Neurobiology of the Gustatory–Salivary Reflex

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All neural information resulting from chemical stimulation of taste buds in the oral cavity, pharynx and larynx travels via the facial (VII), glossopharyngeal (IX) and vagus (X) nerves to terminate in the nucleus of the solitary tract (NST) in the brainstem. The NST is responsible for initial processing and distribution of chemosensory information. At higher relays in the central nervous system the processes of detection, discrimination and affective responses occur resulting in the sensation we call taste and the behavioral reactions to that sensation. In addition, the NST connects to efferent motor systems involved in oral facial motor reflexes and systems controlling the initiation and flow of saliva. Thus, the NST plays a pivotal role in the neural processing of chemosensory information derived from stimulation of taste buds.

Beginning in 1961 (Pfaffmann et al., 1961) a large number of investigators in different laboratories have examined the NST using anatomical, and neurophysiological techniques. The topographical projections of the VII, IX and Xth nerves conveying sensory information to the NST have been determined using different methods in several species (Torvik, 1956; Norgren, 1981; Whitehead and Frank, 1983; Hamilton and Norgren, 1984). The morphology of the NST has been studied and the neuronal architecture defined (Whitehead, 1988). Neurons in the NST have been described as belonging to three major anatomical types—multipolar, elongate and ovoid (Whitehead, 1988; Lasiter and Kachele, 1988; King and Bradley, 1994; Mistretta and Labyak, 1994), and using immunocytochemistry the presence of GABA and other neuropeptides has been described (Lasiter and Kachele, 1988; Barry et al., 1993).

Responses of NST neurons to chemical stimuli applied to the tongue have also been examined many times in different species (e.g. Doetsch and Erickson, 1970; Hill et al., 1983; Smith et al., 1983a). Because stimulation is almost always restricted to the anterior 2/3 of the tongue, only neurons with input from the VIIIth nerve have been extensively characterized. Moreover, because the recordings have been accomplished with extracellular electrodes, the type of neuron and its projection pattern are often undetermined. Thus, it is not known if the NST neurons recorded from send information rostrally, or to brainstem areas, or to both terminations. Regardless, these recordings have only recently been studied (Kim et al., 2004). Neurons innervating the parotid gland are significantly larger than those innervating the von Ebner glands although the neurons innervating either of these glands have similar repetitive discharge characteristics. Measurements of the latency of response of postsynaptic potentials (PSP) recorded from the ISN neurons indicate a multisynaptic pathway between the primary afferent synapse and the second order neurons in the NST (Wang and Bradley, 1995), that GABA-mediated inhibition plays a major role in synaptic processing by NST neurons (Wang and Bradley, 1993; Grabauskas and Bradley, 1998) and that neurons in the NST have different biophysical and repetitive discharge characteristics (Bradley and Sweazea, 1992). Some of these in vitro results have been confirmed in vivo (Li and Smith, 1997; Smith and Li, 1998). More recently in an attempt to understand NST circuits, we have examined neural elements of the gustatory–salivary reflex circuit responsible for taste-initiated secretion of saliva, assuming that this is a relatively simple circuit. The reflex is typified by a high flow rate secretion of a bicarbonate-containing saliva in response to sour or low pH stimulation of taste buds. The reflex involves relatively few synapses and the overall details of the circuit are well understood, making it amenable for the study of NST circuits that process neural information originating in taste buds. Our previous investigations of NST neurons and synaptic characteristics of the NST have focused on the input circuit and now we are concentrating on neurons of the output circuit.

Parasympathetic preganglionic neurons controlling the salivary glands form a column of cells closely associated with the medial border of the NST (Contreras et al., 1980). The most rostral extension of the salivatory nuclei innervating the submandibular and sublingual salivary glands has been studied in some detail (Matsuo and Kang, 1998; Mitoh et al., 2004). The caudal extension of this column, the inferior salivatory nucleus (ISN), innervates the von Ebner and parotid glands. While the general topography of the parasympathetic neurons is known, detailed analysis of their morphology has only recently been studied (Kim et al., 2004). Neurons innervating the parotid gland are significantly larger than those innervating the von Ebner glands although the neurons innervating either of these glands have similar repetitive discharge characteristics. Measurements of the latency of response of postsynaptic potentials (PSP) recorded from the ISN neurons indicate a multisynaptic pathway between the primary afferent synapse and the ISN neurons. In addition all the PSPs recorded are a mixture of both excitatory and inhibitory activity. Recently we have examined the effect of a number of neuropeptides on the ISN neurons and have found that Substance P depolarizes and excites the ISN neurons.

These results indicate the complexity of the NST and suggest caution in interpreting the role of the NST in coding before more details of the network of neurons responsible for processing chemosensory information are available.

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References


