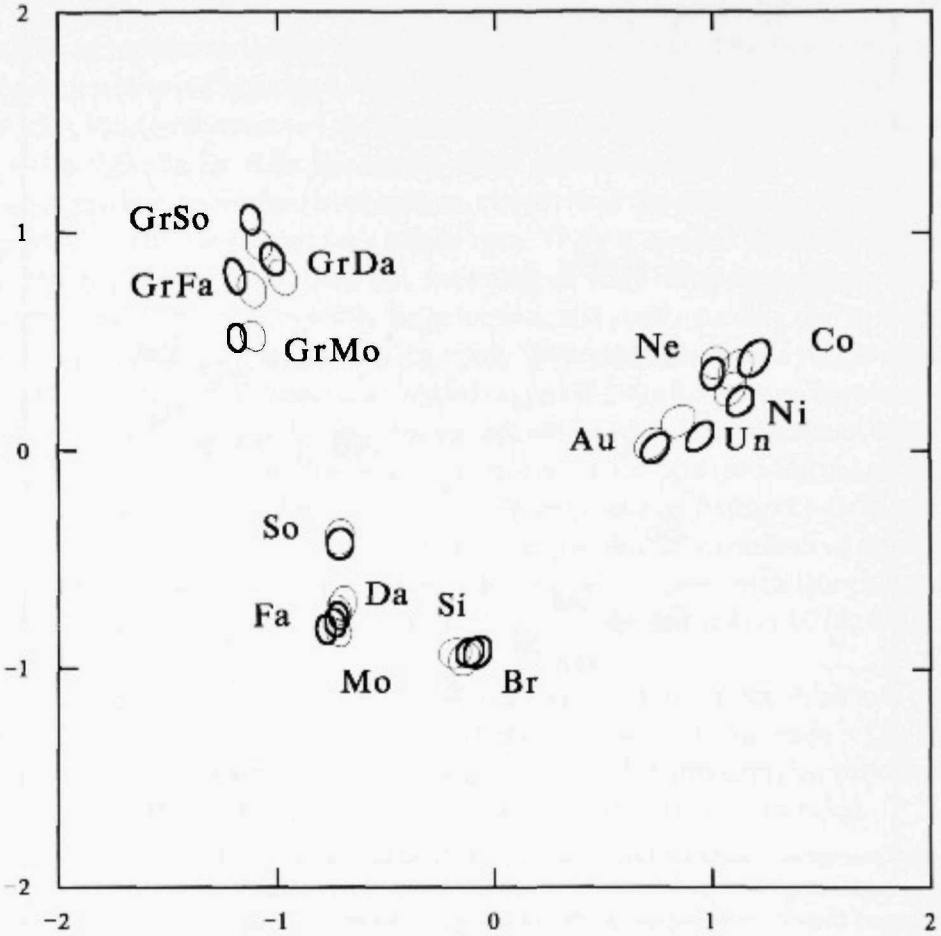


Figure 3. Semantic structure of English kinship terms represented as 95% confidence ellipses of the mean position of each term comparing 64 female subjects (bold outlined ellipses) with 58 male subjects (light outlined ellipses) (adapted from Romney et al. 1996:4702).

In this section we have reviewed the results of applying techniques to measure, with known accuracy, the extent to which “pictures” or cognitive representations in the mind of one person correspond to those in the mind of another person. Our research on various semantic domains such as animals and kinship has demonstrated that typical members of a culture have similar “pictures” in their minds. Further detailed evidence for these assertions may be found in the cited references. We turn now to a theory that helps account for culture as shared cognitive representations and to make predictions about cognitive processes that can be derived from such similarity structures.

