Reduced neural satiety responses in women affected by obesity

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INTRODUCTION

Overweight and obesity are major risk factors for a number of chronic diseases. Obesity rates are on the rise worldwide with women more frequently affected than men. Hedonic responses to food seem to play a key role in obesity, but the exact mechanisms and relationships are still poorly understood. In this study, we investigate in women the perceived pleasantness of food rewards in relation to satiety states as well as BMI status and calories consumed during an ad libitum meal.

METHODS

Participants
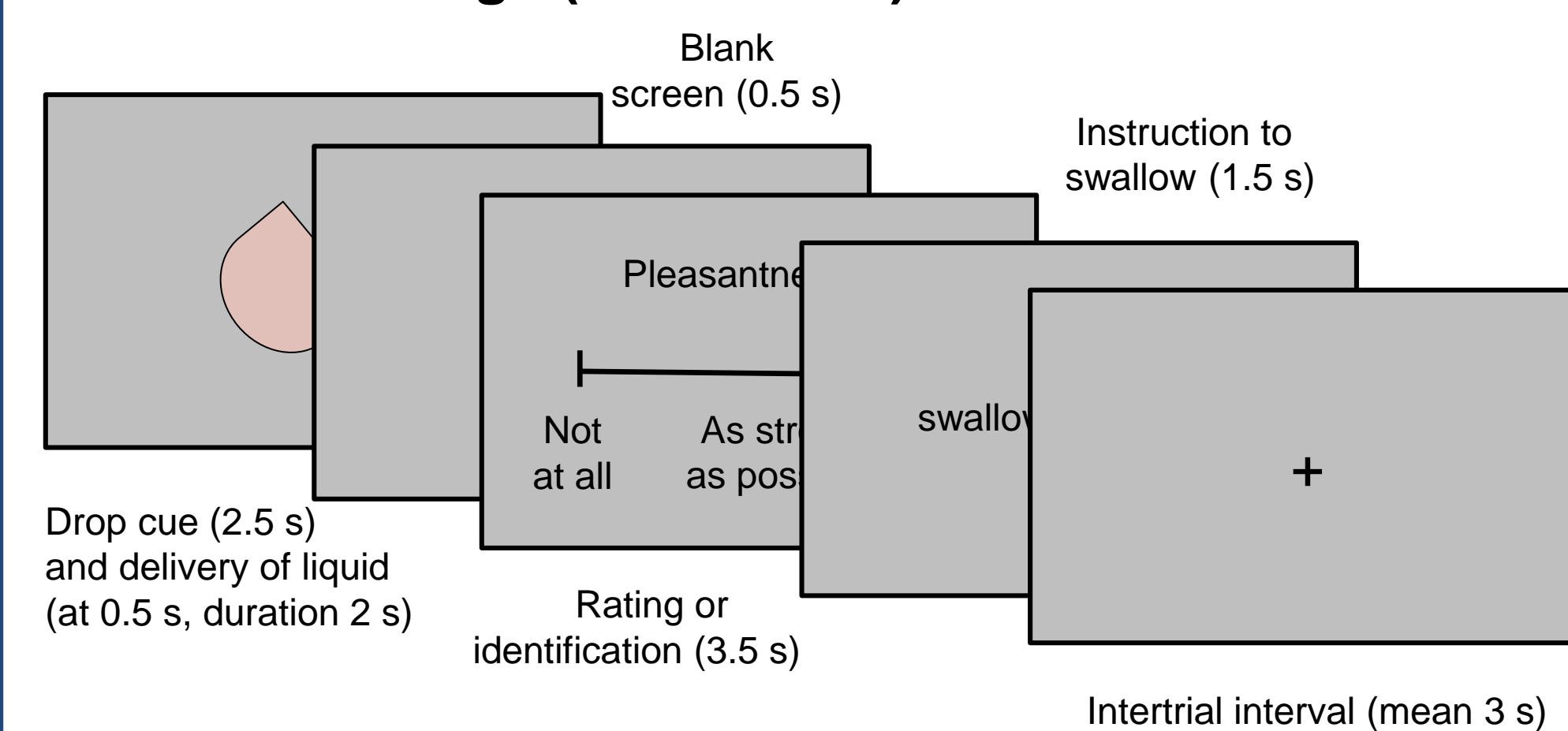Healthy weight: n=32; BMI: 19-25; mean: 21.9

