Ethnoecology: The Relevance of Cognitive Anthropology for Human Ecology

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Anthropologists have defined culture variously in their pursuit of diverse theoretical goals. Keesing (1974) distinguishes two fundamentally distinct perspectives on the study of culture, the adaptational (or materialist) and the ideational. Examples of the first approach include cultural ecology and cultural materialism. They are characterized by a focus on the adaptive value of culturally patterned behaviors. In cultural materialism "culture" reduces to learned behaviors (Harris 1979). Ideational theories define cultures as semiotic systems. The relations between such systems of signs and the realities of behavioral adaptation is of only peripheral interest. Keesing contrasts ideational theories associated with Lévi-Strauss, Geertz, Schneider, and Goodenough, the last of which is cognitive anthropology, the guiding perspective of this reading.

Keesing, as an ideational theorist, like Harris on the materialist side, reflects the widely held view that adaptational and ideational perspectives are fundamentally incompatible. I would like to argue to the contrary—that our best hope of developing an effective theory of culture is to bridge the chasm separating adaptationist and ideational positions. The synthesis I propose here may be called "ethnoecology" (but not as described by Fowler 1977). This synthesis should combine the strengths of modern ecological anthropology with those of cognitive-semiotic anthropology while avoiding the weaknesses of both.

The strength of the adaptational approach is its recognition that human behavior both affects and is affected by a complex environment, the social and ecosystems of which humans are but one part. This strength becomes a weakness if it is not clearly recognized that social and ecosystems are composed of individual organisms, each of which is pursuing its own "selfish" plans (Dawkins 1976). The functionalist fallacy results from attributing goal direction to systems rather than to individual actors (Richerson 1977). This problem is avoided by more recent models based on evolutionary ecology, in which adaptation is interpreted in terms of the effect traits have on the individuals who express them, rather than the effect such traits might have on the encompassing system *qua* organism (Smith 1984).

The strength of ideational approaches lies in their focus on symbolic thought and communication. Learning may take place in the absence of symbolic

means of expression. Thus culture, defined as learned behaviors, may also exist without such communication. However, such learning is limited in quantity and adaptive flexibility, and thus nonsymbolic culture remains rudimentary. The fact that humans possess a highly elaborated, species-specific, and universal capacity for language should be sufficient motivation to give symbolic expression a central role in our theories of human adaptation.

Some adaptational theories, such as Harris's cultural materialism, treat the symbolically coded information by which human behavior is planned, evaluated, replicated, and manipulated as if it served primarily as an ideological smoke screen that it is the analyst's task to dispel. Other adaptationists perceive only a quantitative difference between nonsymbolic social learning (by imitation) and symbolically mediated cultural transmission (Richerson and Boyd, 1989). On the other hand, ideational theorists of culture have often devoted inordinate attention to expressive, in preference to instrumental, aspects of culture (Hunn 1982). This emphasis on the noninstrumental may then be combined with a radical relativism and/or a virulent antipositivism (positivism being used loosely as an epithet for modern science) that borders on a rejection of the possibility of a science of human culture. Such ideational theorists define the proper goal of cultural analysis as interpretation rather than explanation. Ideational theorists are also prey to the same functionalist fallacy that waylaid early cultural ecology, subordinating the individual actor to the controlling influence of the encompassing system, whether social, cultural, or ecological.

COGNITIVE DEFINITIONS OF CULTURE

Cognitive anthropology among the ideational theories seems best suited to propose a theoretical marriage of ideational and adaptationist approaches. Cognitive anthropology seeks to develop a scientific approach to ethnography, one that can produce systematic and replicable descriptions of particular cultures (or segments thereof) as a first step toward valid cross-cultural generalizations (Kay 1970). Cognitive anthropology focuses on the individual as the bearer and creative user of culture. The cognitivist culture concept was first clearly articulated by Goodenough, who defined culture as that which one needs to know to act appropriately in all the normal social contexts of the society in question (1957:167). Culture is thus information, not behavior, a point of agreement with leading cultural evolutionary theorists such as Cloak (1975) and Boyd and Richerson (1985). This definition was inspired by a reaction to the positivistic excesses of behaviorist psychology and descriptive linguistics. This same reaction gave impetus to the Chomskyan revolution in linguistics (Chomsky 1959) and led to the development of cognitive psychology (Neisser 1975). Mental phenomena were not to be ignored as impenetrable and insubstantial, but were to be explained by reference to testable cognitive models. Observed behavior was seen as a superficial phenomenon generated by underlying cognitive processes interacting with—not simply reacting to—external reality. For anthropologists this meant that the seemingly infinite variety of human behavior could be understood in terms of cultural rules learned by individuals in society. Systems of such cultural rules, or cultural grammars on the linguistic model, were necessarily finite and otherwise constrained by the limits of human mental capacity.