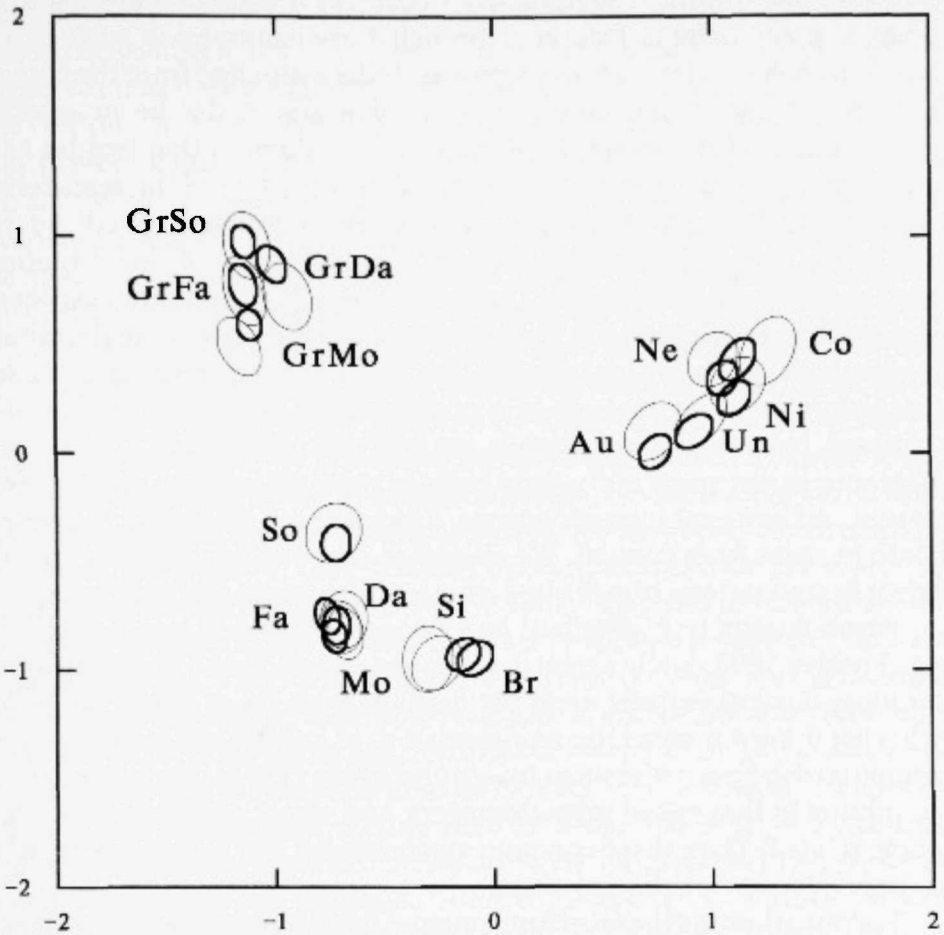


Figure 4. Semantic structure of English kinship terms represented as 95% confidence ellipses of the mean position of each term comparing 43 monolingual English speakers (bold outlined ellipses) with 69 subjects with English as a second language (light outlined ellipses) (adapted from Romney et al. 1996:4702).

THEORY OF CULTURE AS SHARED COGNITIVE REPRESENTATION

The plan for the remainder of this article is, first, to present a theory that relates functional localized cognitive representations in the minds of individuals to an optimally aggregated composite model of culture as the shared aspects of the cognitive representations, and, second, to present some results of tests of predictions derived from the theory. Before turning to the theory we need to make some brief remarks concerning the terminology that we use in this paper.

Semantic domain and *semantic structure* refer to a set of words as defined above and the interrelations among those words as inferred from

judged-similarity tasks. The similarity structure for animals and kinship as displayed graphically in Figures 1 through 4 are examples of such structures. This representation is an empirical model estimated from the data. A *cognitive representation*, on the other hand, is assumed to be an internal representation of the structure of the semantic domain that resides as a functional unit in the mind of an individual. It is the task of the researcher to investigate the degree of correspondence between what is actually in the mind of the individual and the external representation of that structure constructed by the investigator. *Culture* is viewed as the shared aspect of the cognitive representations. In that respect it clearly resides in the minds of individuals. When we, as investigators, talk about the structure of a semantic domain as an example of a small cultural unit, however, our descriptions, both verbal and graphic, are external constructs. Thus we are ambiguous in our usage of the term *culture* since we use it to refer to both internal and external representations. The meaning we intend to convey should be clear from context. We recognize that our descriptions are imperfect first steps toward reflecting what is in the minds of individuals.

Psychologists (e.g., Shepard and Cooper 1982) and neuroscientists (e.g., Kosslyn 1994) know a great deal about perception and mental images. Our ideas depend entirely upon the findings from these fields. We begin with what is known about the representation of a single concrete object as summarized in Kosslyn's recent *Image and Brain* (1994). His fundamental assumption is that visual mental imagery and visual perception are intimately related. They share common mechanisms, and imagery is an integral part of how perception operates.

For our purposes the most fundamental finding from the neuroscience of vision is that many visual areas in the brain are *retinotopically mapped*. This simply means that "the neurons in the cortical area are organized to preserve the structure (roughly) of the retina. These areas represent information depictively in the most literal sense" (Kosslyn 1994:13). This fundamental fact is both dramatic and literal. It means that when an individual looks at an object (for example, a dog) a representation or copy of the image is formed in the brain in which the elements that form the image of the dog on the retina are replicated in a one-to-one fashion in the brain. Thus in the image in the brain the elements that represent an ear and a mouth are closer to each other than to the elements that represent the tail. A literal topographically accurate spatial representation is formed in the brain and can be accessed by memory as an image at a later time. Of course, a great deal of neural processing takes place beyond the retinotopically mapped imaging stage.

Dramatic evidence of the mapping of spatial structure of observed patterns of lights into specific cortical regions in monkeys may be found in an article by Tootell et al. (1982). Their figure 1 is of special interest and deserves

careful study (1982:902). They trained a monkey to stare at the center of a pattern of flashing lights. They then injected the animal with radioactively tagged sugar as it viewed the pattern. The more active a neuron was during this viewing, the more of the radioactively tagged sugar it absorbed. Tootell et al. present an actual photograph of the distribution of the radioactivity in a region of the primary visual cortex of the monkey. The picture shows magnification in the foveal areas of the retina (where visual receptors have the highest density) and some other distortions, but the spatial structure of the physical pattern of lights is clearly evident. Their experiment and photographs demonstrate that the pattern of lights that the monkey was looking at was clearly and literally mapped into the brain tissue of the monkey.

A series of experiments reported by Shepard and Cooper (1982) in *Mental Images and their Transformations* demonstrated that individuals can perform transformations on mental images. Shepard's long series of research established that mental images were not only available in memory but, more importantly, that complex operations could be performed on them. In a typical experiment an individual is shown two intricate three-dimensional geometric figures and is asked to judge whether they are the same or different. The orientation of the two figures varies from the same to a 180-degree difference. When the reaction time to decision is recorded it is found that there is a linear relationship between the size of the difference in orientation and the reaction time for making a same-different judgment. The fact that people require more time for larger rotations of the imaged object demonstrates that individuals are performing mental operations on internal images, in this instance, "mentally rotating" the figures. Several variations on the basic design of the experiment were carried out in order to verify these results. We consider the ability to form mental images to be a consequence of the associative nature of cortical information processing. In practical functional terms it means that there is a mechanism that allows us to view an object, say a dog, and to later recall it to memory and use the mental image to make a comparison: for example, to a dog that we can currently view and make a judgment as to whether it is the same as the one we saw yesterday.