Overweight: n=10; BMI: 26-29; mean: 28.2

Obese: n=24; BMI: 30-37; mean: 33

Age: 18-40; mean: 25.7

EXPERIENCED FOOD VALUE

Milkshake ratings (3T scanner)

Participants received artificial saliva as a neutral liquid and four different milkshakes. The milkshakes were chocolate or strawberry flavored, mixed with water or white cream, resulting in different fat concentrations (low/high). The task was performed four times, during two menstrual cycle phases (preovulatory and postovulatory), and different levels of satiety (fasted and fed).

MODEL
Generalized Linear Mixed Model: beta regression
(all covariates and predictors were z-scored)

$Pleasantness\ Ratings = (\beta_0 + u_{0j}) + (\beta_1 + u_{1j})\ Satiety_{ij} + (\beta_2 + u_{2j})\ Day_{ij} + (\beta_3 + u_{3j})\ Milk_{ij} + \beta_4\ ALCL_{ij} + \beta_5\ BMI_{ij} + \beta_6\ Satiety_{ij}Milk_{ij} + \beta_7\ Satiety_{ij}BMI_{ij} + \beta_8\ Satiety_{ij}Day_{ij} + \beta_9\ Satiety_{ij}ALCL_{ij} + \beta_{10}\ ALCL_{ij}Milk_{ij} + \beta_{11}\ ALCL_{ij}BMI_{ij} + \beta_{12}\ ALCL_{ij}Day_{ij} + \beta_{13}\ Satiety_{ij}BMI_{ij}Milk_{ij} + \beta_{14}\ ALCL_{ij}Milk_{ij}BMI_{ij} + \beta_{15}\ Satiety_{ij}ALCL_{ij}BMI_{ij} + \beta_{16}\ Satiety_{ij}Milk_{ij}BMI_{ij} + \beta_{17}TrialNumber_{ij} + \beta_{18}\ TrialNumber_{ij}Milk_{ij} + \beta_{19}\ TrialNumber_{ij}BMI_{ij} + \beta_{20}\ TrialNumber_{ij}BMI_{ij}Milk_{ij} + \beta_{21}\ CP_{ij} + \beta_{22}\ Prop_{ij} + e_{ij}$

i = trial, j = participant, ALCL = AdLibitumConsumptionLevel


HEDONIC SYSTEM

Fasted vs. Fed
High vs. Low Caloric Milkshake
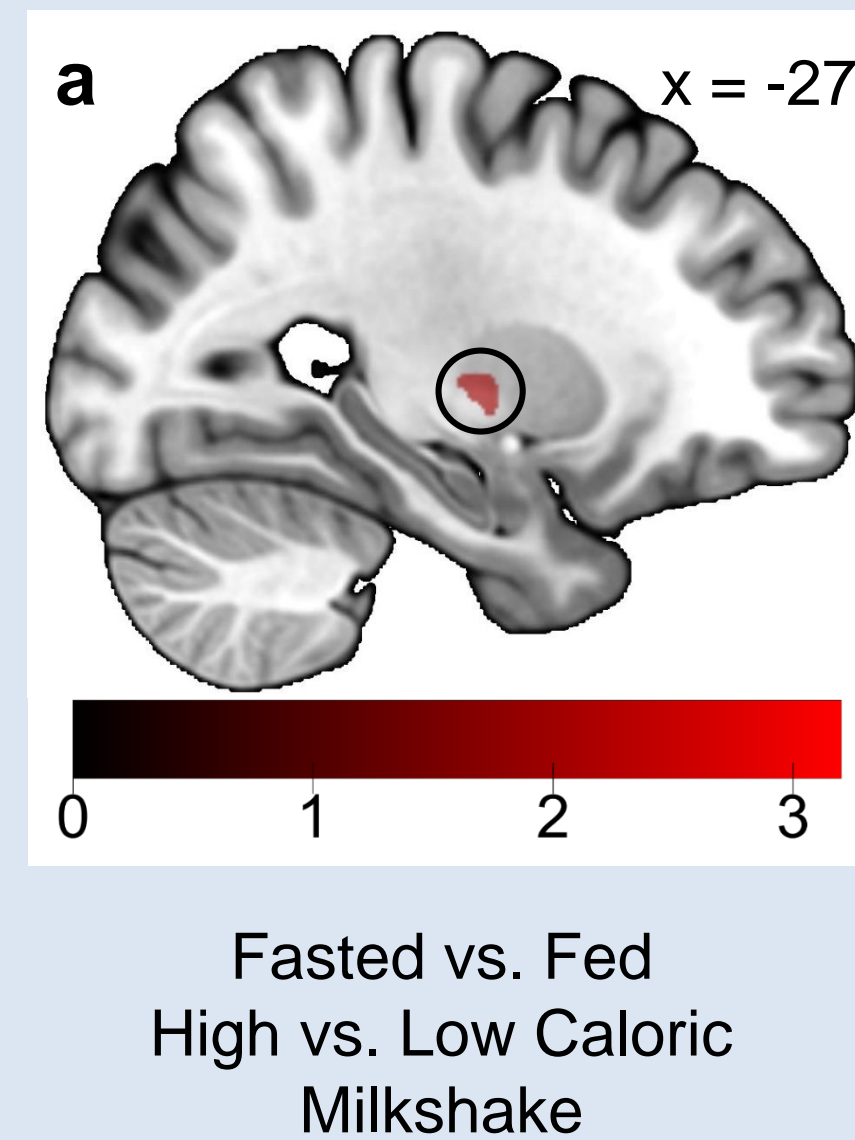
b Illustration of effects for the Putamen

