TASTE PERCEPTION—INDIVIDUAL REACTIONS TO DIFFERENT SUBSTANCES

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There are four tastes common to man—bitter, sweet, sour, and salt (in order of sensitivity). The complex perception of taste involves odor, temperature, and touch. The various tastes are brought about by the many papillae which cover the tongue. Though there are four different types of papillae on the human tongue, only two, the fungiform and circumvallate papillae, are concerned with taste perception. These papillae possess, on their surfaces, taste buds, which, in turn, contain the fundamental cells for taste perception. It is impossible to distinguish the different types of taste buds by appearance. Most of the taste buds are situated on the upper surface of the tongue. The center of the tongue is devoid of taste buds. The sweet taste is most easily sensed at the tip of the tongue, bitter at the back, sour at the edge, and salty both on the tip and the edge. It is believed that the papillae are not generally exclusively sensitive to one taste. There are approximately 9,000 taste buds on the human tongue. There is no difference between men and women as to the number of taste buds, but the number of taste buds has been found to decrease with age. The sense of taste has a duration of from 0.0015 to 0.0040 seconds. The optimum temperature for taste is from 20° to 40° C.[1]

In the present series of experiments twenty-one persons were tested, all being members of the student body or faculty of Illinois Wesleyan University. They ranged in age from nineteen to thirty-two. In the group tested there were four women and seventeen men. Personal habits, including the use of tobacco and alcohol, and to what extent they are used, were recorded for possible correlation with the individual's perception. Place of residence was also recorded.

The following general procedure was used. The individual was told before starting the taste tests that there are four principal tastes: bitter, sweet, sour, and salty. He was also told that the solutions he was about to taste might possess any one of these tastes or that the solution might be insipid. It was made clear to the subject that by insipid we meant the taste of distilled water. (Although they knew that all substances possess some taste or impart some feeling when tasted, the testers called the taste of distilled water "no taste".) All subjects were asked if they knew and if they had ever experienced the taste of distilled water. If their answer was negative or in doubt they were given distilled water to taste. All subjects

[1] R. W. Moncrieff, *The Chemical Senses:* John Wiley and Sons, Inc., 1946.

were told that there was a possibility that some solutions might be distilled water. This was done so as to eliminate any possible guessing on the part of the taster. In reality, however, all solutions given in the tests contained substances, of one kind or another.

The first series of solutions which the subject was asked to sample consisted of varying dilute concentrations of hydrochloric acid (HCl), after which the following series came in respective order: sucrose, sodium chloride (NaCl), saccharine, and quinine sulfate. Following the solutions three types of crystalline substances were tasted. They were: diphenyl-guanidine, thiourea, and diortho-tolyl-guanidine. Separate five mililiter beakers were used for each series of solutions tested. The subject was never told what the solutions contained or whether the solution was supposed to possess a certain taste or not. It was left to the tester's discretion whether to give a solution once, twice, or not at all. It was believed that if the subject was able to distinguish the respective taste in two or three consecutive solutions in a series, further test solutions in that series would not have to be given. After each series the subject was asked to wash out his mouth with water. If a taste persisted after one concentration in a series was given the subject was asked to wash his mouth out until that taste sensation disappeared; then the next concentration in that series was given. When testing the solids, the subject was asked to place but a few crystals on his tongue. In both the crystalline and the solution tests all subjects were instructed to allow the solutions or solid to come in contact with the tongue's entire surface.

The experimenter realizes that there are errors of method in the procedure outlined. Some of these errors are correctable and some are not. There was an attempt by the experimenter to keep possible errors down to the minimum.

The possibility of excessive stimulation from the preceding concentration of solution in each series was considered negligible, since it was the policy of the tester never to give a more concentrated solution before a less concentrated solution in a specific series. A solution in a given series was half the concentration of a succeeding more concentrated solution except in the case of quinine sulfate, in which the most concentrated solution was four times the concentration of the preceding solution.

