ROLE OF CATECHOLAMINES IN EFFERENT REGULATION OF TASTE RECEPTORS

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The action of efferent stimulation on unit activity of the taste receptors of the frog tongue was studied. A deficiency of catecholamines following reserpine administration or perfusion of the lingual vessels with adrenoblocking agents (inderal, dibenamine) prevents centrifugal inhibition, whereas perfusion with an adrenomimetic (adrenalin) potentiates this effect. These effects of adrenergic substances were also observed in animals after bilateral extirpation of the first ganglion of the sympathetic chain. It is concluded that catecholamines present in the papillae are essential for central inhibitory effects on activity of the taste receptor apparatus.

KEY WORDS: lingual papillae; catecholamines; sympathetic system.

The afferent flow of impulses in the lingual nerve can be controlled by influences reaching the taste receptor apparatus along efferent fibers [1, 3, 14]. The existence of efferent synapses on the receptor cell [7, 16, 18] and of the recordable intracellular hyperpolarization response to stimulation of the lingual nerve [4] suggest that this control may be effected through centrifugal influences on processes taking place in the receptor cell itself. However, the question of the mediator of these influences has not yet been adequately studied. The possibility of participation of a cholinergic mechanism in these centrifugal influences has been suggested [5]. Meanwhile the extensive sympathetic innervation of the taste papillae [9, 11, 19], the presence of adrenergic fibers inside the papilla [10], and the high content of monoamine oxidase in the central part of the papilla [12, 13] point to a possible role of catecholamines in the control processes. The presence of vesicles with an electron-dense core has been demonstrated electron-microscopically in efferent endings forming synaptic contacts with the receptor cell [7, 15].

The investigation of the physiological role of catecholamines in the efferent control of functions of the chemoreceptor apparatus of the tongue is therefore of considerable interest.

EXPERIMENTAL METHOD

Experiments were carried out on frogs (Rana temporaria) immobilized by injection of diplacin* or listhenon (0.3-0.4 ml of a 2% solution) into the dorsal lymph sac. Afferent impulses in response to irrigation of the receptor surface of the tongue with tap water or 2% NaCl solution were recorded from branches of the lingual nerve. The central end of the contralateral lingual nerve was stimulated electrically (100 Hz, 3-5 V, 0.3 msec, duration 15 sec). If necessary, centrifugal activation of the sympathetic system was blocked by preliminary bilateral extirpation of the first ganglion of the sympathetic chain.

To investigate the role of catecholamines in efferent regulation, substances inducing catecholamine deficiency (reserpine) and substances blocking adrenergic transmission (inderal, dibenamine) or exerting an adrenomimetic action (adrenalin) were used. Reserpine (5 mg/kg) was injected into the dorsal lymph sac of the animal 24 h before the experiment. The catecholamine deficiency was verified histochemically. Dibenamine ($1 \cdot 10^{-6}$ g/ml) was applied to the receptor surface of the tongue for 20 min. Inderal ($2 \cdot 10^{-6}$ g/ml)

*1,3-di(β-platyneciniumethoxy)benzene hydrochloride.

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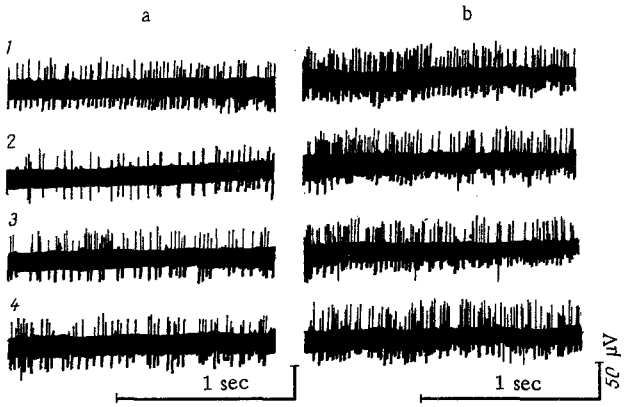

Fig. 1. Effect of reserpine on inhibitory effect induced by electrical stimulation of contralateral lingual nerve: A) effect of stimulation of the central end of contralateral lingual nerve; B) the same as A after preliminary administration of reserpine; 1) initial receptor activity to action of 2% NaCl solution; 2-4) the same, 2, 10, and 20 min respectively after electrical stimulation