In our theory the internal mental images are considered to be an elementary form of cognitive representation. We say "elementary" because the examples above involve only a small number of objects at a given time. In a typical semantic domain there may be dozens of objects that are included in the total structure. To understand the complexity introduced by this consideration requires a basic understanding of the interrelated psychological concepts of similarity and generalization.

In our theory the concept of "similarity" plays a central role. The structure of a semantic domain is derived from similarity judgments and is therefore a similarity structure in the most literal sense. Our representation

of the structure is a spatial one in which items judged more similar are placed closer to each other than items judged as less similar. In this metric representation there is an assumed identity between closeness in the model and similarity as judged by individuals.

Pinker has the following to say about similarity:

The unavoidable implication is that a sense of “similarity” must be innate. This much is not controversial; it is simple logic. In behaviorist psychology, when a pigeon is rewarded for pecking a key in the presence of a red circle, it pecks more to a red ellipse, or to a pink circle, than it does to a blue square. This “stimulus generalization” happens automatically, without extra training, and it entails an innate “similarity space”; otherwise the animal would generalize to everything or nothing. These subjective spacings of stimuli are necessary for learning, so they cannot all be learned themselves. [Pinker 1994:416–417].

In more technical terms, as well as more directly relevant to our theory, Shepard (1987) has formulated a universal law of generalization for psychological science. Shepard notes that “an internal metric of similarity . . . exists at birth, when habituation of one stimulus already exhibits unequal generalization to different test stimuli” (1987:1317). His abstract of the article contains several elements critical to the development of our theory. We subscribe to it completely.

A psychological space is established for any set of stimuli by determining metric distances between the stimuli such that the probability that a response learned to any stimulus will generalize to any other is an invariant monotonic function of the distance between them. To a good approximation, this probability of generalization (i) decays exponentially with this distance, and (ii) does so in accordance with one of two metrics, depending on the relation between the dimensions along which the stimuli vary. These empirical regularities are mathematically derivable from universal principles of natural kinds and probabilistic geometry that may, through evolutionary internalization, tend to govern the behaviors of all sentient organisms. [Shepard 1987:1317]

Although Shepard applies his theory to all sentient beings he is careful to point out that it strictly applies “only to the highly idealized experiment in which generalization is tested immediately after a single learning trial with a novel stimulus” (1987:1322). Our theory applies his ideas to a very limited aspect of culture and cognitive representations, namely, to the similarity structure of semantic domains. Consider, for example, a rephrasing of the first sentence of his abstract, with reference to Figure 1 as a metric representation of the structure among 21 animals. An Euclidean spatial representation (a psychological space) is obtained (established) for the semantic domain of 21 animals (any set of stimuli) by scaling judged-similarity data from triadic comparisons (by determining metric distances) among animals (the stimuli) such that the probability that an association (a response learned) from any animal (any stimulus) to any other animal (generalization) will be an invariant monotonic function of the distance between them.² This is precisely equivalent to the theory in the study by Romney, Brewer, and Batchelder (1993) reported in the next section.

There is strong evidence to suggest that the set of words in a semantic domain may be localized functional units in the brain. The evidence for physiologically localized semantic domains comes from research that suggests that deficits in aphasic patients tend to involve selective loss of entire homogeneous domains. Neuropsychological studies that find aphasic patients with selective impairment or preservation of specific semantic categories such as fish, vegetables, or animals include Goodglass and Budin 1988, Goodglass et al. 1986, Hart et al. 1985, McCarthy and Warrington 1988, Sartori and Job 1988, Silveri and Gainotti 1988, Warrington and McCarthy 1987, and Warrington and Shallice 1984.

These studies imply that homogeneous semantic domains may be localized functional units in the brain since selective impairment or preservation corresponds to semantic domains. For example, Hart, Berndt, and Caramazza (1985) report on a 34-year-old, right-handed male college graduate patient who suffered from a left-hemisphere cerebrovascular accident who was tested on his ability to name and categorize pictures of fruits, vegetables, vehicles, toys, tools, animals, body parts, clothing, colors, trees, and so on. His ability was almost perfect for all domains except for fruits and vegetables where his performance for naming and categorizing was severely impaired. In the Goodglass and Budin 1988 study the deficit was for body parts, colors, numbers, and letters with “excellent comprehension” for all other word categories.

It is clear that each item (concept, word) in a concrete semantic domain is represented by an internal depictive mental image, as described in Kosslyn 1994, that in our theory is considered an elementary cognitive representation. *Elementary* is used to signal a difference from a cognitive representation of the total structure of a semantic domain that includes all items or words that make up that domain. Tootell et al.’s experiment proved that these cognitive representations can be quite literal in form. Shepard (1975) and Shepard and Chipman (1970), who did their work years earlier than Tootell et al., developed the idea of second-order isomorphism for the relation between the object and its internal representation. Shepard allows for differences in the exact nature of this second-order isomorphism for different domains such as color and shape (1975:91). The major conclusion of this body of research is that individuals form internal representations that allow one to operate on the internal image in ways that are equivalent to the way one can operate on a direct perception.

Thus, when one visits a zoo one sees animals like elephants, gorillas, monkeys, and so on and is able to make judgments about the similarity among these animals. For example, it is obvious to any human that a monkey is more similar to a gorilla than either is to an elephant. The importance of Shepard’s work is that it demonstrates that “judgments of similarity among objects are essentially the same whether the objects are actually

presented or only named” (Shepard 1975:96). Individuals can recall an image and perform mental operations on that image in the same way that they can perform mental operations on the perceptual image when the object is actually present. This finding is supported by evidence that “judgments of similarity are explainable in terms of identifiable properties of the objects judged (whether or not those objects were actually presented)” (Shepard 1975:97). This is simply another way of saying that they operate on the same basis (features) on the internal cognitive representation as they operate on in the presence of the object itself.