A subject was submitted to all the taste-test series at one sitting. It was most regretable that this part of the procedure was carried out as such, but the experimenter was pressed for time, and the subject's time was not always available to the tester. Still, an attempt was made in which the solutions were staggered, so as to have differential tastes following one another. The system used was as follows: sour, sweet, salt, sweet, and bitter. In reference to the solids, since all were bitter in taste, no system of staggering could be used. After one solid was tasted by the subject a short space of time was permitted to elapse before the next crystals were tasted. It was found that the taste experienced from each solid was strong enough to give definite positive results.

Subjects were usually tested during mid-morning or afternoon. No test was given to a person who had just previously smoked, chewed gum, or had anything to eat.

The one factor which the experiment rested heavily upon was the human element. All taste experiences and descriptions of such rested with the subject. It became apparent to the tester that several subjects were not fully familiar with the four fundamental tastes. These subjects were asked to describe the test solutions with respect to any other substances that they may have previously experienced. The errors which may have been incurred by the human factor seemed unavoidable.

There were eight substances used in the tests, five in solution and three in crystalline form. A stock solution was made for each series of solutions to be tested. These stock solutions were the most concentrated solutions for each series. From each stock solution was derived succeedingly more dilute solutions. A dilution factor of two was used, except in the instance of quinine sulfate, which had a dilution factor of four. All solutions were made with distilled water. For the sour taste, solutions of 1:400, 1:800, and 1:1600 HCl were used. In the salt taste, solutions of 1:200, 1:400, and 1:800 NaCl were used. Bitterness was presented in solutions of 1:5M, 1:20M, 1:40M, 1:160M, and 1:640M quinine sulfate. Two series of solutions were used to test the sweet perception. Saccharine was used in 1:20M, 1:40M, 1:80M, and 1:160M solutions, and sucrose was used in 1:40, 1:80, 1:160, 1:320, and 1:640 solutions. (Note: M is equivalent to the multiple 1000.) The three solids tested were thiourea, diphenyl-guanidine, and di-ortho-tolyl-guanidine (fig. 1).

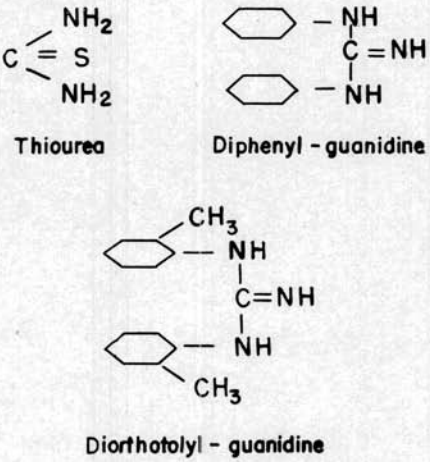

FIG. 1.

The crystalline solids were served to the subject on white filter paper. The solutions were given to the subjects in 5 ml. beakers each containing from 1 to 3 ml. of solution. All solutions were kept at room temperature. The solutions were kept in 500 m. Florence flasks labeled with code letters and numbers to eliminate any possible psychological effects that might be developed.

Previous work has been done in the study of the solutions mentioned. As to the three solids used, work in regard to taste perception has been done on di-phenyl-guanidine by Snyder & Davidson (1937), who found a 3:1 ratio of tasters to nontasters. In the present experiment the taste thresholds of different individuals, with respect to the solutions, are recorded in table 1. It was our desire to see if there were any nontasters in the group, but all subjects

TABLE 1.—THRESHOLD CONCENTRATION OF INDIVIDUALS FOR VARIOUS SUBSTANCES

Subject No.	HCl	NaCl	Quinine sulfate	Saccharine	Sucrose
1	1:1600	1:800	1:640M	1:160M	1:320
2	1:1600	1:800	1:320M	1:160M	1:320
3	1:800	1:400	1:320M	1:160M	1:160
4	1:1600	1:800	1:160M	1:160M	1:160
5	1:1600	1:800	1:320M	1:160M	1:320
6	1:1600	1:400	1:40M	1:80M	1:160
7	1:1600	1:800	1:80M	1:80M	1:80
8	1:800	1:400	1:5M	1:20M	1:40
9	1:1600	1:800	1:40M	1:80M	1:320
10	1:1600	1:800	1:20M	1:160M	1:160
11	1:1600	1:400	1:320M	1:160M	1:640
12	1:1600	1:800	1:320M	1:80M	1:160
13	1:1600	1:800	1:640M	1:160M	1:640
14	1:1600	1:800	1:640M	1:160M	1:640
15	1:1600	1:800	1:320M	1:160M	1:320
16	1:1600	1:400	1:40M	1:40M	1:320
17	1:800	1:800	1:640M	1:160M	1:160
18	1:1600	1:800	1:40M	1:80M	1:160
19	1:1600	1:800	1:160M	1:40M	1:80
20	1:1600	1:800	1:320M	1:40M	1:160
21	1:1600	1:800	1:80M	1:160M	1:160

