

## **Some Like it Hot: A Temporal Analysis of Hedonic Responses to Chili Pepper**

PAUL ROZIN, LORI EBERT and JONATHAN SCHULL  
*University of Pennsylvania*

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Possible explanations for the acquisition of a liking for the initially negative oral "pain" sensations produced by chili pepper are reviewed. In addition, a temporal hedonic rating technique developed to facilitate systematic investigation of this phenomenon is described. Results suggest a system for categorizing hedonic responses to chili pepper. Some subjects dislike chili pepper at all concentrations. For other groups of subjects, weaker or stronger burns are found to be pleasant and to enhance the accompanying flavors. A subset of these latter subjects liked the isolated burn that remains in the mouth after the other flavors have disappeared. The cross-sectional data suggest a developmental sequence for the acquisition of a liking for chili pepper.

This paper is concerned with acquired likings for initially unpalatable foods. Humans come to like many initially aversive substances such as coffee, cigarettes, beer and strongly spiced or salted foods. From among this group, chili pepper was selected because of its widespread use, non-toxicity, non-addictiveness, and the fact that the pungent agents, a family of chemicals called capsaicins, can be obtained in pure form (Maga, 1975; Rozin, 1978; Todd, Bensinger, & Biftu, 1977). Working with a specific substance always entails the risk that one's findings will relate only to the case under study. However, one can reasonably expect the operation of some general processes. Furthermore, by studying what is probably the most commonly used spice in the world, we can at least aim to find out something about the acquisition of liking for an important substance.

Our previous research with Americans and Mexicans, has confirmed that chili pepper preference is an instance of the acquisition of positive affect. People initially dislike the burn, and come to like it or love it with exposure (Rozin & Schiller, 1980). Besides developing a taste for the burn, people typically like the aroma and flavor of chili pepper, whose hundreds of varieties vary widely in aroma and flavor, as well as in the intensity and characteristics of the burn (Rozin, 1978; Rozin & Schiller, 1980; Todd *et al.*, 1977).

Frequent chili eaters (chili-likers), in comparison to subjects who rarely or never eat chili, show a slightly higher absolute threshold for detection of the burn of capsaicin, and salivate slightly less to fixed levels of oral capsaicin (Rozin & Schiller, 1980; Rozin, Mark, & Schiller, 1981). However, this small desensitization effect cannot account for the large affective shift; subjective reports strongly indicate that people come to like the same sensory burn they used to dislike (Rozin & Schiller, 1980).

An important precondition for increased liking is exposure (Harrison, 1977;

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Zajonc, 1968). However, we doubt that "mere exposure" explains enhanced liking, and note that reported "mere exposure" effects are rather small compared to the major "hate to love" changes associated with chili pepper. Other possible explanations are of two types: (a) those that might hold for any substance, and (b) those that require that the "stimulus" initially has a negative affective value.

In the first category, the most obvious explanation would invoke association with positive events such as the satiation or nutritional consequences produced by food eaten with chili pepper. Such mechanisms have been shown to increase preference in animals (Le Magnen, 1980; Zahorik, 1977) and humans (Booth, 1981). However, what is actually demonstrated in these studies, is an enhanced preference, which may or may not be caused by an affective shift (see Rozin, 1979, for a discussion of the affect-preference distinction). A particular effect of chili that might support positive associations is the salivation that it stimulates: with a mealy and bland starch base diet, typical of the areas where chili pepper is commonly eaten (Rozin, 1978), chili aids in the ingestion and swallowing of food and may enhance the palatability of the food. The most common explanation Mexicans give for their liking of chili pepper is that it "adds flavor to food" (Rozin & Schiller, 1980). Positive association explanations are somewhat embarrassed by the fact that while the postulated processes should also work for animals, it is extremely difficult, if at all possible, to produce a chili preference in laboratory rats (Rozin, Gruss, & Berk, 1979). However, it is possible that uniquely human social factors are part of the necessary reinforcement.

A few possible accounts of chili-liking are based upon its innately aversive properties. Chili-liking can be seen as a variety of thrill seeking, in which one comes to enjoy an apparently dangerous stimulus that one discovers is really safe. In this view, liking chili pepper is like liking roller coaster rides (Rozin & Schiller, 1980).

