BOLD fMRI assessment of the functional response to taste stimulation in rat brain

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Introduction

In mammals, the process of encoding taste information into taste perception extends from the receptor level to the primary gustatory cortex. The neurons in the gustatory cortex are multimodal; they respond not only to the 5 basic tastes—salty, sour, bitter, sweet, and umami—but also to the textures, temperature, and viscosity of foods. Thus, the neurons in the gustatory cortex are involved in the complex processing of a tastant. Electrophysiological examination has long been used to investigate the gustatory system [1], and recently, optical imaging using intrinsic signals has been used to identify the in vivo encoding process for basal tastants in rat and pig gustatory cortex [2, 3]. However, because of the spatial limitations of these techniques, some aspects of taste information processing have not been conclusively clarified, such as the process by which the gustatory cortex uses spatial codes in the cortical taste area to characterize taste information. In this study, we performed BOLD fMRI measurements at 7 T in an animal system to investigate the process by which taste information is encoded in this system.

Materials and Methods

Animal preparation: Male Sprague-Dawley rats (250-350 g) were initially anesthetized with 2% isoflurane. Before the rat was placed into magnet, the anesthesia was switched to urethane (i.p. 0.8 g/kg). The head was secured in a holder designed to minimize movement and the body temperature was maintained by a water-heated blanket. *Taste Stimulation:* Sucrose solution (0.5 M, diluted in distilled water) prepared on the day of the experiment was used as the tastant. The tastant was delivered through a polyethylene tube using a syringe pump. The polyethylene tube was inserted 10 mm into the oral cavity without touching the tongue of the animal, which was held agape. Another polyethylene tube was inserted to wash out the tastant using distilled water. The stimulation paradigms for one-block design were employed. The tastant was delivered at the rate of 0.3 mL/min for 3 min. After each fMRI experiment, the papillae were rinsed using sufficient distilled water to wash out the tastant on the tongue. After rinsing, the excess distilled water was removed by passing air at the rate of 1 L/min for 1 min. *MRI measurements:* MRI experiments were performed on a horizontal 7 T magnet interfaced to a Varian^{INOVA} console with a circular radio-frequency transmit-receive surface coil. The magnetic field homogeneity was optimized by coronal slice shimming. T1 weighted FLASH anatomical images were obtained (image dimension = 128 × 128 pixels; in-plane resolution = 0.2 × 0.2 mm; slice thickness = 1.0 mm; repetition delay = 5.0 s; echo time = 15 ms) with variable inversion recovery weighting per slice. FMRI data were acquired using a gradient-echo sequence with scan parameters as follows: TR/TE = 470/12 ms, slice thickness = 1 mm, FOV 25.6 × 25.6 mm^2, matrix size = 64 × 64 for five slices. Activated regions were represented as Student's t maps (the taste solution elicited significant signal-change with a p value) for each run.

Results and Discussion

Taste stimulation produced a BOLD signal increase in the gustatory cortex (GC in Fig. 1); this signal increase was located between +0.6 and +2.3 mm anterior of the bregma (e.g. Figs. 1 and 2). The BOLD responses were in accordance with the observations of the neurophysiological and optical techniques [1, 2]. During taste stimulation, BOLD signals were also detected in the lip region of the primary somatosensory cortex (S1Lip in Fig. 1), secondary somatosensory cortex, and amygdalae. After the first run, rinsing and removal of the tastant on the tongue produced reproducible BOLD responses in the gustatory cortex and other regions in the same subject (Run 1 and 2 in Fig. 1). We also observed BOLD responses in the gustatory cortex of a different animal under identical experimental conditions, thus confirming the good intersubject reproducibility of this approach (Fig. 2).

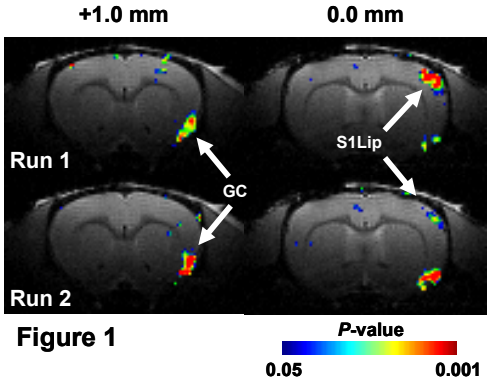

Figure 1

Conclusion

We used sucrose solution and successfully elicited BOLD signals in the gustatory and somatosensory cortex; these signals were reproducible in identical trials in the same animal and in different animals. This is the first study that used BOLD fMRI to observe the process by which taste information is encoded in rodents.

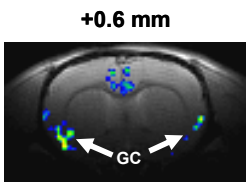

Figure 2

References

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