Human Taste and Cognition in Tzeltal Maya Medicinal Plant Use

DAVID GREGORIO CASAGRANDE[1]

Abstract

Results of recent research strongly suggest that people find beneficial phytochemicals by selecting plants to use as medicinals and that taste plays a major role in this process. The research reported here involved an experiment performed with Highland Tzeltal Maya of Chiapas, Mexico to determine if bitterness served as a chemical cue for plants appropriate for treating gastrointestinal versus respiratory illnesses. Eight Tzeltal men and two women were asked to taste common medicinal preparations, describe the taste, and provide the name and medicinal use of the source plant. They were also shown dried specimens of the same plants and asked for taste, name, and use. Consensus analysis showed that participants had a good knowledge of medicinal plants and agreed about their use, but could not predict the use of individual plants based on taste alone. Bitterness was not correlated with any particular class of illnesses; probably because there is not enough resolution in human taste to deal with the diversity of chemicals that taste bitter but produce different physiological effects. The role of taste is more likely mnemonic than chemical-ecological, and functions in combination with other plant attributes and illness experiences to facilitate human cognition and communication. Results of this study suggest that prototype theory, in which a few plants serve as best examples of a subset of plants used to treat a group of illnesses, may provide a theoretical perspective for understanding how people reduce informational complexity and reconcile the very different domains of plant classification, epidemiological context, and illness experience.

Introduction

Anthropologists working in regions far from their homes quickly become familiar with new illnesses. Working with the Tzeltal Maya in the Central Highlands of Chiapas, Mexico, I have become personally acquainted with many of the gastrointestinal (GI) afflictions familiar to the people who live there. Recently, while experiencing an illness, I described my symptoms to a Tzeltal collaborator. He didn't consider himself a healing specialist. But without hesitation he claimed that he knew of a particular plant appropriate for relieving my symptoms and speeding my recovery, and he left to search for the plant. Within a half-hour he returned with a handful of leaves of a plant called **balam k'in**, which he crushed into a cup of cold water. He advised me to drink the bitter fluid all at once, and claimed that no further treatment would be necessary. Within eight hours my symptoms diminished, and by the next morning all evidence of the affliction had vanished. This was the fastest I had ever recovered from the GI distress that I experience all too frequently while working in the region.

I later determined that the scientific name of the plant was *Smallanthus maculatus*, a member of the sunflower family (Asteraceae). Pharmacological studies have shown that extracts of the leaves of this plant are effective at killing bacterial parasites, such as *Staphylococcus aureus*, and controlling the spasms associated with cramping (Berlin and Berlin 1996). My collaborator was unimpressed with this "new" information. After all, the efficacy of the plant is common knowledge among the people who live in the area.

[1] University of Georgia, Department of Anthropology, bighouse@arches.uga.edu

The Tzeltal Maya, like most traditional people, have a complex pharmacopoeia involving hundreds of plant species. The degree of consensus among the population about the complex medicinal uses of around 200 of these species is remarkable (Berlin and Berlin 1996). The process of experimentation, discovery, and transmission of knowledge can be considered a process of ecological adaptation involving complex relationships between pathogens, phytochemicals in the ecosystem, and the biological and cultural constraints on human cognition and communication. These relationships allow one to ask interesting questions. For example, how are discoveries of medicinal plants made? And more importantly, how has the vast amount of information that has accumulated been organized in the mind and maintained in communities without writing?

Anthropologists have argued that traditional people do not rely on blind trial-and-error in their search for medicinal plants (Moerman 1998). Instead, characteristics of plants may help guide traditional experimentation and "discovery" of beneficial phytochemicals (Brett 1994, Etkin 1988, Foster 1994). The way plants taste, especially if bitter, may serve as such a guide (Brett 1994, Johns 1990). Many chemical compounds found in plants have evolved as defense mechanisms that induce detrimental responses in attacking organisms, such as herbivorous insects and mammals, fungi, and other pathogens (Harborne 1991). Many animals, in turn, have evolved mechanisms for detecting these allelochemicals, such as the ability for humans to taste toxins in plants. Some researchers believe that taste, combined with cognitive and cultural mechanisms to overcome aversions to bad tastes, allows humans to optimize the amount of allelochemicals they ingest in order to combat parasites without poisoning themselves (Johns 1990). This argument is supported by evolutionary evidence ranging from monarch butterflies eating milkweed to ingest cardiac glycosides as a defense against predatory birds (Harborne 1993), to wild chimpanzees eating bitter and toxic plants during times of high intestinal parasite loads (Huffman et al. 1996).