An alternative account comes from opponent process theory (Solomon, 1977), which holds that initially negative affect gives rise to internally generated compensatory, positive affect (the opponent process). Over repeated exposures to the hedonic stimulus, this positive affective response is strengthened and becomes able to neutralize and eventually overwhelm the primary negative response to the stimulus. The compensatory opponent response might be an innate response strengthened simply by exercise (Solomon & Corbit, 1974) or it might be a conditioned compensatory response which develops through learning (Schull, 1979; Siegel, 1977). In the latter case, one would expect that the compensatory response would be elicited only in contexts in which the hedonic stimulus had been experienced in the past. However, the two hypotheses are not incompatible.

A physiological realization of the opponent process account for the transformation of dislikes into likes comes from a consideration of some similarities between the hypothetical properties of the opponent-process for aversive events, and the actual properties of exogenous and endogenous opiates. The opponent process for an aversive event must be able to (1) counteract the aversiveness of the event, and (2) produce pleasure. These are the properties of opiates such as morphine and heroin, and they may well be the properties of the newly discovered endogenous opiates, the endorphins. Just as patients with pain report that with morphine the pain is still there but it no longer bothers them, experienced chili-likers report that the burn is still there but they no longer mind it. Indeed they now experience pleasure, or perhaps even a "high" (Weil, 1976). This affective response might be mediated by capsaicin-stimulated endorphin activity, which has built up gradually as an affectively positive opponent to the aversive burn, over the course of many experiences with chili pepper.

To begin the investigation of these issues, we report a technique for systematically measuring and analyzing the time course of hedonic reactions to chili. Surprisingly, the temporal dynamics of affective responses have rarely been measured in humans (but see Pangborn, 1981). In this study, we compare the ratings of mouth pleasure over time given by chili-likers and dislikers, following ingestion of crackers with varying piquancy levels.

## METHOD

### *Subjects*

The subjects were forty adults: 21 male and 19 female. Thirty-six were members of the University of Pennsylvania community, and all but three were students in the age range of 18–22 years. Forty-one members of the same community participated in related studies that provided reliability data for the methods used.

### *Materials*

The stimuli used in the experiment were 1.5 cm square cheese–potato crackers, made in our laboratory<sup>1</sup>. Both chili-likers and dislikers found this basic vehicle to be quite palatable. Piquancy was manipulated by exchanging measured amounts of shortening in the dough of the basic cracker, for equal amounts of capsicum oleoresin, an oil extract of chili pepper that includes the fat soluble capsaicins. This is the standard vehicle for conveying piquancy in the food industry. Crackers at five different levels of pungency were produced, ranging from 0 to 8500 Scoville Units, in log or half-log unit graduations (0, 85, 268, 850 and 8500 Scoville unit crackers). The Scoville unit is a commonly used linear measure of piquancy such that one Scoville unit is the concentration in a sweet solution at absolute threshold, under ideal testing conditions (Scoville, 1912). Henceforth, a particular stimulus will be referred to in terms of its piquancy in Scoville units.

### *Procedure*

The initial testing procedure was the same for all subjects. Subjects were informed of the general purpose of the experiment: comparison of the response of chili-likers and dislikers to crackers containing chili pepper. Subjects were told that they were going to be given several crackers to sample. The first cracker would not have any chili pepper in it but each subsequent cracker would be more piquant than its predecessor. If at any time subjects felt that the next cracker in the series might be too strong for them they were permitted to terminate the experiment with the trial they had just completed. Thirty-nine of 40 subjects were willing to try the second strongest (850 Scoville unit) cracker; 20 subjects sampled the most piquant (8500 Scoville unit) cracker. The crackers were always presented in the order: 0, 85, 268, 850, 8500.

Most subjects were run individually, but some were run in small groups. Based on pilot data indicating the time for the burns from the different crackers to return to hedonic zero, the time allowed from the presentation of each cracker to the next was set

<sup>1</sup>The recipe for the basic cracker was: 800 g flour, 500 g boiled potatoes, 280 g butter, 145 g parmesan cheese (dried, grated), 45 g water, 25 gm onion powder, 8.5 gm baking powder and 4 gm garlic powder. Ingredients were combined, the resultant dough was rolled out and stamped with a mold to produce a criss-crossed square pattern. The rolled-out dough was baked at 350 degrees Fahrenheit until golden brown (20–25 min). Capsicum oleoresin (850,000 Scoville units) replaced butter in appropriate amounts to produce the designated levels of piquancy. Crackers measured approximately 1.1 × 1.1 × 0.3 cm.

as: 3 min for the 0 cracker, 5 min for the 85 cracker, 12 min for the 268, 15 min for the 850, and 18 min for the 8500. In this way subjects were almost always at affective zero at the beginning of a trial. Subjects did not rinse their mouths between crackers.

