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The Nature and Acquisition of a Preference for Chili Pepper by Humans[1]

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This paper deals with the general problem of the acquisition of positive affective responses, by study of the reversal of an innate aversion to the irritant properties of chili pepper. Interviews, observations, and measurements were carried out in both Mexico and the United States. Exposure to gradually increasing levels of chili in food seems to be a sufficient condition for preference development. Chili likers are not insensitive to the irritation that it produces. They come to like the same burning sensation that deters animals and humans that dislike chili; there is a clear hedonic shift. This could be produced by association with positive events, including enhancement of the taste of bland foods, postingestional effects, or social rewards. It is also possible that the initial negative response to chili pepper is essential for the eventual liking. Chili stimulates an innate sensory "warning" system but is not harmful. The enjoyment of the irritation may result from the user's appreciation that the sensation and the body's defensive reaction to it are harmless. Eating of chili, riding on roller coasters, taking very hot baths, and many other human activities can be considered instances of thrill seeking or enjoyment of "constrained risks."

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Evidence for and against various explanations of chili ingestion is presented.

The majority of adults in the word ingest, every day, at least one innately rejected substance. These substances often taste bitter or irritate the oral mucosa. They include items of major commercial and/or medical importance, such as coffee, beer, spirits, tobacco, chili pepper, and other strong spices. In most cases, the development of these preferences is associated with an affective shift, from dislike to like. This basic transformation has not been seriously explored, even though it exemplifies a fundamental issue in the psychology of affect.

Previous studies of food preference provide only suggestive information about positive affective responses and their causes. One can prefer A to B, though one likes B more, as when a dieter forgoes ice cream for cottage cheese (Rozin, 1979). Although this distinction is obvious, it has often been blurred, with a resulting neglect of the affective side. Perhaps this is because affect is harder to measure than preference, especially in animals. However, the affective component may well be the psychologically most interesting aspect of food selection, and a major determinant of food choice. Ultimately, one must face the serious issue of distinguishing preferences based on consequences (which we shall call medicine effects) from preferences based on liking. In order to do so, verbal reports are of fundamental value. However, they may be supplemented by direct observations (e.g., of facial expressions) and by analysis of the history of interaction with a food, to determine if there is a basis for learning that a food has a particular consequence.

This study addresses, through a specific case, the general problem of the development of affect. At this point, it is not clear whether the reversal in affective responses to chili pepper shares common mechanisms with the frequent development of affective responses to initially neutral foods. By the same token, it is not obvious that the same affective mechanisms are at work in food preferences and other types of preferences (friends, toys, music, etc.). There is very little information in any of these areas; they have received little attention since the emphasis some decades ago on affective processes (e.g., Young, 1948). Since the chemical senses seem more "primitive" and "affect-laden" than other input channels (Pfaffman, 1960), study of the development of affective responses to food seems particularly appropriate.

The existing literature on affect does not provide us with a well-defined set of theories to test. There is no answer to the question: "How can I get X to like Y?" where Y can be food or almost anything else. We will examine a number of explanations that might reasonably account for the affective response we have chosen to study: the liking for chili pepper. We will evaluate

the role of mere exposure (Zajonc, 1968), the possibility of sensory changes, the importance of associative factors such as positive aftereffects, and the role of thrill seeking or "masochism."

Chili pepper has been selected as the subject for study for a number of reasons. It is a substance of importance in its own right. It is probably the most widely consumed spice in the world (Rosengarten, 1969; Moore, 1970; Rozin, 1978). It is cheap, nontoxic (its bark is worse than its bite), and easily available. The source of pungency, capsaicin, is available in purified form. While it shares its initial unpalatability with other popular substances like tobacco and coffee, it stands out because it does not seem to be addictive: it provides a way of studying the development of liking for initially unpalatable addictive substances, with the addictive feature factored out.

All chili peppers (*Capsicum sp.*) come from the Americas (see Rozin, 1978; Heiser, 1969; Maga, 1975, for more detailed discussions of chili peppers). Four species account for most of the hundreds of varieties available in the word today. There are records suggesting use of chili pepper dating back to 7000 B.C. in Mesoamerica; they were domesticated some thousands of years after this (Pickersgill, 1969). These fiery foods made their debut in the Old World when they were brought back by Columbus and other early explorers. In spite of their initial unpalatability, they became accepted as a basic part of the diet in many parts of the world: West and East Africa, India, Southeast Asia, parts of China, Indonesia, Korea, and other smaller geographic regions, such as Hungary. It is hard to explain this spread, either in terms of mechanisms or in terms of adaptive value. When eaten in sufficient amounts, these peppers are a good source of vitamins A and C (see Rozin, 1978, for a discussion of other possible adaptive values). Chili peppers are typically used as a flavoring ingredient in cuisines with bland grain staples.

There is no literature on the nature or acquisition of chili preference. Although the preference is widespread in humans, there are no reports of equivalent preferences in omnivorous animals in nature. This should not be surprising, since the pungency is surely an adaptation to keep animals from eating the fruit. Furthermore, extended experimental attempts to induce a preference in rats, through exposure or reinforcement procedures, have not established a clear parallel for human chili liking (Rozin, Gruss, & Berk, 1979).

The approach used here is to study the phenomenon in its "natural" home, in humans. The approach is broadly based, appropriately for an initial exploration. The techniques of interview, observation, and sensory-hedonic measurements are employed. Two populations are studied: adults in the United States, and children and adults in a rural village in the highlands of Mexico, the setting in which chili pepper has been used traditionally for thousands of years. We will first describe the natural

history of chili use and the development of the preference, and then consider the evidence in favor of a series of hypotheses that might explain the acquisition of preference.

METHOD

Subjects and General Procedures

The American subjects were 57 members of the University of Pennsylvania community. All but 1 were students, 17–25 years old. There were 22 males and 35 females. Ten subjects were Hispano-Americans.

The Mexican subjects were all residents of a village in the highlands of Mexico. Sixty-three residents, 4–56 years old, provided interview, sensory measurement, and/or observational data. In addition, 265 residents, mostly children, participated in a brief preference test.

