HHS Public Access

Author manuscript

Eur Eat Disord Rev. Author manuscript; available in PMC 2021 April 15.

Published in final edited form as:

Eur Eat Disord Rev. 2020 September ; 28(5): 594–602. doi:10.1002/erv.2746.

Multi-method assessment of palatable food exposure in women with and without eating disorders

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Abstract

Objective: Eating disorders (EDs) are characterized by dysregulated responses to palatable food. Using a multi-method approach, this study examined responses to palatable food exposure and subsequent ad libitum eating in women with binge-eating disorder (BED: $n = 64$), anorexia nervosa (AN: $n = 16$), and bulimia nervosa (BN: $n = 35$) and 26 healthy controls (HCs).

Method: Participants were exposed to palatable food followed by an ad libitum eating opportunity. Affective and psychophysiological responses were measured before and during the task.

Results: Participants with EDs reported greater negative affect, particularly fear, following the food cue exposure, whereas HCs reported no change. BN and BED groups reported greater urge to binge after the food cue exposure, whereas AN and HC groups reported no change.

Respiratory sinus arrhythmia levels, skin conductance and tonic skin conductance levels increased during food exposure for all groups. Across baseline and during the food exposure, the BED group had lower respiratory sinus arrhythmia levels relative to the BN and HC groups. The BED group consumed significantly more palatable food than the AN group.

Conclusions: 'Palatable' food stimuli elicited more negative affect, particularly fear, in individuals with EDs; and this, rather than psychophysiological responses, distinguishes individuals with EDs from those without.

Keywords

consumption; eating disorders; palatable food; respiratory sinus arrhythmia; skin conductance

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CONFLICT OF INTEREST

The authors do not have conflicts of interest.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

1 | INTRODUCTION AND AIMS

Eating disorder (ED) groups relative to groups without EDs including psychiatric control groups tend to report greater negative affect, such as fear and disgust, and less pleasure when exposed to palatable food cues (Foroughi et al., 2020; Hay & Katsikitis, 2014; Pla-Sanjuanelo et al., 2019). Repeated exposure to food, such as in virtual reality interventions decrease negative affective responses to food cues in EDs (Ferrer-Garcia et al., 2017). However, there may be behavioural and affective differences between ED groups.

Systematic reviews suggest that individuals with anorexia nervosa (AN) or bulimia nervosa (BN), compared to healthy controls (HCs), rate food pictures as less pleasurable (Giel et al., 2011; Lloyd & Steinglass, 2018). However, there is also evidence that individuals with binge-eating disorder (BED) and BN rate high-calorie food images as more pleasurable (Leehr et al., 2016), have greater reward responsivity to these stimuli in neuroimaging protocols (Schienle, Schaefer, Hermann, & Vaitl, 2009), and report greater urges to binge after food exposure (Meule et al., 2018; Staiger, Dawe, & McCarthy, 2000), and behavioural tasks (Svaldi et al., 2014). In general, samples with binge eating or obesity consume larger amounts of food after food cues (Mirch et al., 2006; Ng & Davis, 2013; Privitera, King-Shepard, Cuifolo, & Doraiswamy, 2019). Although research is limited, one study found that individuals with BN did not differ from controls in consumption after food cue exposure (Nederkoorn, Smulders, Havermans, & Jansen, 2004), although another study found that people with BN report greater urge to binge and lower confidence to resist bingeing than controls (Staiger et al., 2000). In contrast, samples with AN tend to show avoidance biases to palatable food (Paslakis et al., 2016). However, it is unclear if these affective responses to palatable food cues translate to subsequent increased consumption after food cue exposure in experimental paradigms with ED groups.