Further support for the role of taste in medicinal plant selection comes from the observation that species of the sunflower family (Asteraceae) tend to be represented in traditional pharmacopoeia in numbers much higher than would be predicted by the number of Asteraceae species found in people's environments (Moerman et al. 1999). People may be more likely to experiment with Asteraceae because those species are more likely to contain bitter phytochemicals. For example, the Asteraceae are believed to contain over 2000 types of sesquiterpene lactones, all of which are bitter and many of which induce physiological responses or are otherwise toxic (Bruneton 1995).

The Tzeltal Maya of Highland Chiapas use many bitter plants as medicinals (Berlin and Berlin 1996), and also "favor" Asteraceae species (Moerman et al. 1999). Most of the plants used by the Highland Maya are used to treat GI illnesses and they tend to be bitter. Indeed, *Smallanthus maculatus*, the Asteraceae used to treat my affliction, is said by Tzeltal Maya to derive its power to cure from bitterness (Berlin and Berlin 1996). Brett (1994) has suggested that bitterness serves as a cognitive cue to the Highland Maya for phytochemicals that are appropriate for treating GI illnesses. Observations of physiological response after ingestion, cultural interpretations of illness events and sharing of information among people may result in a tendency for the Highland Maya to focus on bitter plants when searching for new cures for GI illnesses.

This idea leads to a prediction that Highland Tzeltal Maya should be more likely to associate bitter tasting remedies with GI illnesses than other types of afflictions, such as fevers, coughs or skin ailments. I conducted an experiment to determine how taste influences the ways in which Highland Tzeltal Maya think about medicinal plants. The goal was to isolate taste as a variable by preparing remedies from commonly used medicinal plants and having participants taste the remedies without knowing the identity of the source plant. This allowed me to test three hypotheses. First, participants should agree about the taste of the unknown remedy (i.e., they would all use the same Tzeltal lexeme to describe the taste). Second, they should agree about what medicinal uses bitter remedies are best for. And third, bitterness should be statistically correlated with GI illnesses. It was my intention that the results would help shed light on the adaptive processes by which people experiment with and share information about medicinal plants.

Methods

I conducted the study in the municipality of Tenejapa in the Central Highlands of Chiapas, Mexico working with a bilingual (Tzeltal and Spanish) collaborator who is an herbalist with a widely respected practice in Tenejapa. We elicited freelists (Borgatti 1996) of medicinal plants from six men and three women. Nine plants were selected from

TABLE 1. PLANT AND CHEMICAL STIMULI USED IN TASTE TESTS AND THE NUMBER OF INFORMANTS WHO CITED EACH TASTE QUALITY.

Plant species or chemical	Tzeltal name[2]	Taste	English gloss	No. participants citing taste
Alnus acuminata	najk	sup	astringent	7
		ch'a	bitter	1
		ya	spicy hot	1
			unidentifiable	1
Citrus limonia ('lime')	lima	paj	sour	7
		lek	pleasant	2
		sup	astringent	1
Eupatorium sp.	ch'aj te'	ch'a	bitter	10
Liquidambar styraciflua	so' te'	sup	astringent	5
		paj	sour	3
		lek	pleasant	2
Myrica cerifera	ch'aj k'olol te'	ch'a	bitter	9
		sup	astringent	1
Psidium guineense	pajchak'	lek	pleasant	4
		ch'a ch'a tik	slightly bitter	4
		sup	astringent	2
Quercus crassifolia	jij te'	sup	astringent	7
		paj	sour	1
		ch'a	bitter	1
			unidentifiable	1
Sigesbeckia sp.	takin ch'iel	ch'a	bitter	10
Tagetes lucida	tzitz ak	lek	pleasant	10
Verbena litoralis	yakan k'ulub wamal	ch'a	bitter	10
phenylthiocarbamide (PTC)	—	ch'a	bitter	10
thiourea	—	ch'a	bitter	10
sodium benzoate (NaB)	—	ma'yuk	no taste	3
		paj	sour	3
		chi' pik pik	salty	2
		ch'a	bitter	2
control	—	ma'yuk	no taste	8
		ch'a ch'a tik	slightly bitter	1
		sup sup tik	slightly astringent	1

