

Brain Responses to Visual Food and Non-Food-Stimuli in Lean Subjects in Fasted and in Sated State

H. Schloegl¹, J. Lepsien², A. Horstmann², S. Kabisch¹, F. Busse¹, K. Mueller², B. Pleger^{2,3}, A. Villringer^{2,3} & M. Stumvoll¹

¹ Department of Medicine, University of Leipzig, Leipzig, Germany

² Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

³ Day Clinic of Cognitive Neurology, University of Leipzig, Leipzig, Germany

hschloegl@cbs.mpg.de



MAX-PLANCK-GESELLSCHAFT

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

Introduction

Increased energy uptake is an important factor for the worldwide fast growing prevalence of obesity and the associated Diabetes mellitus type 2 [1, 2]. Both are causal for numerous health problems [3]. Although food related brain responses have been identified in a series of neuroimaging studies [4 - 6] there is growing interest in taking account of individual food preferences when measuring brain activity. This subjective evaluation of food is likely to be influenced by the state of hunger or satiation of the individual.

Methods

We included 21 male, lean (mean body-mass-index, BMI 23.0, range 19.6 - 25.9 kg/m²), healthy subjects with an average age of 25.2 (range 22 - 31 years). Functional magnetic resonance imaging (fMRI) was performed on two different days, one HUNGRY day (after 16 hrs. of abstinence from food or caloric drinks) and one SATIED day (after a mixed all-you-can-eat buffet). Order of days was randomized for each subject, with one week between the two scans. On each day we performed an fMRI scan (3T MR scanner, Siemens TIM Trio, 12 channel head coil, TR 2 s, 28 slices, voxel size 3 x 3 x 4 mm, 1 mm interslice gap, 1020 volumes, scanning time 34 min.). When lying in the scanner, pictures of food (FOOD) and food unrelated items (TOOLS) were presented on a back-projection screen. Each picture was displayed for 1 s. In the following 2 s subjects had to rate pictures regarding their personal preferences along the dimensions 'not at all tasty - very tasty' for FOOD and 'not at all useful - very useful' for TOOLS using a 4 button keypad (see Figure 1 for an example of the trial design). In total, 250 pictures were presented, consisting of 200 FOOD and 50 TOOLS stimuli. MRI data was analyzed with SPM 5 software using Matlab 7.7.

Figure 1



Presentation screen with durations during functional scan. ITI: inter trial interval, duration randomized between 1 and 6 s.

Results

Behavioral data

In hungry state subjects selected significantly more often the highest rating (4, very tasty) than in sated state when seeing the 200 FOOD pictures (in average 75 times when hungry, 44 times when sated).

For TOOLS pictures, there was no significant difference between the two states (See Charts 1 and 2).

Functional MRI data

The main effect FOOD > TOOLS showed significant activations in the bilateral insular regions and in the bilateral primary and secondary visual cortices ($p < 0.05$, corrected for multiple comparisons (FDR)), and a trend towards significant activity in the left orbitofrontal cortex ($p < 0.08$ on voxel level) (see Figure 2). When comparing hungry and sated state (HUNGRY > SATIED), a trend towards significant activity in the bilateral associated visual cortex (V3, V4) was found ($p < 0.001$, uncorrected for multiple comparisons) (see Figure 3).

Figure 2

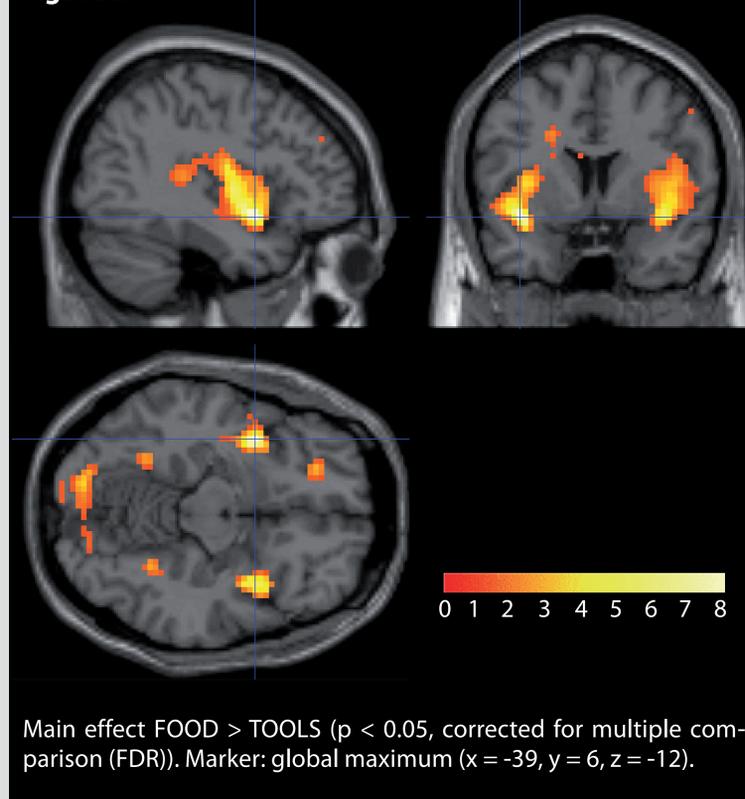


Chart 1

Number of ratings for FOOD pictures, categories 1: not tasty - 4: very tasty, mean for all subjects ($n = 21$). * Paired t-test value < 0.05 , all other rating categories were $p > 0.05$.