Milkshake Type — High — Low
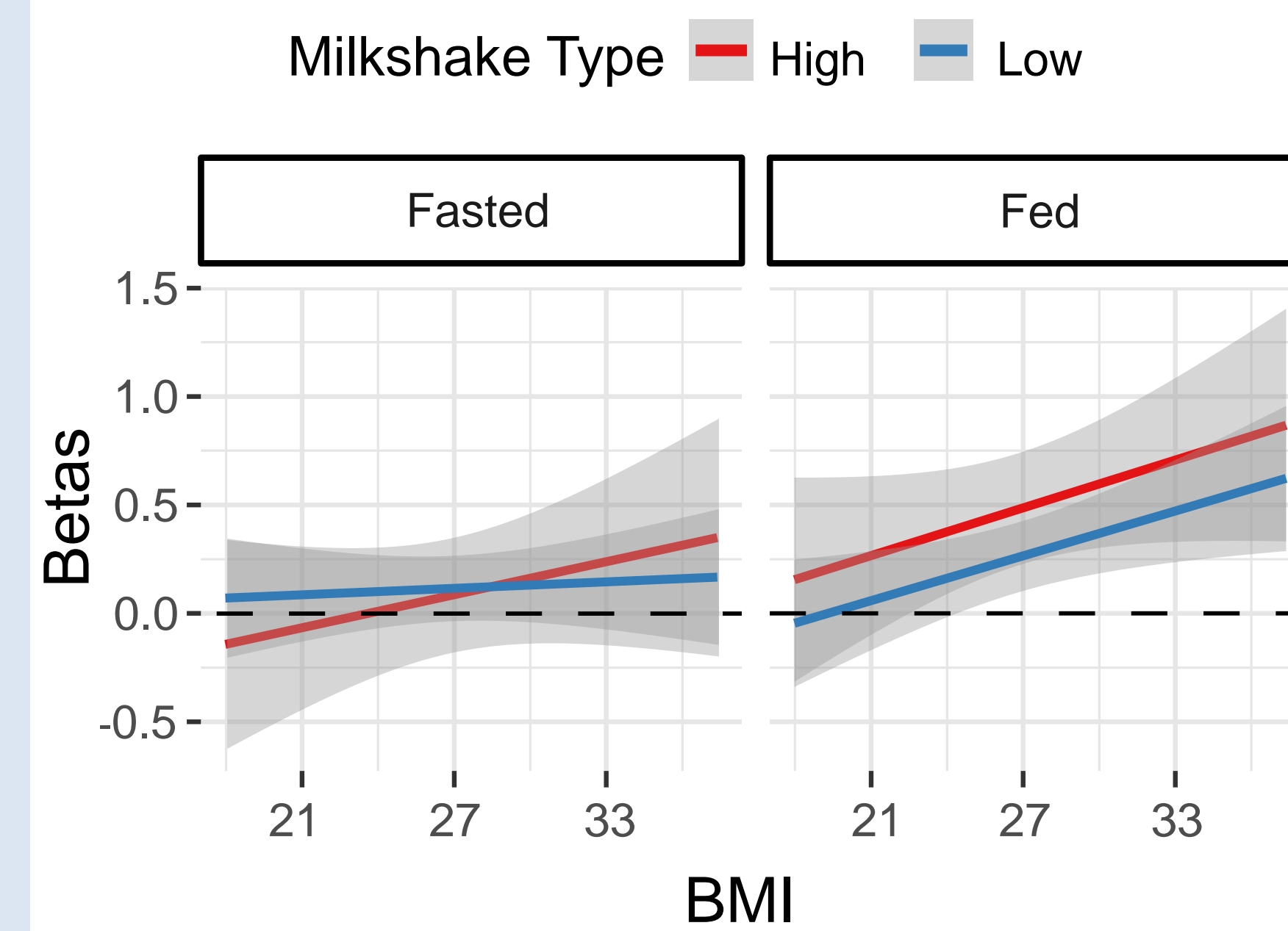
Fig.3 Regions showing interactions between BMI, Milkshake calories, and Satiety. a) Map restricted to the a priori defined hedonic regions and small volume corrected (p < 0.05) after applying Threshold-Free Cluster Enhancement (TFCE). b) Women with obesity consistently showed stronger activity for high than low caloric milkshakes in both states, in line with reduced neural responses to satiety.