This notion of culture as a grammar for behavior—derived from the equation CULTURE : BEHAVIOR :: LANGUAGE : SPEECH—is flawed, for grammars define what is the appropriate form of a sentence, saying nothing of what is its appropriate content. Chomsky's famed nonsensical sentence, "Colorless green ideas sleep furiously," is grammatically correct but "ecologically" absurd. An ecologically appropriate culture concept must address not only what is formally appropriate, but also what is ecologically effective. We should therefore amend Goodenough's definition of culture as follows: Culture is what one must know to act effectively in one's environment. (The environment is understood to include both natural and social components from the individual actor's point-of-view.)

This definition retains an essential ambiguity. What do we mean by "effective"? In Goodenough's original definition there was no question: appropriateness of behavior was to be judged by the native, just as the grammaticality of a sentence must be judged by a native speaker, through introspection. The standard of cultural appropriateness may be equated with Freilich's "proper culture" (1980). But cultural effectiveness includes as well Freilich's "smart culture." Both are emic standards, relevant to culturally defined goals, the one social, the other individual. Alternatively we might adopt an etic standard of effectiveness, that is, by reference to culturally external standards. To a human ecologist effectiveness may refer to the efficiency of energy conversion or ultimately, in evolutionary ecology, to maximizing inclusive fitness. I suggest that ethnoecology adopt as a working hypothesis the assumption that, other things being equal, the effective pursuit of culturally defined goals is the proximate mechanism for realizing the ultimate goals imposed by the biological and cultural evolutionary systems of which the human individual is a part (cf. Durham 1979, 1982).

Thus ethnoecology provides a framework for understanding the mechanisms of human cultural evolution, mechanisms that have only recently been seriously considered by cultural adaptationists (Ruyle 1973; Cavalli-Sforza and Feldman 1981; Cloak 1975; Dawkins 1976; Durham 1979; Pulliam and Dunford 1980; Boyd and Richerson 1985). I believe the analogy CULTURE : BEHAVIOR :: GENOTYPE : PHENOTYPE is more productive than the original Goodenough formulation, promoting a view of a culture as a system of information that serves as a blueprint for a way of life and that is ultimately judged by how well it sustains and promotes that way of life.[1]

[1] Geertz entertained this analogy briefly in his essay on "Religion as a Cultural System" in *The Interpretation of Cultures*, pp. 92–93, but has not, to my knowledge, capitalized upon it.

In this view, behavior is the result of culture, the product of cultural plans. It is my view that such cultural plans are frequently conscious, that is, symbolically coded in and thus accessible through the native language of the culture bearer. Though learned behaviors and thus culture are not necessarily governed symbolically or consciously, conscious, linguistically encoded plans constitute a very large and highly invested segment of human cultural life, the analysis of which should yield substantial progress toward an understanding of the more general phenomenon of the evolution of learning.

It needs to be stressed that such cultural plans are context sensitive, in that the behaviors they call for will vary depending on the conditions of the environment at the time and place the plans are expressed, as biological phenotypes vary depending on the environment of gene expression. Furthermore, such plans serve as blueprints, and a blueprint of a house is not the same thing as the house it describes, though it contains the information required to organize the material means necessary for the house's construction and thus embodies the material need for shelter the house is designed to satisfy. This shift of emphasis from models of cultures as autonomous formal structures to processual models of cultures as adaptive systems parallels the shift toward pragmatics in linguistic analysis (Silverstein 1976) and toward praxis in Marxian theory (Ortner 1984).

IMAGE AND PLAN

If culture consists of the information necessary for effective action, what is the nature of that information and how is it organized, stored, acquired, and passed on? Such questions with regard to genetic information have received a great deal of attention from scientists analyzing biogenetic evolutionary mechanisms. Similar efforts will be needed in the study of cultural evolution.

