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The development of hunger and fullness during a laboratory meal in patients with Binge Eating Disorder

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Abstract

Objective—This study aimed to test the hypothesis that, compared to similarly obese participants without BED, individuals with BED have a disturbance in the development of fullness and reduction of hunger during the course of a standard meal of large size.

Method—Thirteen patients with BED and 14 obese control participants consumed 975 grams of a milkshake. Participants received no information about how much they had eaten or how much of the meal remained to be consumed. Participants were interrupted after every 75 g consumed to rate hunger and fullness.

Results—Final fullness ratings were higher in patients with BED, but there were no differences in mean duration or mean rate of eating, or in changes in subjective ratings of hunger and fullness per gram of food.

Conclusion—The current study reports the surprising finding of no difference in reports of hunger and fullness between patients with BED and obese controls.

Introduction

Binge eating, or eating a large amount of food accompanied by a sense of loss of control (DSM-IV), is the behavioral hallmark of Binge Eating Disorder (BED). Previous research has examined changes in hunger and fullness during a binge meal in a laboratory setting, and found that, compared to normal weight and obese control participants, patients with BED consumed larger amounts of food but reported similar changes in hunger and fullness, which we interpreted as indicating that patients with BED require greater food intake to achieve a similar level of satiety¹. This finding suggested that individuals with BED might have a deficit in the development of satiety. Participants reported reaching maximal fullness at the end of these meals, but since meal sizes varied both among participants and between experimental groups, it was impossible to directly compare fullness ratings during the meals.

The current study was designed to compare hunger and fullness ratings among participants, each of whom consumed the same amount of food, but who, during the meal, received no information about how much they had eaten or how much of the meal remained to be consumed.

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Methods

Participants

Participants were adult women between the ages of 18 and 45 years: thirteen met DSM-IV criteria for BED, and 14 were obese control participants. Patients with BED had a BMI of 34 kg/m² or more, and had no history of bulimia nervosa (BN). Obese control participants were of similar age and ethnicity to the patients with BED, met the same weight criterion and had no history of binge eating. All participants had a clinical screening evaluation, which included a medical interview with a study physician and a semi-structured psychiatric interview using relevant sections of the SCID. Participants with comorbid axis I diagnoses, with the exception of depression, were excluded from participation. All participants had no drug or alcohol abuse in the past 3 months, no current or past psychiatric diagnoses other than depression, and were in good general physical health, as determined by a study physician. All participants were offered a choice of monetary compensation or eating disorder/weight loss treatment in exchange for their participation. This study was reviewed and approved by the Institutional Review Boards of the New York State Psychiatric Institute and St. Luke's-Roosevelt Hospital Center. Written informed consent was obtained from all participants.

Daily Procedure

Following an initial screening visit, participants reported to the eating laboratory for two test days, an adaptation day and a test meal day. On each day, participants reported in the morning after an overnight fast and were given a standardized 300 kcal breakfast consisting of one Thomas' English muffin with 1½ pats of butter, and 250 g of apple juice. Participants were asked to return 5½ h later for the test meal, without eating or drinking anything other than water in the interim. When the participants returned, they were instructed via tape recording to eat a milkshake, pausing to fill out a rating form each time they heard a tone "until the researcher returned to the eating room". Participants were interrupted to fill out rating forms after each 75 g increment of intake and stopped after 375 g had been consumed. Only participants who rated the shake at least a '6' (= "like slightly") on a 9-point category scale of liking, and were able to follow the procedures, were asked to return for the subsequent test day, which took place at least 2 days later. On the experimental day, participants were given the same instructions and were interrupted after eating every 75 grams, but were not stopped until they had eaten 975 g.

The test meal consisted of an ice cream milk shake (1.04 kcal/g) which had the same caloric density as the yogurt shake used in our previous studies^{2,3}, but which we found to be more palatable to the participants with BED. Milkshakes were served in an opaque container, accompanied by a straw, while seated at a universal eating monitor, a specially constructed table with an electronic balance concealed beneath a false panel⁴. Participants consumed the milkshake from the cup, which rested on the eating monitor. The weight of the cup was displayed on a computer in another room. At the start of the study meal the cup contained a little more than 75 g of milkshake. When the eating monitor indicated that the participant had consumed 75 g, the investigator triggered a tone which signaled the participant to stop eating and fill out a rating form. At this time, the investigator activated the pump to deliver 75 g of shake to the drinking cup. The participant was instructed to resume eating as soon as she completed the rating form. Meals were consumed alone in a private room, and were monitored via a closed-circuit TV monitor.

The questionnaire used the generalized Labeled Magnitude Scale (LMS) developed by Green⁵, which may permit a more valid comparison of subjective ratings among individuals⁶. The scale was comprised of 150 mm lines, anchored (left to right) by "barely detectable,"

“weak,” “moderate,” “strong,” “very strong” and “strongest imaginable sensation of any kind,” with the anchors appearing at empirically determined positions such that “very strong” was positioned in the center of the line, allowing a lot of space for responses between “very strong” and “strongest imaginable sensation of any kind”. Participants were oriented to the scale before the meal and were asked to use the scale to rate a variety of common food experiences, such as eating a typical dinner, or eating the largest meal they had ever eaten. Participants were instructed to make ratings comparing their feelings to the strongest imaginable sensation of any kind that they could imagine (i.e. pain, sound, light, etc.). Participants were instructed to place a vertical line on the scale to answer the following questions: “how hungry are you?,” and “how full do you feel?”.