In a masterful and comprehensive treatment of the concrete semantic domains encompassed by ethnobiology, Berlin has made a careful study of contrastive categories and their semantic dimensions of contrast. He says that

Analysis of many distinct systems reveals that the most common semantic dimensions comprise a small number of perceptually based parameters. The most commonly found include color, relative size, shape, habitat, habit (of growth), taste, “sex,” smell, [etc.]. . . . One cannot escape the observation that most of these dimensions correspond to some of the most readily and immediately apprehended sense impressions that human beings have as they interact with the physical and natural world. [Berlin 1992:106–107].

The previous discussion has been limited to describing how individuals form internal representations of one or a few concrete objects at a time. These internal representations can be retrieved from memory, manipulated, and compared. The experimental foundations for these assertions appear to be fairly well established. The answer we give to two further questions in our theory are much more tenuous and speculative. The two questions are: first, how are cognitive representations of total semantic structures, as appear in Figures 1 and 2, related to the elementary images discussed above, and second, how are cognitive representations of abstract domains related to the cognitive representations of concrete domains? We cannot know the detailed processes involved in either case although we think the general outlines are clear.

The cognitive representations of the total structure of semantic domains are probably derived by generalization from the representations of elementary representations. In a concrete domain like animals, for example, an overall cognitive representation of all the animals is formed of smaller elements consisting of the images of the individual animals. There should be a second-order isomorphism between something like Figure 1 and the cognitive representation of the similarity structure in the mind. In the association experiments reported in the next section it is clear that the strengths of association from one animal to another vary greatly and that the variation is strongly related to similarity. It would be expected that the similarity structure should be represented in the brain with more neurons coactive between highly similar pairs of animals, for example, than with less similar pairs of animals. This suggests that there is a possibility that the similarity structure may also have a spatial representational aspect in the

brain where the more similar animals are closer together than less similar animals. At the least, as the experiments in the next section show, there should be a second-order isomorphism between the internal cognitive representation of the structure of semantic domains and our aggregated scaled representation of the similarity structure.

The final question concerns the relationship between cognitive representations of concrete and abstract semantic domains. Animals are concrete objects that occupy space and have strong inherent features that can be apprehended with our primary sensory apparatus. When we recall a specific animal we can image it in a very direct and physical way as discussed above. In a similar manner the similarity relationships among animals can be mapped into Euclidean space in an obvious and intuitively convincing manner. Our theory was developed with such natural categories as examples of our ideal type of domain. We argue that the evolution of the perceptual and cognitive abilities to manipulate the images of concrete semantic domains like plants and animals were evolved earlier as compared to more abstract domains like kinship. Moreover, since all humans share the same perceptual and cognitive mechanisms, they would share similar cognitive representations of the animal domain (assuming they were acquainted with the animals). This would be true since the animals would present the same inherent physical characteristics (Berlin 1992:106–107) to all humans (and other higher organisms as well). It follows that the structure of the animal domain would be the same regardless of language spoken (López et al. 1997). It is highly likely that humans and other higher animals would share the same similarity structure of the animal domain. This hypothesis is testable and could be subjected to experiment in the field or laboratory without too much difficulty.

The situation with more abstract domains such as kinship is very different. In this domain the semantic structure would be expected to be different in different languages. Furthermore, we would not expect to be able to elicit such semantic structures from nonhuman animals. The difference, we think, is related to the existence of language. Language makes possible, indeed is dependent on, abstract distinctions among categories as well as abstract categories. Distinctions such as lineal collateral and cross parallel have no physical embodiment and must be socially transmitted and inculcated. Distinctions can be made among categories of kinship that have no concrete loci but are distinguished purely on the basis of abstract components or features as described in our discussion of kinship earlier. It is our view that such abstract domains are modeled on and generalized from concrete semantic structures. Similarities among kin terms are judged in terms of abstract features or components derived from language rather than on immediately apprehendable physical features as in the case of animals. Because of this critical difference we would expect to observe

the different semantic structures of kinship in widely divergent linguistic areas of the world that we do.

We are not claiming that the structure of all semantic domains has to be either concrete or abstract. Nor do we want to deny that there may be other ways of characterizing differences within and among semantic domains than those used in this article. Berlin (1992), for example, has found it very productive to characterize ethnobiological semantic structures in terms of taxonomic hierarchy classifications. We also realize that many complexities will arise as our knowledge advances. One mentioned by Berlin is that a set of plants and animals may be characterized in terms of two distinct systems of classification at the same time: for example, “the classification of food, which cuts squarely across a second morphologically based general purpose classification of plants and animals” (1992:186).

We find it useful to distinguish concrete from abstract domains since we assume that the neural mechanisms for concrete domains evolved prior to those for more abstract domains. Those mechanisms were then adaptively modified to apply to abstract domains in which abstract distinctions were developed to be used in place of more immediately apprehendable physical and concrete features. We would also argue that the “inculcation” of culture (both vertically and horizontally) involves a social process whereby attention is (implicitly or explicitly) directed to the abstract features. More evidence is needed to establish the validity of the theory.

PREDICTION OF COGNITIVE BEHAVIOR

In this section we mention several experiments that relate to the theory. One recent experiment is given more detailed treatment in the following paragraphs. Each of the experiments draws on some predictions from similarity structures about the outcome of cognitive tasks that involve cognitive processes other than similarity judgments. Aggregate scaled spatial models of domains like those illustrated in Figures 1 and 2 for animals and kinship are known to relate to a number of cognitive functions. For example, distances in such models have been shown to predict categorical judgment time (Caramazza et al. 1976; Rips et al. 1973; Shoben 1976), completion of analogies (Rips et al. 1973; Rumelhart and Abrahamson 1973), and reaction time to solve triadic comparisons (Hutchison and Lockhead 1977; Romney 1989). As Nosofsky says, “The beauty of deriving a similarity-scaling representation by modeling performance in a given task is that the derived representation can then be used to predict performance in independent tasks involving the same objects and stimulus conditions” (1992:26).