At one level cultural information is coded neurophysiologically, but among humans it is most often transmitted and manipulated symbolically via language. Thus, a substantial core of human cultural information will be manifested in the language of the culture bearer. Cognitive anthropology is concerned primarily with the form and content of cultural information as it is expressed linguistically. This strategic focus on natural language as the medium of culture is shared by Schank and Abelson, leading artificial intelligence (AI) theorists, who note that "a great deal of the human scene can be represented verbally" (1977:5).

A primary distinction relevant to understanding how cultural information is encoded is that between systems of information organized by similarity and those organized by contiguity (cf. iconicity versus indexicality). The former focus on features intrinsic to the "things"[2] classified and relevant to their identification regardless of context. The latter refer to extrinsic features of things, i.e., relationships between things and their contexts, which are primarily relevant to understanding how things function, their roles in events.

Models of human knowledge and memory based on abstract similarity have dominated cognitive theorizing in cognitive psychology and cognitive anthropology into the mid-1970s. Concept formation by reference to similarity has traditionally been judged a more "mature" mode of thought than that based on functional association (Bruner, Goodnow, and Austin 1956:6–8), being characterized as "abstract" (because context free), as opposed to the "concrete" associations of contiguity. Semantic theories of memory conceive of memory as "organized in a hierarchical fashion using class membership as the basic link" (Schank and Abelson 1977:18), with class membership typically defined in terms of shared similarity. Cognitive anthropology has viewed cultural knowledge similarly, defining as the primary units of analysis "semantic domains" by reference to shared similarity (cf. Sturtevant 1964). Culture in this view is an Image of the world (cf. Boulding 1956) that includes cultural "maps," "taxonomies," and "paradigms" as particular organizational forms. The Image is analogous to the lexicon in models of natural language. It consists of "models of," not "models for," a way of life (Geertz 1973:93).

Relations of contiguity have recently been emphasized in models of the conceptual organization of human behavior, that aspect of cultural knowledge more directly involved in interpreting events and selecting courses of action than in describing what the world looks like (Randall 1977, 1987). I will contrast such models of the cultural Plan (cf. Miller, Galanter, and Pribram 1960) with those of the Image. A cultural Plan includes "information processing rules" (Geoghegan 1973); "scripts, plans, goals" (Abelson 1976, 1981; Schank and Abelson 1977); and "routine action plans" (Randall 1977, 1987) as particular organizational forms. It involves episodic rather than semantic memory (Schank and Abelson 1977:18). "Hierarchical decision trees" (Gladwin 1980) may be incorporated as required.

Cognitive anthropologists have made substantial progress in the analysis of the cultural Image, of Image domains such as color, kinship relations, folk biological taxonomies, and folk anatomy. Considerable progress is also evident in the study of decision trees, cultural rules, and routine planning. What is lacking is an effective integration of our models of Image and of Plan (see Figure 1). I will discuss below several cases of cognitive anthropological research that suggest the direction such an integration of Image and Plan might take. Each illustrates how cognitive anthropologists have addressed the ecological relevance of cultural knowledge.

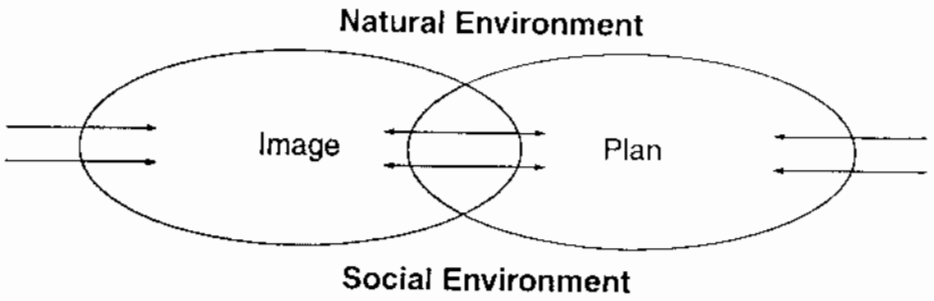
Preliminary Illustrations

Case 1. "Cultural Ecology and Ethnography," Charles Frake (1962)

In this brief note Frake illustrates how a local settlement pattern of scattered homesites in the southern Philippines could be "generated" from just three

[2] By "things" I mean to include not only material objects but also events and relationships.