Studies examining psychophysiological measures of parasympathetic and sympathetic response to food cues in EDs are sparse. Respiratory sinus arrhythmia (RSA) is a marker of parasympathetic response, which captures heart rate variability, while taking into account the breathing cycle, while skin conductance (SC) measures assess sympathetic nervous system responses. A systematic review of food cue studies that also assessed RSA and/or SC in overweight and disordered eating samples yielded only five relevant studies (see Supporting Information S1). 2/5 reported no differences in response to palatable food images on SC or heart rate indices between (a) restrained compared to non-restrained eaters (Overduin, Jansen, & Eilkes, 1997), and (b) women with and without BED (Svaldi, Tuschen-Caffier, Peyk, & Blechert, 2010). 1/5 found that AN and BN groups compared to HCs had greater heart rate and SC responses to food presented in vivo and in virtual reality (Gorini, Griez, Petrova, & Riva, 2010). In women with BN, eyeblink startle responses to food pictures were modulated by low frequency heart rate variability responses (Rodríguez-Ruiz, Guerra, Moreno, Fernández, & Vila, 2012). Finally, in adolescent girls with loss of control eating, lower heart rate variability was significantly associated with loss of control eating episodes (Ranzenhofer et al., 2016). Overall, studies using palatable food cues and measures of RSA and/or SC have yielded mixed findings.

Different responses to palatable food are core to our understanding of EDs; however, multi-method studies incorporating self-report, behavioural and psychophysiological measures in response to palatable food cues and ad libitum paradigms across the ED spectrum are lacking. The aim of this study was to examine patterns of self-report, RSA and SC in a large group of women with EDs compared to women without current psychiatric disorders. We hypothesized that compared to women without EDs, women with AN would report greater negative affect, no difference in urge to binge and higher RSA levels during palatable food cues. We predicted that women with BN compared to HC women would report greater negative affect, greater urges to binge and higher RSA. Finally, we predicted that women with BED compared to HC would show lower negative affect, increased urges to binge and reduced RSA in response to these stimuli. Given the mixed findings for SC levels (SCL) and SC responses (SCR), we did not have an a priori hypothesis to differentiate the different ED groups and HCs. In terms of ad libitum eating, we predicted food cues would promote food avoidance behaviour in women with AN, and increased food consumption in women with BED relative to the HC group. Given the mixed findings for consumption in women with BN, we did not have an a priori hypothesis to differentiate BN and HCs.

2 | METHOD

2.1 | Participants

The sample consisted of 115 women with an ED and 26 HCs with no history of psychiatric disorders (see Table 1 for demographic and Table 2 for clinical characteristics). Of the participants with an ED, 30.4% of the sample was diagnosed with BN ($n = 35$), 55.7% with BED ($n = 64$) and 13.9% with AN ($n = 16$). Participants with EDs were recruited from treatment studies for EDs conducted at a university hospital and the HC group were recruited from the community using flyers and online postings. Prior to the start of the study, all measures and procedures were approved by the Institutional Review Board and all participants provided informed consent before participating.

Prior to beginning treatment, participants completed two sessions. The first session consisted of the administration by a Masters-level clinician of the Eating Disorders Examination-16 (Fairburn, 2008) and the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders–IV-Text Revision (DSM-IV-TR; American Psychiatric Association, APA, 2000) Axis I Disorders (SCID–I; First, Spitzer, Gibbon, & Williams, 2002). The second session consisted of the experimental procedure. See Supporting Information S2 for Inclusion and Exclusion criteria.

2.2 | Measures

2.2.1 | Self-reported affect—An abbreviated Positive and Negative Affect State (Watson, Clark, & Tellegen, 1988) measured subjective affective state at baseline, before the food cue exposure, and after the food cue exposure. Self-reported anxiety, fear, frustration, happiness, sadness, tension, and urges to binge eat were scored on a 100-point Likert scale. We created a negative affect composite using an average of scores from anxiety, fear, frustration, sadness and tension. Internal consistency of the negative affect composite score at each time-point ranged from $\alpha = .86–.90$.

2.2.2 | Psychophysiological measures—

We collected electrocardiogram data utilizing a modified Lead II configuration. We derived RSA by using a band pass filter on the electrocardiogram signal and spectral analysis to extract the high-frequency component (>.15 Hz) of heart rate variability. We measured SC by using two electrodes placed on the palm of the non-dominant hand. Tonic SCL refers to level SC collected over each period, whereas SCRs refer to the number of responses per period.

2.3 | Experimental procedure

2.3.1 | Resting baseline—

Participants completed a 5-min resting baseline in which they were instructed to sit quietly while psychophysiological data were collected.

