Influence of Verbal Suggestion on the Parotid Gland Response to Gustatory Stimuli.* (29402)

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The quantitative measurement of human parotid gland response to gustatory stimuli affords an exquisite approach in the evaluation of neurophysiological mechanisms associated with gustation, salivary gland function, and human behavior. This procedure has been recently employed to determine the relationship between secretory response and affector intensity(1), and properties of acids which are responsible for their stimulatory action on the gustatory chemoreceptors(2).

The current communication is the first in a series of studies designed to determine the effect of verbal or symbolic stimulation and hypnosis on the gustato-salivary reflex.

Materials and methods. Sixty sophomore dental students were assessed on response to the Barber Suggestibility Scale, administered when awake, as described by Barber and Glass(3), and Barber and Calverley(4). To determine the response obtained with persons who rated low on the suggestibility scale 12 students who scored in the lowest quartile were selected.

Two gustatory modalities, sour and sweet, were employed. Each subject applied solutions of citric acid or sucrose to his own tongue using wetted cotton tipped applicator sticks. A constant rate of 4 swabs per minute was carefully maintained throughout the series of tests. Each application consisted of running the wetted cotton around the lateral edges of the tongue followed by swabbing the entire dorsum.

Parotid saliva was collected unilaterally using vacuum cups(5). Sampling was done early in the morning, before the subjects had eaten breakfast, brushed their teeth, or smoked. The secretion was collected in tubes graduated to 0.1 ml. The flow rate—ml/10 min/gland—was calculated by recording the volume secreted during a 10 minute interval.

A standardized procedure was used to test each solution. First a 5 minute "acquaintance" interval of stimulation was given to allow the gland to adjust to the stimulus. The secretion obtained was discarded. Immediately after the acquaintance interval a 10 minute "experimental" saliva sample was collected. The participants were then given a drink of water and rested for 5 minutes. Using this sequence 6 different concentrations of test solution were evaluated during one test period. The entire test period occupied one hour and 55 minutes and the participants were tested only once per week.

An introductory test period, employing solutions of both sucrose and citric acid, was used to familiarize the subjects with the collection procedure. This also served to allay subject apprehension, which might alter their normal secretory response to the stimuli.

The effect of the solution concentration on the parotid gland secretion rate was then determined without and with verbal suggestion. Concentrations of citric acid were 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 g per 100 ml, while 5, 10, 15, 20, 30, and 40 g per 100 ml solutions of sucrose were employed. To determine the response resulting from tactile sensation, 2 tests were conducted using water. The mean value obtained with water was subtracted from all experimental values so that only the response arising from gustation was obtained.

The sequence of testing was as follows: citric acid without suggestion, water without suggestion, citric acid suggested to be a strong, sweet solution, citric acid suggested to be tasteless, sucrose without suggestion, water without suggestion, sucrose suggested to be a strong sour solution, and sucrose suggested to be tasteless.

When verbal stimuli were employed, spe-

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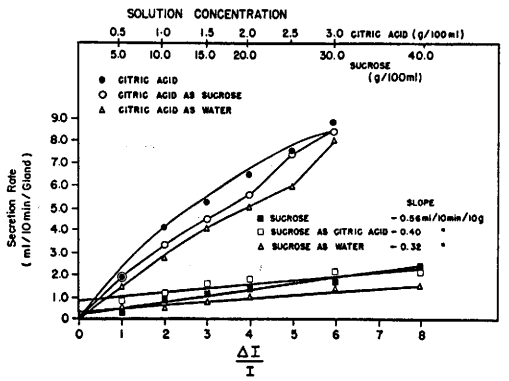

FIG. 1. Effect of verbal suggestion on parotid secretion rate.

cific suggestions were given to the subject just prior to the acquaintance sample, and were repeated once before and once during the collection of the experimental saliva sample. For example, verbal suggestions given when the citric acid was suggested to be sucrose were as follows: "You all remember tasting a strong sweet solution in one of the previous experiments. Disregard the actual taste of the solution you are using and vividly imagine that it is the same strong sweet solution you tasted previously. Continue to imagine, trying as best you can, all during the collection interval, that the solution is a strong sweet solution."