FIGURE 1 A Model of Image and Plan



cultural "rules." The rules were the bases on which individuals selected sites preferred for constructing their houses. They sought simultaneously to minimize the distance between home and fields and to maximize the distance to their nearest neighbor's house, while also minimizing the labor of fence construction around the periphery of their fields. The rules were readily elicited in the native language and clearly define appropriate choices of action in terms of social and ecological variables. Thus the observed settlement pattern is the collective behavioral expression of many individual culturally and environmentally governed choices. The behavioral pattern may change, that is, we may observe cultural evolution, without change in the cultural rule, if environmental parameters, such as population density, should change.

Case 2. "Residential Decision Making among the Eastern Samal," William Geoghegan (1970)

In this classic study Geoghegan constructs an "information-processing model" of residence mode selection in a Philippine Island community. The rule is graphically represented as a flow-chart—a popular convention in cognitive anthropological studies of choice—each node of which represents an environmental assessment relevant to the choice of "appropriate" residence mode. The validity of the model is tested against census data from the original community as well as from a population of war refugees. Predictions were 98 percent and 94 percent confirmed for the two populations. Marvin Harris (1974), in a critique of this and similar cultural accounts of behavior, argues that this demonstrates that etic outputs require etic inputs. However, Harris redefines etic here as "real" versus "imagined." This is a distortion of Pike's (1956) original formulation of the emic-etic contrast. Furthermore, the inputs required by Geoghegan's model are emic in the proper sense of that term, being distinctions relevant to the actor's cultural frame of reference. That cultural rules incorporate information—linguistically encoded—about the "real" world does not make them etic. Clearly, if cultural Images of reality were not more or less faithful to that reality, cultural Plans based on such information would be ecologically ineffective. So Harris is right to demand that cultural systems effectively link objective environmental states (his "etic inputs") to behavioral practice (his "etic outputs"). He is wrong only in suggesting that cognitive anthropologists believe otherwise.

Case 3. "Ice and Travel among the Ft. Norman Slave," Keith Basso (1972)

Basso shows how an elaborate Slave Indian ice taxonomy, incorporating thirteen named varieties of ice of three major types, is relevant to subsistence and survival in the boreal forest environment. The well-worn example of the elaboration of Inuit snow terminology is presumed to illustrate how cultural knowledge reflects adaptive requirements, though no one has actually demonstrated such a relationship. Basso does so for his Ft. Norman Slave case. The thirteen named ice varieties are associated with seven contrasting combinations of mode of travel (on foot, on snowshoes, by sled) and strategies of approach to water barriers (cross at full speed, test before crossing, circumnavigate) encountered by hunters during winter travel. These relationships between named environmental conditions and behavioral options are explicitly taught to the younger generation by means of a word game in which the child is given two of the three conditions and must select the appropriate third element. In this case the Image is an efficient repository of information about the environment essential to ecologically effective choices of action. The importance of language in cultural transmission is also clear in this example.

Case 4. "Talking About Doing: Lexicon and Event," Michael Agar (1974)

Agar argues that the specialized terminology of the heroin addict subculture in the United States is better represented in terms of events characteristic of the addict's life-style rather than in terms of semantic domains defining an Image of the addict's world. In other words, relations of contiguity regarding actors, actions, means, and locations provide a more meaningful characterization of this subculture than do relations of similarity defining, for example, taxonomies of such actors, means, and locations, as had been traditional in ethnoscience. The terms characteristic of the addict subculture, when arranged as in an English sentence, with terms filling slots in the sentence representing actions (verbs), agents (subjects), objects of actions, and means and locations of the labeled actions succinctly summarized "what one needed to know to act appropriately" within the addict subculture.

The possibility that all human languages are built upon an underlying universal "case grammar" (Fillmore 1968, 1977) suggests that the human understanding of events may be as regularly structured as human semantic memory. Schank's Conceptual Dependency Theory (1975) and the various computer simulations of how people understand natural language accounts of human events represent parallel efforts by psychologists and AI researchers to develop a theory of human knowledge of "the world of psychological and

physical events occupying the mental life of ordinary individuals . . . [of] the common sense . . . assumptions which people make about the motives and behavior of themselves and others—and also a kind of 'naive physics,' or primitive intuition about physical reality" (Schank and Abelson 1977:4). From this theoretical perspective the cultural Image (as well as the Plan) is primarily structured by functional relations of contiguity; thus the Image, the Plan, and the grammatical structure of human language share a common analytical framework.