2.3.2 | Food cue exposure—

For the food cue exposure, a research assistant brought a plate of a dozen freshly microwaved (15 s on high) 12-cm diameter chocolate chip cookies (supermarket bakery) into the experiment room. The participant was asked to observe the cookies (i.e., view, touch and smell but not taste) in order to rate them later. After a 5-min period, the cookies were removed from the room. Participants completed affective ratings prior to and after the cookie stimulus. We chose chocolate chip cookies as surveys have shown these to be some of the most frequently purchased and popular cookies in the United States (May, 2017, November 30; Persistence_Market_ Research, 2017, September) and because unlike chocolate cookies, which are also popular, they can be microwaved to emit a scent.

2.3.3 | Ad libitum eating—

The research assistant informed the participant that the experimental portion of the study was completed. Electrodes were removed and the participant was taken to a separate room and left alone for 10 min to complete payment paperwork. A bowl of M&M's was placed on the desk prior to the participant's arrival, and participants were instructed to eat as much as they desired. The bowl was weighed before and after this period to calculate the amount of M&M's consumed. M&Ms were chosen because they are one of the most popular American candies (Ballard, 2018, 30 October; Hoeffner, 2018, September 24). Furthermore, the use of the M&M's allowed us to use a more continuous measurement of consumption as each M&M weighed less than 1 g, as compared to the cookies, which were larger (12 cm diameter) and would be likely to be consumed in whole units.

2.4 | Statistical analysis

Six separate general linear models were conducted in SPSS 24.0 with self-reported affect outcomes: (a) negative affect, (b) urge to binge eat and (c) happiness; and psychophysiological variables (d) RSA, (e) SCRs and (f) SCLs. Self-reported affect was assessed before the food cue exposure ratings and after the food cue exposure ratings. Psychophysiological responses were assessed at baseline and averaged over the 5-min food cue exposure. We used planned simple contrasts for significant main effects for time or diagnostic group or time by group interactions. We examined differences in consumption using a nonparametric Kruskal Wallis one-way analysis of variance, as these data were not normally distributed.

3 | RESULTS

3.1 | Self-reported negative affect

When predicting negative affect, in addition to conditional main effects for time and diagnosis (p's < .001), there was a significant time by diagnosis interaction (F [3,130] = 4.87, p = .003, η^2 = .101). Each ED group relative to the HC group (p's < .05) reported greater negative affect following the food cue exposure (p's < .05), whereas the HC group reported no change in negative affect (p = .825). See descriptives of self-reported affect in Table 3.

A post-hoc exploratory analysis of each negative emotion showed significant time by diagnosis interactions for anxiety (F[3,130] = 4.88, p < .003, η^2 = .102) and fear (F[3,130] = 6.04, p < .001, η^2 = .122). Fear increased for all ED groups (p's < .05), but not for HCs (p = .958) and anxiety significantly increased for the BN and BED groups (p's < .05) but not for HC (p = .253) or AN groups (p = .413). See Supporting Information S3 for the estimated power for these analyses and Supporting Information S4 for descriptive statistics.

3.2 | Self-reported positive affect

For happiness, the conditional main effect of time and the time by diagnosis interaction were non-significant (p's > .10), however there was a trend for the conditional main effect of diagnosis (p = .093). Post-hoc comparisons revealed ED groups rated lower levels of happiness than HCs (p's < .05).

3.3 | Self-reported urge to binge

In addition to significant conditional main effects for time and diagnosis (p's < .001), there was a significant time by diagnosis interaction (F[3,130] = 7.84, p < .001, η^2 = .153). BN and BED groups reported greater urge to binge after the food cue exposure (all p's < .001), whereas the AN and HC groups reported no difference in urge to binge after the exposure (all p's > .60).

3.4 | RSA during food exposure

The time by diagnosis interaction was not significant (F [3,137] = 0.39, p = .763, η^2 = 0.008). However, there was a significant conditional main effect for diagnosis (F (3,137) = 5.34, p = .002, η^2 = 0.105; p < .05) with RSA values being lower in the BED group relative to the BN and HC groups (p < .05). There was also a significant conditional effect for time (F[1,137] = 10.12, p = .002, η^2 = .069), with RSA increasing for all groups during the food cue exposure (p < .05). See Supporting Information S5 for figure and further post-hoc analysis.

