Medical Neuroscience | Tutorial Notes

Chemical Senses—Gustation

Map to Neuroscience Core Concepts[1]

NCC1. The brain is the body's most complex organ.

NCC3. Genetically determined circuits are the foundation of the nervous system.

Learning Objectives

After study of the assigned learning materials, the student will:

1. Characterize the peripheral and central organization of the gustatory system.
2. Discuss sensory transduction in gustatory receptor cells.
3. Describe information coding in the gustatory system.

Tutorial Outline

I. Organization of the gustatory system

  A. anatomical overview (see **Figure 15.17**[2])

    1. chemical constituents of foods interact with **taste receptors cells** located on epithelial specializations, called papillae, which contain the **taste buds** (see **Figure 15.18**)

    2. taste buds are distributed on the tongue, soft palate, epiglottis, pharynx and upper esophagus

    3. taste receptor cells make synapses on the peripheral axons of cranial nerves VII, IX and X

      a. anterior tongue (soft palate) $\rightarrow$ facial nerve (CN VII)

      b. posterior tongue $\rightarrow$ glossopharyngeal nerve (CN IX)

      c. epiglottis (esophogus) $\rightarrow$ vagus nerve (CN X)

    4. these central axons project into the **solitary tract** and synapse in the *rostral division* of the **nucleus of the solitary tract**

      a. the posterior division of this nucleus is a visceral sensory relay (more on that in Unit 4 of this course)

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[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

b. integration of gustatory and visceral sensory inputs across the rostral-caudal axis of this nucleus facilitates appropriate visceral motor activities in response to harmful tastants, such as gagging or vomiting

5. the nucleus of the solitary tract projects to a distinct part of the **ventral posterior complex** in the thalamus

6. this part of the ventral posterior complex projects to several cortical areas, including areas in the rostral **insula** and the frontal operculum (in the depth of the rostral lateral fissure)

7. these cortical regions are interconnected with the posterior **orbital prefrontal cortex**, where olfactory, gustatory and somatic sensory information is combined to produce *flavor* sensations from which the hedonic values of foods are represented

B. sensory transduction (see **Figure 15.20**)

1. taste receptor cells have a variety of transduction mechanisms (see **Figure 15.21**)

a. some tastants interact with receptors on ion channels in the apical tip of the cell; the opening of Na^+ channels or the closing K^+ channels leads to the generation of a receptor potential

b. other tastants interact with G-protein coupled receptors that use second messengers to elevate intracellular Ca^{++} concentrations and depolarize the membrane

2. depolarization and elevated intracellular Ca^{++} leads to the exocytosis of a chemical neurotransmitter (serotonin), which binds to receptors on the sensory axon

C. gustatory coding & perception

1. tastant identity is encoded by the activation of different receptors that are most sensitive to distinct chemical substances (see **Figure 15.19**)

a. there are receptors that are especially sensitive to:

i. sucrose (sweet)

ii. NaCl (salt)

i. HCl (acid)

ii. quinine (bitter)

iii. glutamate (Japanese, “umami” = “delicious”)

b. detection thresholds are higher for substances that are important in our diet (e.g., salts and carbohydrates); in the *millimolar* range

c. detection thresholds are lower for potential harmful compounds (bitter-tasting alkaloids); in the *nanomolar* range

2. the concentration of a tastant is generally correlated with the number of receptor cells activated and the intensity of afferent activation, as well as the perceived intensity of the taste

3. in central gustatory centers, as in olfactory centers, there are no obvious 'maps' or systematic representations of tastants or the sensory periphery

4. the nature of the gustatory code remains obscure, but it appears to operate according to a "labeled-line" code

   i. different tastants activate distinct classes of receptor neurons that make synaptic contact onto peripheral processes of afferent neurons that are "labeled" by receptor specificity

   ii. the responses of subcortical central neurons are tuned for tastant identity, reflecting receptor specificity

   iii. nonetheless, at higher centers of processing (especially in the orbital cortex), the hedonic value of food becomes the most salient feature of representation, rather than the molecular identity of any particular tastant

STUDY QUESTION

Which of the following statements concerning the encoding of gustatory signals is most accurate?

A. Most gustatory receptor neurons express the full complement of genes that encode the five basic classes of gustatory receptors.

B. Subcortical gustatory processing appears to implement a "labeled-line code" with the neural responses of sensory cells reflecting the molecular properties of the gustatory receptors that drive the response.

C. There is a "combinatorial code" operating in the orbital cortex, since individual cortical neurons respond selectively to just one tastant.

D. At higher stages of gustatory processing in the brain, the most salient property of food is the relative concentration of sour, bitter, salty, sweet, and "glutamate-like" tastants.