After each solution in the 4 suggestion series—2 with citric acid, 2 with sucrose—each subject was asked whether he could or could not imagine the suggested effect. This information was recorded in order to correlate this subjective evaluation with the secretion rates.

Results. The relationship between secretory response (group mean) and solution concentration is illustrated in Fig. 1. These concentrations were all above the absolute threshold for each individual. All subjects were able to discern changes in gustatory intensity from one solution to the next. Previous studies have indicated that the secretory response remains quite consistent over a prolonged period when a constant solution concentration and swab rate are employed (1). Thus, during the time period employed in the current study, there should have been no measurable fatigue effect or accommodation to gustatory stimuli.

Secretory response to citric acid increased in a curvilinear manner as the concentration increased. When citric acid was suggested to be sweet, the secretory rate was depressed until the solution concentration reached 2.0 g per 100 ml, at which point the response approximated the results obtained for citric acid without suggestion. The secretory rate was depressed still further when citric acid was suggested to be tasteless. It remained depressed until a concentration of 2.5 g per 100 ml was reached and then at 3.0 g/100 ml was the same as that obtained for citric acid without suggestion.

The response elicited by sucrose solutions was considerably lower than that produced when citric acid solutions were employed. There is, however, a direct linear relationship between secretory rate and solution concentration. When the sucrose was suggested to be a strong sour solution, the secretory rate was greater than the nonsuggested rate until a concentration of 30 g per 100 ml was reached. When the sucrose solutions were suggested to be tasteless the rate, except for the 5 g % concentration, was lower than the nonsuggested rate. It is of interest to note the gradients or slopes obtained for the latter 2 series. Both sucrose suggested to be sour and tasteless have lower gradients than the nonsuggestion series.

The non-parametric chi-square test and sign test were used to determine whether the means were in the predicted direction. Seventy-one comparisons (data were incomplete on one comparison) in secretion rate (12 subjects $\times$ 6 soln. conc.) were obtained from the 3 citric acid series. Based on the hypothesis that the rate when subjects received citric acid without suggestion would be greater than the rate when citric acid was suggested to be sweet, and in turn the latter would be greater than the rate obtained when citric acid was suggested to be tasteless, this frequency would by chance follow the predicted pattern once in 6 times for a total of 11.9 of the 71 recorded rates. The actual frequency of secretion rates which followed this pattern was 21 and this observed frequency

TABLE I. Significance of Change in Secretory Rate Due to Verbal Suggestion.

Prediction	Probability level
$C_1 > C_2 > C_3$	<.01
$C_1 > C_2$	.17
$C_1 > C_3$	<.001
$C_2 > C_3$	<.001
$S_2 > S_1 > S_3$	<.01
$S_2 > S_1$	.20
$S_2 > S_3$	<.001
$S_1 > S_3$	<.001

Legend:

Series—

C_1—Citric acid.
C_2—Citric acid suggested to be sweet.
C_3—Citric acid suggested to be tasteless.

S_1—Sucrose.
S_2—Sucrose suggested to be sour.
S_3—Sucrose suggested to be tasteless.

was significantly different from the chance frequency beyond the 0.01 probability level.

In a similar manner it was hypothesized that the secretion rate obtained when sucrose was suggested to be sour would be greater than the rate obtained when sucrose was given without suggestion, and the latter, in turn, would evoke a greater response than that elicited when sucrose was suggested to be tasteless. As above, the frequency secretion rate that would fall into this predicted pattern by chance is 1/6 of 72, or 12. Twenty-one of the observations obtained with the 3 sucrose series followed the predicted pattern, thus the observed frequency was significantly different from the chance frequency (Table I).

The above overall predictions can be broken down into 3 component predictions (Table I). Since the direction of the difference was predicted the mean differences in secretion rates for the citric acid and sucrose series were taken in pairs and tested using a one-tailed sign test. All of the differences were in the predicted direction, however, for each taste modality only 2 of the 3 components were significant in the predicted direction beyond the 0.001 level of probability. When the citric suggested to be sweet was compared to citric acid alone, and sucrose suggested to be sour was compared with sucrose alone, the differences in the secretory response between the variables were not statistically significant (Table I).

