Enhancement of Gustatory Neural Response to Salts Following Adaptation of Frog Tongue to Quinine–HCl

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SATO, T. Enhancement of Gustatory Neural Response to Salts Following Adaptation of Frog Tongue to Quinine–HCl. Tohoku J. exp. Med., 1975, 117 (4), 381-384 — After a frog tongue was adapted to 0.001 M quinine-HCl (Q-HCl), a change in the gustatory neural responses to salts was investigated. The initial phasic response to a variety of salt solutions such as 0.1 M NaCl, KCl, LiCl, MgCl₂, and CaCl₂ was greatly potentiated as a result of the Q-HCl adaptation. A weaker enhancement of the response to salts was observed after the tongue was adapted to deionized water, compared with the control response to salts during Ringer adaptation. Therefore, the Q-HCl-induced enhancement of salt responses is due to the summated effect of Q-HCl solute and water solvent. Concerning the enhancing mechanism of Q-HCl, it is postulated that the membrane potential of some salt-sensitive taste cells will be displaced in the hyperpolarizing direction during the Q-HCl adaptation, and that large depolarization, which may be related to the enhanced nerve response, will be produced by applying salts after Q-HCl. —— frog tongue; gustatory response; enhanced taste; quinine

An electrophysiological investigation has demonstrated that the magnitude of gustatory nerve response to a taste stimulus is either reduced or potentiated by the adaptation of the tongue to other taste stimuli. Smith and Frank (1972) have indicated that the adaptation of the rat tongue to quinine hydrochloride (Q-HCl) reduces the gustatory neural response to a variety of salts. In the present study, it will be shown that a marked enhancement of the responses of frog gustatory nerves to various salt solutions occurs after the tongues have been adapted to Q-HCl. The mechanism underlying this enhancement will be discussed.

MATERIALS AND METHODS

Bullfrogs, Rana catesbeiana, anesthetized with urethane were used in the present work. The glossopharyngeal nerve was exposed and the whole nerve activity was recorded with standard electrophysiological equipments. The nerve impulses recorded were integrated with an electronic integrator with the time constant of 0.4 sec. A gustatory stimulator used for taste stimulus presentation was the same as that described previously (Sato 1972). The rate of solutions flowing over the tongue surface was 0.36 ml/sec. The taste solutions, made from reagent grade chemicals and deionized water, were the following: 0.00001–0.001 M Q-HCl; 0.1 M NaCl, LiCl, KCl, MgCl₂, KNO₃, NaNO₃, Na₂SO₄.

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MgCl₂ and CaCl₂; mixtures of 0.00001–0.001 M Q-HCl plus various 0.1 M salts; and deionized water. The frog tongues were usually adapted to Ringer's solution for 3 min or longer before the application of adapting taste solutions, and were rinsed with Ringer's solution after test solutions.

RESULT AND DISCUSSION

The records in Fig. 1 show an example of integrated gustatory neural responses to 0.1 M NaCl when the tongue was adapted to Ringer's solution (A), deionized water (B) and 0.001 M Q-HCl (C) for 10 sec. No rinse solution was interposed between two successive applications of the adapting solutions and test solutions. The histograms of Fig. 2 illustrate the peak amplitude of initial phasic neural responses to five salt solutions of 0.1 M and to deionized water following 10 sec adaptation to Ringer's solution, deionized water and 0.001 M Q-HCl. It is obviously seen that the gustatory responses to all five salts when adapted to the Q-HCl are much larger than the responses to the salts when adapted to the Ringer's solution and deionized water. This indicates that the stimulating effectiveness of the salts is greatly enhanced by the previous Q-HCl adaptation. The

![Fig. 1. Integrated gustatory neural response to 0.1 M NaCl following 10 sec adaptation to Ringer's solution (A), deionized water (B) and 0.001 M Q-HCl (C). Lower traces indicate the application of adapting and test solutions.](image1)

![Fig. 2. Histograms showing gustatory neural responses to five 0.1 M salts and deionized water. These test stimuli were given after a tongue was adapted to Ringer's solution (R), deionized water (W) and 0.001 M Q-HCl for 10 sec. Ordinate denotes peak amplitude of initial phasic responses in arbitrary units. Data from one preparation.](image2)
response to the other salts tested was also enhanced by the adaptation to 0.001 M Q-HCl. As shown in Fig. 2, a weaker enhancement of salt responses was observed after the tongue was adapted to deionized water, compared with the control response evoked by salts following Ringer adaptation. Therefore, the enhancing effect of an adapting 0.001 M Q-HCl solution made with deionized water resulted from the summated effect of the Q-HCl solute and the water solvent.