The 57 American subjects were interviewed and tested, 1 at a time, for approximately 1 hour. No subject had eaten spicy foods within 3 hours of the interview. The session consisted of three segments. The first was a test for the threshold for detection of the oral irritant effects of pure capsaicin in solution. These results are reported elsewhere (Rozin, Mark, & Schiller, 1980). The second segment was a 30-minute structured interview about chili-eating habits, experiences related to chili, and reasons for consuming it. The specific questions will be mentioned as they become relevant in describing the results. Some asked for preference ratings. All of these were based on a 5-point scale: strong like, like, neutral, dislike, and strong dislike. Some questions were open-ended, such as, "Why do you like chili pepper?" Others offered specific choices (e.g., specific reasons for liking chili pepper). Open-ended questions always preceded specific questions on the same subject, so that the choices would not suggest "spontaneous" responses.

The third phase of the session was a determination of the threshold, preference, and tolerance level for chili. The stimuli were highly palatable corn-cheese bite-sized snacks, similar to commercial products. Corn flour collets were coated with a mixture of cheese and oil. Pungency was varied by adjusting the level of capsicum oleoresin (a pungent oil extract of chili pepper, used commercially) in the oil phase.[3] Eighteen different levels were

[3]The corn snacks were composed of 56.8% corn flour (the collet) and 35% hydrogenated soy oil, 7% dehydrated cheese, and 1.2% salt (the coating). They were prepared by the Frito-Lay Corporation. The snacks are described here by the Scoville level of the collet coating. Since the coating constitutes only 35% of the weight of the final product, the actual Scoville level is about one-third of the level referenced here. The snacks weighed .706 g (mean) with a standard deviation of .090 g.

produced, ranging from 0 to 262,000 Scoville units, by successively doubling the concentration of oleoresin. A Scoville unit is the commonly used linear measure of pungency, such that 1 Scoville unit is the concentration at the absolute threshold for detection, using trained panels and optimal conditions.

The sequence of snacks (in Scoville units of the coating) offered to each subject was: 0,4,16,0,32,64,0,128,256,0,512,1024,0, etc.[4] The blank (0) stimuli were eliminated in the later part of the series, as indicated below. Subjects sampled one snack per minute.[5] They were told that some of the snacks would contain small accounts of chili and that they were to report any tingling or slight burning in their mouths when asked by the experimenter (40 seconds after ingestion). They were informed that the first snack had no chili. The subject was also asked if he/she was sure about sensing the burn, and if the last snack was liked more, less, or the same as the one before it. This procedure continued until the subject completed the next blank trial after a "sure" positive response. The threshold was set as the lowest concentration to which the subject responded with a "sure" positive. After the subsequent blank, no additional blanks were used, and the subject was told that each stimulus would be stronger than the one before. The same procedure was followed, except that the subject was asked whether he liked each snack more, less, or the same as the one before, and whether he would like to continue with a stronger cracker. Fifty-four of the 57 American subjects completed this sequence. Thirty-six of these had "clean" thresholds: they showed neither false positives nor false negatives.[6]

The preferred level was set as that snack that was preferred to both its predecessor and its follower. When more than one snack met this criterion, the preference level was calculated as the geometric mean of the extreme values given a maximum rating. In cases where the subject reported that the threshold level of chili was less palatable than the snack without chili, the pungency value of the stimulus just below the threshold value was used as the preference level. The tolerance level was simply the highest level accepted. The strongest snack (262,000 Scoville units) was sampled by only a few subjects.

The Mexican subjects did not receive the liquid threshold tests. Fourteen residents of the village were interviewed, using a Spanish translation of the interview protocol. Thirty-six subjects, 5 to 56 years of age, experienced the same snack test as the Americans. No subject had eaten

[4]Snacks of 2 and 8 Scoville units were eliminated after pilot runs, since thresholds rarely dropped below 16 Scoville units.

[5]For stimuli offered before a clear threshold was established, if a subject still experienced a burn 10 seconds before the next snack was scheduled, it was put off for as many minutes as necessary for the burn to dissipate.

[6]About half of the subjects experienced a stronger snack after the threshold snack and before the final blank, allowing for the possibility of a false negative.

chili within 3 hours of the test. Twenty-four of the subjects showed clean thresholds. A parallel series of threshold-preference-tolerance measures was carried out on 18 children (ages 4 to 15 years) in the village. The stimuli in this case were made in our laboratory and were tortilla squares containing measured amounts of capsaicin, in concentrations from .62μg/g to 637 μg/g. The tortilla sequence was run in exactly the same way as the corn snack sequence.

The reliability of threshold measures can be assessed by comparing thresholds from the same subjects with aqueous solutions of capsaicin (Rozin, Mark, & Schiller, 1980) and corn snacks. The thresholds for 31 American subjects who performed without errors on both tests correlated .73 (Pearson *r*).

The Mexican and American samples differed markedly in exposure to chili. Chili is eaten at least three times a day by almost every Mexican in the sample, while in the American population, the median frequency of ingestion was once per week and the mean was 2.62 times per week. Preference differences between the samples were smaller: 68% of Americans and 88% of Mexicans liked chili,[7] while 16% and 4%, respectively, disliked it. (The difference is probably greater than this, because Mexicans interpreted "liking" chili to refer to adding chili to food that is often already moderately piquant, as cooked.)

RESULTS

The Natural History of Chili Use in a Mexican Village

Fieldwork was carried out in a traditional Zapotec village (Whitecotton, 1977; Selby, 1974), on the high plateau near the city of Oaxaca.[8] Most of the approximately 1,500 residents speak both Zapotec and Spanish. Almost all of the families grow their own food and have minimal cash income. Electricity was installed in the early 1970s; electric lights and radios are common, but there are only a few televisions or refrigerators. There are no modern sanitary facilities, and there is one elementary school.

The food habits and kitchens are quite traditional. Tortillas are made by hand in each home from corn prepared each day from the family

[7]Subjects rated their preference for chili on a 5-point scale (strong like, like, neutral, dislike, strong dislike). (American subjects were asked to rate chili in "preferred" levels.) Subjects reporting "strong like" or "like" are classified as chili likers.

[8]The studies in Mexico were carried out during three visits, varying from 4 days to 14 days in length. They were made posible because of the generosity of Professor Henry Selby, of the University of Texas. He had been carrying out studies in cultural anthropology in the village for some 10 years (Selby, 1974). He accompanied Rozin to the village for the first visit and introduced him to friends and families with whom he had worked. From this point on, Rozin continued the studies under the general aegis of the projects supervised by Selby.

storehouse, ground in one of the few mills in the village each morning. The basic diet is very similar to the diet of pre-Columbian Mexicans: corn (in the form of tortillas), beans, tomatoes, chili, squash, and a variety of vegetables, plus meat in small amounts. The major change in the diet in the last 500 years has been the introduction of a variety of meats (pork, beef, chicken) to supplement the only native domesticated animal, the turkey. Food is prepared in the traditional manner, on a stone hearth with a wood fire. The beverages used now are markedly different from those in pre-Columbian times. Soda and beer are most common when they can be paid for. Otherwise, water is the principal beverage.

