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# Acquired Preferences for Piquant Foods by Chimpanzees

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Humans frequently develop likings for innately unpalatable substances, while this occurs very rarely in non-humans. In this study, we establish a preference for crackers seasoned with chili pepper in two domesticated chimpanzees. Chimps were offered a series of increasingly piquant crackers by their caretaker, and gradually came to prefer these crackers to unseasoned crackers. The preferences were stable over months, and generalized to a different piquant cracker. Available evidence suggests that these are acquired likes rather than preferences maintained because of positive consequences that follow ingestion. We note that all existing instances of acquired likings for innately aversive foods in animals (including some informal results from dogs presented in this paper) involve animals with a close personal relationship with humans, suggesting an important role for social-affective factors in the reversal of innate aversions.

One of the most striking features of human food choice is the widespread preference for innately unpalatable bitter and irritant substances (Rozin, 1976). Such preferences are rare, if present at all, in non-human animals. Preferences of this type can be motivated primarily by anticipated positive consequences (e.g., satiety, positive pharmacological effects) or by acquired liking for the sensory properties ("taste") of the relevant substance (Rozin, 1979; Rozin & Fallon, 1981). In general, the evidence indicates that the most commonly accepted innately unpalatable items (e.g., chili pepper, coffee) are consumed primarily because of a liking for their tastes (Rozin & Schiller, 1980; Cines & Rozin, 1982).

We know very little about what determines whether any object (food, possession, person) will change in affective value, or more specifically, how foods come to be liked or disliked. There is one well established principle. When nausea follows ingestion of a food, humans tend to come to dislike its taste, whereas when other negative consequences follow (e.g., headache, respiratory problems, diarrhea), humans tend to avoid the food but not dislike its taste (Rozin & Fallon, 1980; Pelchat & Rozin, 1982). A similar distinction can be made for rats (Pelchat, Grill, Rozin, & Jacobs, 1983).

The complementary effect for learned good tastes would involve positive upper gastrointestinal events. Booth and his colleagues (1982; Booth, Mather, & Fuller, 1982) have reported enhanced preferences in animals and humans for flavors associated with rapid satiation in hungry subjects. The enhanced liking produced in these studies may be dependent on the degree of hunger of the subject at the time of testing. There is no

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other evidence for special potency of other positive gastrointestinal or other postingestional consequences in enhancing liking (Cines & Rozin, 1982; Pliner, Rozin, Cooper, & Woody, Note 1; Rozin & Schiller, 1980).

The search for causes of acquired likes for foods is hampered by the absence of a good animal model. It has been very difficult to establish strong, stable preferences for foods (tastes) in rats (Rozin & Kalat, 1971; Zahorik, 1979; Rozin, Gruss, & Berk, 1979; but see Booth, 1982, for an alternative view). This contrasts with the great ease in producing learned aversions. Furthermore, whereas humans clearly come to like initially aversive tastes, the few positive animal results allow for the more conservative interpretation that increased preference is motivated by anticipation of positive consequences. For example, a morphine addicted rat may learn to swallow bitter morphine "medicine" to obtain relief from morphine withdrawal without coming to like the taste.

The lack of success in establishing substantial preferences for innately unpalatable substances may reflect a poor choice of species (typically, laboratory rats). Animals closer to humans, either phylogenetically or in social-affective relations might be more appropriate. Alternatively, failure in the rat studies may result from the artificial laboratory environment in which these studies were carried out. Humans experience these tastes in association with a variety of foods in the social setting of a meal. We explore these two possibilities in this study, by experimental studies on chimpanzees, and informal examination of piquant preferences in Mexican dogs and pigs, and American pet dogs.

If clear acquired likes for innately aversive substances are exclusively human, then theories to explain these likes should engage uniquely human features. On the other hand, the set of possible explanations of reversals of innate aversions would be broadened by a definitive demonstration of reversal of innate aversions in a non-human.

The two major groups of innately unpalatable substances are "bitter" and "irritant." Avoidance of bitter is well documented (e.g., Garcia & Hankins, 1975). Attenuations of aversions to mildly bitter substances have been established in rats with extensive exposure (Warren & Pfaffman, 1959). In a few cases, preferences with respect to water have been established after pairing with positive events. For example, addicted rats show a preference for bitter tasting morphine when its ingestion is paired with recovery from morphine withdrawal (Parker, Failor, & Weidman, 1973).

