

## Posterior Insular Cortex in Rats: Response Characteristics and Function

Takamitsu Hanamori

Department of Physiology, Miyazaki Medical College, University of Miyazaki, Miyazaki 889-1692, Japan

Correspondence to be sent to: Takamitsu Hanamori, e-mail: thanamo@med.miyazaki-u.ac.jp

### Introduction

Since the first report by Cechetto and Saper (1987) showing the viscerotopic sensory representation in the insular cortex, various studies on the posterior insular cortex have been performed. We previously studied the response properties of neurons in the rat insular cortex to gustatory, visceral and nociceptive stimulation, and to electrical stimulation of the various sensory nerves (chorda tympani, CT; lingual-tonsillar branch of the glossopharyngeal nerve, LT-IXth; pharyngeal branch of the glossopharyngeal nerve, PH-IXth; superior laryngeal nerve; SL), using single unit recordings (Hanamori *et al.*, 1997a,b, 1998a,b). The results from these studies indicated that neurons in the posterior insular cortex (posterior to the region where the CT projects) receive convergent inputs from various sensory organs. In the present study, first, we summarized the data from previous our studies concerning response properties and convergence in the insular cortex.

Previously several studies (e.g. Ruggiero *et al.*, 1987) have shown that electrical or chemical stimulation of the posterior insular cortex induces changes in the cardiovascular system [increase or decrease in heart rate (HR) or blood pressure (BP)]. In addition, it has been shown that neuronal activity in the posterior insular cortex was increased or decreased by chemoreceptor or baroreceptor stimulation. In the present study, we found neurons in the posterior insular cortex that show fluctuations in the spontaneous discharge. The fluctuations were also observed in BP and HR recorded simultaneously. The relationships among fluctuations in neuronal activity of the insular cortex, mean arterial pressure (MAP), and HR were analyzed using the Pearson correlation coefficient ( $r$ ).

### Results and discussion

#### Response properties and convergence

Ninety-four neurons were responsive to electrical stimulation of, at least, one of the four taste nerves. Most neurons (69%) received convergent inputs from three nerves (mostly from LT-IXth, PH-IXth, and SL; Figure 1A). Ninety-one neurons showed an excitatory or inhibitory response to baro- and/or chemoreceptor stimulation [methoxamine hydrochloride (Mex), pressor drug; sodium nitroprusside (SNP), depressor drug; sodium cyanide (NaCN), activate arterial chemoreceptors]. Of 46 Mex-sensitive neurons, 67% were also sensitive to SNP. Of 69 NaCN-sensitive neurons, 72% were also sensitive to baroreceptor stimulation (Figure 1B). Twenty-six neurons were sensitive to taste stimulation of the posterior tongue (the stimuli were NaCl, HCl, QHCl and sucrose). Many neurons showed relatively narrow sensitivity to taste stimuli (53% of the taste-sensitive neurons responded to only one stimulus). However, 77% of the taste-sensitive neurons responded to tail pinch, and 81% responded to visceral (baro- and chemoreceptor) stimuli. Most taste-sensitive neurons (61%) received convergent inputs from all three stimuli (taste, tail pinch, and visceral) (Figure 1C). Twenty-two neurons were sensitive to taste stimulation of the pharyngolaryngeal region. Taste-sensitive neurons were also responsive to tail pinch (91%) and to visceral stimulation (86%). Most neurons (82%) received convergent inputs from all three stimuli (taste, tail pinch,

and visceral) (Figure 1D). In summary, most neurons showed multi-modal sensitivity. Two hundred and seven neurons obtained in these studies were located in the insular cortex between 2.9 mm anterior and 1.4 mm posterior to the APo (APo, the anterior edge of the crossing of the anterior commissure). The mean location was 0.9 mm ( $n = 207$ ) anterior to the APo. Thus, most neurons recorded in our study were located in an anterior portion of the posterior insular cortex. In conclusion, many neurons in the posterior insular cortex receive convergent inputs from various sensory organs (taste, visceral and nociceptive).

