CHEMOSENSORY APPARATUS OF FEEDING BEHAVIOR OF MATURE AND IMMATURE MAMMALS DURING ONTOGENY

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The structural and functional organization of the orosensory periphery of adult mammals is determined by the nature of their feeding. Receptor formations of the tongue are an example of this adaptive diversity [1-4]. Despite these differences, however, the young of all mammals in their early postnatal ontogeny are characterized by a single method of feeding, namely a liquid (milk) diet. In the lactotrophic period responsibility for the quality of the food for the young rests largely with the mother. Accordingly, it is particularly interesting to study characteristics of the structural and functional formation of the chemosensory and mechanosensory apparatuses of the tongue, that are involved in the evaluation of the chemical and mechanical components of the diet, and organize and correct feeding behavior in postnatal development. The orosensory apparatus or young immature and mature mammals, characterized at birth by different degrees of maturity of the feeding system, was investigated.

EXPERIMENTAL METHOD

The investigation was conducted on mammals of different ages (up to 2 months), born immature (cat, rat) and mature (guinea pig, sheep, goat). From the 1st day after birth all the young animals were artificially fed.

The dorsal surface of the tongue was investigated by scanning electron microscopy by the method described previously [2]. Chemosensory activity was studied after deprivation for 2-6 h (depending on age) daily for the first 15 days, and then on the 20th and 30th days of postnatal development. The following solutions were used: glucose (0.03-0.146 M), sodium chloride (0.05-0.51 M), ascorbic acid (0.085-0.227 M), and quinine hydrochloride (0.0014-0.007 M). Chemosensory behavioral reactions were accounted for as latent periods of appearance of jaw and tongue movements, reactions of sucking and lapping, and the quantity of liquid swallowed in response to chemical stimulation. The solutions were applied to the tongue by various methods: to the anterior part from a pipet, to the base of the tongue with a curved cannula. Syringes with special nozzles were used for sucking.

EXPERIMENTAL RESULTS

Electron-microscopic investigation of the dorsal surface of the tongue of the immature mammals revealed heterochronous development of the chemo- and mechanosensory apparatuses. This was shown by the total (rat) or partial (cat) absence of tactile outgrowths in the mechanosensory papillae, involved in evaluation of the mechanical component of the food, and of taste pores in the papillae on the anterior free surface of the tongue, at birth (Fig. 1a-d). Taste pores in the papillae at the tip of the rat tongue were not found until the 3rd week after birth (Fig. 1f). Meanwhile, by the time of birth the sensory formations on the dorsal surface of the body and base of the tongue had features indicative of their comparative maturity: high density of taste buds and the presence of pores in them.