HOMEOSTATIC SYSTEM

Fasted vs. Fed
High vs. Low Caloric Milkshake

b Hypothalamus

Milkshake Type — High — Low
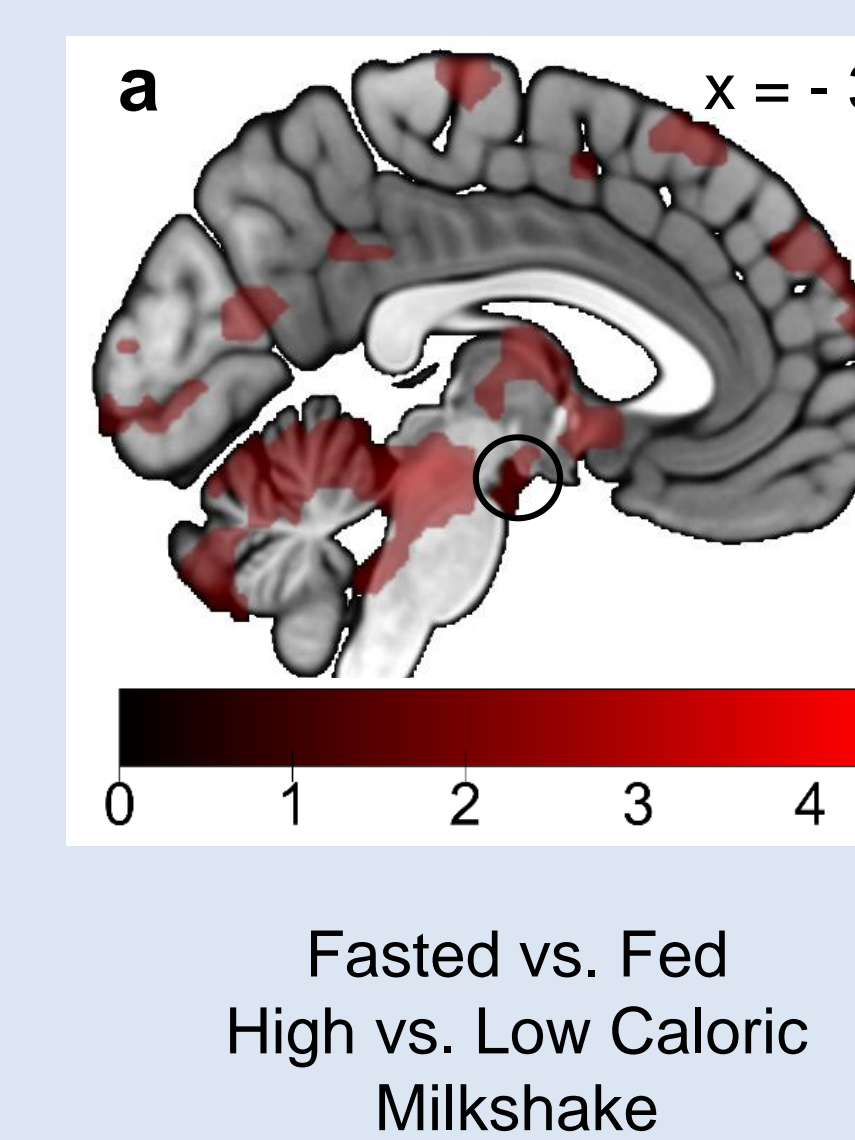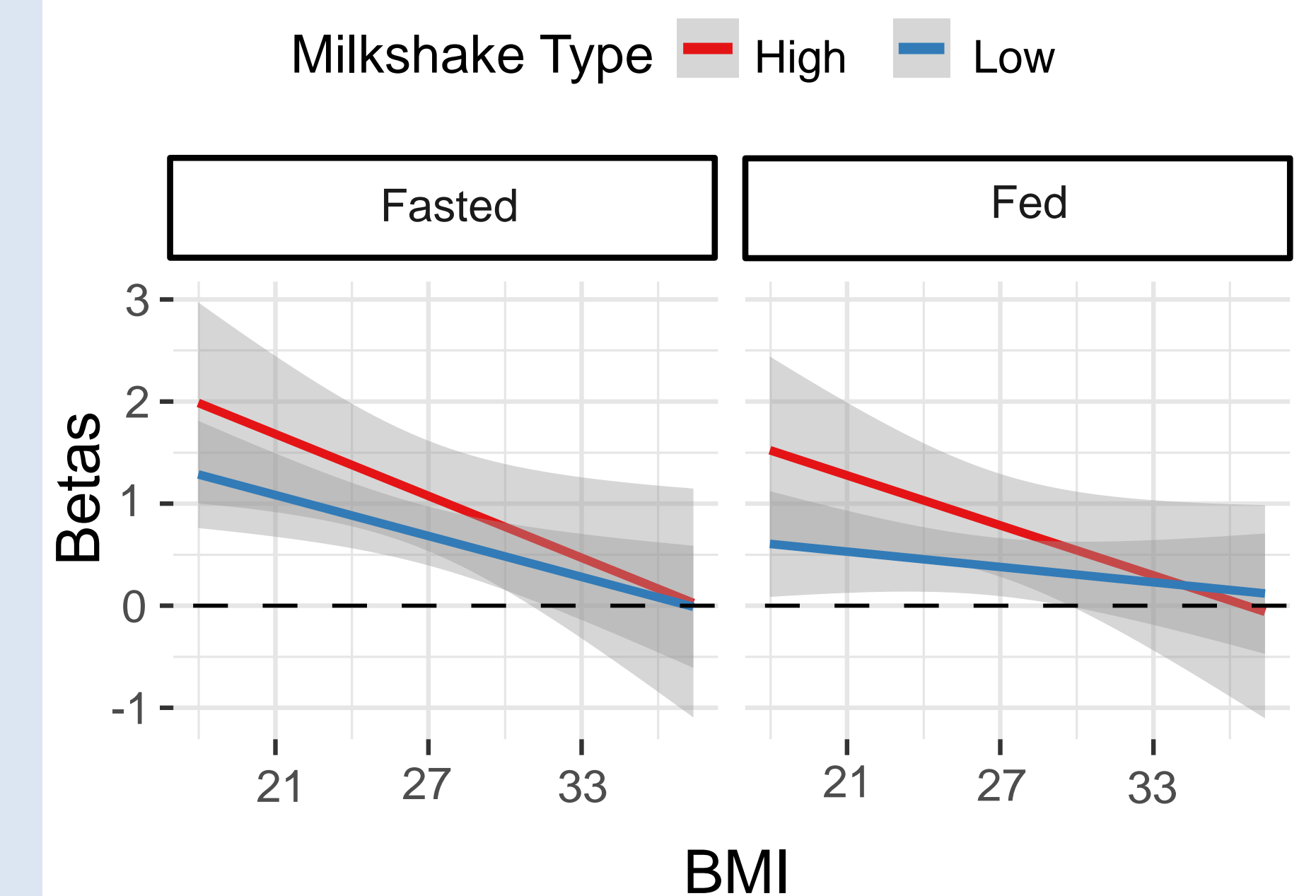
Fig.4 Regions showing interactions between BMI, Milkshake calories, and Satiety. a) Statistical parametric map whole brain corrected (p < 0.05) after applying TFCE. b) Illustration of effects shown in (a) for the hypothalamus. The hypothalamus responded more strongly to milkshakes and differentiated more between low and high caloric milkshakes in women with healthy weight compared to women with obesity.

