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FACILITATORY EFFECT OF CERTAIN CHLORIDES ON TASTE NERVE RESPONSES OF THE TOAD TO ACIDS

BY

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ABSTRACT

The responses of the whole glossopharyngeal nerve of the toad to inorganic and organic acids were markedly enhanced by the addition of univalent chloride and calcium chloride.

The ratios of response of mixtures to the sum of respective responses of M/512 acids and M/4 chlorides were 1.2–2.7.

The facilitatory effect of sodium chloride on responses to M/512 hydrochloric acid and acetic acid was observed in concentration of M/16 and the facilitation appeared in the concentration of the salt.

INTRODUCTION

There have been comparatively few electrophysiological studies made on acid stimulation, though a great number of experiments on taste in general exists[1]. Neural responses to various organic and inorganic acids were studied in the rat by Beidler[2]. On the frog specific receptor for acid in the tongue was first observed by Pumphrey[3]. Recently, Kusano obtained a single glossopharyngeal nerve fiber of the frog responding mainly to acetic acid[4]. Furthermore, the neural responses to several acids were investigated using the frog and toad by Tateda[5]. However, electrophysiological profiles of acids in the presence of other substances such as salts still remain obscure.

Therefore, effect of certain chlorides on glossopharyngeal nerve responses of the toad to acids was studied in the present experiment.

MATERIALS AND METHODS

The tested acids were hydrochloric acid, sulfuric acid, acetic acid, glutamic acid, and citric acid in concentration of M/512. Chlorides of sodium, potassium, ammonium, calcium, barium, aluminium, and iron(III)

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were examined.

The method of recording the response was as follows: The whole glossopharyngeal nerve of the toad was isolated, the peripheral end of the nerve was placed on a silver electrode and impulse discharge was fed through a tape-recorder to the Nerve Impulse Count-Summator[6], both being monitored by a cathode ray oscilloscope, to pick up the impulses above ca. 20 μV selectively. The summated impulses were amplified by a DC amplifier and recorded by an ink-writer[7]. Thus, the temporal response pattern of the whole glossopharyngeal nerve elicited by application of taste stimuli to the tongue was recorded on the paper and the number of impulses in each 0.1 or 0.2 second after the onset of impulses was calculated.

Results and Discussion

1. Facilitatory action of certain chlorides for responses to acids

Enhancement of the glossopharyngeal nerve response produced by mixing sodium chloride with above five acids is shown in Fig. 1. The response to a mixture containing M/4 sodium chloride and M/512 acid was significantly greater than the sum of responses to each substance alone.

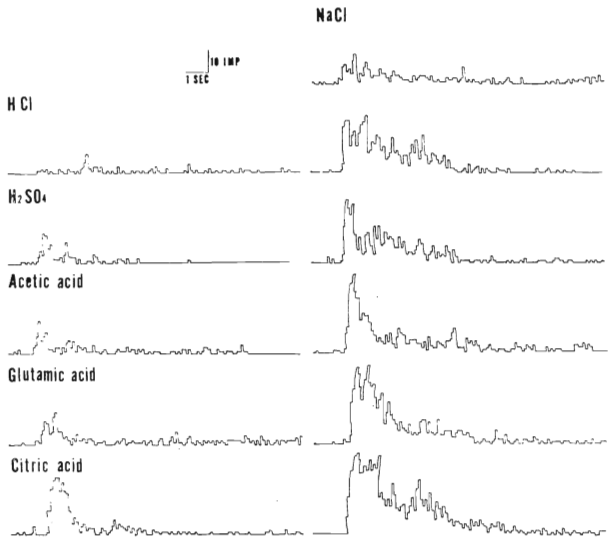

Fig. 1. Summated responses to stimulations by acids, with or without sodium chloride.

The records in the left column indicate the responses to acid solutions of M/512 and those in the right column show the responses to a mixture of corresponding acids with M/4 sodium chloride. Ordinate: Number of impulses. Absc: Time in seconds.

A similar phenomenon was observed when potassium chloride, ammonium chloride, or calcium chloride was used instead of sodium chloride. The effect of barium chloride could not be estimated because of a specific sensitivity of barium treated nerve, as it well known[8]. Aluminium chloride and ferric chloride did not show any effect on discharges elicited by acids, but response to both trivalent chlorides were not always encountered as a slight shrinkage of tongue muscle produced often some noises in the oscilloscope. The ratio of response of a mixture to the sum of respective responses to acid and chloride R(a+s)/Ra+Rs (the so-called facilitation ratio)[9] was calculated from the number of impulses during 5 seconds, as summarized in Table 1. The values for calcium chloride were lower than those for univalent chlorides.