The experiment that most closely follows from the theory described above is a recent one on clustering in free recall of items from a judged-

similarity triads task (Romney et al. 1993). In the experiment a triads task was administered. “Immediately after the triads tests were completed and collected from the subjects, and without previous warning, the subjects were asked to recall, in writing, as many of the items appearing on the triads test as possible within 75 s” (1993:28–29). Data were collected from 17 different semantic domains and the similarity data for each were scaled into an Euclidean representation like that for animals in Figure 1. The key assumption of the study was that recall of adjacent items was based on the association between those items as a function of the similarity of those items defined by proximity in a multidimensional space. A formal model was constructed in which clustering between two items in recall was a function of their semantic similarity measured as the simple inverse of distance.

In terms of our earlier discussion this simply means that if an individual were asked to remember the animals scaled in Figure 1, there would be a strong tendency for adjacent items in the recalled list to be “close” to each other in the picture rather than “distant.” The results reported in this experiment are very robust and are consistent in all 17 semantic domains investigated. In terms of the theory the results support the notion that there is some coherent internal mental representation of the total semantic structure available to an individual “all at once” (as a totality) to associate successive items in recall.

DISCUSSION

The extent to which individuals agree on the similarity configuration among animals and kin terms as represented in Figures 1 and 2 is quite remarkable. The methods that make possible the measurement and presentation of such agreement are also remarkable. Such findings would have been entirely unimaginable fifty years ago. Neither the scaling methods nor the computers required to apply them existed. Advances in scientific knowledge have been developed at an exponentially increasing rate during this time. The evolution of cultural knowledge, including all of scientific knowledge, is completely dependent upon the sharing of linguistic meanings. The learning of these shared meanings by individuals as members of human groups is a highly selected-for-human-survival skill transmitted from generation to generation (cf. Deacon 1997). Our views on this are consistent with the developments in the field of evolutionary psychology (Barkow et al. 1992) and other recent literature on human cognitive evolution (e.g., Donald 1991, 1993; Plotkin 1994). We also believe that human knowledge evolves through a process of natural selection as described by Campbell who argues that “a blind-variation-and-selective-retention process is fundamental to all inductive achievements, to all genuine increases in knowledge” (1974:421), including science.

A large part of our motivation to measure the agreement on kin terms displayed in Figure 2 was to present a visualization of the reality of a semantic structure as a step toward the “demystification” of culture. We think our findings support the philosophical ideas of Searle in his outline of some rough guidelines to the rediscovery of the mind.

First, we ought to stop saying things that are obviously false. The serious acceptance of this maxim might revolutionize the study of mind. Second, we ought to keep reminding ourselves of what we know for sure. . . . Third, we ought to keep asking ourselves what actual facts in the world are supposed to correspond to the claims we make about the mind. It does not matter whether “true” means corresponds to the facts, because “corresponds to the facts” does mean corresponds to the facts, and any discipline that aims to describe how the world is aims for this correspondence. . . .

A fourth and final guideline is that we need to rediscover the social character of the mind. [Searle 1992:247–248]

We think we know for sure that individuals who speak English and live in the United States share the same cognitive representations of the kinship domain. The concept of culture as shared cognitive representations helps reveal the social character of the human mind.

Our distinction between the nature of the domain of animals and the domain of kinship is fundamental. Both representations are equally “real” even though that of animals is concrete and universal among all humans as well as other organisms while that of kinship is abstract, restricted to humans, dependent on language, and varies from one area of the world to another. These ideas closely parallel the arguments of Searle’s discussion of the construction of social reality.

To the “transcendental argument” of the previous section—a public language presupposes a public world—we add a “transcendental argument” in this section—a socially constructed reality presupposes a nonsocially constructed reality. . . . It is a logical consequence of the main argument of the book that you cannot have institutional facts without brute facts. [Searle 1995:191]

In our development of the theory we claimed that abstract categories such as kinship terms were compared in terms of abstract features or components. The components were developed from the analogy of comparisons among concrete categories like animals that have concrete physical characteristics. In Searle’s terms kinship concepts are institutional facts that depend on shared understandings and language while animal categories are brute facts because animals existed prior to and independent of humans. On “our normal understanding, statements about money require the existence of representations as part of their conditions of normal intelligibility. Statements about mountains are entirely free of any such requirement. . . . Money is understood as socially constructed; mountains are not understood as socially constructed” (Searle 1995:194). Kinship terms are socially constructed; animals are not.

Our theory and findings have obvious research implications relevant to a variety of fields. We think that comparative research would show that the structure of most domains of a natural “brute force” sort are universal among humans. The search for universals in anthropology is important and the semantic structure of natural object domains should be added to the kinds of universals discussed in *Human Universals* by Brown (1991). We expect the semantic structure of the domain of animals to be universal (assuming, of course, familiarity with the animals by the individuals being investigated). An important study has already demonstrated remarkable similarity among the people of six countries (Spain, Vietnam, Hong Kong, Haiti, Greece, and United States) for the domains of animals and emotions (Herrmann and Raybeck 1981).³ Emotion terms would be a strategic domain to study further because of its relation to the findings on facial expression by Ekman. (See, e.g., 1992a, 1992b, 1992c, 1993, although note that Ekman’s findings are questioned by Russell 1994.) Emotion terms have also been shown to be related to color in terms of synesthesia in an elegant study by D’Andrade and Egan (1974). They demonstrated that color chips and emotion terms show very similar patterns of association in Tzeltal-speaking adults and English-speaking college students.