RESULTS

"The effect of BMI status on pleasantness ratings depends on the amount of food needed to reach satiety"
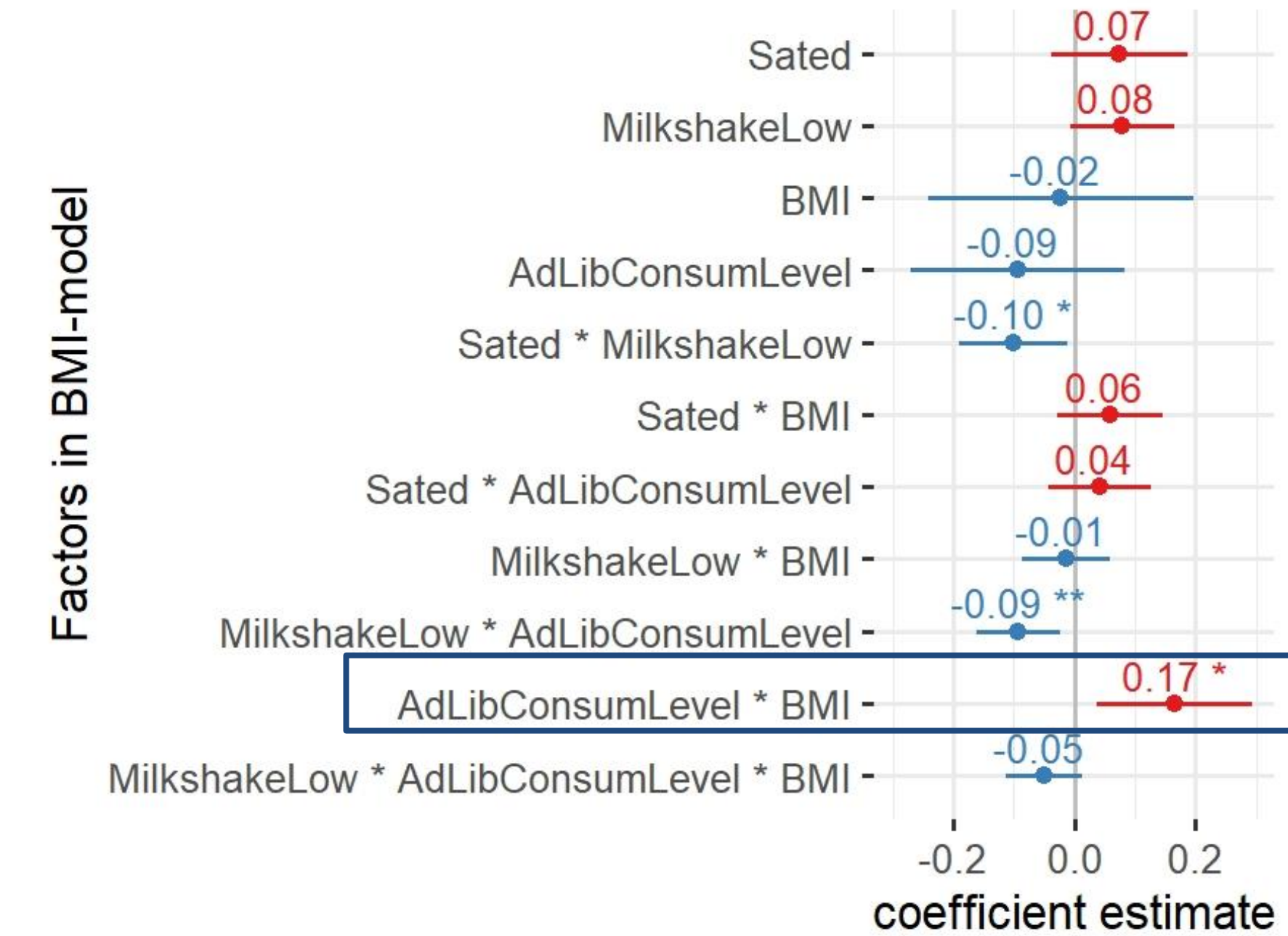
Fig.1 Milkshake pleasantness ratings as function of satiety states, milkshake calories, BMI and ad libitum consumption level. The plot shows the mean estimates and the 95% confidence intervals.