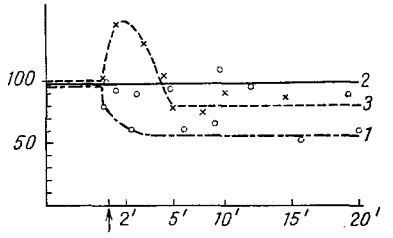

Fig. 2. Action of reserpine and inderal on the inhibitory effect of electrical stimulation of contralateral lingual nerve in desympathized animals: 1) initial inhibitory effect; 2) effect of reserpine; 3) effect of inderal. Moment of stimulation marked by arrow. Abscissa, time (in min); ordinate, magnitude of receptor response (in %).

and adrenalin ($2 \cdot 10^{-7}$ g/ml) were perfused through the blood vessels of the tongue. When the data were analyzed the number of spikes in 5-sec time intervals was counted under steady-state discharge conditions.

EXPERIMENTAL RESULTS AND DISCUSSION

Electrical stimulation of the central end of the divided lingual nerve clearly inhibited afferent activity in the contralateral nerve. This effect was observed immediately after the end of stimulation and reached its maximum (up to 50% of the initial activity) by the second minute. By the 10th-15th minute a gradual increase in firing rate was observed, but by the 20th-25th minute the normal rate was restored (Fig. 1A). Preliminary (24 h before the experiment) injection of reserpine substantially weakened the centrifugal influences on the taste receptor apparatus (Fig. 1B). These results suggest that for centrifugal influences on the receptors to take place, a definite level of catecholamines is necessary in the structures of the lingual papilla, for histochemical investigations showed a decrease in the intensity of specific luminescence of adrenergic structures in the papilla after reserpine administration [8].

However, reserpine could exhaust the catecholamine reserves in the central adrenergic structures participating in centrifugal influences also, and this would be reflected in the character of the observed effect. To assess the role of catecholamines located in the peripheral structures, the character of the centrifugal influences was studied during the action of adrenoblocking agents and adrenomimetics on the receptor apparatus of the tongue. Application of dibenamine or perfusion with inderal was found to block the centrifugal effects. Conversely, perfusion with adrenalin as a rule potentiated these effects.

The results are evidence of the participation of the local adrenergic system in the mechanism of centrifugal effects on the taste receptor apparatus, and they agree with data indicating changes in the afferent spike flow from the receptors during electrical stimulation of the sympathetic system [2].

According to data in the literature, in some cells of the retina [17] and hair cells of the cochlea [20] catecholamines are present and they do not disappear after desympathization of the organ. To study the question of a possible link between the effect observed in the present experiments and the sympathetic nervous system, experiments were carried out on animals after desympathization of the tongue. The effect of stimulation of the central end of the lingual nerve on the receptor apparatus of the tongue remained in these animals (Fig. 2, curve 1). However, reserpinization in this case also abolished the centrifugal effects (Fig.

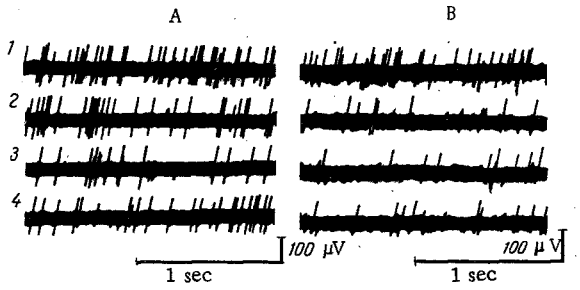

Fig. 3. Effect of adrenalin on the inhibitory effect of electrical stimulation of the contralateral lingual nerve in the desympathized animal; A) inhibitory effect on desympathized animal; B) the same after perfusion with adrenalin ($1 \cdot 10^{-7}$ g/ml); 1) initial receptor activity in response to action of tap water; 2-4) the same, 2, 5, and 20 min respectively after electrical stimulation.

2, curve 2). The inhibitory centrifugal effect observed in the desympathized animals could also be abolished by perfusion with inderal. Moreover, after administration of inderal, a temporary reversal of the effect was observed, with marked facilitation of the responses of the receptors to centrifugal stimulation (Fig. 2, curve 3). Perfusion with adrenalin potentiated the inhibitory effect (Fig. 3).

Preservation of the effects of reserpine, adrenoblocking agents, and adrenomimetics after desympathization of the tongue may indicate either that catecholamines of nonsympathetic origin participate in the mechanism of the centrifugal effects or that adrenergic fibers unconnected with the first ganglion of the sympathetic chain are present.

The problem of whether catecholamines are the true mediators of centrifugal influences on the taste receptor system, like the problem of the mechanism of their action, still remains open for discussion.

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