Chili pepper is a ubiquitous feature in the Mexican dietary. Although eaten in relatively small amounts, its distinctive taste and pungency contribute enormously to the basic character of Mexican cuisine. Chili pepper can be considered as the major flavoring element (flavor principle) in the cuisine (Velazquez de Leon, 1972; E. Rozin, 1973). In the village, virtually all residents over the age of 5 or 6 eat chili pepper in some form at all three meals, along with the solids of the meals. Over eight varieties of chili are used in this village, some dry and some fresh. All are pungent, although they vary in degree of pungency. They are eaten in three ways: (1) whole, or in slices placed on foods; (2) cooked in stews or soups; and (3) ground up, usually with tomatoes and other seasoning, into a sauce (*salsa*) that is placed on tortillas with other foods. Chili pepper flavors almost all nonsweet foods, but it is seldom eaten with sweet foods, and never in beverages.

Villagers rarely, if ever, go without chili pepper. They say that they miss it when forced to go without it (for example, on a few-day trip to the mountains to cut wood). There is voluntary abstention from chili ingestion during periods of illness, especially of the gastrointestinal system (a not uncommon occurrence). Most residents interviewed claim to crave chili during these periods, but they abstain on "doctor's advice." Of course, any food has a place in a culture that may not be captured by a description of usages. Chili may well have symbolic functions. It may, for example, be associated with strength or manliness (*machismo*).

The Natural History of Chili Preference Development

Studies on the development of alcohol and tobacco preferences suggest that the acquisition of preferences for innately unpalatable substances can be divided into two phases. First, initial samplings and exposures occur in the absence of a desire of the novice user for the sensory properties of the substance. These initial exposures can be motivated by the potent social forces of peer pressure and the desire to be adult (Albrecht, 1973) or by the incorporation of these substances into religious or

traditional practices (Damon, 1973; Bacon, 1973). Such substances are rarely forced on children: rather, the social situation dominates over the child's aversion to the taste. In the second phase, for many (but not all) traditional users, the sensory properties become palatable in themselves, so that the behavior may survive even if the social support disappears. It is this transition from extrinsic to intrinsic control that concerns us here. For the cases of alcohol or tobacco, the intrinsic control may relate to addictive or nonaddictive seeking of the pharmacological effects, as well as, or instead of, liking for the taste. In the case of chili pepper, we are more likely to be concerned with a pure hedonic shift related to flavor.

Examination of some anthropological sources on cultures that use chili pepper suggests a pattern of introduction that resembles that for tobacco or alcoholic beverages in some ways, but that occurs earlier in life. In some chili-eating cultures, chili is placed on the mother's breast to facilitate weaning (Jelliffe, 1962; Sanjur, Cravioto, Rosales, & van Veen, 1970). It is commonly believed that chili is not good for infants or very young children (Sanjur et al., 1970). In general, young children seem to be protected from explicit exposure to chili in the first few years of life. There are no systematic data on the time course of preference development; the age of 10–11 was suggested as the point where a positive preference appears in an Indian community in the southwestern United States (Hacker & Miller, 1959).

We used three sources of information in a more systematic study of preference acquisition: (1) interviews, (2) direct observations at meal time in Mexican families, and (3) measurements of preference.

The American subjects were asked in the interview, "How did you get to start eating chili?" The most common responses among chili likers (see footnote 7) were that it was used at home (37%), that the parents put it on the food (29%), and that the first exposures were in restaurants or eating out (18%). In response to "How did you come to like chili?" the most common answer was that it was never disliked (43%); that is, the subject could not remember disliking it. Discussions with parents in both the United States and Mexico have indicated that only very rarely do children like moderate levels of chili from the start. The next most common responses were "development" of a taste (23%), through exposure (23%), and enhancement of the flavor of food (11%).

Fourteen Mexican and 57 American respondents were asked to indicate whether a series of statements described their early exposure to chili pepper. All Mexican subjects claimed that chili is introduced initially in small amounts, with the level increased gradually. All agreed that by about 5–6 years of age, children come to season the food as they wish. Among Mexicans, no specific rewards were given to children for eating chili, but

there was some friend or sibling pressure to eat it (77%). All Mexican adults agreed that chili was not pushed aggressively on the children and that they were always free to refuse seasoned food without serious consequences. They would just eat an unseasoned version of the same food (e.g., without *salsa,* the piquant tomato and chili sauce), or plain tortillas and other available foods, if the chili was cooked with the food. The American data do not reveal a clear pattern. The major difference between the early experiences of likers and neutral-dislikers is the more frequent use of chili by parents of the likers (46% in likers vs. 6% in neutral-dislikers). Some likers (21%) but no dislikers were exposed to gradually increasing concentrations. Mixing with favorite foods (56% vs. 41%), some parental pressure (36% vs. 24%), introduction in very small amounts (42% vs. 59%), and freedom to season foods to taste (72% vs. 65%) occur at similar frequencies in both the liker and disliker populations.

Discussion of chili-feeding practices with 11 Mexican mothers and observation at mealtime in three different homes, all with young children, provided information that confirmed the data from interviews. The mothers agreed that children in the 1- to 3-year age range are introduced to chili in mild forms cooked in the food (such as soup or mole). However, practices seem quite variable: some mothers said that they might make a less piquant or a nonpiquant version of a soup if they had a very young child. (In our limited observations, the earliest instance of eating a piquant soup was a 9-month-old child, and the youngest child eating a tortilla with *salsa* was 1 year old). All informants agreed that chili, in soup or as a *salsa,* was not forced on children. In the case of *salsa,* a small amount was put on a tortilla for children in the 3–5- (but occasionally 2-) year range. If the child rejected it, the mother would prepare another tortilla, with less or no *salsa.* Direct observations confirmed the spreading of *salsa* by the mother, but no case of refusal was observed. All informants agree, and our direct observations are in accord, that at about 5 years of age children begin to season foods for themselves; *salsa* is placed on the table, and children add it themselves (Figure 1).