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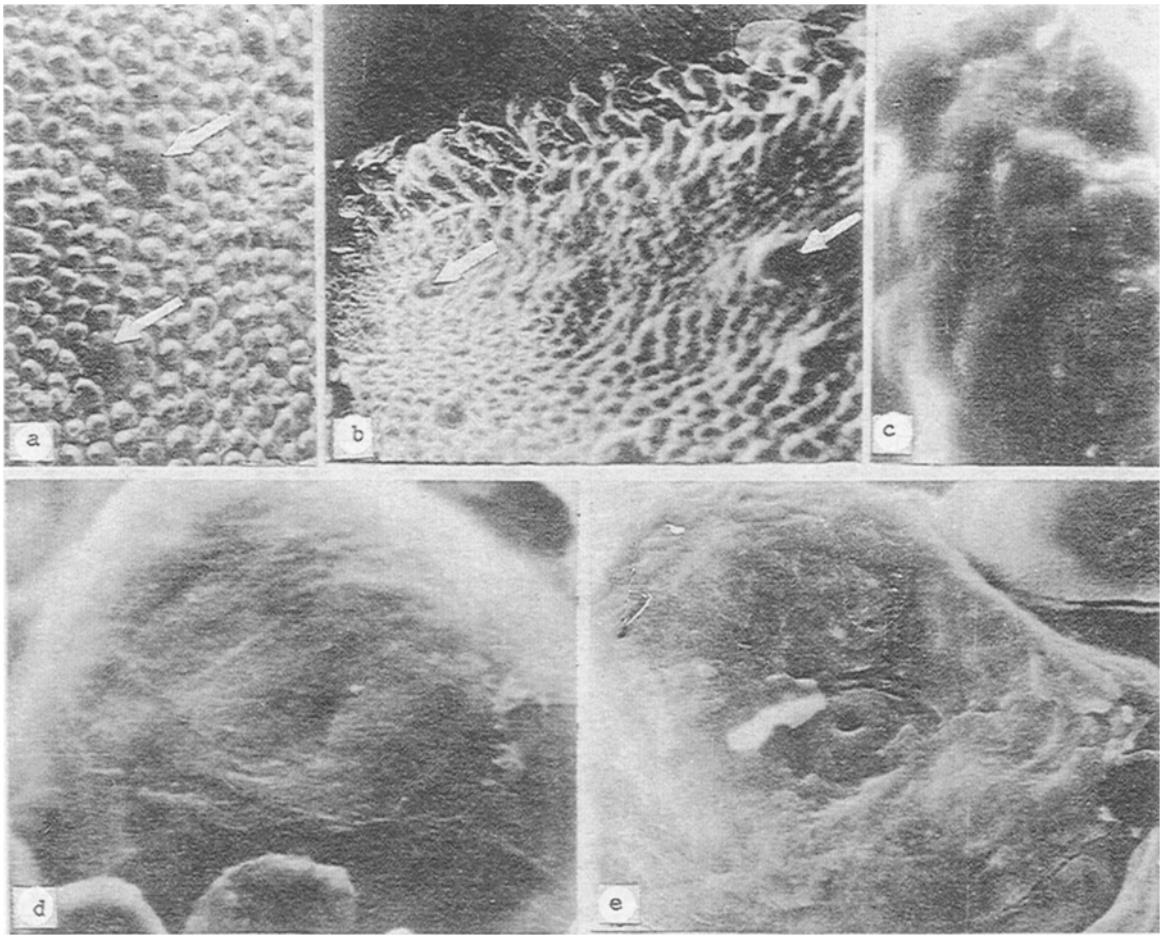

Fig. 1. Formation of papillae on tongue of immature animals in ontogeny: a) fragment of anterior free surface of tongue of newborn rat. Arrows indicate fungiform papillae. 50×; b) lateral part of tongue of day-old kitten. Arrow indicates fungiform papillae. 20×; c) fungiform papilla with bulblike swellings but without pores, in day-old kitten. 800×; d) fungiform papilla of rat aged 2 days: pore absent. 1200×; e) pore of fungiform papilla of rat aged 14 days. 2000×.

Chemical stimulation of the anterior free surface of the neonatal rat tongue caused no movements of the jaws and tongue, such as were clearly observed at the age of 10 days in response to both chemical and tactile stimulation. At this time the latent periods of these movements in response to chemical stimulation were 12-15 sec and to tactile 3 sec, and by the 15th day they had decreased to 5-10 and 2 sec respectively (Fig. 3A)

Thus the chemosensory apparatus of young immature mammals at birth is characterized by structural and functional immaturity. Movements of the jaws and tongue in animals aged 10 days, 12-15 sec after chemical stimulation, may be associated with gradual penetration of the taste stimulus toward the base of the tongue, where the sensory formations mature earlier. In the 1st week of postnatal life no significant differences are found in the consumption of sweet (preferred) and sour (rejected) solutions and distilled water by the young rats; they were found after the 9th-10th day of postnatal development (Fig. 3B). The appearance of gustatory pores on the tip of the tongue toward the 12th-14th day makes it possible for a sweet solution to be chosen when the response of preference of glucose solution and distilled water is investigated.

Like young rats, kittens also did not distinguish the chemical qualities of solutions during the first days after birth, as shown by the unchanged velocity of the sucking movements on replacement of one solution by another. Toward the end of the 1st week of life of the kitten replacement of distilled water by glucose or isotonic sodium chloride solution increased the rate of the sucking movements, which decreased on replacement of the water by ascorbic acid (the rejected solution; Fig. 3b).

