

## Representation of sweet and salty taste intensity in the brain

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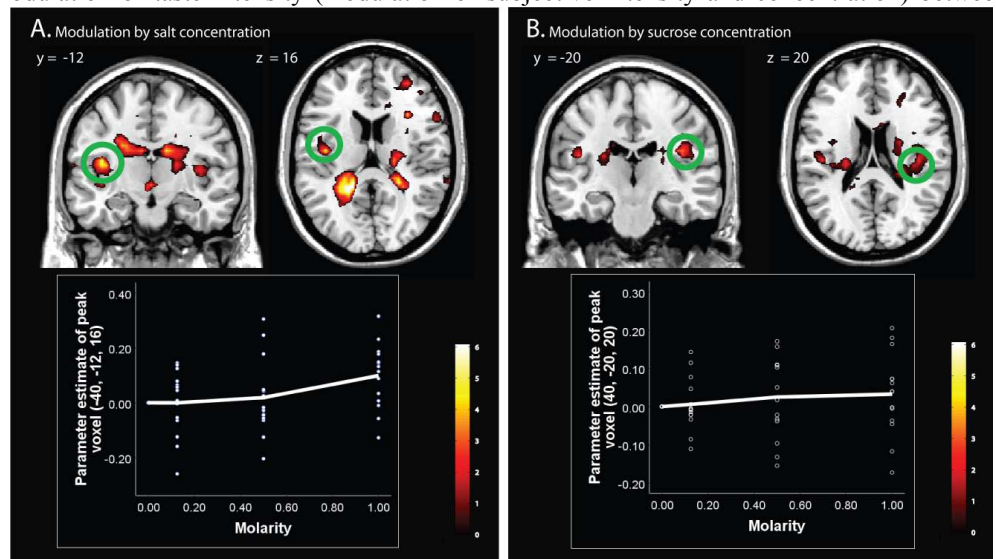
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**Introduction** Most foods can be classified as either sweet or savoury. Sucrose and salt are commonly used to season foods. When a savory food is eaten to satiety its pleasantness decreases, while an uneaten sweet food is still perceived as relatively pleasant and is more likely to be eaten, and vice versa. This phenomenon is called sensory-specific satiety [1]. Taste intensity is one of the determinants of sensory-specific satiety: e.g. highly intense-tasting foods are eaten in smaller quantities [2]. So far, only one study investigated taste intensity in the brain, using low and high concentrations of a sweet (pleasant) and a bitter (unpleasant) taste [3]. In this study it was found that the middle insula and amygdala represent taste intensity. Here, we investigate the brain representation of sweet and salty taste intensity using fMRI as a first step to be able to investigate more complex sweet and salty (savory) tastes.

**Methods** Data from 14 healthy normal-weight right-handed male-volunteers (mean age  $23.3 \pm 1.7$  y, mean BMI  $22.0 \pm 1.5$  kg/m<sup>2</sup>) were acquired. Subjects fasted 2h before the fMRI scan, which was performed on a 3T Philips system. A 2D single-shot EPI sequence was used (TR/TE= 1600/23 ms, flip=90°, 30 interleaved slices,  $4 \times 4 \times 4$  mm<sup>3</sup> voxels, FOV =  $256 \times 208$  mm). Subjects were scanned twice on separate days (two sessions: salt and sucrose). During the scan, subjects tasted four sucrose (sweet-session) or salt (salty-session) solutions varying in concentration (0M, 0.13M, 0.5M and 1M). After tasting, subjects rated the stimulus on intensity and pleasantness on a Visual Analog Scale (VAS), followed by a visual cue for swallowing and a rinse with water. FMRI data were preprocessed and analyzed using SPM5 and the WFU-Pickatlas-tool. For both sessions contrast images for linear parametric modulation of taste activation by intensity (first parameter) and pleasantness ratings (second parameter) were calculated, once using the subjective ratings and once using the concentrations (objective measure) as the intensity parameter. In addition, contrast images of taste activation were calculated for all concentrations. For the group analyses, the contrast images of intensity modulation of all subjects were entered into t-tests. Differences between sweetness and saltiness intensity modulation were tested for using a paired-samples t-test. A priori regions of interest (ROIs) were the insula (primary taste cortex) and amygdala.

**Results** Mean intensity ratings did not differ between the sucrose and salt solutions (paired t-test,  $p > 0.05$ ). Insula activation increased with increasing concentration for both salt (MNI (-40, -12, 16),  $p < 0.05$ , FWE-corrected) and sucrose (MNI (40, -20, 20),  $p < 0.005$ , uncorrected), see figure 1. Moreover, insula activation by salt increased more with concentration than that by sucrose (paired t-test,  $p < 0.005$ , uncorrected). Differences in modulation of taste intensity (modulation of subjective intensity and concentration) between sucrose and salt were found in the anterior insula (MNI (-32, -20, -8),  $p < 0.05$ , FWE-corrected). Amygdala activation increased with increasing salt only (MNI (24, 0, -12),  $p < 0.005$ , uncorrected).

**Discussion & Conclusion** We determined the brain areas that represent taste intensity, using a range of salty and sweet solutions. Sweet and salty taste intensity modulate taste activation in the insula. This is in line with previous research in which two sweet and two bitter tastes, which differed in intensity, were used [3]. Despite similar subjective intensity ratings, the insula activation by salt increased more with concentration than it did in response to sucrose. This greater responsiveness of the brain to saline provides support for the idea that SSS may be stronger for savoury than for sweet tastes [4]. Given the unpleasantness of a pure salt solution we are currently performing a follow-up study using sweet and savoury foods instead of simple tastants. This may further elucidate potential differences in SSS for sweet and savoury foods [4].



**Figure 1.** Modulation of insula taste activation by salt and sucrose concentration. Top: Color-coded SPMs of the t-tests, thresholded at 2.8. Green circles indicate the insula clusters. Bottom: Mean parameter estimates of taste activation for the insula peak voxels per concentration. **A.** Left insula modulation by salt concentration. Peak voxel MNI (-40, -12, 16), z score = 4.87. **B.** Right insula modulation by sucrose concentration. Peak voxel MNI (40, -20, 20), z score = 3.83.

**References** [1] Rolls, B.J. et al. *Physiol Behav.* 29, 409-417 1982 [2] Vickers, Z. *Food Quality and Preference* 12, 521-526 2001 [3] Small, D.A. et al. *Neuron* 39, 701-711 2003 [4] Weenen, H. et al *Food Quality and Preference* 2005