Case 5. "Making Plans to 'Make a Living' in the Southern Philippines," Robert Randall (1977)

Randall's analysis of Linungan fishing plans is an ambitious attempt to describe what one must know to "make a living" in this particular ecological setting. His analysis adds a dimension of ethnographic reality to the efforts of AI theorists to account for human understanding of everyday life. Randall stresses the significance of having or acquiring the means necessary for successful action, an environmental constraint on the selection of culturally appropriate behaviors. Randall carefully distinguishes how routine choices of action are implemented, in contrast to the selection of exceptional or marked alternative actions when unusual obstacles or opportunities are encountered (Randall 1987). His analysis describes some microevolutionary changes in Linungan subsistence plans.

These studies are but a sample of cognitive anthropological research relevant to cultural ecology. Basso demonstrates that cultural knowledge has adaptive significance. Frake, Geoghegan, and Randall show the ecological relevance of cultural plans. Geoghegan, Agar, and Randall propose general models of such cultural plans. I will now describe in greater detail an ethnobiological case from my own research to suggest the form an ethnoecological ethnography might take.

Sahaptin Root Digging

This example begins with a traditional ethnoscientific analysis that organizes terminologically labeled elements of the Image as a taxonomic domain structured by relations of perceptual similarity (Kay 1971; Berlin, Breedlove, and Raven 1973; Hunn 1976). The elements of the Image are analyzed in terms of their role in the cultural Plan. The two perspectives are then contrasted.

I have recorded over 200 basic plant taxa for the Columbia River dialects of the Sahaptin language of the Plateau of northwestern North America.[3]

[3] Sahaptin is a Penutian language spoken today by several hundred Indians in south central Washington and north central Oregon. My research pertains most directly to the dialects of that language spoken by Columbia River Indians whose ancestral winter villages were located on the Columbia River between Celilo Falls and the Umatilla River.

A basic category is distinguished from more or less inclusive categories in the same domain by a characteristic combination of features, including high information content, an unmarked name, and a cognitive representation as a prototypical image (Hunn 1976; Berlin 1978; Rosch 1978). The fact that most of these 200-odd categories correspond to scientific species or closely approximate them demonstrates that perceptual similarity is the primary basis for the classification of individual plants into basic level categories. In this respect Sahaptin resembles other folk biological classification systems. However, Sahaptin is unusual in comparison with other well-known folk biological systems in its minimal hierarchical structure. Morphologically based "life form" taxa and folk specific taxa are virtually nonexistent. (Life forms are defined by Berlin, Breedlove, and Raven [1973] as taxa inclusive of a range of "folk generic" or basic-level taxa, while specifics are defined as subdivisions of folk generics characteristically labeled by names of binomial form.) The Sahaptin taxonomic hierarchy thus reduces to a nearly unstructured list of basic level categories.

I would like to be able to say more than this about Sahaptin ethnobotany. To do so I must consider more than the perceptual basis of Sahaptin folk classification. I must consider not only relations of similarity among plant taxa but also relations of contiguity between plant taxa and other conceptual elements of the Sahaptin Image. One way to approach this task is to describe what I call the "activity signature" of each plant (Hunn 1982), which is the set of Sahaptin sentences incorporating each plant name. Activity signatures are lists of admissible predications for which the plant serves as an argument. Those sentences delimit a set of contexts that collectively define the plant's cultural relevance.

Context-defining sentences may be compared among a set of plants to appreciate the contrasting relevance of each plant. As an initial step in this ethnographic program I have drawn from open-ended, native language texts on gathering activities that I recorded from several Sahaptin elders. From these texts I have abstracted an outline of a root gathering plan, a cultural context central to the meaning of the Sahaptin ethnobotanical category *xni-t*, "plants that are dug, roots." I then asked my Sahaptin teacher, James Selam, to review and correct my interpretations.