Chili pepper is the irritant most commonly consumed by humans. It is eaten, on a daily basis, by more than one-fourth of human adults in the world. It is not harmful, and may be a "mimic" that triggers an innate sensory-based avoidance system. The evidence for avoidance of irritants by animals is less pervasive than for bitter. We know of no direct evidence that insects or other invertebrates are deterred by irritants, and there is at least one case (Hume, 1874) of a species of bird that consumes hot peppers in large amounts. However, generally those birds that do consume hot peppers in the field are reported to eat the flesh and seeds, but avoid the most piquant placental tissue that attaches the seeds to the flesh (Villa, pers. comm.).

Attempts to establish preferences for spices (irritants) in rats have failed (Hilker, Hee, Higashi, Ikehara, & Paulsen, 1967; Rozin, Gruss, & Berk, 1979). Mimicking human experience with chili pepper, with long-term exposure (up to 11 months) or gradual introduction of more and more piquant foods leads only to a minor attenuation of the innate aversion (Rozin *et al.*, 1979). Pairing of chili with recovery from vitamin deficiency does lead to a significant attenuation of aversion, but not an

absolute preference. And again, these minimal changes can be interpreted as being motivated by anticipated consequences. The only report of an acquired preference (liking?) in mammals is an abstract describing a preference for chili by two ten-year old Rhesus macaques raised as pets in a home in India (Dua-Sharma & Sharma, 1981). These animals were given graded exposure to spicy foods, and preferred piquant rice to plain rice. One ate whole, piquant, green peppers, in spite of the fact that they caused lacrimation. In the present study, we systematically set about to convert the natural chili pepper aversion to a preference in chimpanzees.

## Method

Subjects were five chimpanzees (*Pan troglodytes*) who spent most of their time as subjects in studies in cognition at the University of Pennsylvania Primate Center. The study took place over a two year period. Ages of the chimpanzees at the beginning of the study were 16 years for Sarah, and five to seven for the other four chimps. Sarah is the distinguished "literate" chimp who has mastered a symbolic "system" and participated in a wide variety of experiments (Premack, 1976). She had been in the company of humans for almost all of her life. Although her diet consisted primarily of monkey chow and fruit, she had been offered many typical human foods. Yogurt, snack foods, sweets, and vegetables were eaten moderately often. She had also experienced some cooked human foods, as well as beer, coffee and tea. The other four chimps, Jessie, Sadie and Luvie (females) and Bert (male) had lived in the laboratory for more than four years. They, too, had participated in a wide variety of studies and had extensive human contacts, but they had not been taught a symbolic system. Their prior food experience was more narrow than Sarah's. In addition to fruit and chow, they were free to consume what they liked (plants, insects, etc.) in a half-acre outdoor enclosure, and had consumed yogurt, candy, snacks and perhaps a few other types of human foods in their interactions with humans or as rewards in experiments. As far as we can determine, all subjects had some exposure to bitter substances (e.g., fruits, fruit rinds and for Sarah, coffee), but none to piquant foods.

Pilot work was carried out to find an appropriate, palatable vehicle for chili pepper. During this phase, Sarah, Bert and Jessie were exposed to a variety of commercial snack foods, and a few types of crackers baked in our laboratory. On a few occasions, these were mildly piquant.

The vehicle used for this study was a slightly sweet cracker that we made in the laboratory. The crackers were about 1·5 cm on a side, and about 0·25 cm thick[1]. Piquancy was produced by adding measured amounts of capsicum oleoresin, an oil extract of chili pepper that is the common form in which piquancy is added to foods commercially. Piquancy is measured in Scoville units (Scoville, 1912), a linear measure, such that one Scoville unit is the absolute threshold of detection of piquancy in a sweet solution, under ideal conditions. The crackers used in the main part of this study were green or yellow[1]. In some choices, the yellow crackers were made with capsicum oleoresin in amounts to produce crackers of 100, 200 or 400 Scoville units. The mildest

[1] The sweet "honey" crackers were made from a batter containing: 1800 g wheat flour, 750 g whole milk, 540 g sweet butter, 330 g sucrose, 288 g clover honey, 150 g vegetable oil, 60 g sodium chloride, 18 g vanilla extract, and 6 g cinnamon. Capsicum oleoresin (Kalsec, 1,000,000 Scoville units) was added in appropriate amounts, in terms of wet weight of the batter. Green food coloring (Durkee's) was added in sufficient amounts to obtain a rich green color, when appropriate. Crackers were baked in an oven.

cracker (100 S.U.) has a very weak, but definitely detectable burn for humans, while the 400 S.U. cracker has a substantial burn comparable to levels of hotness in well seasoned (but not very hot) foods.

