Asymmetrical gustatory cortex but symmetrical gustatory representation in the left and right hemispheres of the rodent brain

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Introduction – While anatomical and functional asymmetries are well known in the human brain, asymmetrical processing of brain function is not fully understood in rodents. A gustatory cortex has been identified near the anterior and posterior regions of the middle cerebral artery (mca) and the dorsal regions of the rhinal vein (rv) in the insular cortex of rodents.[1,2] The intersection of these two blood vessels is a known anatomical landmark of the gustatory cortex. However, most studies of this region have only focused on the insular cortex of a single hemisphere. Our previous study demonstrated that the responses to tastant solutions observed using BOLD fMRI were bilateral but asymmetrical in the left and right insular cortices of rodents.[3] Two interpretations may explain this asymmetry. First, this region may contain asymmetrical functional representations with respect to anatomical boundaries. Alternatively, the representations may be symmetric, but have asymmetric anatomical landmarks. To investigate these two possibilities, we performed optical imaging of intrinsic signals to measure the functional representations elicited by tastant solutions. We also used magnetic resonance angiography (MRA) at 11.7 Tesla to observe the landmark coordinates within the insular cortices of both hemispheres.

Materials and Methods – *MRI experiment.* Male C57BL6J mice were anesthetized with 1.2% isoflurane during the experiment. The head was fixed in a holder designed to minimize movement, and the body temperature was maintained using a water-heated blanket. MRI scans were performed on an 11.7 T vertical bore imaging system (AVANCE II, Bruker) with a 15-mm inner diameter transmit/receive volume RF coil (m2m imaging). The TOF-MRA technique was performed by acquisition of coronal slices using a FLASH-3D sequence with the following parameters: FOV, 12 × 12 mm^2; matrix, 192 × 192; number of slices, 104; slice thickness, 62.5 μm; TR/TE, 50/1.5 ms; flip angle, 30°; number of average, 2; total scan time, 24 min 36 s. MRA datasets were saved in DICOM format and analyzed using the SPIN and ImageJ. *Optical imaging experiment.* Male Sprague Dawley rats were anesthetized using 2% isoflurane for surgery. The temporal bone on both sides was thinned over the insular cortex around the intersection of the mca and rv. After the skull was thinned, the anesthesia was switched to urethane (1.2 g kg^{-1}, i.p.). The rats were placed on the stage of a stereoscopic zoom microscope that was equipped with a CCD camera, and cortical images were obtained from both hemisphere. To investigate the hemodynamic responses, we used transmission filters that were centered at 586 nm, which is an indicator of cerebral blood volume (CBV) in activated cortices.[4] Sucrose solution (0.5 M, diluted in distilled water) was used as the tastant. We delivered tastant stimuli through separate silicone tubes that were connected to a perfusion pencil that was made of independent polyimide lines with a valve control system. The cone-shaped tip of the pencil was inserted to a depth of 1 cm into the open oral cavity of the animal. Starting 5 s after frame acquisition, tastants were delivered for 2 s, which was a time that was sufficient to flood the whole tongue. Then after stimulus offset, distilled water was delivered for 5 s to wash away the tastant. The application of tastant was controlled by a computer-driven array of pinch valves.

Results and Discussion – The sucrose solution increased the CBV in the anterior and posterior areas of the mca and the dorsal regions of the rv in the insular cortices of both hemispheres (Fig. 1 left bottom). The averaged changes in CBV were not statistically significant between the anterior and posterior regions in both hemispheres (Fig. 1 right), which indicates a symmetrical functional response with respect to the mca in both hemispheres. This result contradicts those of a previous fMRI study,[3] which showed that the positive BOLD signals were asymmetrical in the insular cortices of both hemispheres. However, MRA indicated that the landmark location in each hemisphere was asymmetrical; the landmark in the left hemisphere was more anterior than the one in the right hemisphere (Fig. 2, 0.5-mm difference). Therefore, taken together, these findings are consistent with those of the previous work[3] because functional images by BOLD fMRI were obtained in a plane perpendicular to the midline.

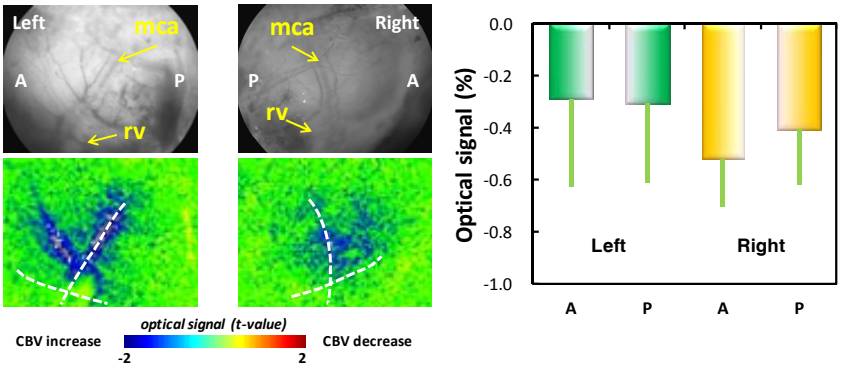

Figure 1. Reflectance (left top), functional image (left bottom) and the averaged optical signals (right) in the insular cortices of both hemispheres

Conclusion – We found that a functional gustatory representation was symmetrically preserved in both hemispheres based on the landmark, but the position of the landmark was asymmetrical between the hemispheres in rodents. This suggests that the mca and rv provide a good approximation of the location of the gustatory cortex, and that these landmarks should be obtained for representational maps.

References – 1. Accolla et al (2007) J Neurosci 27:1396-1404; 2. Yamamoto et al (1984) J Neurophysiol 51:616-35; 3. Kida et al (2011) NeuroImage 56:1520-5; 4. Nemoto et al (2004) J Neurosci 24:3850-61.

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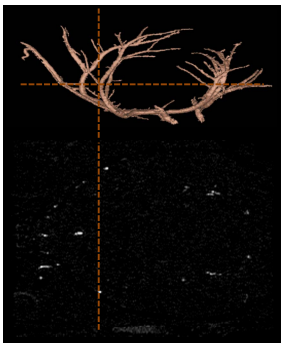

Figure 2. Maximum Intensity Projection-reconstructed MRA (top) and MRA horizontal images (bottom) in rodent brain