MORPHOLOGY AND PATHOMORPHOLOGY

Development of the Chemosensory Apparatus of Human Tongue in Postnatal Ontogeny

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The development of the chemosensory apparatus of the tongue and taste perception in infants is studied by morphological (scanning electron microscopy) and physiological (vegetative and motor responses) methods. The chemosensory elements on the radix and body of the tongue develop more rapidly than those on the tip of the tongue. Heterochrony in the development of the sensitivity of the tongue tip to various gustatory stimuli (sweet, bitter, salty, and sour) is demonstrated.

Key Words: *taste; tongue; ontogeny; scanning microscopy*

Gustatory apparatus in humans and other immature-born mammals is characterized by structural and functional immaturity [2,5,8]. After birth, the receptors on the body and radix of the tongue, which contact with the mother's nipple during sucking, are the only structures capable of executing the chemosensory control. Generally, food is tasted with the tip of the tongue. In immature-born mammals, taste buds on the anterior part of the tongue are not fully developed, lacking the taste pores [3]. On the other hand, the fetus can swallow amniotic fluid to which a sweet substance had been added [6]. At the same time, heterochrony in the development of taste perception in humans has been poorly investigated.

MATERIALS AND METHODS

Structural organization of the chemosensory apparatus of the tongue was studied by scanning electron microscopy using autopsy material from newborns in the first year of life. The specimens were processed as described previously [2,3].

Taste perception was studied in infants aged 1-3 months (group 1), 5-7 months (group 2), and 9-10 months (group 3). Sweet (1 M glucose), bitter (3.3×10^{-6} M quinine), salty (0.5 M salt) and sour (0.154 M citric acid) solutions were applied onto the tip of the tongue. These concentrations slightly exceeded the taste threshold. The oromotor reactions and facial expression in response to different solutions were videotaped with a Panasonic-G120 camcorder. The heart rate (HR) and stress rating (SR, assessed by the method of Baevskii) were recorded using an MM-01 monitor.

RESULTS

Scanning electron microscopy showed that the tongues of infants and adults differ not only in the size and shape of taste papillae, but also in the presence and number of taste pores. In newborns, there were no more than 1-3 taste buds in the fungiform papillae (Fig. 1, *a-d*), many of the buds lacking taste pores. The number of taste pores increased by the end of the 1st month, while by the 3rd month all taste buds bore open taste pores.

On the other hand, the number of taste buds with open pores in the papillae on the radix and

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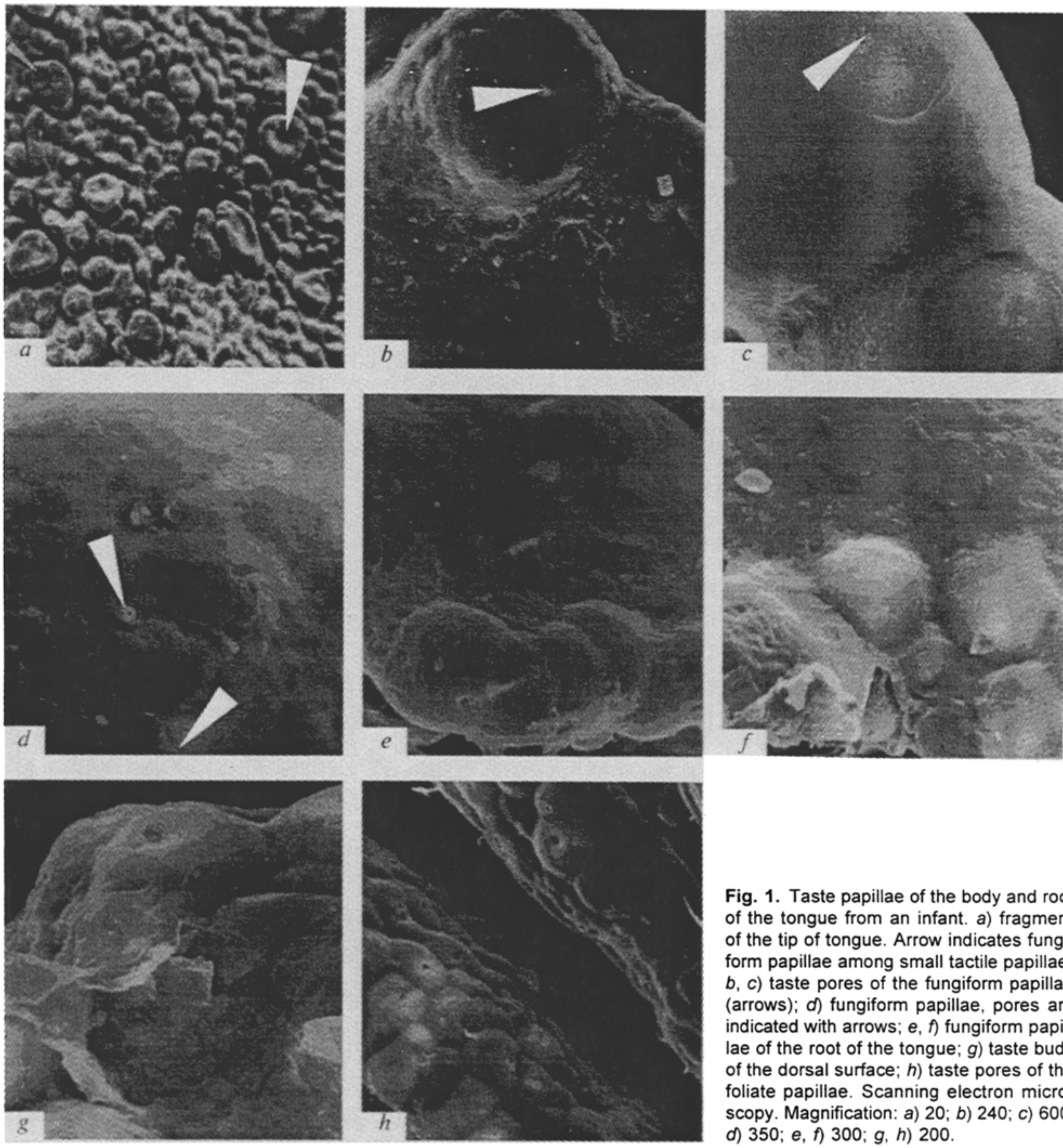