The preference test consists of 24 trials (12 trials on two consecutive days). On each trial, a choice between a green and yellow cracker is offered, with cracker position randomized. Because the burn from chili pepper can last for a few minutes or more, we separated individual choice trials by at least ten minutes. The chimp could only choose and ingest one cracker on each choice trial. This was necessary because they would otherwise consume both quickly, and would be unable to attribute the burn to one or the other cracker. (The chimps rapidly learned that they could only ingest one cracker, and willingly cooperated with this procedure). On the day before each 24-trial preference test, chimps were given a day to sample five instances of each type of cracker that would appear in the subsequent test. These crackers were offered one at a time, never with an intercracker interval of less than ten minutes.

The basic design was to establish a baseline green–yellow blank cracker preference (24 trials), and then introduce a mildly piquant cracker (100 S.U. yellows, called Y-100s subsequently). The chimps were indifferent between the yellow and green blank crackers (see Table 1), and yellow was selected arbitrarily as the vehicle for piquancy. After one day of (pretest) exposure to five new Y-100 and green (G) crackers, they were tested (for 24 trials) on a choice between G and Y-100. They were then given 25 Y-100 crackers at the rate of five per day, spaced at least 5 min apart (inadvertently, for the first two exposure cycles, 30 and 20 crackers were given, respectively). These crackers were given to them by an experimenter who was very well known to them and their principal caretaker. The chimps were observed to be certain that the cracker was consumed (it always was). There was then another pretest familiarization, and a test between G and Y-100. This exposure–pretest–test cycle was continued until we observed a clear preference for the piquant yellow cracker. This was defined as two consecutive 24-trial tests (separated by 25 additional exposures to the appropriate piquant yellow cracker) in which the piquant cracker was preferred on at least 19 out of the 24 trials ($p < 0{\cdot}01$ on the binomial exact test, two-tailed). At this point, we moved to the next hotter yellow cracker, carried out a pretest and test, and moved through exposure–pretest–test cycles until the criterion was met. The sequence of tests and exposures is indicated in Table 1, along with some occasional departures from the procedures described above.

Sarah refused to consume any crackers after four preference tests and the consumption of 75 Y-100 crackers. Hence, her data is not included in this study. The sequence through Y-400 crackers was completed for Jessie and Bert over a period of about one year. The animals were run sporadically, because of scheduling problems, illnesses, etc. They experienced crackers (exposures or tests) on 50 to 70 days, over a period of less than one year.

When the sequence from Y-100 to Y-400 was completed, the experiment terminated for over two months. The chimps were then retested with Y-400 vs G, and then tested for "generalization" of the piquant preference. For this purpose, we used another cracker which was not sweet, and had an Italian flavor[2]. This is a cracker that we use in studies with humans, and is what might be considered an appropriate context for chili

[2] The "Italian" crackers were made from a batter containing: 480 g wheat flour, 300 g potatoes (boiled), 118 g sweet butter, 88 g Parmesan cheese, 80 g vegetable oil, 67 g water, 15 g onion powder and 5 g baking powder. Capsicum oleoresin was added in appropriate amounts (see Note 1), along with Durkee's red or yellow food coloring. Crackers were baked in an oven.