Subjects were instructed to take the whole cracker into their mouth, chew and swallow it. They were asked to write down a quantitative pleasure–displeasure rating of the sensation in their mouths, at various times after eating the cracker. The experimenter asked for a rating every 10 sec for the first minute and every 30 sec thereafter. Subjects rated the cracker on an affective scale, ranging from +100 to –100. The experimenter indicated that a rating of +100 would represent the best possible taste imaginable. –100 the worst and zero a neutral state—the rating the subject would give to his mouth sensation before eating the first cracker. Subjects wrote each response on a pad in front of them, and turned the page after each rating, so that they would not see their previous ratings.

At the termination of the experiment, all subjects filled out a brief questionnaire. They indicated their liking for chili pepper on a five-point scale (strong-like, like, neutral, dislike, strong-dislike), their most recent exposure to chili pepper and to spicy foods, and the frequency (per week, month or year) with which they ate foods flavored with chili pepper.

In order to provide data on the reliability of hedonic ratings of chili, data from two unpublished experiments are analyzed below. The rating procedures and crackers were almost identical to those described above. Experimental design and selection of subjects differed. In one experiment, ratings of crackers were obtained on the first and second days of a study of the development of the acquisition of a liking for chili by subjects who disliked chili. All subjects ( $N=27$ ) in this study gave negative ratings to crackers with chili pepper. The other experiment investigated the role of endogenous opiates in pleasure and pain (Schull, 1980; Schull, Kaplan & O'Brien, *in press*), and included a preliminary exploration of the effect of naloxone on liking for chili pepper. Subjects rated 0, 268, and stronger crackers on 3 consecutive days, 10 min after completing ratings for two pain procedures. During one of the last two days of the experiment, subjects were given naloxone (10 mg/kg), and during the other day, saline. Naloxone and saline were given in randomized order, by intravenous catheter, in a double-blind procedure. Since these injections produce variations in the sessions, the resulting reliabilities can be taken as underestimates of the true reliability.

## RESULTS

The basic datum in this study is a temporal hedonic curve, plotting a subject's hedonic ratings over time for a particular cracker (see Figure 1). Reliability was estimated from two other studies by comparing two temporal hedonic curves for the same cracker given on different days by each subject. The measure used is the area under each curve (counting area below zero as negative). The reliability (Pearson  $r$ ) for the 27 chili-dislikers in the first study is 0.625 for a 0 Scoville unit cracker, and 0.791 for a 312 Scoville unit cracker (roughly equivalent to the 268 cracker used in this study). In the naloxone study ( $N=14$ ), which included both chili-likers and dislikers, we obtained three reliability scores for each cracker (initial versus naloxone session, initial versus saline session, and saline versus naloxone sessions). The average of the three reliability scores was 0.579 for the 0 Scoville unit cracker, and 0.780 for the 268 Scoville unit cracker.



In the present experiment, results from the hedonic curves are in accord with other measures obtained from the questionnaire on chili use and preference. The most piquant cracker for which there was an almost completely positive hedonic response over time provides a measure of chili-liking from this study. This correlates  $+0.630$  with the subjects' ratings of their own chili preference from the questionnaire, and  $0.58$  with frequency of use. However, there were six subjects who disliked all of the piquant crackers but claimed to like chili pepper (in other foods), and five subjects who disliked all of the piquant crackers yet ate food with chili pepper at least once a month.

We find three basic patterns of response to the series of crackers. All included a positive response to the blank cracker; the critical differences were in the responses to the piquant crackers. Examples of each type of response are displayed in Figure 1.