The basic plant categories grouped under the heading *xni-t* correspond closely to scientific species. Nineteen of the twenty-six roots, or 73 percent, correspond perfectly to scientific species, while the remaining seven are near misses. The perceptual basis for these basic-level taxa is thus clear. However, the collectivity of roots represents a diverse assortment of plants from several plant families. This category includes the edible species of some scientific genera and families while excluding other very similar but inedible species of the same genus or family. Clearly, the category *xni-t* is not based on perceptual similarity. Rather it reflects the common role each such species plays in the cultural Plan. All roots, for example, are appropriate as objects of the transitive verb *xni-* "to dig [something]." The similarity here is a functional equivalence;

TABLE 1 A Sahaptin Root Digging Plan XNI-T

I. Primary goal: to eat *tkʷáta-sha*
  A. Have means to eat, e.g., is there food? *i-wá tkʷáta-t*
    1. If yes, go to B. If not, select means, e.g., option 1d.
      a. Fish *np'íwi-sha*: select means, for example,
        1) Fish by hook-and-line *wac'ílak-sha*
        2) Fish by bone choker *shapá?axch-sha*
        3) Spear fish *tayxáy-sha*
        4) Dip-net fish *twalúu-sha*
        5) Set-net fish *tapatúk-sha*
        6) Fish by weir *shapá-xaluu-sha*
      b. Hunt *tkʷáynp-sha*
      c. Pick fruit *á-tmaani-sha*
      d. Dig roots *á-xni-sha*
      e. Use stored foods *yáxaynakt-pamá*
    2. Enact root digging plan *wishushuwa-sha xnít-atash*
      a. Have means to dig roots *wás-nas xnít-pamá*, e.g., digging stick *kápin*, twined bag *wápas?*
      b. If not, acquire means. if yes, initiate plan.
        1) Plan trip *wishushuwa-sha wína-tash*
        2) Pack up gear *i-wiwalakʷ'ik-sha kutkut'áwas-na*
        3) Go for roots *máana sha*
        4) Travel to camp *wishána-sha wáwtukash-kan*
        5) Go around [looking for a camp site] *waqit-sha wáwtuk-awas*
        6) Camp overnight *wishwáwtuk-sha*
        7) Find digging site *á-yax-sha xnit-pamá-na*
        8) Look around for roots *q'inuq'inú-sha xnit-pamá-na*
        9) Select root species, e.g., bitterroot *pyaxí*, camas *wáq'amu*, Indian potato *anipásh*
        10) Dig roots *á-xni-sha*
        11) If bitterroot, strip skin *á-chapyax-sha*
        12) Put in twined bag *á-nich-sha wápas-pa*
        13) Repeat 10) & 12) until bag is full *káakim*, then go on
        14) Collect in large bag *á-yakta-sha ánpsh-pa*
        15) Repeat 14) until full, then continue
        16) Pack roots back to camp *kʷ náyti-sha*
    3. Prepare roots, select means, e.g., option 3b.
      a. Store underground *á-tamki-sha*, go to I, A, 1, e.
      b. Eat them now *áw tkʷáta-sha*, go to A4.
      c. Keep them for winter *á-nich-sha ánwich-tash*, initiate sequence
        1) Wash roots *áw-iix-sha*
        2) Peel roots *á-miik-sha*
        3) If bitterroot, go to C6
        4) If camas, bake underground *á-tamaych-sha*
        5) If *luksh*, make root cakes *áwi?ani-sha sap , initiate sequence*
          a) Pound roots á-tut-sha
          b) Mix dough *shapátwa-sha*
          c) Form cakes *áwi?ani-sha sap*
        6) Dry in sun áwilaxyawi-sha ichú-pa
        7) Pack them home *áwishapashap-sha túxna-t*
        8) Put them away in the cellar *á-nich-sha wulchí-pa*
    4. Cook roots *á-shapa?at'i-sha xnít-na*: select means, e.g.,
      a. boil them *á-shapa-lamulayt-sha*
  B. Eat *tkʷáta-sha*

the members of the category may substitute for one another in a particular role within a characteristic activity, in this case an ecologically fundamental one.

If all twenty-six kinds of roots are functionally equivalent, why bother to name each separately? This seems wasteful of mental effort and of memory capacity. Why not call them all simply *xni-t*? Such a strategy is, in fact, adopted with regard to two categories of useless plants in Sahaptin, *latít* (flower) and *c'ic'k* (grass) (Randall and Hunn 1984). However, all roots on closer inspection are not precise functional equivalents. Though all roots may be harvested with the same digging movement, in the larger context of using these roots, highly salient contrasts appear. To appreciate the cultural need for naming so many roots we must describe root digging in more detail.