The last histogram of Fig. 2 illustrates that the response to a deionized water test stimulus after adaptation to 0.001 M Q-HCl is slightly larger than that after adaptation to Ringer’s solution. However, the water solvent in the test salt solutions of 0.1 M did play a negligible role in generation of the enhanced salt responses, because an ability of a water stimulus to produce the taste response is suppressed in the presence of various 0.1 M salts (Kusano and Sato 1957). It is concluded that the response to salts following 0.001 M Q-HCl adaptation is elicited by the stimulating effectiveness of salts’ solutes per se.

There remains a question, however, that small amount of adapting 0.001 M Q-HCl solution, which is mixed with a 0.1 M salt at the moment of the test solution presentation, will potentiate, to some extent, the stimulating effectiveness of the salt solution. Fig. 3 shows an experiment made by using 0.1 M MgCl₂ for examining this possibility. Fig. 3A illustrates the dose-response curves obtained with Q-HCl and with a combination of Q-HCl and 0.1 M MgCl₂ after the tongue was adapted to Ringer’s solution. The response to mixtures of Q-HCl plus 0.1 M MgCl₂ was smaller than a total response of Q-HCl and 0.1 M MgCl₂ respectively. This was due to the inhibitory action of 0.1 M MgCl₂ in the mixtures on the Q-HCl responses. On the other hand, Fig. 3B illustrates the dose-response curves obtained with Q-HCl and with mixtures of Q-HCl and 0.1 M MgCl₂ following 10 sec 0.001 M Q-HCl adaptation. It is seen that after the 0.001 M Q-HCl adaptation various test Q-HCl stimuli below 0.001 M elicited only small responses,

![Fig. 3. Gustatory nerve responses to various concentrations of Q-HCl and to mixtures of various concentrations of Q-HCl and 0.1 M MgCl₂. A, Responses to Q-HCl and mixtures after Ringer adaptation. B, responses to Q-HCl and mixtures after 0.001 M Q-HCl adaptation. Ordinates, peak amplitude of integrated responses in arbitrary units. Data from one preparation.](image)
which were derived from the water solvent in the test Q-HCl stimuli. This indicates
that the tongue was completely adapted by the solute in the adapting Q-HCl
solution during its presentation. The response magnitude to mixtures of Q-HCl
and 0.1 M MgCl₂ after 0.001 M Q-HCl adaptation was the same as that to plain 0.1
M MgCl₂ after 0.001 M Q-HCl. If Q-HCl in the mixture stimuli following 0.001
M Q-HCl enhances the response to the MgCl₂, the response to the mixtures may be
changed depending on the Q-HCl concentration. This was not the case as shown
in Fig. 3B. The same relation was obtained with mixtures of Q-HCl and other
0.1 M salts. It is clear from this experiment that the small quantity of 0.001 M
Q-HCl, momentarily mixed with the test 0.1 M salt solutions, did not contribute
to the enhancement phenomenon of salt responses: the enhancement was merely
due to the process of Q-HCl adaptation.

Sato (1973) and Sato and Beidler (1973) have indicated that the resting
potential of a salt-sensitive frog taste cell is larger under water adaptation rather
than that under Ringer adaptation, and that the depolarizing receptor potential of
the water-adapted taste cell in response to a NaCl solution is larger in amplitude
than that of the Ringer-adapted cell. Concerning the enhancing effect of Q-HCl
adaptation on the salt response, therefore, it is proposed that adaptation of some
salt-sensitive taste cells to 0.001 M Q-HCl solution produces the resting potential
larger than that during Ringer adaptation, and that the taste cells of the larger
resting potential generate the larger amplitude of depolarization in response to
0.1 M salt. This enhanced depolarization might be related to the enhanced salt
response in the gustatory nerve.

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References