Some evidence for the development of preference can be seen in the data collected on corn snack and tortilla series with children. There is a significant correlation between age and both tolerance for chili in corn snacks (age range 5–16 years) and preference for chili in tortillas (age range 4–15 years), but there is a great deal of variation (Table I). Systematic changes in preference or tolerance do not seem to occur after late adolescence (Table I).

More systematic study of preference development became possible when we noticed that children in the local school were consuming a reddish powder during a morning recess period. Queries and a sampling of this

Fig. 1. Four children eating lunch in a home in the village studied. Each child has a large tortilla. Refried beans (large bowl with dark contents, on left), salt (on a napkin in front of this bowl), and the "salsa" of chili and tomatoes (small bowl to right of beans) are placed on the tortilla. The boy on the extreme left is seen dipping a piece of tortilla into the hot sauce. The children at this meal are three brothers and one first cousin. Their ages, going clockwise from the child in front, with back to the camera, are 5, 8, 10, and 14 years. In this family, the 5-year-old seasons his own tortilla with hot sauce, though his 4-year-old sister (not in this picture) has the sauce added in small amounts by the mother.

snack revealed that it was a mixture of chili and salt (called *sal de picante*), sold at a booth in the central square. The powder was in small cellophane envelopes (about 4 cm square) and weighed about 2.5 g. The powder had a piquacy level of 2,5000 Scoville units. A natural "control" choice was sold in the same booth: cellophane packages of the same size and price (about .5 U.S. cents per package). These snacks, called *sal de dulce,* were made of sugar and fruit flavor and came in four appropriately flavored colors: red,[9] green, yellow, and orange. They were sweet but also had a distinct sour (tart) taste. A preference test was arranged using both of these well-known and popular snacks. And so it occurred that the little booth in the center of town received the largest order it ever got for *sal de picante* and *sal de dulce* (or anything else): some 500 individual cellophane packets. A full class in each of the six grades in the elementary school was tested. The test consisted of the choice of one of five snacks: the piquant item, and one of each of the

[9]The red sweet snack was easily distinguished by color from the red *sal de picante.*

Table I. Correlation between Age and Chili Threshold, Preference, and Tolerance in Mexican Subjects[a]

	Group		
	Tortilla test (Ages 4–15)	Corn snack (Ages 5–16)	Corn snack (Ages 18–56)
Number	18	18	18
Threshold[b]	+.17[b]	−.04[b]	+.22[b]
Preference	+.52[c]	+.20	−.07
Tolerance	+.28	+.41[d]	+.01

[a] All values are Pearson r's.
[b] Only includes subjects with clean thresholds. N = 11 for children on snacks. N = 13 for adults on snacks.
[c] $p < .025$.
[d] $p < .05$ (one-tailed).

colors of the sweet variety. These were laid out in a row, with order varied from subject to subject. Children were asked to pick the one they wanted and were allowed to eat it. The choice was made at the teacher's desk in each class: children came up one by one and selected one snack. Age, sex, and choice were recorded for each child. A similar preference test was carried out with a "nursery school" group of 4- and 5-year-olds, and on individual children (in the 2–5-year range) and adults in their homes. A total of 265 subjects was run; 52% were female.

The data are analyzed in 2-year age groups (from 2–3 to 12–13) up to 13, and one "adult" group (14 years and older) (Figure 2). There is a gradual increase in piquancy preference, in comparison to sweet-sour over the age range of 2–3 to 8–9 years. This emerges as a clear piquant preference (passing over the indifference point of 20% piquant choices) by age 6–7. This finding fits well with parental descriptions and our observations. The dip in preference after age 8–9 is puzzling. The stabilization of preferences

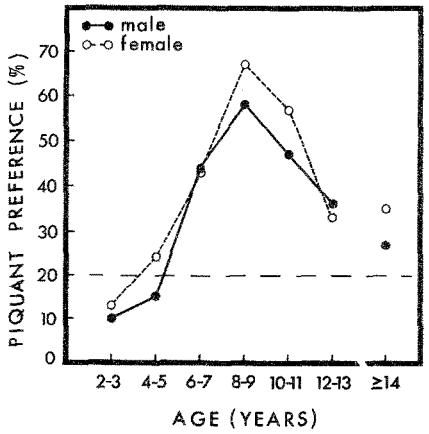

Fig. 2. Preference for a salty-piquant snack (*sal de picante*) versus four sweet-sour snacks (*sal de dulce*). The dotted line represents the predicted level of piquant selection, if the subjects chose randomly. The points represent data from a minimum of 8 to a maximum of 32 subjects.

at adult levels by about age 10 is consistent with our other measurements. The net piquant preference is small in the adults and older children. This may reflect a change in taste for snacks in this group; all of their food at meals is highly seasoned with chili, and the preference for a sweet snack may simply reflect the desire for variety. The choices of the 6–10-year-olds may have been partly enhanced by a desire to eat an adult taste. It is also possible that the dip is not as great as it appears to be: a pilot run with these same choices yielded a similar curve up to age 10, but no dip following that age.[10]

In summary, there is a gradual increase in preference for chili over the period of 2 to 8 years. Exposure to gradually increasing amounts (without much overt social pressure) seems to be the major factor necessary to produce this change.

The Role of Desensitization

Chili preference might be related to receptor desensitization. However, there would have to be positive features of chili that support a preference once the desensitization took place; otherwise, desensitization would lead to neutral responses. There is some reason to believe that desensitization to capsaicin could be a factor in human chili ingestion. High concentrations of capsaicin placed on the skin of humans or rats produce drops in sensitivity to subsequent applications of capsaicin that last for hours up to days after the initial treatment (Jancsó, 1960). Systemic injections of high levels of capsaicin into rats and guinea pigs produce months-long complete desensitization to the effects of capsaicin and other chemical irritants. Desensitized rats do not respond (as with paw wiping) to irritating solutions of capsaicin or ammonia placed in their eyes (Jancsó-Gábor & Szolcsányi, 1969). However, all evidence for long-term desensitization comes only from systemic capsaicin. We do not know to what extent orally ingested capsaicin is absorbed.

There is some evidence against desensitization from ingested chili at levels typical for humans in chili-eating cultures. Rats raised on such a diet (chili pepper in rat chow) for 11 months showed no reliable drop in their rejection threshold for chili pepper in chow (Rozin, Gruss, & Berk, 1979).