Fig. 1. Taste papillae of the body and root of the tongue from an infant. *a*) fragment of the tip of tongue. Arrow indicates fungiform papillae among small tactile papillae; *b*, *c*) taste pores of the fungiform papillae (arrows); *d*) fungiform papillae, pores are indicated with arrows; *e*, *f*) fungiform papillae of the root of the tongue; *g*) taste buds of the dorsal surface; *h*) taste pores of the foliate papillae. Scanning electron microscopy. Magnification: *a*) 20; *b*) 240; *c*) 600; *d*) 350; *e*, *f*) 300; *g*, *h*) 200.

body (from 10 to 400) of the tongue far exceeded that on the tip (Fig. 1, *g*, *h*). Fungiform papillae in the medial part of the body and radix of the tongue were larger and had more buds with open pores (5-6) than those on the tip of the tongue (Fig. 1, *e*, *f*).

Thus, the study of the structural organization of the gustatory apparatus revealed heterochrony in the development of tongue receptors in humans which was similar to that observed in immature-born mammals. The chemosensory apparatus first developed in the areas contacting with the mother's nipple during sucking, i.e., papillae of the body and radix of the tongue. Taste buds and pores of the anterior surface responsible for the chemosensory control over the quality of food developed later.

The vegetative responses of infants to the application of flavored solutions on the tip of the tongue were as follows. In group 1, HR dropped in most cases after presentation of sweet solution (Fig. 2, *I*, *a*). An increase in HR occurring in some infants re-