3.5 | SCR and SCL during food exposure

There were conditional main effects of time for SCRs (F[1,101] = 100.63, p < .001, η^2 = 0.499) and tonic SCL (F[1,105] = 11.97, p = .001, η^2 = 0.102), where these values were greater for all groups during the food cue exposure (p < .05), see Table 4 and Supporting Information S1. The conditional main effect for diagnosis and the time by diagnosis

interaction were not significant for SCRs or SCLs (p's > .400). See Supporting Information S5.

3.6 | Ad libitum eating

There were significant group differences in M&M (grams) consumption during the ad libitum eating period, H (3) = 7.88, p = .049. Pairwise comparisons showed that the BED group consumed significantly more than the AN group (p = .021). See Table 4.

4 | DISCUSSION

Exposure to highly palatable food resulted in greater fear response across ED groups relative to a HC group. Additionally, ED groups had greater levels of negative affect throughout the protocol. There was no change in positive affect following the palatable food exposure, although there was a trend for ED groups to report less positive affect than HCs. BN and BED groups reported a greater urge to binge following the palatable food exposure compared to the AN and HC groups. Exposure to chocolate chip cookies resulted in the same pattern of increased parasympathetic and sympathetic response in ED and HC groups; however, in terms of parasympathetic response, the BED group had lower overall RSA levels compared to the HC group at rest, and during the 'palatable' food cue. The BED group consumed more than the AN group during the ad libitum opportunity.

Our results suggest self-reported negative affect, especially fear responses, rather than psychophysiological response to palatable foods may more reliably distinguish between individuals with and without EDs. Previous studies have also not found differences in RSA reactivity in response to food cues in samples with disordered eating (Overduin et al., 1997; Svaldi et al., 2010). In ED samples, differences between AN, BN and HC groups on parasympathetic activity may be minimized because RSA reflects inhibitory control (Thayer et al., 2012). In AN and BN, this may reflect an ability to inhibit responses, that is, food restriction, whereas for HC individuals it may reflect more adaptive levels of executive control (Mazurak, Enck, Muth, Teufel, & Zipfel, 2011; Peschel et al., 2016). Binge eating, purging and over exercise, which occur more frequently in AN and BN (Faris et al., 2008), are associated with higher RSA. Thus, RSA patterns may look similar between AN, BN and HC groups, but may arise from different sources.

The reduced baseline RSA levels of the BED group may reflect the blunted cardiovascular reactivity (Carroll et al., 2012; Masi, Hawkley, Rickett, & Cacioppo, 2007) associated with disorders that co-occur with BED, such as diabetes and hypertension (Kessler et al., 2014; Raevuori et al., 2015; Reichborn-Kjennerud, Bulik, Tambs, & Harris, 2004). Reduced baseline RSA in the BED group relative to the other groups may reflect the higher BMI and older age of the BED group (Thayer, Yamamoto, & Brosschot, 2010).

Increased SCR may not reliably differentiate between groups as elevated SCL and SCR may indicate a general increase in arousal, rather than affective valence (Boucsein, 2012). Further work is needed to understand if the non-specificity of findings is due to methodological limitations of SC response or to a lack of difference in reactivity between ED groups and

controls and may utilize other measurements to capture reward processing, like pre-ejection period (Newlin & Levenson, 1979).

We found that the BED group ate significantly more M&M's than the AN group, but no differences between any other groups. This may have been due to within-group variability in food consumption, demand characteristics of the task, or because different foods were used during exposure and ad libitum feeding (Fedoroff, Polivy, & Herman, 2003). We chose to use M&M's rather than cookies in our ad libitum feeding because their smaller size allowed for a more continuous measurement of consumption. As consumption may differ when the anticipated food cue matches the ad libitum food, future studies are needed to evaluate the effect of using the same anticipated food as consumed food.

Our sample size for participants with AN was small and both AN restricting and AN binge/purge subtypes were included in this group. Our sample was cross-sectional and treatment-seeking, limiting the generalizability of these findings. Future studies using a more comprehensive assessment of positive affect, satiety and hunger and using BMI-matched controls are needed.

This study provides evidence that highly palatable food elicit negative affect in ED groups and this, rather than RSA and SC responses, differentiate EDs. The high level of negative affect reported by ED participants has an implication for food cue research designs, as food stimuli regarded as 'rewarding' by individuals without EDs, may induce fear in individuals with EDs. This study contributes to the currently small literature examining affective, psychophysiological, and consummatory responses to commonly encountered palatable food cues across multiple ED groups.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

This work was funded by NIMH K23 MH081030 (E.Y.C.). NIMH had no role in the decision to write or submit this manuscript for publication.