were able to taste the three solids. One person had difficulty in initially being able to taste di-phenyl-guanidine, but after a minute the subject was able to perceive the taste. Though all persons were able to taste thiourea, three out of the twenty-one tested claimed that it was sour and not bitter. All persons agreed that di-ortho-tolyl-guanidine was bitter. Some claimed it to be more bitter than di-phenyl-guanidine. Possibly the two methyl groups could be the attributing factor.

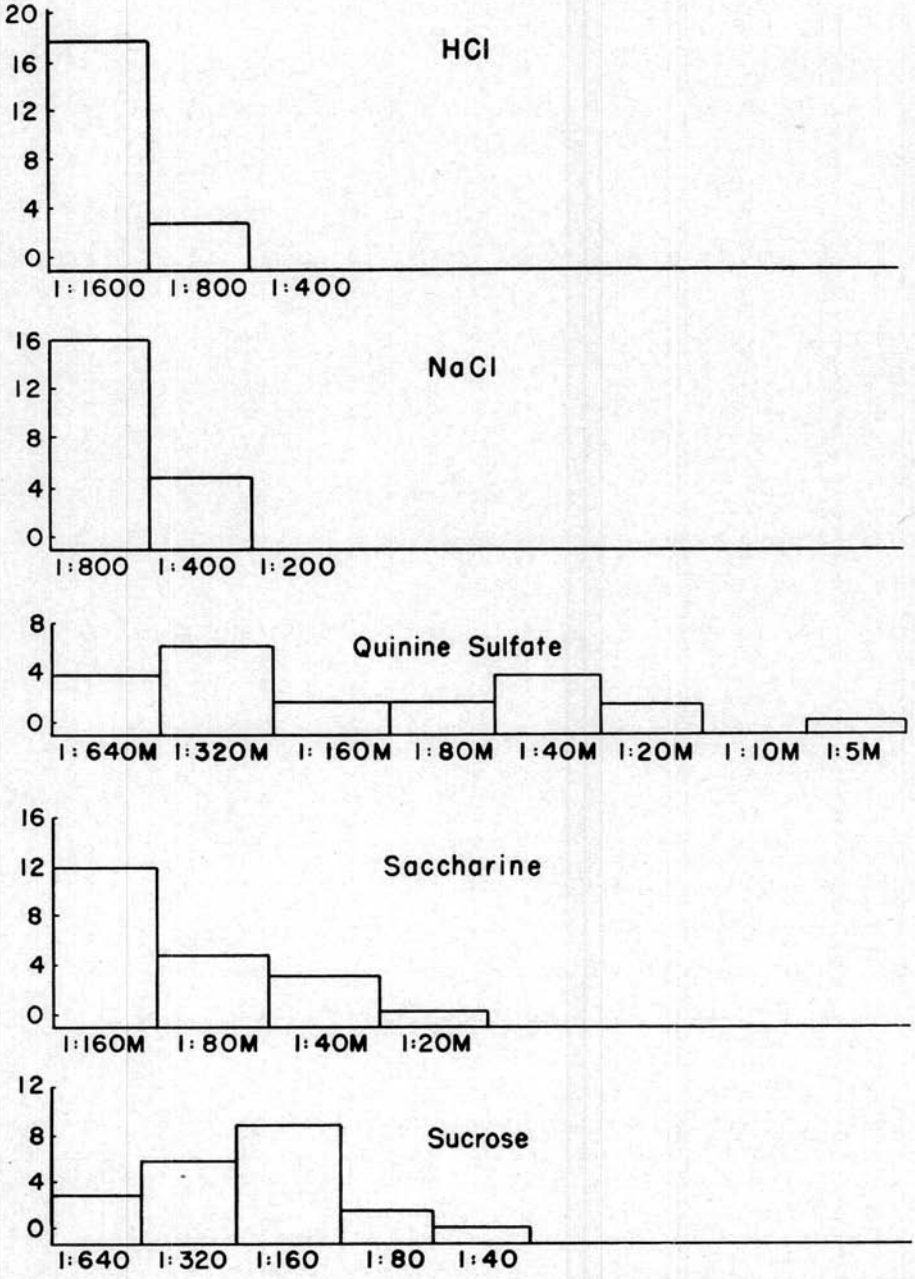

FIG. 2.—Number of individuals in each threshhold concentration for each series of solutions.

TABLE 2.—TASTE REACTIONS OF INDIVIDUALS TO HCl AT VARIOUS CONCENTRATIONS

Subject No.	1:1600	1:800	1:400
1	Sour	Sour	
2	Tarty	Sour	Sour
3	No taste	Alkaline	Sour
4	Bitter	Sour	
5	Sour	Sour	
6	Sour	Bitter	Sour
7	Slightly astringent	Sour	
8	No taste	Sweet	Sweet
9	Slightly sour	Bitter	Bitter
10	Bitter	Bitter	Bitter
11	Sour	Sour	
12	Bitter-sweet	Bitter-sweet	Salty
13	Bitter	Bitter-sour	Bitter
11	Sour	Sour	
15	Sour	Sour	
16	Slightly astringent	Bitter	Astringent
17	No taste	Bitter	Sour
18	Sour	Sour	
19	Acid	Sour	
20	Bitter	Sour	
21	Sour	Sour	

The tester considered a threshold point as the concentration at which the subject could differentiate some sort of a taste aside from distilled water. Occasionally the taste experienced at the threshold did not correspond to the taste usually associated with the substance in solution. In most of these cases the subject would distinguish the true taste in stronger concentrations of the test solution. Occasionally, however, another taste differing from the familiar taste of the solution was reported. An example of this is subject No. 10, who experienced a bitter taste in all three of the HCl solutions. Subject No. 12 declared that the two diluted HCl solutions were bitter-sweet and that the concen-