Ten subjects, whom we call strong-dislikers, were completely negative to any level of piquancy. Because the burn onset is slower than the taste onset, there were some cases in which the ratings for the first 10 or 20 sec of a piquant cracker were positive,

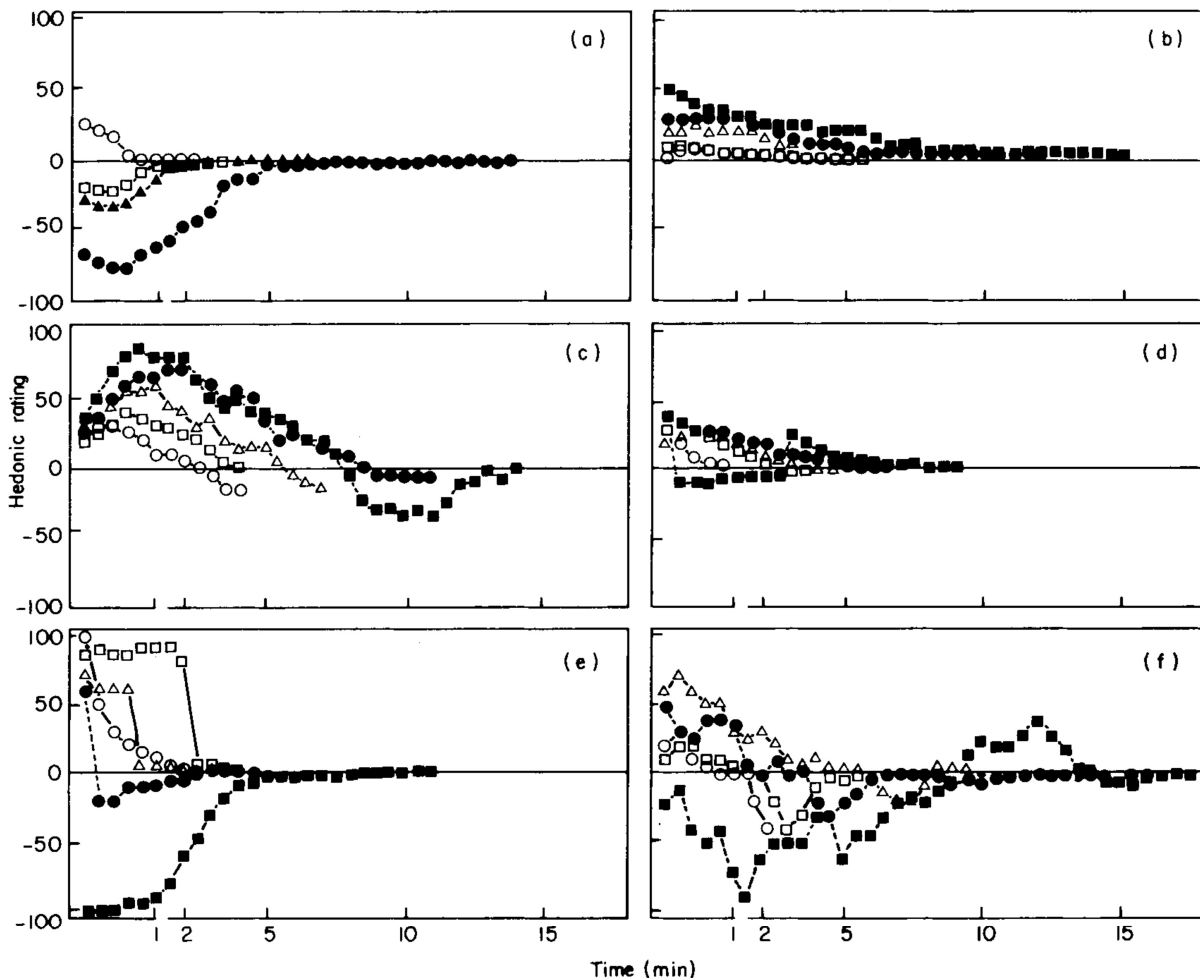


FIGURE 1. Temporal hedonic curves for six subjects. The coding for piquancy of crackers is shown below. Because measures were taken at 10 sec intervals for the first minute, and at 30 sec intervals thereafter, there is a break in the abscissa between 1 and 1.5 min, representing a shift in scale. Successive measures are spaced equally, whether separated by 10 sec (first minute) or 30 sec (after the first minute). (a) Displays a representative strong-disliker; (b) displays a representative strong-liker; (c) represents a moderate-liker; (d), (e) and (f) represent slight-likers. Key: (—○—) 0; (—□—) 85 S.U.; (—△—) 268 S.U.; (—●—) 850 S.U.; (—■—) 8500 S.U.

and then turned and remained negative. With this exception, all hedonic points for these subjects, on any cracker other than the standard (blank) were negative. On the whole, the stronger the cracker, the lower the hedonic ratings and the more time it took to return to hedonic neutrality. A clear instance of a strong dislike is shown in Figure 1(a). In addition to the ten subjects who fit perfectly in this category, six others showed only minor deviations from it, and are classified as moderate-dislikers. They differed from the strong-dislikers either in that the least piquant stimulus was about equal in hedonic ratings to the blank or, more commonly, that there was a slight positive response at the tail end of at least one hedonic curve for a piquant stimulus. This slight positive cross-over usually occurred only on the weakest (85 S.U.) piquant cracker.