Chi coefficients of correlation were computed between the dichotomized verbal reports (could or could not imagine the suggestion) and the dichotomized secretory effect (secretion rate did or did not change in the predicted direction). As illustrated in Table II non-significant correlations were obtained between the subjective reports and rate of secretion when citric acid was suggested to be sweet and when sucrose was suggested to be sour. Significant correlations, however, were obtained between the subjective reports and the alteration in secretory rate when citric acid was suggested to be tasteless, and when sucrose was suggested to be tasteless.

Discussion. Brunacci and De Sanctis(6) were the first to employ changes in the "direct" gustato-salivary reflex to indicate objectively the effect of cortical behavior on the human organism. Using a dilute solution of acetic acid as the stimulus they observed that mental activity caused a diminution of the parotid gland secretory rate. Subsequently, Winsor(7-16) studied the effect of innumerable variables on the parotid gland secretory rate. His initial investigations were primarily involved with changes in parotid secretory rate induced in the absence of extero stimuli. Later Winsor noted that mental activity had an inhibitory influence both on the unconditioned and conditioned (extero stimuli induced) salivary reflex.

Some of the earliest studies dealing with the effect of direct suggestion on gustation and salivary gland response were conducted by Bowles and Pronko(17), and Pronko and Hill(18). Stimuli were given in both the hypnotic and non-hypnotic condition. They determined the non-hypnotic response to

TABLE II. Correlation of Subjective Report and Change in Secretory Rate.

Condition	Phi correlation coefficient	Probability level
Citric acid suggested to be sweet	−.08	N.S.
Citric acid suggested to be tasteless	+.28	.02
Sucrose suggested to be sour	+.11	N.S.
Sucrose suggested to be tasteless	+.22	>.05

lemon juice suggested to be maple syrup, maple syrup suggested to be lemon juice, maple syrup as maple syrup, and lemon juice as lemon juice. In the non-hypnotic state suggestion did not significantly alter the responses elicited by the maple syrup and lemon juice.

The current findings indicate that the parotid gland secretory response to citric acid can be significantly depressed by suggesting that the acid is tasteless. Similarly, the parotid response to sucrose solution can be significantly depressed by suggesting that the sucrose solution is tasteless. These suggestions were found to be effective with subjects who had been rated as relatively unresponsive on a scale of "hypnotic-like" suggestibility. The effect of suggestion on parotid gland secretory rate in subjects rated high on "hypnotic-like" suggestibility and alteration in response following administration of a hypnotic induction procedure remain to be demonstrated.

Summary. Parotid gland secretion rate was measured in a group of 12 subjects selected as being relatively non-amenable to suggestion. Parotid fluid was obtained using a vacuum cup and collected in tubes graduated to 0.1 ml. Secretion rate was determined by measuring the volume secreted during a 10 minute stimulation interval. Solution concentrations were: citric acid—0.5, 1.0, 1.5, 2.0, 2.5, 3.0 g/100 ml; sucrose—5, 10, 15, 20, 30, 40 g/100 ml. After the subjects had experienced the gustatory sensations under control conditions (non-suggestion), and their secretion rate ascertained, they were asked to imagine various experimental (suggestion) conditions. It was observed that the parotid gland secretion rate was greater when the subjects received citric acid without suggestion than when citric acid was suggested to be sweet. The latter, in turn, was greater than the rate obtained when citric acid was suggested to be tasteless. The flow rate obtained when sucrose was suggested to be sour was greater than for sucrose without suggestion, while sucrose suggested to be tasteless evoked the lowest secretory rate in this triad.

Chi square analysis of the data indicated that the differences among secretion rates for each triad were statistically significant. However, when the variables were compared separately, using the sign test, it was observed that the differences between citric acid *vs* citric acid suggested to be sweet and sucrose *vs* sucrose suggested to be sour were not statistically significant.

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