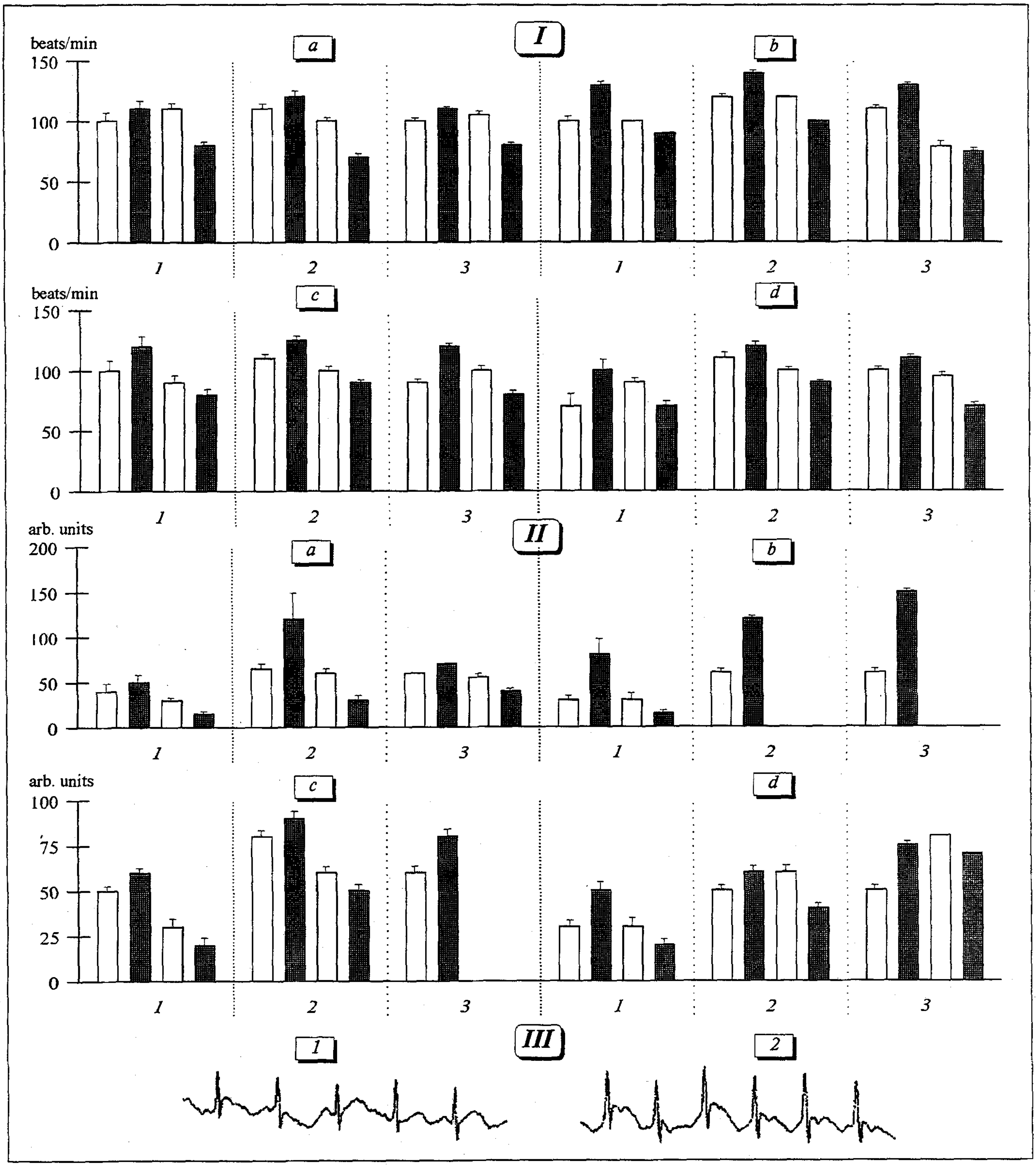

Fig. 2. Vegetative parameters: heart rate (HR, *I*) and stress rating (SR, *II*) before (open bars) and after (shaded bars) presentation of sweet (*a*), bitter (*b*), salty (*c*), and sour (*d*) taste stimuli. The first pair of bars corresponds to a rise of HR and SR, the second pair corresponds to a drop of these parameters. *1*, *2*, *3*) correspond to different age groups. *III*: cardiogram of a 5-month-old infant before (*1*) and after (*2*) presentation of a bitter stimulus.

sulted probably from general motor excitation caused by a sweet stimulus. Presentation of a bitter solution elevated HR in the majority of these infants (Fig. 2, *I*, *b*). Both sweet and bitter stimuli significantly changed SR: it dropped to "relaxation" and rose to "tension" after presentation of sweet and bitter solu-