The most impressive demonstration of a universal semantic structure to date is contained in the classic study of color terminology by Berlin and Kay (1991). Their figure 3 (1991:9) shows the normalized foci of basic color terms in 20 languages and reveals that the agreement among languages is comparable to the agreement among individuals concerning animals and kinship that we find in our study. They also found “that there appears to be a fixed sequence of evolutionary stages through which a language must pass as its basic color vocabulary increases” (Berlin and Kay 1991:14). Numerous studies have validated the major thrust of the Berlin and Kay contributions. (For a summary see Durham 1991:218.)

The methods we have presented lend themselves to testing in any situation that requires the comparison of individuals or groups including the multiple testing of a single individual. One area that should be fruitful for future investigation is that of bilingualism. In this case a bilingual person could be tested in both languages and the resulting structures compared. Further comparisons could be made with the performance of monolingual individuals in each of the relevant languages.

Probably the most exciting area for new research is to uncover the actual location of various semantic domains (if such exist) in the brain. Recent advances in brain-imaging technology, including both positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), make possible a variety of new studies in locating various semantic lexicons as well as related functions. Cognitive anthropologists can be informed by as well as make significant contributions to these studies. An

example of a recent study utilizing PET to study bilingual word generation found “no evidence to support the hypothesis that a language learned later in life is represented differently from the native language, nor . . . differences in the neural substrates that subservise within- and across-language searches” (Klein et al. 1995:2903).

In another PET study Martin et al. (1996) found differences in associations to the naming of animals and tools. Naming animals showed more activity in the visual areas of the brain while naming tools showed more activity in the motor areas. We would hypothesize that the location of the semantic content of the domain of animals and the domain of kinship should be in slightly different loci in the brain. Note that we are predicting something different than Martin et al. found. We can assume from what they found that animals would evoke more activity in the visual area than would kinship. We are predicting that when it becomes possible to pinpoint the semantic areas of animals and kinship (something the Martin et al. study did not do) that they should occupy detectably different locations.

As to measurement, we have presented a quantified model of culture as shared cognitive structures. We argue that every normal member of a culture shares similar cognitive structures for common semantic domains, even abstract ones like kinship terms. These shared cultural structures may be localized functional units in the brains of informants. The validity of our measurements of the shared semantic structure is demonstrated by successful predictions of important cognitive behaviors including categorical judgment time, completion of analogies, reaction time to solve triadic comparisons, and clustering in memory. These structures are fairly “easy” to learn as evidenced by the performance of linguistically diverse samples.

The degree of sharing is remarkable; one can confidently assume that every individual shares the same structure. One implication of this is that researchers can prudently use cultural definitions of cognitive representations in applications predicting individual cognitive behavior. It is of interest to note that, due to statistical aggregation considerations, the cultural definition of semantic structure is a better estimate of “what is in the mind of the individual” than an estimate based on the subject’s own responses.

This article has constructed a self-conscious model of culture as shared cognitive representations of cognitive structures. The model is accompanied (in this essay and in more detail in the sources referred to) by specifications on how to measure and display such structures. This model is scientifically productive in the sense that it generates numerous testable predictions about human behavior in performing various cognitive tasks. We intend our model to be taken as universally applicable to all human beings and to all semantic domains, abstract as well as concrete. It is meant to

approximate what is in the mind of individuals in some important aspects, even though we recognize that it is, like all scientific models, necessarily a simplification.

NOTES

Acknowledgments. The research was supported, in part, by a National Science Foundation grant no. SES-9210009 made to A. K. Romney and W. H. Batchelder.

1. A preliminary version of this article was given at the fourth biennial meeting of the Society for Psychological Anthropology in San Juan, Puerto Rico on October 7, 1995, in a session organized and chaired by Roy G. D'Andrade entitled "Bioculture: A Paradigm in the Making."

2. Recent studies on the categorization and representation of phonetic information illustrate in an elegant way some of the details of category formation and generalization from prototypic sounds that are relevant to Shepard's ideas. See, for example, Iverson and Kuhl 1995 and Kuhl 1991.

3. One anonymous reviewer commented, "A great deal of relativism is likely to fall in the cracks between object images, concept and word images, and images of whole semantic structures. The theory should, at least, be tested in cross-cultural comparisons with a sample of non-Indo-European cultures." Since that comment was received still another such study has appeared (Romney et al. 1997). The research investigated the semantic structure of 15 emotion terms as measured by judged-similarity tasks for English speakers in the United States and Japanese speakers in Japan (with tasks administered in Japanese characters). The major finding was that English-speaking and Japanese-speaking subjects shared similar models of the semantic structure of emotion terms (66%). The incremental contribution of two culture-specific models, one based on an English norm and one based on a Japanese norm, accounts for relatively little of the total variance (6%). These results are consistent with the theory presented in this article.

REFERENCES CITED

- Arabie, Phipps, J. Douglas Carroll, and Wayne S. DeSarbo
1987 Three-Way Scaling and Clustering. Newbury Park, CA: Sage.
- Baker, Robert F., and Forrest W. Young
1975 A Note on an Empirical Evaluation of the Isis Procedure. *Psychometrika* 40:413-415.
- Barkow, Jerome H., Leda Cosmides, and John Tooby
1992 *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*. New York: Oxford University Press.
- Berlin, Brent
1992 *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies*. Princeton, NJ: Princeton University Press.
- Berlin, Brent, and Paul Kay
1991[1969] *Basic Color Terms: Their Universality and Evolution*. Berkeley and Los Angeles: University of California Press.
- Brazill, Timothy J., A. Kimball Romney, and William H. Batchelder
1995 A Comparison of Methods for Collecting Judged Similarities among Items in a Semantic Domain. *Journal of Quantitative Anthropology* 5:359-374.
- Brown, Donald E.
1991 *Human Universals*. New York: McGraw-Hill, Inc.

