Reward Sensitivity and Positive Affect Influence Brain Activation to Food Pictures of Different Caloric Value

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Introduction

Functional magnetic resonance imaging (fMRI) studies have demonstrated that activity within brain reward regions is modulated by rewarding properties of food (e.g. viewing high-calorie vs. low-calorie foods), internal cues such as nutritional state, individual reward sensitivity, mood, and obesity [1-9]. For example, we previously reported that fasting selectively increases activation to pictures of high-calorie over low-calorie food in the ventral striatum, amygdala, anterior insula, and medial and lateral orbitofrontal cortex (OFC) [9]. We now examine whether the individual differences in activation within these brain reward systems to viewing food pictures when fasted is influenced by reward sensitivity and mood.

Material and Methods

Twenty healthy, non-obese subjects (10 male, age 26 ± 1 years (mean ± SEM), range 19-35, body mass index (BMI) 22.1 ± 0.5 kg/m^2, range 18.2-27.1) were scanned twice on separate days in randomized order, once after fasting overnight (15.9 ± 0.3h since supper) or when fed (1.6 ± 0.1h since breakfast). fMRI was performed while viewing pictures of (i) high-calorie or (ii) low-calorie foods in a block design (6 pictures per block, 2.5sec per picture, 0.5sec ISI) using a 3T Philips Intera MR scanner (EPI, TR 3sec, TE 30ms, SENSE 2, 44 x 3.25mm slices, 2mm voxels). SPM5 (Wellcome Trust Centre for Neuroimaging, UCL, UK) was used for pre-processing with motion and slice timing correction, registration to standard EPI MNI template, smoothing (8mm FWHM), and GLM with random effects region of interest (ROI) analysis using statistical threshold of P<0.005 uncorrected. The co-ordinates of peak voxel activation in each ROI for high-calorie vs. low-calorie food contrast at the group level when fasted were used to extract the magnitude of activation separately for each hemisphere for individual subjects when fasted and when fed (MarsBar).

To assess reward sensitivity we used the Behavioral Inhibition and Activation Scale (BIS/BAS) [2,10], a questionnaire measuring three personality traits (BAS Drive, Reward Responsiveness and Fun Seeking), and one related to behavioral inhibition/anxiety (BIS). To assess mood, subjects completed the Positive and Negative Affect Schedule (PANAS) [3,11], a measure of current affective state (PA = enthusiasm and active positive engagement; NA = distress and unpleasant emotional activation).

Separate simple linear regressions were used to correlate the questionnaire scores and BMI with brain activation in each ROI for the contrast of high-calorie vs. low-calorie foods. Paired t-test was used to compare brain activation between fasted and fed visits.

Results

There was no significant activation in any of the ROIs (L or R ventral striatum, amygdala, anterior insula, and medial and lateral OFC) at the group level when fed, but activation was seen in each ROI when fasted (all survived FWE correction P<0.05). The magnitude of activation was significantly greater when fasted than when fed (P=0.03-0.002).

When fasted, BAS Drive was positively correlated with activation in the right ventral striatum (r=+0.61, P=0.004), left amygdala (r=+0.50, P= 0.03), and left medial OFC (r=+0.61, P=0.004) (Fig.1a-c). BAS Reward Responsiveness was also positively correlated with activation in the right ventral striatum (r=+0.54, P=0.01) and left medial OFC (r=+0.54, P=0.01) (Fig.1d,e). There was no significant correlation of activation with BAS Fun Seeking or BIS rating in any ROI.

Positive affect was positively correlated with activation in the left insula when fasted (r=+0.53, P=0.02, Fig.1f). There was no significant correlation between activation in any ROI and negative affect or BMI.

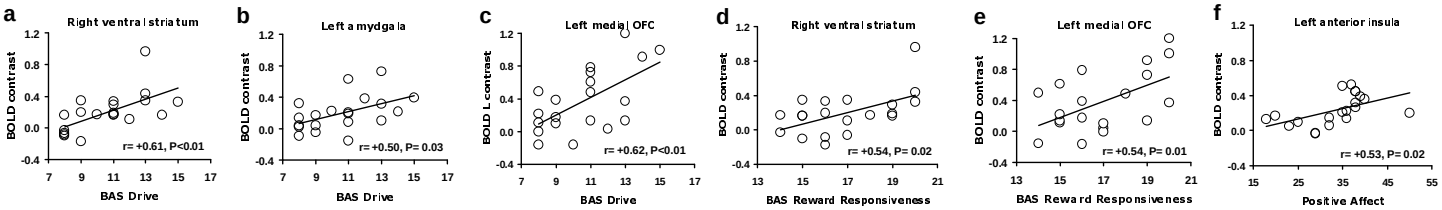

Figure 1. Relationship between activation in brain reward systems when viewing high-calorie relative to low-calorie food and Reward Drive (a-c), Reward Responsiveness (d,e) and Positive Affect (f). r represents Pearson coefficient.

Discussion

Individual differences in reward sensitivity (BAS Drive and Reward Responsiveness) were positively correlated with activation to viewing pictures of high-calorie relative to low-calorie foods when fasted in ventral striatum, amygdala and medial OFC, a neural network involved in food reward. A previous study showed similar correlations for BAS Drive and Reward Responsiveness [2]. Positive affect was associated with increased activity in the left anterior insula, a region involved in gustatory processing. These findings suggest a neurobiological mechanism underlying the relationship between individual personality traits and affective state with the preference for appealing, palatable high-calorie energy dense foods.

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