[10]Two other factors might be considered in the interpretation of these data. First, the *sal de picante* is very salty, and it is conceivable that this aspect of the taste is a potent determiner of choice. (The sour component in the *sal de dulce* may also have influenced choice.) While this is almost certainly true, the inclusion of a piquant taste in this very popular snack can hardly be considered an accident. Second, the measures taken are of relative preference. The choice of sweet-sour over salty-piquant snacks by young children does not imply that they do not like piquant foods, only that in this particular vehicle, at "snack time," they prefer the sweet-sour choice.

Table II. Chili Thresholds, Preference, and Tolerance in American Subjects as a Function of Chili Liking[a]

Measure	Chili likers			Chili neutral or dislikers		
	N	$\bar{X}$	s	N	$\bar{X}$	s
Threshold (clean)	27	8.04	1.48	9	7.44	.73
Threshold (all)	38	7.55	1.69	16	7.31	.95
Preference	38	11.26	2.16	16	7.31[c]	1.20
Tolerance	38	13.34	2.04	16	10.31[c]	1.49
Tolerance minus preference	38	2.08	1.41	16	3.00[b]	1.51
Tolerance minus threshold	38	5.79	2.44	16	3.00[c]	1.93

[a] All values are expressed as $\log_2$.
[b] $p < .025$, likers vs. neutral-dislikers, t test, one-tailed.
[c] $p < .001$.

Among humans, chili users (or likers) were shown to have higher detection thresholds for capsaicin, and less salivation in response to it (Rozin, Mark, & Schiller, 1980). These effects were small in magnitude, and there was substantial overlap between likers (users) and dislikers.

The desensitization position holds both that use leads to desensitization and that desensitization leads to or permits liking. We can test for predictions that would come from a desensitization position with the data gathered in this research:[11]

1. Mexicans, eating chili a number of times a day, should show higher thresholds than Americans averaging a few exposures a week. There is a slight, nonsignificant difference between Mexican (8.31 $\log_2$ units) and American (7.31) thresholds. The difference does favor the desensitization hypothesis and is confirmed by a similar effect in the capsaicin threshold studies (Rozin, Mark, & Schiller, 1980).

2. Americans who like chili should have higher detection thresholds than those who are neutral to it or dislike it. American chili likers have a slightly higher threshold, though the effect is not significant (Table II). The difference is very small, compared to the large differences in preference and tolerance between these groups (Table II, rows 3 and 4).

3. In both popultions, chili preference and tolerance should correlate positively and substantially with chili threshold. These data are analyzed separately for Mexican and American populations. For the Americans, Pearson correlations have been computed between both liquid and corn

[11] For the results on threshold desensitization reported here, only subjects with "clean" thresholds (no false positives or negatives) are included in the analysis.

Table III. Relations among Threshold, Preference, and Tolerance for Mexican and American Subjects

Measure	Mexicans		Americans	
	N	*r*	*N*	*r*
Corn snacks				
Threshold vs. preference	24	+.39[b]	36	+.29[b]
Threshold vs. tolerance	24	+.36[b]	36	+.20[b]
Preference vs. tolerance	24	+.89[d]	54	+.83[d]
Liquid capsaicin and snacks[a]				
Threshold vs. preference			47	+.32[c]
Threshold vs. tolerance			47	+.23
Tortilla chips				
Threshold vs. preference	18	+.37		
Threshold vs. tolerance	18	+.35		
Preference vs. tolerance	18	+.88[d]		

[a] Liquid capsaicin thresholds from Rozin, Mark, and Schiller (1980).
[b] $p < .05$, one-tailed.
[c] $p < .025$.
[d] $p < .001$.

snack thresholds and corn snack preference and tolerance. For the Mexicans, threshold versus preference and tolerance correlations were computed for both the corn snack and the tortilla stimuli. The results (Table III) are remarkably consistent: for liquid, corn snack, or tortilla vehicles, for Mexicans or Americans, for preference or tolerance measures, correlations with thresholds are all in the range of .20 to .39 (Table III). In comparison, preference and tolerance correlate in the .8 to .9 range (Table III).

4. Threshold should increase with exposure, and hence with age, in the Mexican population. Unlike the American population, the Mexican population represented a large age range (4 to 56 years). Since there is a steady exposure to chili in this culture from at least age 6, there should be an increase in threshold with age because of the hypothesized desensitization. There are no significant relations between age and threshold, within either the group of children or the adults (Table I).

In summary, there is probably a weak desensitization effect, but it is too small to explain liking (or failure to dislike) in typical cases. Furthermore, many of the American chili likers ate it very infrequently.

It may be that extremely heavy chili eaters ingest enough capsaicin to produce true desensitization, either through topical action in the mouth or by absorption of sufficient amounts to produce systemic effects. Two subjects tested in Mexico regularly ate whole hot chillies. One (age 14),

exposed to both the corn snack and tortilla tests, had not yet reached his preference value when he had consumed the strongest stimulus in each series. He showed no signs of physiological response to these fiery stimuli, and he had the highest threshold in both series (5 $\log_2$ units above the mean). Another subject, a 20-year-old female, who also ate whole chilies daily, was given the tortilla test.[12] She reported that most whole chili peppers hardly burned, and she produced no obvious physiological response (sweating, tearing, runny nose) to a few peppers eaten in our presence. Her threshold for the tortilla chips (80μg/g) was the second highest level. (The mean threshold for the 4–15-year-olds was 8.1μg/g). Finally, the American subject with the highest chili intake, including straight hot peppers, had the highest threshold in the American group. The next two highest thresholds were also from subjects who ate whole hot chilies. All three of these subjects were Mexican-Americans.

Alternatives to Desensitization: Getting to Like the Burn

If the oral receptors are sending about the same message to the brain in the chili liker and the chili hater, then the chili liker must have come to like the very same sensation that the chili hater, the infant, and nonhuman animals find aversive. One gets to like the burn. There is direct evidence in favor of this view from interviews with both Americans and Mexicans who were asked why they liked chili. Most of the Mexicans (N = 63) and Americans (N = 57) responding to this question offered only one reason. Of the 125 responses, 106 referred either to the flavor, the piquancy, or the enhancement of flavor of food. Most subjects mentioned the flavor rather than the piquancy. However, 28 of the Mexican subjects who mentioned the flavor were then asked if they meant to include piquancy as part of the flavor; 26 of 28 responded affirmatively. The modal Mexican response was: "da sabor a la comida" (adds flavor to food). Only 15% of responses dealt with consequences of eating chili, such as improving health or giving strength. When asked to indicate the relevance of a list of specific reasons for liking chili (Table IV), both Mexicans and Americans affirmed a larger range of reasons, including some consequences of chili ingestion. However, flavor-related reasons remain prominent.

