Journal of Comparative and Physiological Psychology
1975, Vol. 89, No. 8, 971–975

Taste Rejection of Nonnutritive Sweeteners in Cats

Linda M. Bartoshuk
John B. Pierce Foundation Laboratory, New Haven, Connecticut, and Yale University School of Medicine

Harry L. Jacobs, Thomas L. Nichols, Louis A. Hoff, and James J. Ryckman
Behavioral Sciences Division, Food Science Laboratory, U.S. Army Natick Laboratories, Natick, Massachusetts

Cats reject saccharin and cyclamate and are indifferent to dulcin, although they, like other mammals, prefer sucrose. The rejection threshold for saccharin found in this experiment, .0001 M, is about 2 log steps lower than a previously reported rejection threshold for sodium saccharin. Water produces a taste in cats adapted to their own saliva. The high sodium saccharin threshold may have resulted because the taste of the sodium saccharin was masked by the taste of the water solvent; however, saccharin may also be somewhat more aversive to the cat than sodium saccharin. Saccharin may produce an aversive taste because it stimulates receptor sites sensitive to substances bitter to man as well as those sensitive to sugars. In addition, saccharin may not be an effective stimulus for all sugar-sensitive sites.

Mammals avidly ingest sucrose; however, their hedonic responses to other substances that taste sweet to man are variable. In particular, rats (Fisher, Pfaffmann, & Brown, 1965), hamsters, rabbits (Carpenter, 1956), and pigs (Kennedy & Baldwin, 1972) show a preference for Na saccharin over its solvent, while squirrel monkeys (Fisher et al., 1965) reject it. Data on the cat have been contradictory. Wyrwicka and Clemente (1970) reported that cats prefer Na saccharin to water, but Carpenter reported that they reject Na saccharin.

The present experiments are intended to examine preference and/or aversion in the cat to four nonnutritive sweeteners: saccharin ($C_7H_5NO_3S$), Na saccharin ($C_7H_4NNaO_3S$), Ca cyclamate ($C_{12}H_{24}CaN_2O_6S_2$), and dulcin ($C_9H_{12}N_2O_2$).

Special precautions are necessary when taste solutions are tested on cats because the taste of the water can mask solute tastes. Water is often considered to be tasteless; however, the taste of water actually varies in quality as well as intensity as a function of the substance that just precedes it. For example, in man, water tastes sweet following quinine (Bartoshuk, 1968) but tastes bitter–sour following NaCl (Bartoshuk, 1974). Similarly, in other species the neural response to water depends on the substance that just precedes the water (Bartoshuk, Harned, & Parks, 1971). Originally, Zotterman and his colleagues proposed that some species have "water fibers" while other species do not (Zotterman, 1961). It now appears that the water fibers in their studies correspond to fibers that we have described as sensitive to water following NaCl, since they used Ringers solution (about .15 M NaCl) to rinse the tongue between stimuli.

The taste of water following NaCl is one of the most behaviorally significant of the water tastes because saliva contains NaCl. In man, the flat or bitter taste often considered to be the "intrinsic" taste of pure water appears to be produced by adaptation to saliva. Adaptation-induced water tastes have caused confusion in threshold experiments (Bartoshuk, 1974) and taste contrast experiments (McBurney & Bartoshuk, 1973). Water tastes can also make the analysis of solute tastes in

Portions of this work were presented in preliminary form at the Eastern Psychological Association meetings in 1971 and 1973. Authors express their thanks to L. H. Parks for technical assistance. This work was supported in part by National Institutes of Health Grant ES-00880.