TABLE 1

*Acquired preferences for chili pepper by chimpanzees*

| Choice sequence[a] | Intervening exposure[b] | No. of choices of chili-crackers (out of 24) | | | |
|---|---|---|---|---|---|
| | | Jessie | Bert | Sadie | Luvie |
| Honey crackers | | | | | |
| G vs. Y[c] | | 12 | 12 | | |
| G vs. Y-100 | | 2** | 4* | | |
| | Y-100 | | | | |
| G vs. Y-100 | | 20* | 11 | | |
| | Y-100 | | | | |
| G vs. Y-100 | | 21** | 3** | | |
| | Y-100 | | | | |
| G vs. Y-100 | | | 7 | | |
| | Y-100 | | | | |
| G vs. Y-100 | | | 19* | | |
| | Y-100 | | | | |
| G vs. Y-100 | | | 23** | | |
| | Y-100 | | | | |
| G vs. Y-100 | | | 24** | | |
| G vs. Y-200 | | 7 | 22** | | |
| | Y-200 | | | | |
| G vs. Y-200 | | 10 | 19* | | |
| | Y-200 | | | | |
| G vs. Y-200 | | 22** | | | |
| | Y-200 | | | | |
| G vs. Y-200 | | 23** | | | |
| G vs. Y-400 | | 20* | 22** | | |
| | Y-400 | | | | |
| G vs. Y-400 | | 22** | 20* | | |
| (Two month interval) | | | | | |
| G vs. Y-400 | | 20* | 20* | | |
| Italian crackers | | | | | |
| BY vs. P[c] | | 7 | 9 | 10 | 8 |
| BY vs. P-200 | | 19* | 20* | 3** | 5* |

[a] Each entry represents 24 two-choice trials, preceded by sampling of five of each item in the choice on the previous day.

[b] Intervening exposure of 25 of the indicated crackers (five/day) for each entry, except that the first Y-100 exposure contained 30 crackers, and the second, 20 crackers. Y-100 means yellow cracker, 100 Scoville units.

[c] G stands for Green, Y for Yellow, BY for Bright Yellow, and P for Pink. On these trials, with no chili in either cracker, the score indicates the number of trials on which the color that would later contain chili was eaten (Yellow or Pink).

* $p < 0.01$ (binomial, two-tailed).
** $p < 0.001$.

in humans (Rozin, Ebert, & Schull, 1982). The Italian crackers were made in two colors, pink (P) and bright yellow (BY), quite different in color from the yellow "honey" crackers used previously. Jessie, Bert and chili-naive Sadie and Luvie were given a standard pretest and test sequence with blank P and BY crackers. The P crackers were less preferred by all chimps (Table 1), and were used as the vehicle for chili in a generalization test, in which a pretest and test using P-200 vs. BY was carried out on all four chimps.

## Results

Both chimps move from an initial indifference to G vs. Y to a strong avoidance of Y-100, when it was first presented (Table 1). However, 30 exposures [plus the exposures that were part of pretest and test, which could amount to anywhere from five to 29 (five pretest + 24 Y choices)] were sufficient to convert Jessie to a chili preference, while 100 exposures (again, plus pretest and test exposures) accomplished the same end for Bert. Jessie acquired a preference for Y-200 after 50 exposures, and then immediately preferred Y-400. Bert showed an immediate extension of his Y-100 preference to Y-200 and Y-400 (Table 1). Both chimps retained their Y-400 preference after a two-month period with no exposures.

All four chimps showed a preference for the BY Italian cracker, and the chili was placed in the Pink (P-200) cracker. The chili-preferring chimps, Jessie and Bert, clearly extended their preference into the new context, with strong preferences for P-200 (Table 1). Chili-naive Sadie and Luvie avoided the P-200 cracker.

## Discussion

It is not easy to determine whether the piquant preferences should be interpreted as affectively based (liking). The distinction between preferences based on liking (good tastes) and those based on anticipated consequences ("medicines" or beneficial substances) in non-humans may be made through analysis of facial expressions (Grill & Norgren, 1977; Pelchat *et al.*, 1983). Alternatively, it can be made by consideration of the actual contingencies that the animal has experienced in the past, to determine if there are "grounds" for anticipating positive consequences. In the absence of any data on expressive changes, our only source of information is history of contact with the substances in question. We can find no basis for a preference based on anticipated positive consequences since there is no indication that the chimps received specific material or social rewards for consuming initially unpalatable crackers. The chili crackers preferentially consumed by the chimps were equivalent in calories to the unseasoned crackers, and were so small that they had no significant "satiety" value. We conjecture that in the absence of any explanation for why these animals would be consuming the irritant items as a means to a desirable end (i.e., as medicines), the most likely explanation is an acquired liking for the sensory properties involved.