There is further evidence that likers specifically like the burn. Mexicans, as a group, do not seem to like the flavor of chili when it is disembodied from the piquancy. The Frito-Lay company attempted to

[12]Because this subject was the only one above 15 years of age in the tortilla series, her results were not included in the group analysis of the results on this series.

Table IV. Responses to Specific Items as Candidates that Might Explain Liking for Chili Pepper in both Mexican and American Populations

Question	Percent affirmative responses	
	Americans (N = 39)	Mexicans (N =13)
I'm used to it.	36	100[a]
It tastes good.	95	100
I like the burning or tingling feeling.	79	85
It makes it easier to chew food.	5	77
It stimulates my appetite.	15	85
It fills me up.	3	69
It wakes me up.	15	46
It puts me to sleep.	0	0
It makes me feel warm inside.	46	69
It cools me off.	3	15
It makes me feel high.[b]	0	—[b]
I feel good after I've eaten it.	44	92[a]
It is good for me.	5	69
It keeps me from getting sick.	3	15
It kills the microbes (bad things) in the food.	3	69
It makes me think clearly.	5	50
It makes me strong.	3	92
I don't want to appear weak.	0	50[a]
Food tastes too bland without it.	41	100

[a]Only 12 subjects responded.
[b]Experimenter could not adequately translate this item.

market in Mexico some of their corn-based snacks with chili flavor but no piquancy. This product was not a success (Sizer, personal communication). Nonpiquant peppers, such as our bell pepper, are not especially popular in Mexico. In the course of the survey in Mexico, we found 10 villagers who had tried nonpiquant peppers; 6 of these 10 did not like them.

Another way of understanding the basis for selection of a food is to look at substitutes for it. The 13 Mexicans interviewed in depth were asked what they and others do when chili peppers are not available. The response to this item was uniform in all Mexicans: they are virtually never without chili; they would go well out of their way to get some, but if it was not available, they would just do without it. They offer no substitute and would only use salt to season their food. In fact, there is little available in the diet of the villagers that has a piquancy like chili. Raw onion and garlic are available but are not seen to share important sensory properties with chili pepper. Raw onion was liked by 12 of 21 villagers asked, and garlic by none of 21.

American subjects provided more useful information, since they have more chili substitutes available. We received 45 responses, from 28 university students who liked chili, when they were asked what they would

use (if anything) if chili was not available. Other chemical irritant substances accounted for 64% of the responses, with black pepper heading the list (24%), and curry, garlic, ginger, onion, mustard, and other strong spices mentioned at least twice. Only 5 subjects claimed that there was no substitute for chili.

Finally, these same 28 subjects were asked: "Would you claim to be as sensitive as always (to chili), but that you have come to like the hot sensation that you used to dislike?" Twenty-two subjects responded affirmatively to this question. These responses and all of the other results presented in this section indicate that chili likers get to like the burn.

Chili Liking and Reinforcement or Positive Associations

Chili ingestion seems to be based on the pleasantness of the sensation rather than on anticipated consequences. The issue is whether it is the association of the initially negative burn with positive events that increases the affective value of these tastes. The minimal literature on associative aspects of the acquisition of affect does not provide clear guidance. Most relevant is the animal literature on taste-aversion learning, which indicates that tastes paired with certain aversive upper gastrointestinal events become affectively negative, as judged by facial expression and other responses (Rozin, 1967; Grill, 1975). It has been suggested (Garcia, Kovner, & Green, 1970; Rozin, 1979) that electric shock paired with tastes leads to avoidance based on anticipated consequences but does not produce an affective shift. There is a parallel with humans, illustrated by *dislike* of the tastes of foods associated with upper gastrointestinal illness (taste-aversions) and avoidance without dislike of foods giving rise to respiratory or cutaneous allergic responses (Rozin & Fallon, 1980a,b).

Generalizing these results to the positive side, we would predict that positive oral or upper gastrointestinal consequences would be most likely to induce positive affective shifts in tastes. Such "relevant" associations that might account for chili liking are:

1. Associations with innately positive tastes. Chili is rarely eaten with sweet foods. However, it is often eaten with foods of high acquired palatability.

2. Association with the enhanced taste quality of ingested foods. This could result directly from a sensory interaction between the burn and other oral sensations. It could also be mediated by the salivation induced by capsaicin. Given the mealy, starch-based diets that characterize most chili-eating cultures, salivation could facilitate both taste and mastication of the food. Note that the modal Mexican explanation for chili liking was that it adds flavor to food. The idea that chili stimulates appetite (Table IV) may also be related to the action of capsaicin as a stimulant for oral and gastric secretion.

3. Association with satiety produced by accompanying food. This remains a possibility, although there is little evidence in favor of it in this study.

There are also a number of "nonrelevant" consequences of chili ingestion that might support affective change:

4. Thermal effects. Capsaicin can produce hypothermia either through a gustofacial sweating reflex or through direct action on the hypothalamus (Lee, 1954; Jancsó-Gábor, Szolcsányi, & Jancsó, 1970). Ironically, chili users attribute a *warming* effect to it, probably as a result of its action on receptors of the mouth and upper gastrointestinal system (Table IV). There is no reason to think that either type of thermal effect is critical. Indeed, chili's original home includes the high plateau of Mexico, where the climate is always moderate.

5. Social effects. No explicit rewards are given for eating chili in the home. There is, however, the possible more subtle reward for being adult and doing what members of one's society do, as well as the less subtle encouragement of parents and peers. The interviews in Mexico, and less formal discussions with Americans, do not reveal any great social importance that is placed on eating or not eating chili pepper. It is associated, in Mexico, with strength. Thirteen Mexican subjects were asked a series of questions about hypothetical twins who were identical, except that one ate chili and the other did not. Their attributions to these twins were determined through a series of questions of the form: "Which twin is stronger? Which twin is female? Which twin is less intelligent? etc. For all attributes except strength, the majority response was that it was impossible to say, i.e., that chili was not an important basis for attribution. Ten of 13 subjects claimed that the chili eater was stronger. This may be related to the Mexican idea of *machismo,* usually implying daring and masculinity. However, it is notable that we found no sex differences in chili preferences in Mexico, even though sex roles are highly differentiated in this culture. The *sal de picante* test and the various corn snack tests in the United States and Mexico failed to uncover a single significant sex difference (Figure 2; Table V). These data, plus the fact that a number of men in the village freely admit that they don't like chili, suggest that it might be an error to put a great deal of emphasis on the sexual or social significance of this food, at least in this culture.[13]

[13]It is surprising that despite the enormous difference between male and female roles in this society, food preferences for "strong" foods do not differ markedly between the sexes. A survey of the preferences of 21 villagers (14 female, 7 male) for "strong" foods (wine, black coffee, beer, raw onion, etc.) revealed a clear sex difference only for cigarettes: these were used by all the males in this sample and by none of the females.