Campbell, Donald

1974 Evolutionary Epistemology. *In* *The Philosophy of Karl Popper*. P. A. Schilpp, ed. Pp. 413–463. LaSalle, IL: Open Court Press.

Caramazza, Alfonso, Harry Hersh, and Warren S. Torgerson

1976 Subjective Structures and Operations in Semantic Memory. *Journal of Verbal Learning and Verbal Behavior* 15:103–117.

Chan, Agnes S., Nelson Butters, Jane S. Paulsen, David P. Salmon, Michael R. Swenson, and Laurence T. Maloney

1993a An Assessment of the Semantic Network in Patients with Alzheimer's Disease. *Journal of Cognitive Neuroscience* 5:254–261.

Chan, Agnes S., Nelson Butters, David P. Salmon, and Kathryn A. McGuire

1993b Dimensionality and Clustering in the Semantic Network of Patients with Alzheimer's Disease. *Psychology and Aging* 8:411–419.

Cunningham, James P.

1978 Free Trees and Bidirectional Trees as Representations of Psychological Distance. *Journal of Mathematical Psychology* 17:165–188.

D'Andrade, Roy G.

1995 *The Development of Cognitive Anthropology*. Cambridge and New York: Cambridge University Press.

D'Andrade, Roy G., and Michael Egan

1974 The Color of Emotion. *American Ethnologist* 1:49–63.

Deacon, Terrence W.

1997 *The Symbolic Species*. New York: Norton.

Donald, Merlin

1991 *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*. Cambridge, MA: Harvard University Press.

1993 *Precis of Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*. *Behavioral and Brain Sciences* 16:737–791.

Durham, William H.

1991 *Coevolution: Genes, Culture, and Human Diversity*. Stanford: Stanford University Press.

Ekman, Paul

1992a Facial Expressions of Emotion: New Findings, New Questions. *Psychological Science* 3:34–38.

1992b Are There Basic Emotions? *Psychological Review* 99:550–553.

1992c An Argument for Basic Emotions. *Cognition and Emotion* 6:169–200.

1993 Facial Expression and Emotion. *American Psychologist* 48:384–392.

Fillenbaum, Samuel, and Amnon Rapoport

1971 *Structures in the Subjective Lexicon*. New York: Academic.

Friendly, Michael

1979 Methods for Finding Graphic Representations of Associative Memory Structures. *In* *Memory Organization and Structure*. C. R. Puff, ed. Pp. 85–129. New York: Academic Press.

Goodglass, Harold, and Clay Budin

1988 Category and Modality Specific Dissociations in Word Comprehension and Concurrent Phonological Dyslexia. *Neuropsychologia* 26:67–78.

Goodglass, Harold, Arthur Wingfield, Mary R. Hyde, and Jean C. Theurkauf

1986 Category Specific Dissociations in Naming and Recognition by Aphasic Patients. *Cortex* 22:87–102.

Hart, John, Jr., Rita Sloan Berndt, and Alfonso Caramazza

1985 Category-Specific Naming Deficit Following Cerebral Infarction. *Nature* 316:439–440.

Henley, Nancy M.

1969 A Psychological Study of the Semantics of Animal Terms. *Journal of Verbal Learning and Verbal Behavior* 8:176–184.

- Herrmann, Douglas J., and Douglas Raybeck
1981 Similarities and Differences in Meaning in Six Cultures. *Journal of Cross-Cultural Psychology* 12:194–206.
- Howard, Darlene V., and James H. Howard
1977 A Multidimensional Scaling Analysis of the Development of Animal Names. *Developmental Psychology* 13:108–113.
- Hutchison, J. Wesley, and Gregory R. Lockhead
1977 Similarity as Distance: A Structural Principle for Semantic Memory. *Journal of Experimental Psychology: Human Learning and Memory* 3(6):660–678.
- Iverson, Paul, and Patricia K. Kuhl
1995 Mapping the Perceptual Magnet Effect for Speech Using Signal Detection Theory and Multidimensional Scaling. *Journal of the Acoustical Society of America* 97:553–562.
- Klein, Denise, Brenda Milner, Robert J. Zatorre, Ernst Meyer, and Alan C. Evans
1995 The Neural Substrates Underlying Word Generation: A Bilingual Functional-Imaging Study. *Proceedings of the National Academy of Sciences* 92:2899–2903.
- Kosslyn, Stephen M.
1994 *Image and Brain: The Resolution of the Imagery Debate*. Cambridge, MA: MIT Press.
- Kuhl, Patricia K.
1991 Human Adults and Human Infants Show a “Perceptual Magnet Effect” for the Prototypes of Speech Categories, Monkeys Do Not. *Perception and Psychophysics* 50:93–107.
- Kumbasar, Ece, A. Kimball Romney, and William H. Batchelder
1994 Systematic Biases in Social Perception. *American Journal of Sociology* 100:477–505.
- López, Alejandro, Scott Atran, John D. Coley, Douglas L. Medin, and Edward E. Smith
1997 The Tree of Life: Universal and Cultural Features of Folkbiological Taxonomies and Inductions. *Cognitive Psychology* 32:251–295.
- McCarthy, Rosaleen A., and Elizabeth K. Warrington
1988 Evidence for Modality-Specific Meaning Systems in the Brain. *Nature* 334:428–430.
- Martin, Alan, Cheri L. Wiggs, Leslia G. Ungerleider, and James V. Haxby
1996 Neural Correlates of Category-Specific Knowledge. *Nature* 379:649–652.
- Nerlove, Sara B., and Michael L. Burton
1972 A Further Examination of Cognitive Aspects of English Kin Terms. *American Anthropologist* 74:1249–1253.
- Nosofsky, Robert M.
1992 Similarity Scaling and Cognitive Process Models. *Annual Review of Psychology* 43:25–53.
- Pinker, Steven
1994 *The Language Instinct*. New York: William Morrow.
- Plotkin, Henry
1994 *Darwin Machines and the Nature of Knowledge*. Cambridge, MA: Harvard University Press.
- Rips, Lance J.
1975 Inductive Judgments about Natural Categories. *Journal of Verbal Learning and Verbal Behavior* 14:665–681.
- Rips, Lance J., Edward J. Shoben, and Edward E. Smith
1973 Semantic Distance and the Verification of Semantic Relations. *Journal of Verbal Learning and Verbal Behavior* 12:1–20.
- Romney, A. Kimball
1989 Quantitative Models, Science and Cumulative Knowledge. *Journal of Quantitative Anthropology* 1:153–223.