Experimental Design and Data Analysis

The outcome measures were meal duration and change in subjective ratings during the course of the meal. The change in ratings during the meal (hunger, fullness) were calculated as the slope of the best fit regression line of the plots of the ratings over grams of food consumed. Outcome variables were compared using an independent-samples t-test; SPSS v15 was used for statistical calculations.

Results

The mean age, BMI, and meal-related parameters for patients with BED and obese controls are shown in Table 1. There were no statistically significant differences between the groups either in demographic characteristics or in duration or rate of eating during the test meal.

The mean pre-meal fullness rating of the BED group was slightly, but not significantly higher than that of the control group. The mean post-meal fullness rating of the BED group was significantly higher but the change in fullness over the course of the meal did not differ between groups. The mean pre-meal, post-meal, and change in hunger ratings were not significantly different between groups. The mean changes in fullness and in hunger per gram of food consumed, estimated using all available ratings for each patient, were also not significantly different.

Conclusion

The current study aimed to test the hypothesis that, compared to similarly obese participants without BED, individuals with BED have a disturbance in the development of fullness and hunger during the course of an identical meal of large size. In our previous studies, participants with and without BED were asked to binge eat and/or eat normally in the laboratory, so the size of the meal was determined by the participant¹⁷⁻⁹. We demonstrated that patients with BED eat more than both obese and normal-weight controls both after being instructed to binge eat and also after being asked to eat a normal meal, a finding that is consistent with those of other investigators¹⁰. While those studies demonstrated differences in the amount of food consumed, the comparison of hunger and fullness ratings during the meals was confounded by the differences in intake. In order to compare participants' responses after eating similar amounts of food, and to eliminate the possibility that subjective ratings are affected by instructions to binge eat or to eat normally, participants in the current study were not told how much they would be eating, and the amount was controlled by experimental design. By providing no expectation of meal size and eliminating participants' control over the amount consumed, we aimed to obtain a measure of participants' response to specific amounts of food relatively unaffected by expectation.

In our prior work, we reported that, compared to obese controls, patients with BED consumed significantly greater amounts of food (macaroni and cheese) in *ad libitum* binge

and non-binge meals, but reported similar changes in fullness and hunger over the course of the meal¹. This led us to hypothesize that BED patients were less sensitive than similarly obese control participants to the satiating effects of food. The current study was designed as a more rigorous test of this hypothesis, and reports the surprising finding of no difference in the response of subjective hunger and fullness between patients with BED and obese controls, as assessed by the overall change in ratings and by the calculation of change in rating per gram of food consumed. The only significant difference we detected was that, in direct contrast to our expectations, BED participants reported higher levels of fullness following the fixed-size meal, hinting that if anything BED participants were more sensitive to the satiating effects of the meal.

How can the seemingly disparate results of these different experimental paradigms be reconciled? One possibility is that ratings of hunger and fullness are not absolute, but reflect, in part, an expectation of the amount a person expects to consume in the remaining portion of the meal based on a variety of circumstantial influences, including whether they have been instructed to overeat. The idea that expectation may affect perception of satiety is supported by our previous study (Guss et al., 2002) in which we reported that obese participants with BED ate more and reported greater satiety following the instruction to binge vs. the instruction to eat normally, while comparably obese non-BED participants ate the same amount following either instruction and reported less satiety following the binge vs. the non-binge meal. This suggests that *a priori* expectation, as provided by a meal instruction, and visual cues of amount consumed may contribute, along with visceral responses, to the overall rating of satiety. In other words, when eating *ad libitum*, it appears that both patients with BED and obese controls may scale their reports, and possibly their perceptions, of satiety based on where in the course of the meal they believe themselves to be. In the current study, by eliminating both expectation regarding the amount to be consumed and visual cues, we also eliminated the apparent difference in the development of satiety.

The results of other studies similarly suggest that changes in hunger and fullness ratings can be similar after different amounts of food have been consumed. Rolls et al.¹¹ gave participants four different sizes of sandwiches and found that, despite consuming significantly more food with each increment of sandwich size, there were no differences in hunger and fullness ratings after the three largest sandwich sizes were consumed. The authors suggest that participants “adjust their level of satiety to accommodate greater energy intakes”. In another study of portion size and intake, Rolls et al.¹² presented participants with four different amounts of macaroni and cheese. Although food intake increased as the amount presented increased, ratings of hunger and fullness did not differ.