Table V. Sex Differences in Chili Preferences[a]

	Male			Female		
	N	% Piquant choice		*N*	% Piquant choice	
Mexico – *Sal de picante*	123[b]	39.5		118[b]	43.0	
	N	$\bar{X}$	*s*	*N*	$\bar{X}$	*s*
Mexico – Corn snacks						
Threshold	17	8.88	1.69	19	8.68	1.49
Preference	17	11.68	2.78	19	10.92	2.80
Tolerance	17	12.65	2.50	19	12.42	2.67
U.S. – Corn snacks						
Threshold	20	7.30	1.84	34	7.59	1.28
Preference	20	10.48	2.98	34	9.87	2.43
Tolerance	20	12.70	2.66	34	12.29	2.17

[a]No differences are significant at less than the .05 level, with a *t* test.
[b]Mean age of males in the *sal de picante* test (using only subjects 15 or less): 8.9 years; mean age of females: 8.1 years.

Chili Pepper Preference and the Masochism of Everyday Life

Viewed in its barest essentials, the chili liker has come to enjoy a sensation that is innately aversive. The sensation is innately aversive "because" it stimulates a receptor system whose function is to keep animals from eating a certain class of substances. Many substances that fall in this class (not including capsaicin) are really dangerous to the health of the organism. The defensive responses to high levels of chili, including running of the nose and tearing of the eyes, are presumably part of the body's mechanisms for ridding itself of a toxic substance. The realization of pleasure from chili sensations seems, in this regard, paralleled by a number of other characteristic human activities. People come to enjoy many other initially aversive experiences. We have already referred to parallel preferences for other irritant or bitter substances. People also come to like the fear and arousal produced by rides on roller coasters, parachute jumping, or horror movies. They enjoy crying at sad movies, and some come to enjoy the initial pain of stepping into a very hot bath or the shock of jumping into cold water. These "benignly masochistic" activities, along with chili preference, seem to be uniquely human. There are no well-documented cases, to our knowledge, of animals that clearly come to enjoy innately negative stimuli or bodily defensive reactions. To be sure, animals can be trained to inflict such situations on themselves, but always in the context of a possible contingent reinforcement. One might explain this class of human affective responses as pleasure derived from experiencing a

"constrained risk." That is, pleasure results from the discovery that the negative stimuli and defensive responses are not, in fact, dangerous or life-threatening. As this is realized, the disparity between cognition and bodily response produces a pleasant "thrill."[14]

Chili preference could be explained within this rubric. Like hot baths or roller coasters, chili only *seems* to be a threat to the body. We offer here some evidence from our studies that makes a "masochism" explanation at least plausible.

In high enough levels, chili produces the defensive responses of running of the nose and tearing of the eyes. Eleven of the 15 Mexican subjects who frequently reported such effects claimed that they enjoyed them. In the American sample, 32 people reported experiencing such effects: 11 liked them, 5 were neutral, and 16 found them unpleasant. The not infrequent consumption, especially among Mexicans, of whole hot chilies, speaks to an appreciation of these same effects.

The results from the preference tests also provide evidence for the "masochism" or thrill view. This view might predict that preferred levels would be very close or equal to the maximum tolerated level: enjoyment would come maximally from levels of stimulation that bordered on being unpleasantly painful. Of 36 Mexican subjects exposed to the corn snack test, 9 had their preference level at the same value as the tolerance level, and 13 more had a preference just 1 $\log_2$ unit below tolerance (Table VI). The data from the tortilla chips test were similar. The same phenomenon is apparent in the data from Americans, although the percentage of cases in which preference and tolerance are close is lower (Table VI). Furthermore, the mean distance between preference and tolerance is smaller for chili likers (2.08 $\log_2$ units) than for chili neutral-dislikers (3.00) in the American sample (Table II). These observations indicate that the chili "preference—aversion" function for likers is not the familiar symmetrical curve but rather one that drops rapidly from peak preference to aversion. It seems that with development of the preference, the threshold stays more or less fixed, while both preference and tolerence migrate upward together. This is supported by the very high correlations between preference and tolerance (Table VI). A further prediction is that the difference between preference and tolerance will get smaller as the preference for chili increases. This is confirmed by the data (Table VI).

It is difficult to imagine tests for the masochism or thrill-seeking hypothesis. If one could assume a personality trait that varied along these dimensions, one could at least ask whether chili eating correlated with a

[14]It is sobering to realize that "thrill" explanations for the liking of pungency have an old lineage. Alexander Bain (1868) suggested "excitement" as a cause for these preferences (pointed out to us by Linda Bartoshuk).

Table VI. Evidence for "Masochistic" Factors in Chili Liking

	Mexico		United States
	Corn snacks ($N = 36$)	Tortillas ($N = 14^a$)	Corn snacks ($N = 54$)
Preference = Tolerance (Number of subjects)	9	2[a]	2[b]
Preference one unit less than tolerance (Number of subjects)	13	7	10[b]
Correlation of preference and tolerance	.89[e]	.88[e]	.83[e]
Correlation between preference and (tolerance–preference)	−.39[d]	.20[c]	−.47[e]

[a] Four of 18 tortilla subjects had not reached maximum preference at the strongest stimulus. They have been dropped from this analysis.
[b] These numbers should be considered with respect to the 36 subjects who liked chili, not the total sample of 54.
[c] Four subjects, dropped because their preference and tolerance was above the maximum value, result in a major change in this number. If their tolerance preference score was included, and taken as zero, this correlation would move markedly in the negative direction. Note also that this correlation is generated entirely by children, in the 4- to 11-year age range, since the subjects eliminated were the older members of this sample.
[d] $p < .01$.
[e] $p < .001$.

whole range of thrill-seeking activities. Zuckerman's (1974, 1978) sensation-seeking scale describes a personality trait that includes thrill seeking, novelty seeking, and some related features. A first approach to this problem with respect to chili would be to determine if there were significant relations among preferences for strong foods. The literature suggests a weak relation among different types of strong food preferences. Wolowitz's (1964) Food Preference Inventory asks subjects to indicate a preference for one member of a series of pairs of foods. Each pair represents what he calls an active–passive dimension: this can be freely translated to mean that active foods are harder, crispier, stronger in taste, etc. A scale of intercorrelating items was constructed in this way, although some of the intercorrelations are low, and some items were discarded because they failed to correlate with others (Child, Cooperman, & Wolowitz, 1969). Fischer, Griffin, England, and Garn (1961) also identified a group of people with a tendency to like strong foods.