At the opposite extreme, the strong-likers ( $N=5$ ) show all positive responses, generally increasing in amplitude and duration as the piquancy of the cracker increases [Figure 1 (b)]. The piquant cracker responses of strong-likers are almost the mirror image of those of strong-dislikers. Two other subjects (moderate-likers) showed essentially this pattern, with minor exceptions. In one case, there was a short latency (30 sec) initial negativity to the strongest stimulus, and in the other, a negative afterresponse to most stimuli [Figure 1 (c)].

Of the remaining 17 subjects, 3 showed inconsistent and complex curves, while the other 14 fell into a group (slight-likers) that liked lower and disliked higher piquancy levels: in other words, our stimulus range included the hedonic cross-over point for these subjects. Three examples from this group are displayed in Figure 1 (d), (e), (f). Figure 1 (d) shows a particularly clear case, representative of 3 other subjects. There is a clear shift from like to dislike. As the unpleasant burn of the strongest stimulus becomes weaker with time, it shifts from negative to positive hedonic ratings. This is presumably because the lower levels of burn some minutes after eating the strong cracker are about as strong as the levels liked following the weaker crackers. This "positive crossover" phenomenon was clearly apparent in seven subjects [Figures 1 (d), (f) are examples] but did not occur in all subjects [e.g., Figure 1 (e)].

There are a number of general and instructive features of the set of 40 temporal hedonic curves. For all subjects, the blank cracker produced hedonically positive sensations; these lasted for 30 sec to a few minutes. For the piquant crackers, positive or negative hedonic reports made more than a few minutes after ingestion can be attributed to the isolated burn, since subjects report that all "taste" from the cracker vehicle has dissipated by this time. The curves are usually quite smooth, indicating gradual and orderly changes in hedonic response [see Figures 1 (a), (b), (d), (e)], but a few subjects showed rather abrupt changes and wavy curves that could be described as "hedonic tremor". [Figure 1 (f)]. Because the burn onset is slower than the flavor onset, it was frequently the case that subjects showed positivity in the first 10–20 sec for what turned out to be an unpleasantly strong cracker [Figure 1 (f)]. On the other hand, some subjects seemed to sense the piquancy earlier, so that readings in the first 20 sec were indicative of later readings [Figure 1 (a)]. It is possible that expectations played a role here; subjects knew that they were receiving crackers with increasing piquancy, and could conceivably have been sensitized to, or anticipated, the onset of the burn.

Since the burn causes the lingering sensation and its hedonic counterpart, it should not be surprising that the stronger the cracker, the longer the time to return to the hedonic baseline (Figure 1), for all types of subjects. There is a weaker relation between strength of stimulus and amplitude of the maximum hedonic response.

Crossovers constitute whatever direct evidence there is for opponent processes. The evidence for opponents is minimal. First, the absence of positive crossovers following

the decay of negative sensations for strong-dislikers argues against them. Of the 40 subjects, 16 showed a positive crossover for at least one stimulus. Similarly, negative crossovers for positive stimuli occur relatively infrequently; of the 40 subjects, only 11 showed negative crossovers. In some cases [e.g., Figures 1 (c), (f)] negative crossovers were characteristic of a subject's responses, but in other cases they occurred for only one stimulus.

Based on the cracker data, we can propose three characteristics that differentiate the chili-lover from the chili-hater, and vary systematically with liking.