[2] Determined by consensus analysis of visual interview data.

among those that were most frequently cited in freelists (Table 1) and that represented various tastes and illness classes. For example, two of the nine were bitter species used primarily for treating diarrhea, while two bitter species were used to treat coughs or rheumatism as described by the Tzeltal collaborator and cross-referenced with the data of Berlin and Berlin (1996). Other plants were known to be astringent, sour, or pleasant tasting and were used for a variety of illnesses. We also asked participants to taste paper strips treated with phenylthiocarbamide (PTC), thiourea, sodium benzoate (NaB), and a control with no taste (Carolina Biological Supply, Burlington, North Carolina).

We collected, pressed and dried voucher specimens of the nine plants and determined their scientific names at the herbarium of El Colegio de La Frontera Sur in San Cristobal de las Casas, Chiapas. These vouchers were also used as visual stimuli in the interviews. While we were collecting the herbarium vouchers we also collected plant material to prepare remedies in the way that they are commonly prepared by the people of Tenejapa. This almost exclusively involves boiling either the bark, stems, or leaves of the plants.

Eight adult men and two women were interviewed individually in Tzeltal with the assistance of the herbalist-collaborator who provided occasional translation into Spanish. Participants were asked to taste each of the preparations one at a time, and then were asked to provide a name for the taste, name of the source plant, and medicinal use. The tasting began with a lemon-water preparation as a primer. This was followed by a pleasant, anise-tasting medicinal tea made from *Tagetes lucida*. The order of the remaining plants and chemical paper strips was independently randomized for each interview to reduce potential bias of one taste masking the next. Participants were also given water, crackers and sufficient time for tastes to subside between each tasting.

Consensus analysis (Romney et al. 1986) was performed using ANTHROPAC (Borgatti 1995) to test the first hypothesis that participants agreed about the taste of the unknown remedy and that lexemes used to describe the taste formed culturally meaningful categories. Consensus analysis was also used to test the second hypothesis that participants could predict medicinal uses of each plant based on taste alone; that is, whether medicinal use categories generated by taste alone formed culturally meaningful categories.

To test the third hypothesis, correlation between answers that a plant was bitter and that it was used to treat a gastrointestinal (GI) illness was tested using the Pearson correlation coefficient (Zar 1996) by treating taste and use as bitter/non-bitter and gastrointestinal/non-gastrointestinal binary (1/0) variables respectively. The same process was used to test for correlation between bitterness and respiratory illnesses (the second most commonly treated class of illnesses after gastrointestinal; Berlin and Berlin 1996). For this discussion, medicinal uses (e.g., to treat various types of diarrheas, coughs, rashes, etc.) are grouped into major illness categories (i.e., gastrointestinal, respiratory, dermatological, etc.) based on the categories of Berlin and Berlin (1996).

After the taste tests, participants were shown herbarium specimens individually, and were asked to identify the Tzeltal plant name, taste, and medicinal uses. Consensus analysis was used to test for participants' overall knowledge of medicinal plants, to determine the "culturally correct" name of each plant, and to determine the common-knowledge uses of each plant.

Results

Consensus analysis of interviews using herbarium specimens as visual stimuli showed high agreement about names, medicinal use and expected taste (Table 2). Taste tests revealed high agreement about how prepared remedies actually tasted (Tables 1 and 2), supporting the first hypothesis. But there was no meaningful consensus about appropriate medicinal use based on taste alone (Table 2) leading to rejection of the second hypothesis. These results indicate that participants were generally knowledgeable about the medicinal plants, and that plant names, medicinal uses

TABLE 2. MEDICINAL PLANT INTERVIEW CONSENSUS.