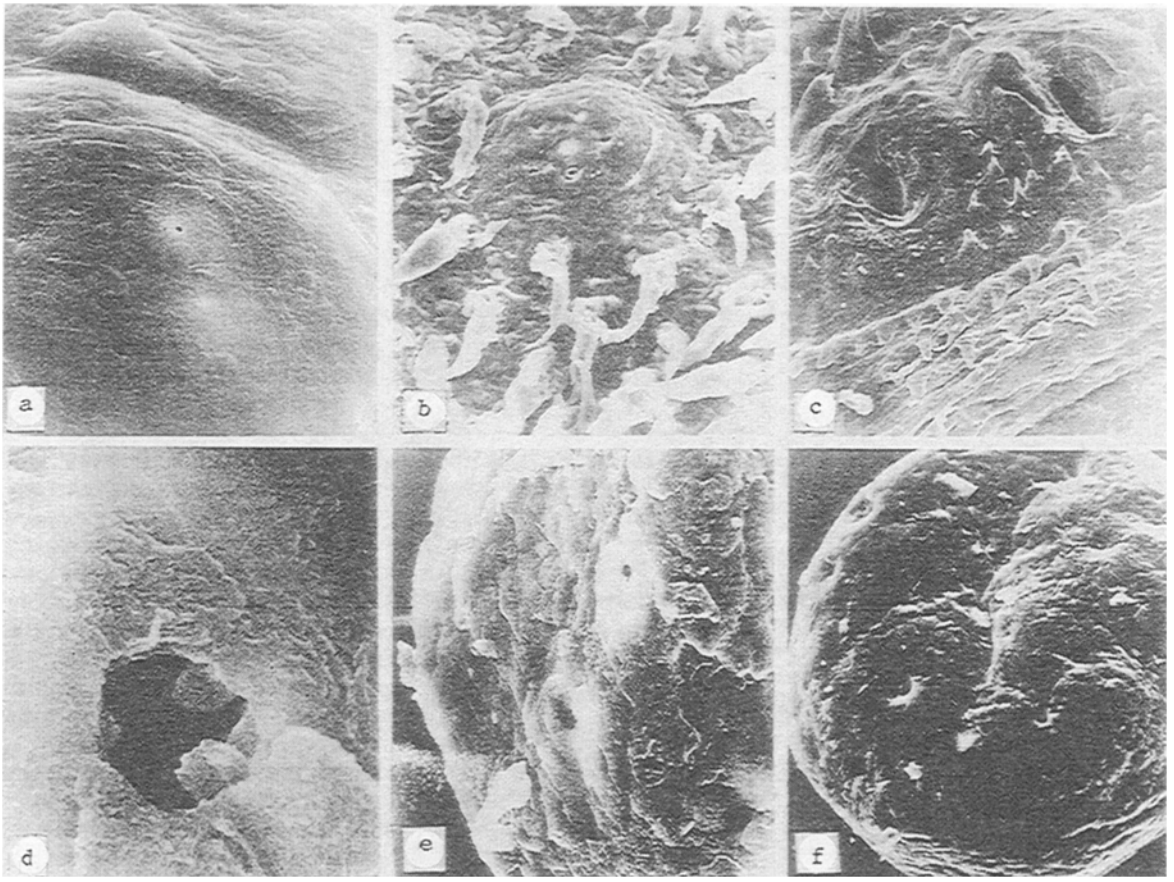

Fig. 2. Age-related changes in lingual papillae of mature animals. a) Pore of fungiform papilla at tip of tongue of newborn guinea pig. 1000×; b) fungiform papilla of 3-day-old guinea pig. 500×; c) foliate papillae of tongue of 3-day-old guinea pig. 200×; d) pore of fungiform papilla of tongue of 4-day-old lamb. 1000×; e) margin of fungiform papilla with pores in 4-day-old lamb. 450×; f) fungiform papilla of tongue of newborn kid. 300×.

