Impact of feeding on olfactory bulb response detected by fMRI

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INTRODUCTION

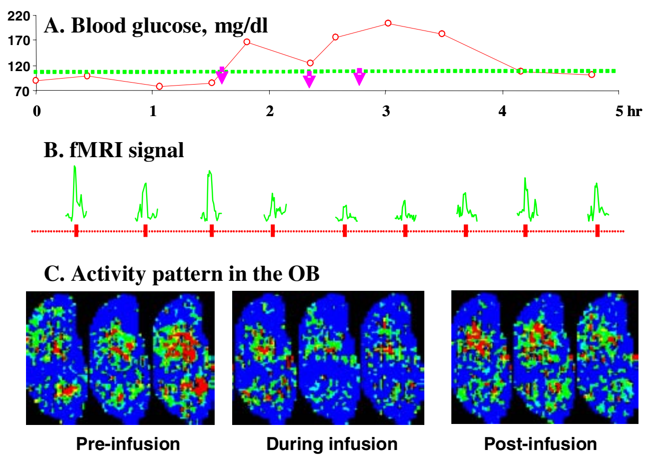
Obesity is poised to overtake smoking as the number one preventable cause of morbidity and mortality in the industrialized world. It leads to a myriad of serious diseases, including hypertension, type II diabetes, and heart disease. The personal costs of such illnesses are enormous and the societal effects of ballooning health care expenditures have the potential to be catastrophic. Aside from major surgical and metabolic interventions for the disparity of energy intake and expenditure, few strategies are able to afford effective and sustainable weight loss. For this reason, there is enormous interest in novel psychological and pharmacological means for modulating appetitive behavior. Smell is a major means to evaluate food from distance without eating the food and a major component of flavor perception of the food as it is eaten. Smell therefore affects both the type and amount of food intake. Therefore studies of the cortical encoding of food-related odors and the relation between olfaction and food intake may provide a neural basis for our inability to healthfully co-exist with modern diet and may suggest fruitful interventions to restore energy homeostasis. Activity patterns in the olfactory bulb, aggregates of the spatial, temporal, and intensity information of all glomeruli, are the initial encoding of all peripheral olfactory information and serve as the substrate on which higher olfactory centers perform various olfactory functions, such as odor detection, discrimination and identification [1-3]. Some of these brain regions also directly or indirectly receive taste inputs and presumably play a role in determining food flavor, gustatory pleasure and satiety. We have developed fMRI methods that allow us to visualize odor-elicited spatial and temporal activity patterns in bulb. Here we applied high resolution fMRI to test the hypothesis that in the bulb the intensity not the topography of the patterns elicited by food related odors is affected by feeding conditions.

MATERIALS and METHODS

Male Sprague-Dawley rats (~300 g) were anesthetized with urethane. Odorants were diluted in mineral oil to adjust the concentrations. The general procedure is as described previously [4]. Briefly the fMRI experiments were performed on a 9.4T Bruker magnet with a FLASH gradient-echo sequence. The whole bulb was mapped with 26 slices at spatial resolutions of 200×200×250 μm^3. The patterns are represented as ΔS/S or *t*-images. The multi-slice images in the glomerular layer were reconstructed into 2-dimensinal odor maps for systematical analysis [5].

RESULTS and DISCUSSION

The animal was fasted overnight so the blood glucose level is below normal. Boluses of glucose were infused during the 5 hr experiment to increase glucose concentration (Figure 1A). The responses of the olfactory bulb (to amyl acetate with the odor-quality of banana) under different conditions were obtained by fMRI. The intensity of the fMRI activity patterns correlated well with the blood glucose levels: The higher the glucose concentration, the weaker the response in the bulb (Figure 1B). The changes in the intensity of activity patterns can be easily recognized in the 2-dimensional odor-maps (Figure 1C). However the topographies (the relative intensity and the positional information among all the glomeruli in the entire glomerular layer) under different conditions were rather similar (Figure 1C). Statistical analysis of these images agrees with the visual observations: values of normalized dot-product (NDP) were 0.75, 0.72, and 0.77 for the images within these three groups (before, during and after infusion), 0.74 for the images among the three groups. These results in the bulb are in agreement with previously reports [6-9]. We are currently working towards being able to image the orbital cortex, where olfactory and gustory information is integrated, to examine the impact of different odorants and compare with the feeding-induced effects detected in the bulb. We hypothesize that, in contrast to the findings in the bulb, both the pattern intensity and topography of the orbital cortex will be modified by the feeding conditions. The current fMRI results suggest that the coding of chemical information in the bulb is not affected by the feeding condition and hypothesize that the coding of the olfactory perception lies in the higher olfactory centers.



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