	Interviews with visual stimuli		
	Plant names	Medicinal use	Expected taste
Agreement (ratio of 1st to 2nd Eigen value)	7.1	5.3	4.9
Average estimated knowledge of participants	0.61 (SD = 0.14)	0.45 (SD = 0.12)	0.39 (SD = 0.18)

	Taste tests	
	Reported taste	Medicinal use
Agreement (ratio of 1st to 2nd Eigen value)	8.1	1.4
Average estimated knowledge of participants	0.78 (SD = 0.11)	0.08 (SD = 0.46)

and taste terms are widely shared and culturally meaningful, but that taste alone was insufficient for participants to ascertain the appropriate, culturally-shared, medicinal use.

Most responses about the medicinal use of plants involved the treatment of GI illnesses (Table 3). However, responses from the taste tests show that bitterness was not significantly correlated with GI illnesses (r = 0.14, df = 90, 0.10 < P < 0.20), leading to rejection of the third hypothesis. In other words, an individual who identified the taste of an unknown remedy as bitter was not more likely to say that the remedy was more appropriate to treat a GI illness than another type of illness. Furthermore, medicinal uses of individual plants obtained by visual stimuli were not correlated with the use obtained using taste stimuli (r = 0.12, df = 38, 0.20 < P < 0.50). This further indicates that taste alone was insufficient to allow participants to infer correct medicinal use.

In the taste tests, bitterness was not significantly correlated with respiratory illnesses either (r = 0.11, df = 90, 0.20 < P < 0.50). Hence, these results do not allow one to say, based on taste stimuli alone, that bitterness is more likely to be correlated with GI illnesses or respiratory.

TABLE 3. TYPES OF ILLNESSES TREATED USING THE NINE PLANTS AS REPORTED DURING THE INTERVIEWS WITH PLANTS IN HAND VS. TASTING UNKNOWN PREPARED REMEDIES.

	Number of responses	
Major illness class	Visual interviews	Taste tests
Gastrointestinal	36	43
Respiratory	6	18
Emotional	1	5
Fever	2	3
Arthralgias	3	4
Headache	1	2
Reproductive	0	1
Weakness/wasting	0	1
Other	3	6
Total	55	87

Discussion

A bitter world

Results of the interviews using visual stimuli indicated that the Tzeltal Maya participants knew the plants well and generally agreed about how they taste and how they are used to treat illnesses. But results from the taste tests indicate that taste alone was insufficient for participants to predict how a plant will be used to treat illnesses, even for the broadest illness categories. Although it is evident that many bitter plants are used to treat gastrointestinal (GI) ailments, it is not clear that bitterness serves as a cognitive guide for the selection of plants for any particular types of illnesses. The emphasis on GI is likely a result of the rapidly expanding human population in the Highlands over the past 20-30 years, which has not been matched by improvements in sanitation (INEGI 1992, 1996). Bitterness only appears to be correlated with GI at first glance because most common illnesses treated by non-specialists are GI and most medicinal plants are bitter.

It is possible that the high number of bitter medicinals used by the Tzeltal, as well as other traditional people, simply reflects a high occurrence of bitter plants in the environment. Ankli et al. (1999) sampled medicinal and non-medicinal plants used by the Yucatec Maya and found that medicinal plants were no more likely to be bitter then non-medicinals.

The notion of bitterness as a biochemical cue would be supported if it could be shown that bitter plants appear in pharmacopoeia more frequently than in the environment. Unfortunately, it is not yet technically feasible to estimate the frequency of bitter phytochemicals that occur in an environment. Thus, it is not possible to claim, for any society, that bitterness is represented in pharmacopoeia in excess of that found in the environment. The high occurrence of bitter medicinals may simply result from the amount of bitterness in the world.

One reason that taste alone, and especially bitterness, may be inadequate for predicting pharmacological properties is that the specificity in human taste reception is not adequate to cognitively link the vast diversity of bitter chemicals with appropriate biological properties. For example, sesquiterpene lactones and alkaloids can all taste bitter, but humans may have a very limited ability to distinguish among them. Because the various types of phytochemicals that taste bitter are structurally dissimilar, and produce dissimilar biological effects, there must be cognitive processes other than taste involved to explain the success of traditional experimentation, memory recall, and sharing of information.