"Women with higher ad libitum consumption levels and higher BMI experience milkshake as more pleasant"
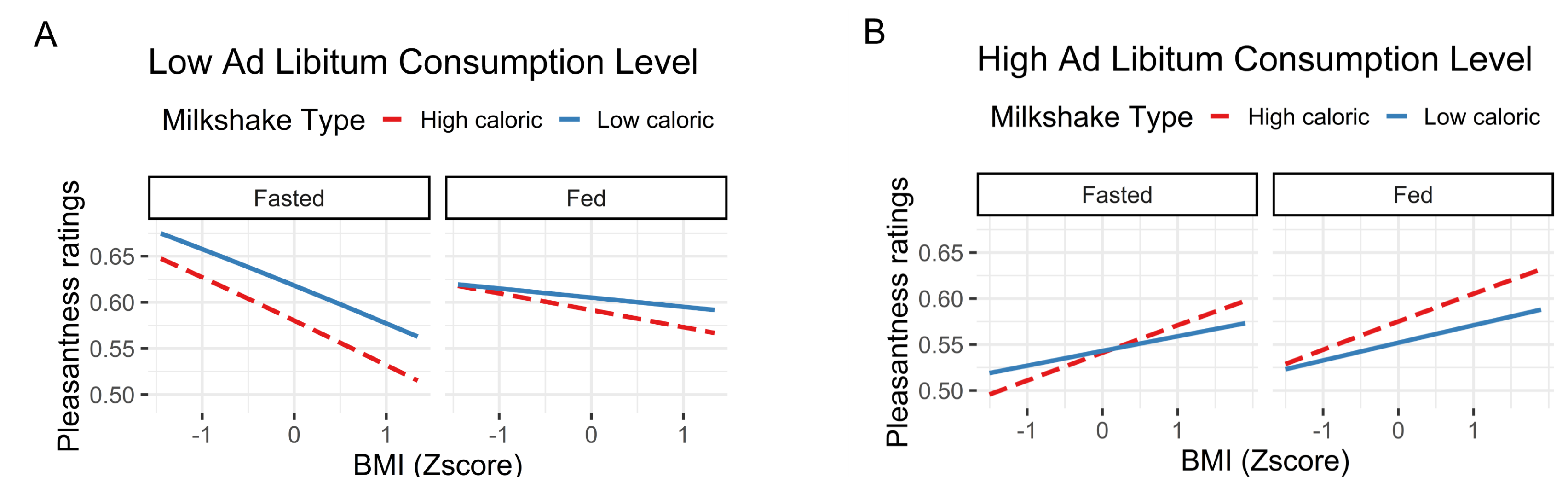
Fig.2 The association between the experienced pleasantness of milkshake rewards and amount eaten during an ad libitum meal differed between women with obesity and with healthy weight.

CONCLUSIONS

- Hedonic responses are more strongly associated with food consumption during the ad libitum meal in women with obesity. Moreover, neural responses to food reward are less sensitive to satiety in women with obesity than with healthy weight.
- The hypothalamus shows lower neural responses in women with obesity, independently of satiety status.
- In women with overweight and obesity, we found possible dysfunctions in the hedonic and homeostatic systems that regulate normal eating. These could potentially promote food overconsumption that leads to or perpetuates obesity.

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