L. A. Hoff is now at the Department of Psychology, Francis Marion College.

Requests for reprints should be sent to Linda M. Bartoshuk, John B. Pierce Foundation Laboratory, 290 Congress Avenue, New Haven, Connecticut 06519.

preference experiments somewhat complicated. Bartoshuk et al. (1971) showed that the cat is indifferent to sucrose dissolved in water but avidly accepts sucrose dissolved in .03 M NaCl. This concentration of NaCl prevents the fibers sensitive to water after NaCl from firing but does not markedly stimulate fibers sensitive to NaCl. It is important to note that the cats in this study could have tasted the sucrose dissolved in water if they had first consumed enough water to rinse off saliva. This is because preference was measured with the Richter two-bottle technique so that both water and sucrose dissolved in water were available. In an earlier pilot version of that experiment, in which cats were allowed unrestricted access to the preferred sucrose solutions, cats developed diarrhea from consuming sucrose because they lack sufficient sucrase to digest sucrose (Hore & Messer, 1968). After this illness, subsequent tests showed an aversion to the previously perferred sucrose in NaCl. However, the cats also avoided sucrose dissolved in water. This suggests that during the experiment they may have learned to sample between sucrose in water and water such that the water rinsed off at least some saliva and thus removed the adaptation condition necessary to produce a water taste.

In summary, certain precautions are necessary before the cat's responses to nonnutritive sweeteners can be evaluated. First, the water taste produced by adaptation to saliva should be eliminated to ensure that the cats are responding to the solute taste. This can be done by removing saliva or by dissolving the solutes in .03 M NaCl rather than water. Second, the cats should be screened to make certain they have not developed a conditioned aversion to the taste of sucrose through their digestive intolerance of it before the preference experiment begins.

Experiment 1

This experiment was designed to eliminate any potential masking of the tastes of nonnutritive sweeteners by dissolving them in .03 M NaCl instead of water.

Method

Subjects. Ten adult cats, four females and six males, were used as subjects. Half of the cats were raised on Purina Lab Chow and tap water in the laboratory. The remainder were obtained as young adults from animal suppliers; their dietary history is unknown.

Apparatus. Cats were housed in individual fiberglass cages (70 × 55 × 60 cm) equipped with stainless steel dishes for food and water and with two glass cylinders attached to the front of each cage which terminated within the cage in glass cups from which the cats could lap solutions. The room was not artificially lighted.

Procedure. The cats were tested at the beginning and the end of the experiments for preference for sweetened, dilute canned milk (1.0 M sucrose made in one part milk and four parts water) versus dilute canned milk in order to ensure that they indeed showed a preference for sucrose. Dilute milk was used because cats approach it more readily than water. Cats were deprived of water for 4 hr prior to the test (conducted about 11 a.m.) and then were presented with both bottles. Cats usually approached the bottles within a few seconds and began to drink. If after 5 min the cat was still drinking from the bottle selected initially, then the experimenter covered that bottle with his hand, and the cat usually switched immediately to the other bottle, which it was permitted to sample for an additional 5 min. This test was devised by trial and error with cats not included in the present study. It provides only a crude measure of preference but has the advantage of preventing the cats from consuming enough sucrose to get sick.

Nonnutritive sweeteners dissolved in .03 M NaCl were tested in the following order: saccharin, dulcin, Ca cyclamate. Concentrations were tested in ascending order, and each concentration was present for four consecutive days along with .03 M NaCl; the positions of the solutions were varied in an ABBA design. Cats were permitted access to the test solutions for 6 hr each day. Food (Purina Cat Chow) was available at all times, but maintenance water (tap water) was removed during testing. At least 2–3 days rest on ad-lib food and water separated the testing of different concentrations of the sweeteners. No deprivation other than the 4-hr deprivation associated with the milk test was used.

Results and Discussion

All 10 cats consumed more sweetened milk at the beginning of the experiment. At the end of the experiment, two cats consumed slightly more of the unsweetened milk but showed no reluctance to consume the sweetened milk.

Intakes of saccharin, Ca cyclamate, and dulcin are shown in Figure 1. Cats rejected saccharin and Ca cyclamate: two-tailed t, $p < .01$ for the three highest concentrations of saccharin and the highest concentration of cyclamate. The intake of dulcin was not significantly different from that of its solvent at any concentration tested, and higher concentrations were insoluble.

There were three major differences between the present study and that of Carpenter (1956): Carpenter permitted constant access to the test solutions, dissolved his solutes in tap water, and used Na saccharin. The present study permitted only 6 hr of access to the test solutions per day, dissolved the solutes in .03 M NaCl, and used saccharin. The sodium salt of saccharin (i.e., soluble saccharin) used by Carpenter is more commonly used in taste research since higher concentrations (up to 3.5 M as compared with about .02 M) can be dissolved in water. In man, the two forms of saccharin have similar detection thresholds (Williams, 1970) and taste similar in the concentration ranges usually used. In the present experiment the acid form of saccharin was used since Na ions were already added as part of the NaCl solvent for the sweeteners.