It is apparent that the Highland Tzeltal "discover" powerful GI treatments that are not bitter. In this experiment, for example, *Tagetes lucida* was readily identified as a pleasant tasting plant known to be used to treat diarrhea and abdominal pain. Pharmacological studies indicate that *Tagetes lucida* contains compounds effective against a variety of intestinal parasites (Berlin and Berlin 1996). Caceres et al. (1990) found *Tagetes lucida* to be the most effective entero-bactericide in the Highland Guatemalan pharmacopoeia–exhibiting the highest antibacterial activity against *Salmonella enteritidis* and *Salmonella typhi*. The frequency with which non-bitter plants occurs in the Tzeltal pharmacopoeia (Brett 1994) suggests that other characteristics may be as important as taste in guiding medicinal plant experimentation.

A more promising direction for future research involves observing the process of human experimentation with medicinal plants. Preliminary research along these lines led Brett (1994) to predict that Tzeltal Maya looking for a new medicinal plant would begin by selecting plants that taste like plants known to induce physiological effects similar to the effects desired in a new treatment. But it is likely that people would have to begin by selecting a plant that *looks* like a known medicinal plant in order to infer that it would *taste* like a known plant. This might at least partially explain a bias to sample within large, morphologically homogeneous botanical families like Asteraceae and Lamiaceae. The alternative is that people continuously and randomly sample plants for taste and maintain a cognitive inventory of potential medicinal plants. This seems unlikely given the danger of tasting unknown plants, the large number of species involved, and the many well-documented cases of selection based on visual characteristics.[3] A valuable experiment would be to take people to an area with an unfamiliar flora and ask them to find plants that might be suitable to cure familiar illnesses, and observe which characteristics they focus on.

In any event, it is unlikely that taste, visual characters, or any other criteria can fully explain medicinal plant selection. Medicinal plants appear to serve as complex packages of information, and different cognitive schemas are evoked by different sensorial stimuli. Memories about illness experiences conjured up upon seeing a plant differ from the state of mind produced by taste or smell. Results from this experiment showed that participants' concepts of medicinal use based on taste were not correlated with that based on visual stimuli, even though people knew the taste of the plant they were looking at. Also, in only a few cases were people able to name a plant by tasting the remedy prepared from it (Table 4). These results suggest that taste is one of several personal and cultural mnemonic devices, along with visual characteristics, past experiences, and intangible cultural assignations such as hot/cold qualities,[4] used to manage information about medicinal plants.

Medicinal plant prototypes

The idea of medicinal plants as complex packages of information raises an important question: how is all of the information organized in a way that is easily recalled and easily shared among people? Many students of human cognition believe that people organize information in their minds by relying on "best examples" or "prototypes" of categories (MacLaurey 1991). People create subsets of the vast array of items encountered in the world by recognizing attributes shared by some items and not by others (Rosch 1978). Birds are expected to fly and have feathers and wings, plants have leaves, chairs are for sitting on, verbs are words that express action. Some items express such attributes better than others, and people tend to focus on those items during childhood learning, when performing memory recall, or attempting to communicate about categories (Kempton 1982, Markman 1989, Winters 1990). Ask several Americans to recall all of the birds they know and they will mention robins or sparrows much more often, and sooner, than penguins (Boster 1988).

Prototyping appears to be a fundamental cognitive mechanism for the organization of complex information (Boster 1988, Coley et al. 1997, Rosch and Mervis 1975) that must be divided up for pro-

TABLE 4. NUMBER OF CORRECT IDENTIFICATIONS OF PLANT NAMES BASED ON TASTE ALONE.

Plant species	Tzeltal name	Number of correct identifications
Tagetes lucida	tzitz ak	3
Verbena litoralis	yakan k'ulub wamal	2
Quercus crassifolia	jij te'	2
Eupatorium sp.	ch'aj te'	1

[3] The most widely known cultural interpretation of visual characteristics is often referred to as the doctrine of signatures (Etkin 1988, Foster 1994). For example, plants that have red sap may be considered appropriate to treat blood-related illnesses, leaves shaped like kidneys to treat kidneys, etc.

[4] Tzeltal illnesses are classified using a dichotomous hot/cold system, and certain plants are appropriate to treat hot or cold illnesses (Berlin and Berlin 1996). This may result from observations of human physiological response to the ingestion or topical application of medicinal plants (e.g., sweating, heat, abdominal sensation, cessation of symptoms; Brett 1994, Berlin and Berlin 1996). Dichotomous classification may also result from historical contact with the European humoral medicinal plant system (Kidwell 1991, Foster 1994).