The actual act of digging the root from the ground is but one step—albeit the conceptually central one—in a sequence of connected activities. Applying ethnoscientific elicitation techniques in this case is useful. If we ask *táynam-chi á-xni-sha kʷáaman?* (why one digs this root or that), the answer will be, *tkʷátat-yaw* (to eat it). One doesn't just dig roots and then discard them! Root digging is a goal-directed activity. If we ask *míshniki-nam á-xni-xa kʷáaman?* (how does one dig roots), we are likely to receive as an answer a description of a sequence of activities. To dig a root requires that one first go root digging *máana-*, on arrival look around for the specific root(s) sought *q'inuq'inú-*, dig them *xni-*,[4] peel them *miik-*, collect them in a bag *yákta-*, pack them back to camp *kʷnáyti-*, wash them *iix-*, pound them *tut-*, dry them *láxyawi-*, cook them *shapá-?at'i-*, and finally eat them *tkʷáta-*.[5] Eating is the culmination of the process as well as its motivating goal.

At each step of this sequence one may ask again, how? For example, "How do you 'cook' them?" *míshniki-nam á-shapa?at'i-xa?* The answers reveal a set of alternative cooking techniques differentially appropriate to various roots. Camas (*Camassia quamash*, liliaceae), for example, must be baked underground *tamáych-*[6], while *pank'ú* (*Tauschia hooveri*, umbelliferae) is eaten raw *xapít*. [The cooking step of the sequence is deleted.] The Sahaptin recognition of two distinct varieties of Canby's lomatium (*Lomatium canbyi*, umbelliferae) makes sense when we discover that the first variety is ground, made into dough, then sun-dried as finger cakes *saptí*, while the other is baked underground. Other ecologically relevant distinctions are revealed by asking "where?" "when?" or "by whom?" the roots are dug.

[4] Note the polysemy of *xni-t* used to describe both the action of digging roots and the sequence of activities of which that is the focal segment. It is a nomenclatural pattern with close parallels elsewhere (Agar 1974; Berlin 1976).

[5] The verbs are cited in their unmodified stem form. Transitive stems such as these would be inflected to indicate impersonal subject and plural object by adding the prefix *á-* and for continuing action in the present by the suffix *-sha*, thus *á-xni-sha* "you are digging [roots]."

[6] The adaptive value of such processing has been demonstrated by Konlande and Robson's nutritional analyses (1972).

Asking how? to do something does not always produce a description of a sequence of activities involved in completing the action. At some point the answer will be a slightly annoyed "You just do it." This response suggests the limits of conscious planning have been reached (or the limits of one's informant's patience). For example, eating ultimately involves a complex sequence of jaw motions, the control of which is largely outside of conscious awareness. Chewing is an atomic activity at the conscious level. Digging likewise involves such atomic physical actions as grasping the digging stick, bending, lifting, and twisting. Such atomic units may be incorporated into a variety of molar activities and are thus not particular to an ethnographic account of activities. Our ethnoecological description need not proceed beyond this level of detail.

In other situations the question how? may generate a list of alternatives requiring a decision as to which is preferred. For example, "How should one fish?" in the Sahaptin Plan is a question that implies alternative technologies appropriate to the time and place and to the species sought. One fishes by hook-and-line or bone choker; with a spear, dip net, or set net; by weir or trap. To accomplish the task of fishing one must first select an appropriate way to fish. A "hierarchical decision tree" (Gladwin 1980) may be required to describe this segment of the Plan.

As should now be clear, a discussion of folk classification restricted to aspects of perceptual similarity will be woefully incomplete as an account of the Sahaptin Image of their natural environment. The Image includes not only the cultural knowledge of what a plant or animal looks like (which is put to use in identification subplans), but also a representation of the plant or animal in its characteristic cultural contexts. The Sahaptin Image of camas would call to mind not only a collectivity of similar plants but also a scene in which camas plays a central role. We would see in our mind's eye a vernal meadow in summer, full of mature camas, with Indian women actively engaged in uprooting the plants with their digging sticks. In the background of the picture would be other plants and animals characteristic of meadows, ecological associates of camas. We would imagine the underground ovens being prepared. We would be reminded of the firewood, the heating stones, and the various plants used to cover and flavor the baking camas, things that are characteristically part of these activities.