The chimps and Rhesus monkeys (Dua-Sharma & Sharma, 1981) who have shown acquired preferences for chili pepper have a number of things in common. They are phylogenetically close to man, and they were all raised more or less as pets, with close relations to humans. All had observed humans eating typical human foods, had partaken of some of these foods, and consumed chili pepper in a vehicle that was palatable to humans. In contrast, the rats that failed to come to like chili (Rozin *et al.*, 1979) were offered it in rat chow, without any significant human interactions or

relations. Some progress can be made in isolating critical differences by looking at other domesticated animals. Domesticated animals in Mexican villages (pigs and dogs), like humans and the other primates studied, regularly consume chili pepper. They eat it with tortillas and other foods, in the meal leftovers discarded at the end of meals or at the end of the day. Hence, they consume chili pepper in a manner comparable to humans. These animals are rarely fed from the hand of humans, and are not treated as pets. As part of a fieldwork project on the acquisition of preferences for chili pepper in Mexican children (Rozin & Schiller, 1980), one of us (PR) surveyed chili preferences in Mexican domesticates in a highland village of central Mexico. Interview of many villagers, and observation of pigs and dogs when offered piquant foods (seven pigs and 12 dogs, altogether) revealed a consistent picture: frequent ingestion of seasoned foods (but not whole peppers) but no indication of a preference for piquant over otherwise equivalent non-piquant foods. Only two villagers claimed to have animals (both dogs) that preferred piquant foods. Both of these animals were given a series of preference tests between pieces of tortilla with or without piquant sauce. These two dogs showed an indifference between these choices (as opposed to clear aversions to the piquant choice in other local animals), but neither showed a consistent preference. We conclude that in spite of extensive ingestion (exposure) of chili pepper along with other foods typical of the Mexican diet, Mexican pigs and dogs do not come to prefer it. Phylogenetic distance from primates or the absence of a social human-related context for ingestion could account for the difference between primates and dogs or pigs.

In contrast to rural Mexico, dogs are treated as pets, often "members of the family" in many American households. They are often fed table scraps. We have now discovered three pet dogs whose owners report that they voluntarily consume and "like" piquant foods. All three dogs regularly consumed table scraps in families that frequently ate piquant foods. We investigated the preference of one of these dogs, Moose Dolgin. Using dark and light crackers of the variety used in the generalization tests with the chimpanzees, and a similar set of familiarization pre-exposures and tests, we obtained evidence for a significant preference for a piquant cracker (268 Scoville units) over a plain cracker (piquant cracker preferred on 34 of 45 trials, $p < 0{\cdot}01$). These results favor the importance of a social-affective context mediated by humans.

We suggest that the pattern of results we report (in humans, chimpanzees, Rhesus monkeys, dogs in two cultures and pigs), cannot be accounted for in terms of phylogenetic differences or type of food associated with piquancy. Three other possible mechanisms (Rozin, 1979) of acquisition of preferences are: reinforcement (e.g., satiety [Booth, 1982]), "mere exposure" (Pliner, 1982) and pairing with an already positive taste (Holman, 1975; Zellner, Rozin, Aron & Kulish, Note 2). Although all three have been demonstrated to produce acquired preferences in some circumstances, none can account for the pattern of negative and positive results we have reviewed. We believe that the most likely explanation invokes a close social-affective relationship with humans that extends into the feeding situation. Bert and Jessie received their piquant crackers from the hands of a human they had been very close to since before the first year of their lives, and Moose and the Indian monkeys are pets that were fed human food by humans. On the other hand, the Mexican domesticates that do not develop preferences are neither treated as pets nor fed in a situation that can be described as a social exchange. Recent research on the development of food preferences in children suggests the importance of the social-affective context; when important others treat a food as if it is good, one is likely to adopt this same attitude (Birch, Zimmerman, & Hind, 1980). The absence of this social-affective context in almost all animal

interactions with food may be responsible for the generally weak acquired positive responses to food in animals.

Independent of the validity of the social-affective hypothesis is the fact of reversal of innate aversions in some animals. For the case of chili pepper, it is clear from other research that there are a number of different possible causes of liking and that there is more than one cause of liking (Rozin 1978, 1982; Rozin & Schiller, 1980). These include processes that would account for animal as well as human preferences [e.g., conditioned endorphin secretion (Rozin *et al.*, 1982) and others that seem more uniquely human (e.g., "benign masochism": the enjoyment of the disparity between a sensation or experience that indicates danger to the body, but at a cognitive level, is considered safe (Rozin & Schiller, 1980)]. Evaluation of these and other possibilities will have to take into account both the existence of chili pepper preferences in some animals, and the limited conditions that will produce them.

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