TABLE 5. POTENTIAL MEDICINAL PLANT PROTOTYPES AS INDICATED BY MOST FREQUENT RESPONSES FOR TASTE CATEGORIES.

Taste	Latin name	Tzeltal name	Number of responses
bitter	*Verbena litoralis*	**yakan k'ulub wamal**	9
bitter	*Salvia lavanduloides*	**ch'a bakal**	4
bitter	*Prunus persica*	**'hoja de durazno'**	3
astringent	*Quercus* spp.	**jij te'**	3
pleasant	*Tagetes lucida*	**tzitz ak**	2

cessing because of the limits of working memory (Miller 1956). Rosch et al. (1976) proposed that because complexity increases as more items are included in a set, set boundaries are established in the most cognitively economical way by paying attention to the fewest number of observable attributes that maximize differences between sets of items. In any group of similar items, some are recognized as prototypical because they best represent the attributes that form the pattern of resemblance within the group (Mervis et al. 1976). Thus, robins or sparrows are recognized as being more "bird-like" than birds like penguins (Boster 1988). This is because the domain of "birds" is bounded by a set of attributes shared by most members (e.g., flight, feathers, wings), but the attributes are not exhibited equally by all members (e.g., penguins have small wings and do not fly). Prototypical members of a domain are those that best express the attributes that define the domain (Rosch 1978). The concept of prototypes is very powerful when applied to sub-groupings within a domain, such as plants and animals grouped into folk genera (Berlin 1992).

Prototype-based set inclusion has also been proposed as a basis for inductive thinking (Gelman 1988). Humans appear to use attributes of one domain to develop hypotheses about contents of other domains and the relationships between domains (Coley et al. 1997). Studies of childhood learning indicate that living things are particularly good for human inductive development because they conform well to children's expectations about essential attributes of living organisms, and biological domains are the earliest to take form as children develop (Keil 1994, Markman 1989, Stross 1973). Illness experiences have also been shown to form domains that include prototypes (D'Andrade et al. 1972, Kay 1979, Young 1981). Medicinal plant prototypes may serve as powerful inductive tools helping to structure concepts of disease by highlighting attributes of illness experiences.

Because pathogens and flora are continually changing, and ideas are shared within and between communities, traditional medicinal systems rely on continuous experimentation with new plants (Barsh 1997, Berlin and Berlin 1996). Sharing knowledge about successful treatments can lead to agreement about a plant's efficacy (Moerman 1998, Trotter and Logan 1986). As a result, selection of medicinal plants is an on-going process and much of the knowledge needed for healing common physical ailments is distributed throughout populations (Caniago and Siebert 1998, Garro 1986, Trotter and Logan 1986). Medicinal plant prototypes may serve as personal and cultural reference points through which information about illness and curing are recalled and transmitted.

The research reported here indicates that some plants in Tenejapa do serve as "best examples." When interviewees tasted a bitter remedy that they could not identify they would most often say it tasted like **yakan k'ulub wamal** (*Verbena litoralis*, Table 5). When asked to recall all of the medicinal plants they knew, *V. litoralis* was mentioned most frequently and sooner than any other plant. Also, all interviewees visually identified *V. litoralis* as **yakan k'ulub wamal**, a better success rate than for any other plant in the study. Other plants were also more likely to be mentioned when people were trying to identify the plant that they were tasting, although not as consistently as *V. litoralis* was for bitterness (Table 5).

To understand the role of prototypes it is necessary to consider what might make some medicinal plants prototypical. Participants did not indicate that *V. litoralis* was particularly powerful,[5] and it has no outstanding visual characteristics. However, it does grow close to peoples' homes where it is abundant. *Salvia lavanduloides* was another potential prototypical medicinal plant (Table 5), but appeared to be less important than *V. litoralis*, perhaps because it tends to grow in small, widely-distributed patches further away from homes. *Smallanthus maculatus*, the plant used to cure me, requires at least a half hour's search, and was never mentioned on freelists or as the identity of a taste. Thus, the frequency with which a plant is encountered may cause it to be "favored" in human cognition and communication. Moerman (1998) has suggested that some plant families (e.g., Asteraceae) dominate traditional pharmacopoeia because their tendency to grow in disturbed habitats near residential areas makes it easier to share information about them. Caniago and Siebert (1998) have shown that residents of a Dayak village in Indonesia were more knowledgeable about medicinal plants found in early successional forests than those of primary forests. Stepp (1998) has also suggested that the Tzeltal rely more on plants from disturbed habitats.