Table I. Facilitation ratios of chlorides for acid responses (R(a+s)/Ra+Rs)

Acid	Chloride			
	NaCl	KCl	NH_4Cl	$CaCl_2$
Hydrochloric acid	1.34	1.86	1.35	1.30
Sulfuric acid	1.96	2.67	1.48	1.28
Acetic acid	1.46	1.78	2.37	1.34
Glutamic acid	2.21	1.75	2.70	1.20
Citric acid	2.14	2.56	1.60	1.81

2. Test of cross adaptation

It was revealed that the mixing of certain chlorides with acids produced stimulating effect on response magnitude. However, it was not clear whether the chloride was an enhancer or not with respect to the results shown in Fig. 1. Therefore, the test of cross adaptation was carried out. Solutions of M/512 hydrochloric acid, M/4 sodium chloride, and a mixture containing both substances were applied twice in succession. As seen in Fig. 2, there was little response in each case to the second application. It was also indicated that the mixture when applied after hydrochloric acid did not elicit appreciable response, whereas when it followed after sodium chloride, it produced a marked deflection of the summated curve. Thus the probability of the facilitatory effect of univalent chloride on acid response was evident.

3. Variation in facilitatory effect by concentration of sodium chloride

The enhancing effect of sodium chloride on hydrochloric acid and acetic acid (each M/512) was observed at varying concentration from M/16 to M/2. As shown in Fig. 3 the effect increased with increasing concentra-

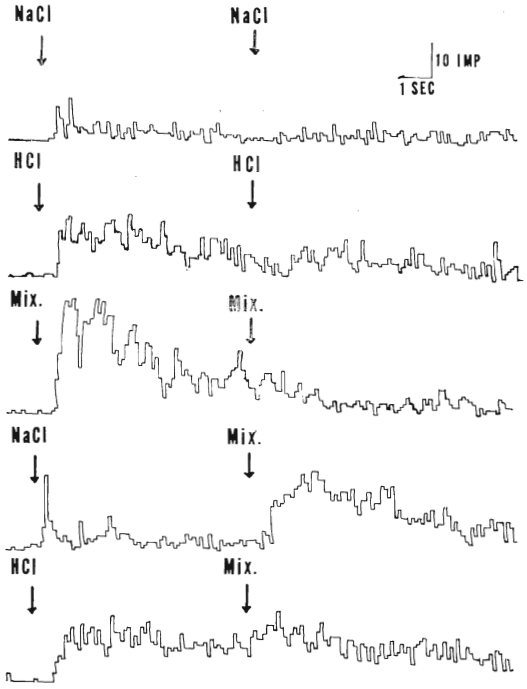

Fig. 2. Summated responses recorded from successive applications of the test solutions.

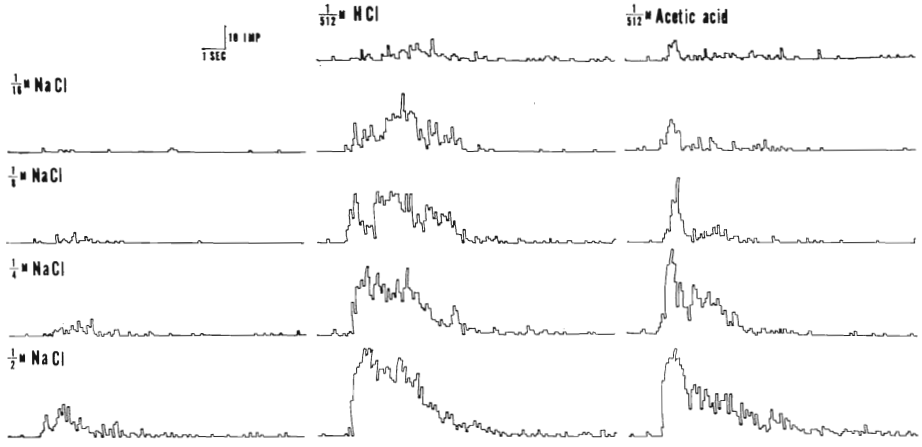

Fig. 3. Summated responses to stimulations by hydrochloric acid and acetic acid, with or without addition of M/16—M/2 sodium chloride.

The records in the left column indicate responses to sodium chloride solutions and those in the middle and right column show the responses to mixtures of sodium chloride and M/512 hydrochloric acid or acetic acid.

tion of the salt.

These results obtained in the present experiments revealed that the addition of a univalent chloride to organic and inorganic acids enhanced markedly the summated responses of the whole glossopharyngeal nerve to both groups of acid. Tateda[5] reported that most of the single taste fibers of the catfish appeared to respond either to organic acid or to hydrogen ion and very few fibers responded to both organic acid and hydrochloric acid. It was assumed that this result might be due to the different receptor cites for hydrogen ion from that for undissociated organic acid molecule. However, in the present experiment, in which the whole glossopharyngeal nerve of the toad was used, the facilitatory ability of chlorides was not different for either inorganic or organic acids. From these facts, it can be assumed that the mechanism of the effect cannot be explained only from the results obtained here and it is necessary to study further the effect on functional single fibers.

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