An appropriate data structure for representing this knowledge is an "event" (Agar 1974) or an "episode," as in theories of episodic memory preferred by Shank and Abelson (1977:17–19), a kind of "schema" (Neisser 1975; Casson 1983) rather than a taxonomy. We would, of course, also recall the camas plant itself, its spike of large blue flowers, its sheathing cluster of leaves, its onionlike bulb pulled fresh from the ground. While a taxonomic structure may be abstracted from such information, such information is also required by the Plan whenever an identification is required to select or enact a Plan segment. We might be reminded of the death camas (*Zigadenus spp.*, liliaceae), a deceptively similar plant. Perceptual similarity is important in this instance because it implies contrasting functional patterns for the two similar items; eat one, carefully avoid the other. Thus similarity and contiguity both play important roles in the Image. Even our plans are reflected in our Image of the environment, as our own activities take place in that environment and are thus incorporated reflexively in the Image.

A cultural Plan is a complex entity, a hierarchical organization of subplans each dominating either a sequence of subsidiary activities or a set of alternatives from which a choice of action must be made (Randall 1977). It is possible to move around in the cultural Plan by systematic questioning, using basic question frames, which are probably linguistic universals. For example, why? moves "the cursor" upward; how? moves it downward through the Plan hierarchy. Each subplan, whether step or alternative, may be expressed as a natural language sentence in which the action or state is indicated by a verbal predicate, the arguments of which include associated actors, objects, implements, and settings indicated by nominal elements marked for case—candidates for status as linguistic universals (Fillmore 1968).

CONCLUSIONS

I have argued for an ethnoecology that unites cognitive anthropology and cultural and evolutionary ecology. I believe this approach answers the most important criticisms that have been raised against each field. Cognitive anthropology's focus on the individual actor who, guided by cultural knowledge, designs a plan for living, is joined with the ecologists' appreciation of the complex web of mutual influence linking individuals and the elements of their natural and social environments. Ecology may also contribute a vision of the encompassing evolutionary processes that govern all life. Cognitive anthropology contributes a method and conceptual framework for understanding the powerful role of culture in evolution. Culture is seen to be an evolutionary mechanism in its own right, capable of independent replication and subject to selection processes distinct from those governing genetically coded information (Dawkins 1976; Durham 1982; Boyd and Richerson 1985), transformed by the power of human language as a medium of symbolic communication.

I have offered a series of examples to illustrate the application of this view of culture to phenomena of ecological significance. In these examples I have sketched the outline of a theory of culture as a symbolic means for adapting to a changing environment. The theory is closely related to models of human understanding developed in the study of artificial intelligence and in cognitive psychology but is informed by the wider perspective of ethnography. I believe we cannot hope to understand cultural evolution adequately without such a theory of human understanding based in human language use, for that is the locus of the cultural analog of DNA.

The model of culture sketched here is an organization of ideas. The ideas are concatenated in a variety of data structures in memory, both semantic

and episodic. Episodic structures, called variously "scripts" or "plans," are stressed here, as they reflect in the Image our experience of significant events as well as the cultural plans that we use to construct our behavior. There is a necessary parallel between the structure of such plans and the structure of sentences in natural language, as human language is the primary means we have of representing to ourselves the reality to which we must adapt.

Detailed and particularistic ethnographic description will be necessary as the basis for generalizations about the effectiveness of cultural practices. The analysis of specific cultural plans should also reveal recurrent patterns of form and content relevant to our understanding of cultural evolutionary processes. Cultural evolution is ultimately the result of changes in the way individuals choose to pursue the goals set by their cultural Plan, changes that may subsequently alter the goals themselves. Cultural evolution is a process sensitive to nuances of environmental variation continuously reflected in the cultural Image. By such a process our ancestors may have been led to substitute—step-by-step—agricultural strategies for those of hunting and gathering, as Pacific Northwest Indians substituted the white man's potatoes for the native camas and planting of crops for the care of stands of wild plants (Suttles 1951). Likewise, market production superseded subsistence production, and wage labor in cities overcame household production. In sum, I believe our comprehension of the course of human history requires that we first understand cultural adaptation in terms of human individuals engaged in the familiar routines of everyday life.

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