But frequency alone cannot explain why some plants may be prototypical medicinals. Fabaceae species, for example, are abundant near peoples' homes in Chiapas (Bye 1993) and have been found to contain many important phytochemicals (Elvin-Lewis 1986), but they are much less likely to be used as medicinals than species of other families (Moerman et al. 1999), and I found no evidence that they might be prototypical medicinals. In his research on bird classification, Boster (1988) suggested that the "typicality" of bird species provides higher informational content about category structure than the frequency with which species are encountered. Results of a study that I conducted on Tzeltal knowledge of plants in a relatively inaccessible, relict primary forest suggested that medicinal knowledge and agreement about plants was high, even though encounters with plants were very infrequent (Casagrande 1999).

It is important to note that the attributes used to define a set, and which are best exemplified by prototypes, can be culturally based but still reflect discontinuities in a large domain (Geeraerts et al. 1994, Hunn 1982). Tzeltal medicinal plant and illness classification includes a dichotomous hot-cold system, in which certain plants are appropriate to treat hot or cold illnesses (Berlin and Berlin 1996). Although the hot-cold classification is fairly rigid for illnesses, many plants can be considered either hot or cold depending on the context of their use (Berlin and Berlin 1996). This suggests that conceptualizations of efficacy, whether biologically or culturally based, are not unique to each individual plant. Cognitive processes must draw on a knowledge base that spans the medicinal plant and illness domains, and this complex information must be organized in an efficient manner.

V. litoralis may serve as a prototypical medicinal plant and facilitates recall and communication because biological, ecological, and cultural-based attributes converge on the species: 1) it is bitter; 2) it is a member of a common medicinal plant family (Moerman et al. 1999); 3) because it is abundant near homes, everyone will probably have used it to cure diarrhea at some point during their lives; 4) it will be easy for people to talk about its hot/cold or biological properties because it is always nearby; and 5) it's used mostly to treat gastrointestinal illnesses, which currently are the most problematic illnesses

[5] Interviews I have conducted suggest that *Nicotiana* spp. and *Datura* spp. are considered the most powerful and dangerous medicinal plants in the area.

in the region. Interestingly, under this bio-cultural scenario, visual characteristics and strength may be less important.

If prototypical plants like *V. litoralis* help people think and communicate about medicinal plants and illnesses by representing salient biological and cultural attributes, then the Tzeltal Maya may draw upon these plants, which are more "medicinal" than others, and extrapolate attributes to other plants and illness experiences. This very likely plays a role in selecting plants for experimentation. An hypothesis that medicinal plant prototypes help guide medicinal plant selection could be tested by immersing people in an unfamiliar flora and asking them to find potential plants to cure illnesses they are familiar with. The hypothesis could also be tested via discourse analysis. In casual, unguided conversation about illnesses and potential medicinal plants, one would expect topics to revolve around prototypical plant species.

Conclusion

It is clear that people find beneficial phytochemicals by selecting plants to use as medicinals, and that taste plays a major role in this process. But for the Tzeltal Maya, taste does not appear to serve as a direct chemical cue for any particular type of illness. The research reported here showed that individual Tzeltal Maya, who had a good knowledge of medicinal plants and agreed about their use, could not predict the use of individual plants based on taste alone. Bitterness was probably not correlated with any particular class of illnesses because there is not enough resolution in human taste to discriminate the diversity of chemicals that taste bitter. Furthermore, some non-bitter plants are very powerful cures. The role of taste is more likely mnemonic, and functions in combination with other plant attributes and illness experiences. Prototype theory may offer a way to understand how human cognition and communication function in attempts to reduce informational complexity and reconcile the very different domains of plant classification and illness experiences.

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