Abbreviations:

AN	anorexia nervosa
BN	bulimia nervosa
BED	binge-eating disorder
ED	eating disorders
HC	healthy controls
SC	skin conductance
SCL	skin conductance levels

SCR	skin conductance responses
RSA	respiratory sinus arrhythmia

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Highlights

- Women with eating disorders compared to those without, report greater negative affect, particularly fear, when exposed to a ‘palatable’ food.
- Eating disorder and healthy control (HC) groups had increased respiratory sinus arrhythmia, skin conductance response and skin conductance levels during palatable food exposure, with the binge-eating disorder (BED) group having lower respiratory sinus arrhythmia levels relative to the HC group over the course of the protocol.
- The BED group consumed more palatable food than the group with anorexia nervosa.

TABLE 1

Demographic information of sample

	Anorexia nervosa *n* = 16		**Binge-eating disorder *n* = 64**		**Bulimia nervosa *n* = 35**		**Healthy controls *n* = 26**			
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	**F/φ**	***p*-Value**
	34.38	**11.94**	**41.52**	**10.08**	**30.00**	**10.24**	**29.00**	**10.49**	**13.818**	**<.000**
Age in years	***N***	**%**	***N***	**%**	***N***	**%**	***n***	**%**	**F/φ**	***p*-Value**
Caucasian	14	87.50	41	64.06	24	68.57	15	57.69	0.370	.081
Black	0	0.00	10	15.63	4	11.43	6	23.08		
Asian	0	0.00	2	3.13	1	2.86	2	7.69		
Mixed	2	12.50	9	14.06	1	2.86	0	0.00		
Hispanic	0	0.00	2	3.13	5	14.29	3	11.54		
American Indian/Alaska Native	0	0.00	0	0.00	0	0.00	0	0.00		
Native Hawaiian /other Pacific Islander	0	0.00	0	0.00	0	0.00	0	0.00		
Marital status: Single[a]	10	83.33	28	44.44	21	61.76	15	62.50	0.244	048
Employment status[a,b]	14	87.50	59	92.19	31	91.18	25	96.15	0.172	.656
Income status[a,c]	12	75.00	19	29.69	20	58.82	17	68.00	0.368	<.001

[a]Note: eight participants (four AN, one BED, one BN, two HC) did not report marital status; one BN participant, Employment status; and two participants (one BN, one HC), income status.

[b]Employment status = Employment/Full-time student status.

[c]Income status = low income status, that is, household income is <$25,000.

TABLE 2

Clinical characteristics of sample

	Anorexia nervosa ***n*** **= 16**		**Binge-eating disorder** ***n*** **= 64**		**Bulimia nervosa** ***n*** **= 35**		**Healthy controls** ***n*** **= 26**			
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	**F**	***p*-Value**
BMI (kg/m^2)	18.72	3.43	37.10	10.67	25.55	5.94	26.97	4.44	31.24	<.001
EDE-EC[a]	2.98	2.00	2.77	1.38	2.74	1.19	0.04	0.08	30.91	<.001
EDE-DR[a]	3.25	1.99	2.16	1.22	3.09	1.36	0.50	0.91	22.66	<.001
EDE-WC[a]	2.85	1.94	3.58	1.07	3.41	1.40	0.50	0.68	40.13	<.001
EDE-SC[a]	3.34	1.84	3.84	1.22	3.66	1.31	0.58	0.80	42.79	<.001
Objective binge episodes[b]	1.06	2.38	4.52	3.89	6.41	6.18	0.00	0.00	15.00	<.001
Vomit episodes[b]	1.72	3.61	0.11	0.87	7.47	8.27	0.00	0.00	24.53	<.001
	N	***%***	***N***	***%***	***N***	***%***	***N***	***%***	**φ**	***p*-Value**
Mood disorders	8	50.00	39	60.94	26	74.29	0	0.00	0.51	<.001
Anxiety disorders	9	56.25	23	35.94	12	34.29	0	0.00	0.35	.001
Medical comorbidities	8	61.54	31	51.67	20	66.67	4	20.00	0.30	.011
Medication use	6	37.50	34	53.13	17	48.57	2	7.69	0.34	.001

Abbreviations: BMI, body mass index; DR, dietary restraint; EC, eating concerns; EDE, eating disorder examination; SC, shape concerns; WC, weight concerns.