The interview protocol for the sample of 57 Americans included hedonic ratings (on a 5-point, strong like (4) to strong dislike (0) scale) for 17 foods or activities. The hedonic response to chili correlated .25 (Pearson r, $p < .05$, one-tailed) with the summed preference scores for three other spicy foods: curry, mustard, and raw onion. The same chili score correlated .31 ($p < .01$) with the summed preference score for 14 strong "foods" (the

three already mentioned plus garlic, wine, beer, hard liquor, quinine water, unsweetened lemon juce, soda water, ripe-smelly cheese, black unsweetened coffee, cigarettes, and anchovies). These data weakly support the notion of a general tendency to like (or dislike) strong foods. Comparable analyses cannot be done for the Mexicans because the number of strong foods that they widely consume is very small.

There is some information in the literature suggesting a weak positive relation between strong food preferences and thrill seeking. One factor in Zuckerman's sensation-seeking score is thrill and adventure seeking. It correlates least (Zuckerman, 1978) with the other factors on the scale, so that the effects reported here may be diluted. The sensation-seeking score correlates −.36 with Wolowitz's active–passive food preference index (FPI). This is the predicted direction (high FPI scores represent passive foods, hence the negative correlation). Child et al. (1969) report negative correlations between the FPI score and a measure of sensory challenge (e.g., preference for swimming in cold water). Brown, Ruder, Ruder, and Young (1974) report a positive correlation between a change-seeker index (a measure similar to the sensation-seeking scale) and preference for spicy foods (.27). In the present study, a correlation was computed for the American sample between chili preference and the summed preference scores (using the same 5-point scale) for three "masochistic" activities: taking very hot baths, attending sad movies, and participating in dangerous sports. The resulting correlation was only + .11 (n.s.). In short, all of the studies suggest weak relations among strong food preferences across individuals, and yet weaker relations in moving from food preferences to other domains. The results are surely inconclusive. Furthermore, it is not clear what one would make of much higher correlations, or even negative correlations. The notion of pleasure derived from participating in constrained risks is compatible both with the notion of a personality difference along this dimension and with the opposite. Each person could be conceived as having some tendency to seek constrained risks, which could be satisfied in a number of alternative ways. This could yield negative correlations among the activities under discussion.

DISCUSSION AND CONCLUSIONS

We have attempted to lay the groundwork for an exploration of the acquisition of positive affective responses through the study of an important food substance. The research highlights possible mechanisms that might explain affect acquisition, and evaluates some of them. It exposes both our current ignorance of basic facts and the paucity of theory in this area. The only reliable empirical relation is that exposure, seemingly

without any obvious consequences, tends to increase positive affective responses to objects of all sorts (Zajonc, 1968). The natural history of chili pepper acquisition fits this mold very well. Since exposure to extremely negative events may negate or even reverse the fundamental familiarity effect, it is appropriate that in the natural setting, chili is introduced at low levels that are gradually augmented.

We have presented evidence that strongly indicates that the development of a chili pepper preference is accompanied by an affective shift. How can this or related affective changes be explained? Mere exposure remains a possibility. All other theories assume that exposure merely provides the opportunity for other processes to work. Most theories of affect acquisition are associative: they link a reference event with other, affect-generating events. We have reviewed possibilities and have not emerged with a highly likely candidate. Relevant (oral, gastrointestinal) events are likely to be most potent. Salivation and oral stimulation may serve as flavor enhancers. Positive social associations remain a possibility.

Two other explanations assume that the initially negative taste of chili is, in itself, instrumental in the generation of the preference. One reasonable possibility, not evaluated by our data, is development of opponent processes (Solomon, 1977). According to this nonassociative theory, repeated exposure to an affect-producing stimulus recruits an opposing and canceling affect, in increasing degree and with a shorter latency with increasing exposure. Although the theory as presented does not explain situations in which initial affective responses reverse, it is consistent with such happenings. The opponent (B) process need only eventually augment with short latency to levels greater than the original affective (A) process. Endorphins may be involved in the B process, just as they may be involved in modulating the affective response to painful stimuli (Schull, personal communication). Endorphin secretion is consistent with both the mere exposure effect and the generation of pleasure from initially aversive stimuli.

A second explanation is that chili comes to be liked because the danger signal it produces becomes an indicator of a "constrained risk," resulting in a "thrill." This seems to capture some of the essence of the phenomenon, but is difficult to test.

It is quite likely that multiple factors are involved in the development of a liking for chili pepper. In particular, it is possible that the salivation effects of chili do naturally enhance the taste of bland foods. Some desensitization might allow these positive effects to emerge and become associated with the burn. Opponent endorphin responses might occur, while at the same time, realization of the essential harmlessness of the burn could lead to addition of a "thrill" component. Reasonable explanations for chili liking cannot be eliminated because they are contradicted by some evidence.

For example, the flavor enhancement effect or endorphin opponent responses are real possibilities, even though they should work as well in animals.

At this point, we have only enumerated a list of more and less likely explanations. However, we deem the enterprise described to be of value for three reasons: (1) We have described some fundamental aspects of the use of, and acquisition of a preference for, one of the most important flavoring substances in the world. This is the first study of its sort for a common flavoring; (2) we have highlighted possible mechanisms for the acquisition of positive affect; and (3) we have presented a model system for studying the acquisition of affective responses to foods. It uses a safe substance that at the same time shares many important properties with the major addictive substances of the world.

We are left with a good part of the puzzle that we started with: How and why did so many cultures, following the discovery of the New World, adopt this fiery new food into their daily diet?[15] And, possibly as a minireplica of this culture change phenomenon, how do tens of millions of little chili haters become chili lovers each year?

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[15]Some of the cultures adopting chili already valued black pepper, a more expensive chemical irritant. In some cases, chili pepper adoption may have been a switch to a cheapter irritant. Of course, one then has to explain why black pepper was desirable.

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