One difference between the current study and our prior studies is the use in this study of the Labeled Magnitude Scale for rating hunger and fullness. This scale was designed to be more sensitive to differences between participants, and across groups of participants that may have different sensory experiences⁶. By using “strongest imaginable sensation of any kind” as the anchor representing extreme sensation, this scale attempts to normalize ratings for groups with differing prior experience of the sensation being rated. However, we would expect, if anything, that, rather than forcing all participants to rate relative to their own experience of “extreme” fullness, this scale would allow stronger absolute sensations among BED participants to be reflected in higher ratings. Despite this, although we did observe higher final fullness ratings in BED participants, the pre-post differences, and differences in fullness per amount consumed, did not differ. The LMS scale used in this study may provide different information than the VAS scales used in our prior studies. Although the LMS scale was developed to permit valid across-group comparisons of oral sensations, accounting for

possible differences in past eating-related sensory experience between the groups, the use of a different scale may account for the unexpected finding.

A few limitations of the current study should be noted. The modest sample size may have affected our ability to detect small differences in our measures; however, differences reported in the previous laboratory studies cited above were detected using similarly modest sample sizes (10 or fewer participants per group). Secondly, as noted in the paper of Walsh and Boudreau¹⁰, eating behavior in a laboratory setting may not perfectly reflect eating in the real world. Thirdly, because the purpose of the current study was to determine the perceptions of the participants' fullness and hunger while eating the same amount of food, a single-item meal was used. Prior studies indicate that patients with BED eat more than obese controls in multiple-item meals, and it is possible that it is in these meals with the greatest differences in eating behavior that perceptual disturbances are revealed. For example, the greatest differences in meal intake between patients with BED and obese participants without BED have been observed in studies using multiple-item meals¹³ or macaroni and cheese¹. No differences in intake have been observed in single item meal studies using vanilla ice cream¹⁴. The current study demonstrates that there are no differences between patients with BED and obese controls in subjective responses to a single-item (ice cream) meal of standard size. It is possible that nutrient-specific or sensory-specific satiety could have contributed to the lack of difference in satiety ratings in this study. It is also possible that the disinhibition that participants with BED display in the presence of highly palatable foods in a multiple-item meal could affect hunger and satiety ratings. However, it would be experimentally difficult, if not impossible, to use the multiple-item meal in a study that controlled intake. It is also possible that the size of the meal in this study, although quite large, was not sufficient to reveal the predicted differences between the groups.

This study aimed to measure participants' responses to a fixed amount of food, while removing the participants' expectations of when a meal would end, as well as their control over the meal size. We were unable to detect a difference between the groups in the changes in hunger and fullness ratings. It is possible that participants with BED do have a disturbance in the development of satiety, but this is not detectable by our method of assessing satiety with subjective ratings. It is also possible that the increased intake exhibited by patients with BED in laboratory ad lib meal studies is not due to a disturbance in satiety but rather a differential response to the eating laboratory environment. Patients with BED are reliably reported as exhibiting less inhibition in a laboratory setting than obese controls, leading to an increase in food consumption. In addition, patients with BED may increase intake in the presence of an array of palatable foods. Although Sysko et al.¹ suggest that patients with BED may display the same blunted satiety response to a meal that has been observed in BN patients, the current study finds that when the instruction to binge eat, visual cues of amount consumed, and participants' control of meal size are eliminated, there are no subjective differences in ratings of hunger and satiety that distinguish BED patients from obese control patients.

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Table 1

Means and Standard Errors of the Mean for age, BMI, amount consumed, duration of eating, rate of eating, change in hunger and change in fullness, among participants with binge eating disorder and obese controls.

	Obese Controls	Binge Eating Disorder	t	p
	(n=14)	(n=13)		
Age (years)	50.9 ± 2.4	44.8 ± 3.1	1.57	0.13
BMI (kg/m ²)	39.0 ± 1.6	36.2 ± 1.2	1.44	0.16
Amount Consumed (g)	963 ± 13	947 ± 15	0.83	0.14
Duration of Eating (g/sec)	757 ± 245	635 ± 195	0.39	0.70
Rate of Eating (g/sec)	2.71 ± 0.76	2.76 ± 0.50	0.06	0.96
Baseline Hunger (mm)	62.1 ± 8.9	65.2 ± 12.7	0.20	0.84
End of Meal Hunger (mm)	8.43 ± 2.94	3.31 ± 0.96	1.60	0.12
Pre-Post Hunger Difference (mm)	53.7 ± 8.1	61.9 ± 12.2	0.57	0.58
Baseline Fullness (mm)	10.0 ± 2.4	26.0 ± 10.5	1.53	0.14
End of Meal Fullness (mm)	72.0 ± 10.1	114 ± 10	2.98	0.01
Pre-Post Fullness Difference (mm)	62.0 ± 10.1	87.7 ± 12.1	1.64	0.11
Change in Hunger (mm/g intake ^a)	-0.0523 ± 0.0099	-0.0682 ± 0.0132	0.97	0.34
Change in Fullness (mm/g intake ^b)	0.0349 ± 0.0167	0.0768 ± 0.0196	1.63	0.12

^a Changes in hunger ratings are based on slopes of least squared estimated of straight lines. R-squared values were 0.67 for obese controls and 0.76 for BED participants.

^b Changes in fullness ratings are based on slopes of least squared estimated of straight lines. R-squared values were 0.73 for obese controls and 0.85 for BED participants.