[a]All EDE scales missing one participant (one HC). Medical comorbidity missing 18 participants (three AN, four BED, five BN, six HC).

[b]Within the previous 3 months.

Eur Eat Disord Rev. Author manuscript; available in PMC 2021 April 15.

TABLE 3

Self-reported negative emotions, positive emotions and urges to binge-eat for groups prior to and after the food cue exposure

	Negative emotions Prior to food cue exposure	**Negative emotions After to food cue exposure**
	M (SD)	***M (SD)***
Anorexia nervosa (*n* = 14)	37.13 (21.24)	47.47 (26.10)
Binge-eating disorder (*n* = 62)	27.82 (22.18)	40.98 (22.86)
Bulimia nervosa (*n* = 35)	30.85 (23.55)	48.39 (31.37)
Healthy control (*n* = 23)	13.14 (14.50)	12.29 (14.19)
	Positive emotions Prior to food cue exposure	**Positive emotions After to food cue exposure**
	M (SD)	**M (SD)**
Anorexia nervosa (*n* = 14)	27.61 (28.53)	27.87 (30.10)
Binge-eating disorder (*n* = 62)	33.56 (22.41)	33.26 (24.14)
Bulimia nervosa (*n* = 35)	34.30 (26.16)	29.52 (24.75)
Healthy control (*n* = 23)	39.38 (28.02)	49.38 (26.27)
	Urge to binge Prior to food cue exposure	**Urge to binge After to food cue exposure**
	M (SD)	**M (SD)**
Anorexia nervosa (*n* = 14)	20.46 (31.32)	23.24 (32.49)
Binge-eating disorder (*n* = 62)	38.24 (30.08)	64.64 (30.77)
Bulimia nervosa (*n* = 35)	35.04 (33.95)	61.34 (36.73)
Healthy control (*n* = 23)	0.33 (0.76)	2.41 (4.89)

Eur Eat Disord Rev. Author manuscript; available in PMC 2021 April 15.

TABLE 4

Respiratory sinus arrhythmia, skin conductance and skin conductance levels in groups prior to and during the food cue exposure

	Respiratory sinus arrhythmia	
	Prior to food cue exposure	**During food cue exposure**
	***M* (*SD*)**	***M* (*SD*)**
Anorexia nervosa (*n* = 16)	5.86 (1.13)	6.09 (1.28)
Binge-eating disorder (*n* = 64)	5.25 (1.58)	5.62 (1.48)
Bulimia nervosa (*n* = 35)	6.21 (1.20)	6.51 (1.06)
Healthy controls (*n* = 26)	6.30 (1.43)	6.46 (1.26)

	Skin conductance response	
	Prior to food cue exposure	**During food cue exposure**
	M (SD)	**M (SD)**
Anorexia nervosa (*n* = 16)	2.15 (2.55)	5.92 (3.59)
Binge-eating disorder (*n* = 54)	2.30 (2.26)	6.24 (3.77)
Bulimia nervosa (*n* = 27)	1.38 (1.86)	4.96 (3.19)
Healthy controls (*n* = 23)	1.91 (1.78)	6.57 (4.52)

	Skin conductance level	
	Prior to food cue exposure	**During food cue exposure**
	M (SD)	**M (SD)**
Anorexia nervosa (*n* = 15)	2.76 (2.79)	12.55 (15.54)
Binge-eating disorder (*n* = 51)	3.05 (2.76)	14.76 (29.75)
Bulimia nervosa (*n* = 22)	2.94 (4.32)	7.67 (7.59
Healthy controls (*n* = 21)	2.58 (3.23)	7.27 (5.37)

	Food consumption (in g)
	M (SD)
Anorexia nervosa (*n* = 12)	0.00 (0.00)
Binge-eating disorder (*n* = 55)	20.69 (87.78)
Bulimia nervosa (*n* = 31)	6.90 (27.71)
Healthy controls (*n* = 16)	8.13 (16.42)