1. Stronger and stronger crackers are hedonically positive with increased liking.
2. The hedonic report in the first minute (while the cracker flavor is still present) is enhanced by the presence of the burn. In slight-likers, only weak burns produce these effects. As liking increases, the level of burn that enhances flavor increases [Figure 2 (a)]. We measure this flavor enhancement effect as an increased positive response to a piquant cracker in the first minute, in the period after the blank cracker has peaked (see definition in legend of Figure 2). In other words, the effect is that the rapid waning of the hedonic response to the blank is attenuated or reversed by the presence of chili. This effect appears for at least some cracker in every subject who can be said to have liked any of our piquant crackers. Note that for slight-likers, it only appears at low levels of piquancy (Figure 2). In contrast, strong-likers are sometimes hedonically indifferent to these very same low levels that enhance the flavor for slight-likers [see data for 85 SU cracker in Figure 2(a)].
3. The isolated burn of chili pepper, unaccompanied by the cracker flavor, is more pleasant with increased liking. This is most easily measured by positive responses that occur at least two minutes after the blank has returned to hedonic zero for the two stronger crackers (850 and 8500 S.U.). [Figure 2 (b)]. Whereas all likers show at least some "flavor enhancement" (see caption to Figure 2), liking for the isolated burn occurs primarily in subjects with a strong liking for chili (Figure 2).

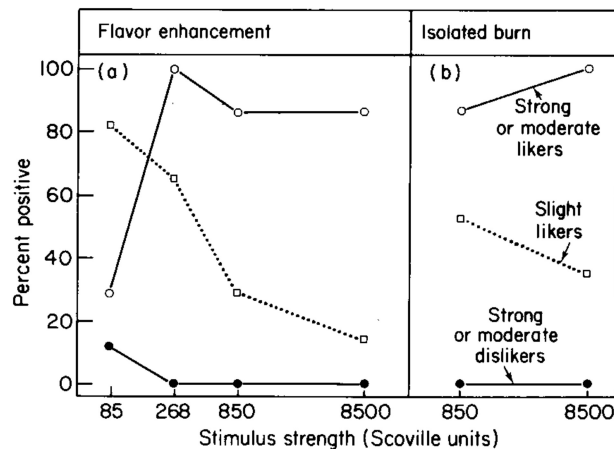


FIGURE 2. Percent of subjects showing flavor enhancement (a) and liking of the isolated burn (b) as a function of strength of liking. Flavor enhancement (a) is defined as the presence of at least two hedonic ratings higher than the blank (at corresponding times) in the period after the blank has peaked, and within the first minute of ingestion (or, within the time it took for the blank to return to zero, if more than one minute). A positive isolated burn response (b) was scored if the subject showed at least two positive hedonic reports at points in time more than 2 min after the blank curve had returned to zero. The open circles represent 7 strong- or moderate-likers, the open squares represent 17 slight-likers, and the solid circles represent 16 strong- or moderate-dislikers. (Note: for the 850 stimulus, there are 15 strong- or moderate-dislikers, and this number drops to 4 for the 8500 stimulus.)

## DISCUSSION

We have described a procedure for investigating temporal changes in mouth sensation, with respect to the oral effects of chili pepper. The basic temporal hedonic analysis is similar to that proposed in the opponent process theory of affect (Solomon, 1977) and used by Pangborn (1981) to study a number of different tastes. Given the relatively slow onset and long duration of the sensations produced by chili pepper, a temporal analysis is of particular importance. This is emphasized by the fact that in many subjects, the sensations produced by a particular stimulus (cracker) cross the hedonic zero point at some time after ingestion.

Our data permit us to make some tentative inferences about the development of the acquired preference for chili. (1) The fact that we find no positive hedonic report for any level of burn in 10 subjects (the strong-dislikers) suggests that the acquisition of liking does not involve the extension of an innately positive response to minimal levels of burn; rather, a complete reversal of an innate aversion seems to be involved. Animal data also indicate that at all detectable levels, chili pepper is aversive (Rozin *et al.*, 1979). [It is conceivable that in the proper vehicle, very low levels of chili (perhaps undetectable as mouth irritation) could enhance liking in the inexperienced chili eater. It is also possible that minimal levels of burn are liked initially by some people, and that these are the people who tend to become strong likers.] (2) The data from slight-likers suggest that when chili-based sensations first do become pleasurable, they usually do so only when accompanied by food, and act by enhancing its flavor. Burns which outlast the flavor of the cracker are rated as unpleasant. (3) In contrast, data from strong-likers suggest that eventually, even the isolated burn becomes pleasant. Thus, the three curves in Figure 2 (a) and (b) suggest a developmental sequence beginning with strong- or moderate-dislikers and ending with strong- or moderate-likers.