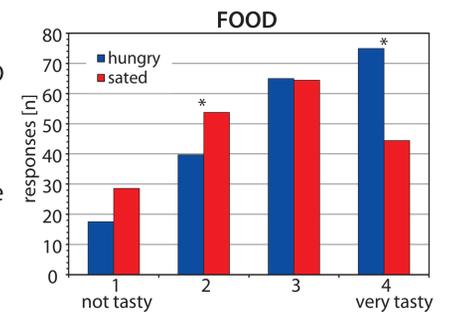


Chart 2

Number of ratings for TOOLS pictures, categories 1: not useful - 4: very useful, mean for all subjects ($n = 21$). T-test: all rating categories $p > 0.05$.

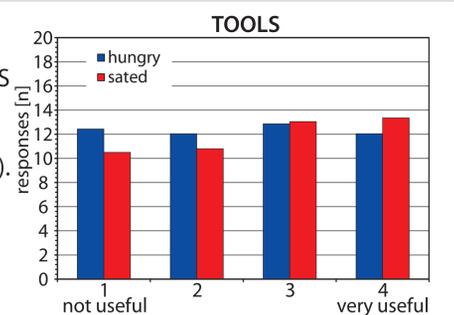
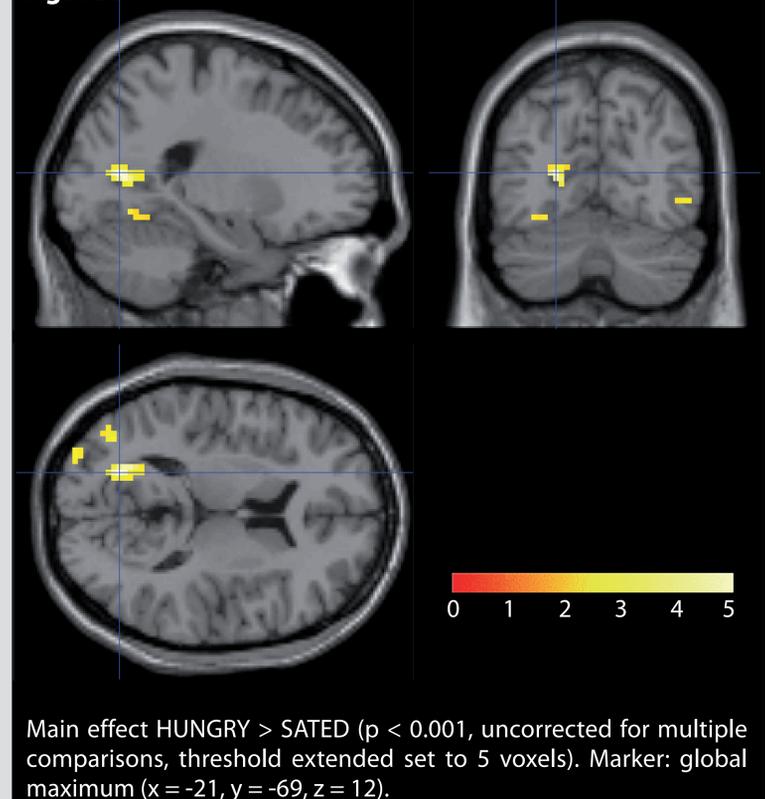


Figure 3



Conclusions

In the FOOD > TOOLS contrast we saw activity in brain regions being known for their involvement in discrimination of food and uneatable objects [5]. With the stimulus rating inside the MRI scanner we were able to measure the subjective effect of the food-stimuli for each subject at the same time point when brain activation was measured by the scanner. Higher ratings in

hungry compared to sated state prove the different perception of food stimuli in the two states. The altered brain activations in V3 and V4 in the HUNGRY > SATIED contrast implicate a different evaluation of visual food stimuli when being hungry compared to being sated, suggesting a higher attentional state to visual food-stimuli in hungry state.

References

- [1] Chan JC, Malik V, Jia W, Kadowaki T, Yajnik CS, Yoon KH, Hu FB (2009) Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *JAMA* 301:2129-40.
- [2] Ford ES, Mokdad AH (2008) Epidemiology of obesity in the Western Hemisphere. *J Clin Endocrinol Metab* 93:S1-8.
- [3] Haslam DW, James WP (2005) Obesity. *Lancet* 366:1197-209.
- [4] Del Parigi A, Gautier JF, Chen K, Salbe AD, Ravussin E, Reiman E, Tataranni PA (2002) Neuroimaging and obesity: mapping the brain responses to hunger and satiation in humans using positron emission tomography. *Ann N Y Acad Sci* 967:389-97.
- [5] Führer D, Zysset S, Stumvoll M (2008) Brain activity in hunger and satiety: an exploratory visually stimulated fMRI study. *Obesity* 16:945-50.
- [6] Gautier JF, Chen K, Salbe AD, Bandy D, Pratley RE, Heiman M, Ravussin E, Reiman EM, Tataranni PA (2000) Differential brain responses to satiation in obese and lean men. *Diabetes* 49:838-46.