trated solution was salty. The greatest discrepancy in taste description was found in the HCl series. The subjects were able to taste the substance, but many claimed it to be other than sour at certain concentrations. Again, in the NaCl series there were a few instances of wrong identification of taste. Subject No. 10 claimed that the 1:800 solution was sweetish and that the 1:400 solution was bitter. Subject No. 20 stated that the 1:800 solution was sour. There was no disagreement in the tastes recorded for the bitter and sweet series of solutions. The bitter solutions were recognized quite distinctly as bitter when perceived. Listed in table 2 are the reactions to the HCl series of solutions. The majority of individuals had difficulty with the sweet solutions. Subjects Nos. 6, 7, 8, 12, 18, 19, and 20 did poorly in the series of sweet solutions. Subjects Nos. 3, 4, 10, 17, and 21 did well in the saccharine series but poorly in the sucrose series. Subjects Nos. 6, 7, 8, 9, 10, 16, 18, and 21 did poorly in the bitter series of solution. Subject No. 8 did the poorest. He was only able to taste the most concentrated solutions in the quinine sulfate, saccharine, and sucrose series, and could taste only the second most concentrated solutions in the NaCl and HCl series. Only two individuals, subjects Nos. 13 and 14, were able to perceive all substances in their most dilute solutions.

It becomes apparent that individuals differ with regard to taste perception, as shown by threshold differences. Some persons differ as to the fundamental taste of a solution or solid. The sour and salty series of solutions are not perceived as well at low concentrations as are the sweet and bitter solutions. No safe correlation may be made between the ability to taste and the impairment of that ability through smoking. At present the only method of measuring the taste ability is subjective and therefore, unreliable. It has been the attempt of the experimenter to report what was considered the truest response, and it is believed that the individuals involved endeavored to do so.