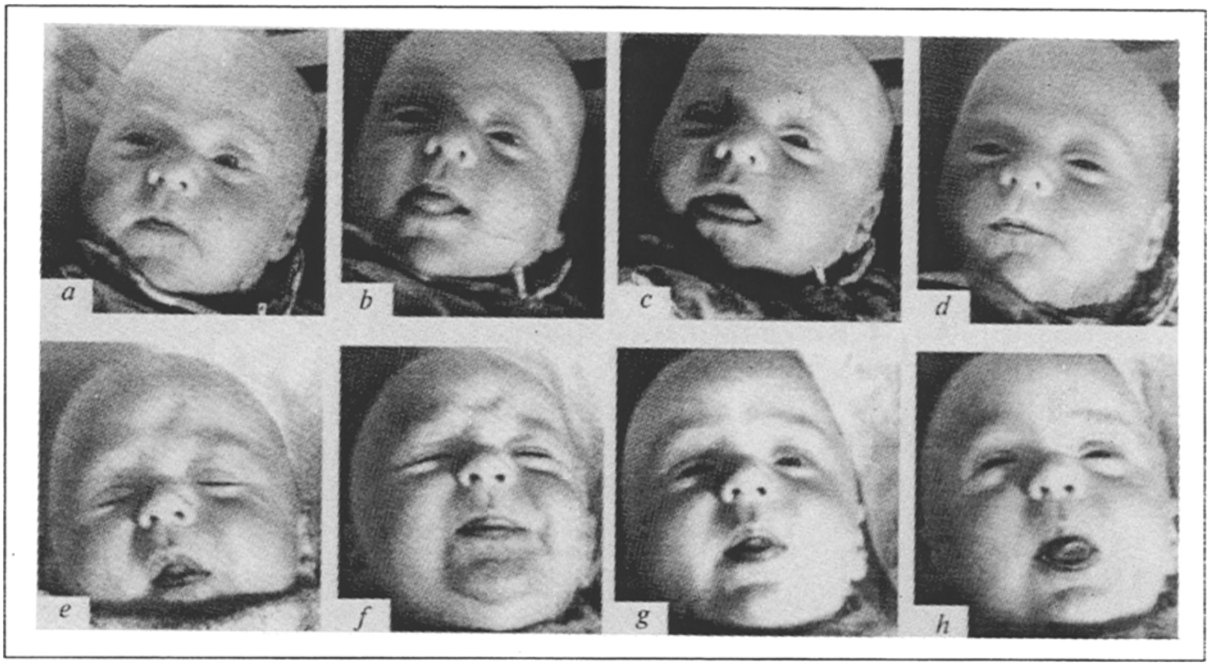

Fig. 3. Facial expression of infants in response to gustatory stimulation of the tip of the tongue. Facial expression after presentation of sour (*a*, *b*) and salty (*c*, *d*) stimuli to a 1-month-old infant. Facial expression after presentation of sour (*e*, *f*) and salty (*g*, *h*) stimuli to a 5-month-old infant.

tions, respectively (Fig. 2, *II*, *a*, *b*). Gustatory stimulation also induced a number of motor reactions: tongue and lip motions, sucking, etc. Practically no mimic reactions to gustatory stimulation were noted in this group (Fig. 3, *a-d*) probably due to poor development of the motor component of these reactions [1].

In group 2, a sweet stimulus induced a significant drop of HR (Fig. 2, *I*, *a*). Oromotor and mimic reactions were well developed. In addition, a sweet stimulus often caused induced bubbling, a specific sign of comfort state of the infant. Presentation of a bitter stimulus significantly elevated HR (Fig. 2, *I*, *b*). The motor reactions and facial expression were indicative of rejection (expression of displeasure, the lower lip and tongue thrusting, etc.). Salty and sour stimuli significantly changed HR (Fig. 2, *I*, *c*, *d*). SR significantly dropped and rose in response to sweet and bitter solutions, respectively. A sour stimulus in some cases increased, and in others decreased SR (Fig. 2, *II*, *a*, *b*, *d*). Sensorimotor reactions and facial expressions indicated that 5-7-month-old infants are able to perceive sour taste (Fig. 3, *e-h*).

In group 3 infants, gustatory stimulation produced statistically significant effects on all studied vegetative and motor parameters.

For instance, a sweet stimulus decreased HR and SR, while a bitter and salt taste increased them (Fig. 2, *I*, *a-c*; *II*, *a-d*). Sour substances in some cases inhibited, while in others stimulated HR (Fig. 2, *I*, *d*).

Thus, it can be hypothesized that the perception of sweet stimuli is well developed in 1-3-month-old infants. The taste buds with open pores in the papillae on the tongue tip are responsible for the perception of sweet stimuli at this stage of ontogeny. Such a selective sensitivity of some taste buds in the fungiform papillae has been reported previously for adults [4]. Further development of taste buds and the appearance of pores provided perception of other gustatory stimuli. This is confirmed by changes in vegetative and oromotor parameters and facial expression in response to gustatory stimulation in elder infants. In full-term newborns taste buds on the tip of the tongue ensure perception of sweet stimuli [7]. However, perception and rejection of bitter substances is also possible. The development of the receptors responsible for perception of other gustatory stimuli provides the widening of “taste contacts” with the environment.

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