It is worth noting that there are several ways in which chili might directly or indirectly enhance the flavor of food in slight-likers. The flavor of the peppers and/or the burn might be pleasant in the presence of food, or in interaction with food. Alternatively, at least for the dry, mealy, bland, grain diets traditionally eaten with chili, it may directly increase palatability by facilitating mastication and making food flavors more accessible through stimulation of salivation. Of course, these possibilities are neither exhaustive nor mutually exclusive.

Our data do not permit us to determine whether a completely isolated burn is pleasant to the strong-liker. That is, in our subjects, the isolated burn was connected continuously in time with the cracker flavor and was attributed to the cracker. This immediate temporal context may or may not be critical. The possible importance of immediate history (temporal context) is highlighted by the response of slight-likers to waning strong burns. Slight-likers, as a group, find the first minute of the 8500 cracker hedonically negative. As this burn wanes, it should reach a level that had previously been rated positively by these subjects in the context of a less piquant cracker. If temporal context were irrelevant, these subjects would show a positive crossover towards the end of the 8500 cracker burn. In fact some subjects do [e.g., Figure 1 (d), (f)], but others do not [e.g., Figure 1 (e)]. We do not know the critical factors determining presence or absence of this crossover, but the split in response on this measure illustrates the importance of temporal context.

These data and our procedures raise a number of important questions and challenges. The cracker rating situation is "natural" in that the chili vehicle is in a food and it does give rise to pleasure. However, eating rarely occurs in a laboratory

environment such as ours and, more importantly, the normal chili experience is of a series of bites of piquant foods, so that only the first is accomplished on a baseline of a non-burning mouth, and only the last is followed by a long isolated burn. We cannot gauge the significance of these departures from the real world situation in this study.

The structure of the normal eating situation, and the enjoyment of the post cracker burn highlight the importance of context in the interpretation of flavors (and everything else). Even confirmed chili-likers like chili only in some contexts (e.g., a few of our subjects rated the piquant crackers negatively, but reported that they do like chili in other foods). This fact becomes particularly interesting in light of our finding that strong-likers like the isolated burn, even after the food taste (the sensory context) has gone. The context-specificity of chili-liking suggests that, if opponent-processes do underlie the preference for chili, then they would have to be conditioned opponents triggered by conditioned contextual stimuli (Schull, 1979; Siegel, 1977). But other interpretations are possible; perhaps it is a matter of attribution. Would the same burn, for the same person, be pleasant if it were attributed to an inappropriate source (such as water or ice cream)? We do not know at this time.

Another general issue raised by our procedure is the role of expectation. Eaters normally have an idea of the taste of what they are about to eat. Our subjects were told that the crackers would be presented in order of increasing piquancy. Some dislikers reported negative hedonic ratings for the first (10 sec) reading for mildly piquant crackers, though in our experience, the burn is not yet evident at that time. Other subjects showed a more "objective" positive sensation (resembling the response to the blank) for the first 10 or 20 sec, before turning negative. This difference illustrates both a problem with the technique and an important factor in the determination of the hedonic response to foods.

We are not yet prepared to provide a coherent explanation of the liking for chili pepper. It is probably a multi-determined phenomenon. Hence, one cannot write off a possible explanation because it is inconsistent with *some* facts about chili pepper preference. For example, based on the ecology and geography of chili use, and on subject reports, we suspect that the salivation effect, as an enhancer of flavor and facilitator of chewing with mealy and bland diets, is a significant factor in the development of liking. Yet, this explanation is inadequate, as (i) it should also work in animals, and (ii) it could not explain the use of chili on meats and in rich soups.

It is clear that the trigeminally based irritant sensation produced by chili pepper is innately aversive, even at the lowest levels. Social influences nonetheless induce people to repeatedly sample this aversive substance, and this allows processes to operate that may produce liking. These processes could be some combination of socialization, desensitization or adjustment to the sensation (allowing the flavors to be perceived along with the burn), associative linkages with positive events, habituation of fear with development of a thrill-seeking motivation, and recruitment of positive (endorphin based?) opponent responses to the innate negative affect. The temporal hedonic measurement technique that we describe here would be of particular value in evaluating some of these possibilities. We are currently employing it to test the endorphin hypothesis, by seeing whether the opiate blocker, naloxone, blocks the pleasure of the chili burn in chili-likers.

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