- Romney, A. Kimball, William H. Batchelder, and Timothy Brazill
1995 Scaling Semantic Domains. *In Geometric Representations of Perceptual Phenomena: Papers in Honor of Tarow Indow's 70th Birthday*. R. D. Luce et al., eds. Pp. 267–294. Mahwah, NJ: Lawrence Erlbaum.
- Romney, A. Kimball, John P. Boyd, Carmella C. Moore, William H. Batchelder, and Timothy J. Brazill
1996 Culture as Shared Cognitive Representations. *Proceedings of the National Academy of Sciences* 93:4699–4705.
- Romney, A. Kimball, Devon D. Brewer, and William H. Batchelder
1993 Predicting Clustering from Semantic Structure. *Psychological Science* 4:28–34.
- Romney, A. Kimball, and Roy G. D'Andrade
1964 Cognitive Aspects of English Kinship. *American Anthropologist* 66:146–170.
- Romney, A. Kimball, Carmella C. Moore, and Timothy J. Brazill
1998 Correspondence Analysis as a Multidimensional Scaling Technique for Non-frequency Similarity Matrices. *In Visualization of Categorical Data*. J. Blasius and M. J. Greenacre, eds. Pp. 329–345. New York: Academic Press.
- Romney, A. Kimball, Carmella C. Moore, and Craig D. Rusch
1997 Cultural Universals: Measuring the Semantic Structure of Emotion Terms in English and Japanese. *Proceedings of the National Academy of Sciences* 94:5489–5494.
- Rosenberg, Seymour, and Moonja Park Kim
1975 The Method of Sorting as a Data-Gathering Procedure in Multivariate Research. *Multivariate Behavioral Research* 10:489–502.
- Rumelhart, David L., and Adele A. Abrahamson
1973 Toward a Theory of Analogical Reasoning. *Cognitive Psychology* 5:1–28.
- Russell, James A.
1994 Is there Universal Recognition of Emotion from Facial Expression? A Review of the Cross-Cultural Studies. *Psychological Bulletin* 115:102–141.
- Sartori, Guuseppe, and Remo Job
1988 The Oyster with Four Legs: A Neuropsychological Study on the Interaction of Visual and Semantic Information. *Cognitive Neuropsychology* 5:105–132.
- Sattath, Samuel, and Amos Tversky
1977 Additive Similarity Trees. *Psychometrika* 42:319–345.
- Searle, John R.
1992 *The Rediscovery of the Mind*. Cambridge, MA: MIT Press.
1995 *The Construction of Social Reality*. New York: The Free Press.
- Shepard, Roger N.
1974 Representation of Structure in Similarity Data: Problems and Prospects. *Psychometrika* 39:373–421.
1975 Form, Formation, and Transformation of Internal Representations. *In Information Processing and Cognition*. R. L. Solso, ed. Pp. 87–122. The Layola Symposium. New York: Erlbaum.
1987 Toward a Universal Law of Generalization for Psychological Science. *Science* 237:1317–1323.
- Shepard, Roger N., and Susan Chipman
1970 Second-Order Isomorphism of Internal Representations: Shapes of States. *Cognitive Psychology* 1:1–17.
- Shepard, Roger N., and Lynn A. Cooper
1982 *Mental Images and Their Transformations*. Cambridge, MA: MIT Press.
- Shoben, Edward J.
1976 The Verification of Semantic Relations in a Same-Different Paradigm: An Asymmetry in Semantic Memory. *Journal of Verbal Learning and Verbal Behavior* 15:365–379.

Silveri, Maria C., and Guido Gainotti

1988 Interaction between Vision and Language in Category-Specific Semantic Impairment. *Cognitive Neuropsychology* 5:677-709.

Smith, Edward E., Edward J. Shoben, and Lance J. Rips

1974 Structure and Process in Semantic Memory: A Featural Model for Semantic Decisions. *Psychological Review* 81:214-241.

Tootell, Roger B. H., Martin S. Silverman, Eugene Switkes, and Russell L. De Valois

1982 Deoxyglucose Analysis of Retinotopic Organization in Primate Striate Cortex. *Science* 218:902-904.

Warrington, Elizabeth K., and Rosaleen A. McCarthy

1983 Category Specific Access Aphasia. *Brain* 106:859-878.

1987 Categories of Knowledge: Further Fractionations and an Attempted Integration. *Brain* 110:1273-1296.

Warrington, Elizabeth K., and Tim Shallice

1984 Category Specific Semantic Impairments. *Brain* 107:829-854.

Wexler, Kenneth N., and A. Kimball Romney

1972 Individual Variations in Cognitive Structure. *In* *Multidimensional Scaling: Theory and Applications in the Behavioral Sciences*, vol. 2. A. K. Romney, R. N. Shepard, and S. B. Nerlove, eds. Pp. 73-92. New York: Seminar Press.