The results of electron-microscopic investigations on the young of early-maturing mammals (guinea pig, sheep, goat) showed that at birth the chemosensory apparatus of the tongue can perform its functions. In the guinea pig fetus (50th-55th day of prenatal development) no gustatory pores yet exist in the chemosensory papillae of the anterior free surface of the tongue, whereas in the newborn guinea pig each papilla has one pore (Fig. 2a), and by the 3rd day their number has increased to 5-6 (Fig. 2b).

In the young of other species of early-maturing animals there are more than 20 pores in each fungiform papilla at birth (Fig. 2b, d-f); they are no different from the papillae in adult animals. Behavioral experiments showed that in the first 2 days after birth young guinea pigs did not distinguish the taste qualities of solutions. They did not respond to replacement of the solutions and they consumed equal amounts of glucose, salt solution, and ascorbic acid, whereas 3-day-old animals chose the sweet solution. Analysis of the sucking movements of the kid after replacement of water or milk by salt solution or ascorbic acid during the first days after birth showed that the intensity and speed of sucking remained unchanged. A change in the sucking response after replacement of the solutions was observed toward the end of the 1st or beginning of the 2nd week of postnatal development. Toward the end of the 2nd week an increase in the intensity of the sucking movements could be observed on replacement or distilled water by the sweet solution. Replacement of glucose by distilled water led to a decrease in the intensity of sucking, whereas replacement of water by salt solutions of various (rejected and preferred) concentrations also changed the sucking reaction (Fig. 3c).

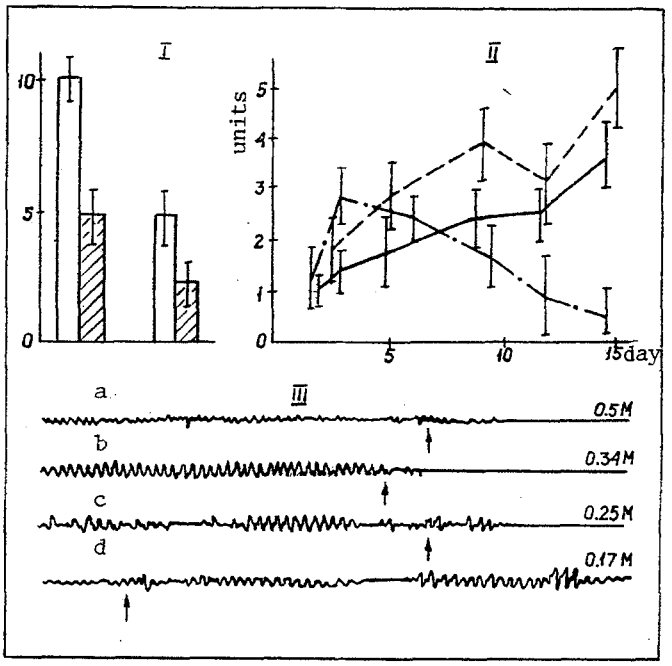

Fig. 3. I: Changes in latent period of motor response of tongue to chemical (a) and tactile (b) stimulation. Unshaded columns – rats aged 10 days, shaded – 15 days. Ordinate, time, in sec; II: age dynamics of consumption of water (continuous line), glucose (broken line), and ascorbic acid (dots and dashes) by young rats. Abscissa, age of animals; ordinate, quantity of liquid consumed in conventional units; III: sucking reaction of kid: a) 15 days, b) 1 month, c, d) 1.5 months. Arrow indicates time of replacement of water by NaCl of various concentrations. a, b, c) Rejection reaction; d) increased sucking activity.

The results of this combined morphological and functional study of the sensory apparatus of the tongue in animals maturing early (guinea pig, sheep, goat) thus indicate an earlier readiness to provide for feeding behavior compared with animals immature at birth (rat, cat). Prolonged structural and functional immaturity of the orosensory periphery of mammals immature at birth may be the cause of the more prolonged feeding isolation or the young from external sensory food stimuli and the complete dependence of its feeding on the mother. In young animals mature at birth, the sensory periphery is capable of ensuring feeding contacts with the environment with effect from the 1st days after birth, with the result that more complex feeding behavior and feeding adaptations of the young of mammals mature at birth may be possible in early ontogeny.

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