#### Fluctuations in the spontaneous discharge of neurons in the posterior insular cortex associated with fluctuations in BP and HR

Three of 20 neurons in the posterior insular cortex showed fluctuations in their spontaneous discharge during recording without stimulation. One example of neuron A is shown in Figure 2A. This neuron showed fluctuation in the spontaneous discharge as well as fluctuations in BP and HR recorded simultaneously. There was a negative correlation between neuronal activity and BP (Figure 2B,  $r = -0.42$ ,  $n = 400$ ). The  $r$  between neuronal activity and HR was  $-0.22$ . In the case of neuron B, there was a relatively high correlation between the neuronal activity and HR ( $r = 0.67$ ). The  $r$  between neuronal activity and BP was  $-0.26$ . For neuron C, an increase in the spontaneous discharge was associated with the changes in BP ( $r = 0.31$ ) and HR ( $r = 0.36$ ). These results showed that fluctuations in neuronal activity in the posterior insular cortex are positively or negatively correlated with BP and/or HR. The data suggest that some of the neurons in the posterior insular cortex may play a role in the homeostatic control of the autonomic system.

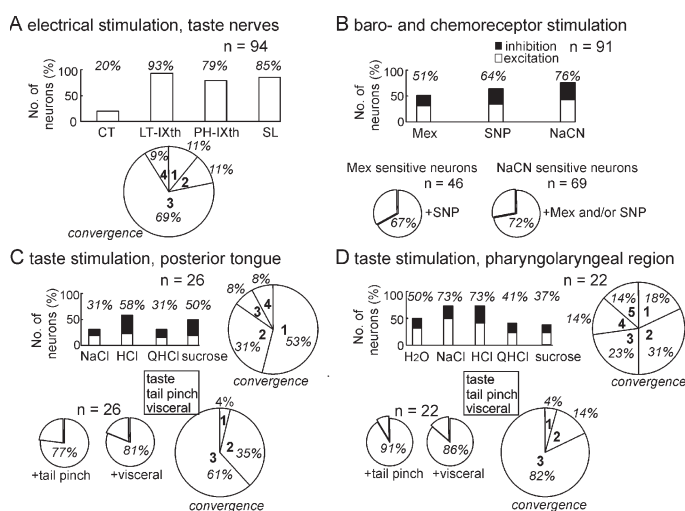
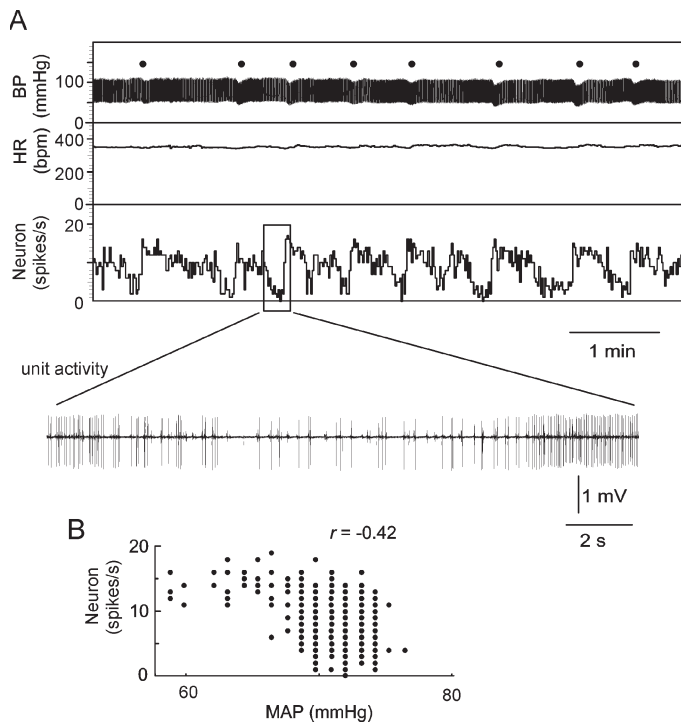


Figure 1 Response properties and convergence in the insular cortex.



**Figure 2** (A) Sample of a neuron showing fluctuations in the spontaneous discharge accompanying fluctuations in blood pressure (BP) and heart rate (HR). The filled circles on the top of the record show fluctuations in BP. (B) The correlation between neuronal activity and mean arterial pressure (MAP).  $r$ ; the correlation coefficient.

## References

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