The cats in the present study were sensitive to concentrations of saccharin much lower than the concentrations of Na saccharin to which Carpenter's cats responded. Saccharin may be aversive to the cat at lower concentrations than is Na saccharin. This will be discussed in Experiment 2. However, Carpenter's cats may also have tasted the water solvent used to dissolve the Na saccharin, and that taste may have obscured the weak Na saccharin taste.

Wyrwicka and Clemente (1970, 1973), in connection with brain lesion studies, trained cats to lever press for water reinforcements and then introduced increasing concentrations of Na saccharin at one of the two available feeders. They reported the concentration (.08–.12 M) at which Na saccharin was rejected altogether in favor of water. This concentration range agrees relatively well with the concentration at which Carpenter's cats almost totally rejected Na saccharin, but both these values are almost 2 log units higher than the equivalent value in the present experiment. Some of their data also appear to show a surprising preference for concentrations of Na saccharin lower than .03 M, but this is not unequivocally demonstrated. Wyrwicka and Clemente (1973) pre-

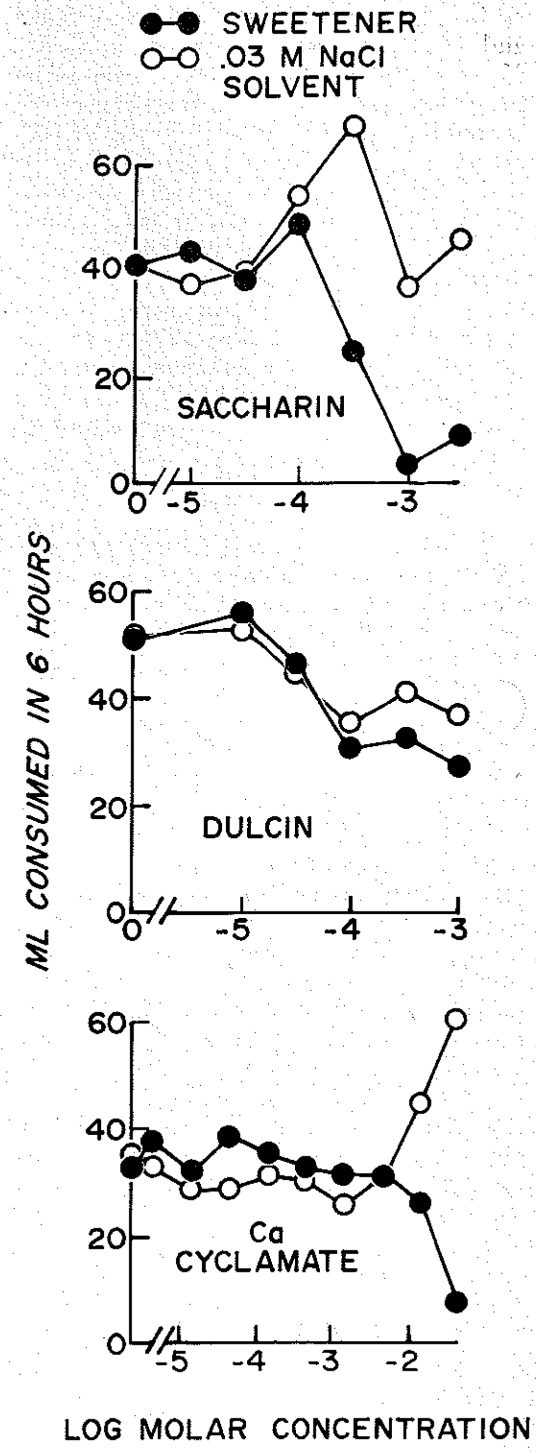

FIGURE 1. Intake (in ml) of each sweetener (dissolved in .03 M NaCl) and the .03 M NaCl solvent with which it was paired.