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Research Article

Emotional Responses to Food Pictures according to Caloric Value in Women with an Eating Disorder

Running title: Food pictures, Emotions and Eating Disorders

Caroline Gagnon [1], Simon Grondin [1], Marilou Côté [1, 2], Marie-Ève Labonté [2, 3], Véronique Provencher [2, 3], Carole Ratté [4], & Catherine Bégin [1, 2]

[1] School of Psychology, Laval University, Quebec, Canada

[2] Institute of Nutrition and Functional Foods, Laval University, Quebec, Canada

[3] School of Nutrition, Laval University, Quebec, Canada

[4] Programme d'Intervention des Troubles des Conduites Alimentaires – Centre Hospitalier Universitaire de Québec, Quebec, Canada

***Corresponding Author:** Catherine Bégin, School of Psychology, Laval University, 2325, rue des Bibliothèques, Québec (Québec), Canada, G1V 0A6

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Abstract

Objective: The aim of the current study was to improve the understanding of emotions evoked by food pictures in women with an eating disorder (ED), by distinguishing anorexia nervosa (AN) and bulimia nervosa (BN) diagnoses, while taking into account the caloric content of food and the influence of participants' nutritional knowledge.

Methods: Thirteen AN, 9 BN and 22 healthy controls (HC) women participated in the study. In a laboratory setting, participants first completed self-report questionnaires regarding their affective state. Then, an emotional rating task of food and non-food pictures was performed in order to examine participants' emotional reactions to these pictures, depending on the caloric value of the food depicted and controlling for internal state. Finally, an energy density ranking task of food pictures was completed to investigate participants' nutritional knowledge and its influence on their reactions to food.

Results: Compared to HC, ED participants experienced more fear towards food, which was neither due to their internal state nor to their nutritional knowledge. In AN, fear occurred towards all food, whereas in BN, fear was observed for high-calorie products only.

Conclusion: The key role of food-induced fear in ED was highlighted, particularly in AN.

Keywords: affective state; caloric value; eating disorders; emotions; food pictures; nutritional knowledge

List of abbreviations

AN: Anorexia nervosa;

BMI: Body mass index;

BN: Bulimia nervosa;

ED: Eating disorders;

HC: Healthy controls;

M: Mean;

SD: Standard deviation.

Introduction

Eating behaviors are known to be influenced by affective states (Aguiar-Bloemer & Diez-Garcia, 2018; Devenport et al., 2019; Macht & Simons, 2000; van Strien et al., 2013). Emotions aroused by food are powerful determinants of individual's food choices and intakes (Lowe et al., 2016;

Martins & Pliner, 2005; Spence et al., 2016). Indeed, positive emotions evoked by food can drive eating behaviors such as disinhibition or craving, whereas negative emotions can lead to its rejection or avoidance (Macht, 2008). This association between food-induced emotions and eating behaviors seems particularly relevant for individuals suffering from an eating disorder (ED) (for review, see Giel et al., 2011). In fact, ED women present altered information processing mechanisms and erroneous thoughts about food and body weight/shape, which modulate negatively their emotional responses towards food and, thus, their caloric intake (Brooks et al., 2011; Coelho et al., 2014; Eiber et al., 2005; Williamson et al., 1999). Due to their enduring nature, these cognitions and reactions contribute to the maintenance and the worsening of patients' feeding behaviors and their long-term consequences on physical health and psychosocial functioning (Dakanalis et al., 2017; Fairburn et al., 2003; Vitousek & Brown, 2015). Therefore, in order to better understand ED women's eating behaviors and improve the efficacy of their treatments, it is important to pursue the exploration of emotional responses evoked by food.

In that perspective, Hay and Katsikitis (2014) collected and compared emotional responses generated by food pictures from three groups of women, namely psychiatric controls, ED participants and healthy controls (HC), while adjusting for their initial affective state. This adjustment was important knowing that prevalence of depressive and anxious symptoms is high among individuals suffering from an ED (Aspen et al., 2014; Godart et al., 2015, Morzola et al., 2020 Swinbourne et al., 2012), and considering that such comorbidities can enhance attention allocation to negative stimuli or reduce the experience of positive emotions (Cisler & Koster, 2010; Dai & Feng, 2011; Eizenman et al., 2003; Okon-Singer, 2018). Their results revealed that ED participants gave higher negative ratings (i.e., fear, disgust) and lower positive ratings (i.e., happiness/joy) to food pictures than psychiatric participants and HC. Not only did Hay and Katsikitis (2014) confirm what had already been shown in past studies (e.g., Santel et al., 2006, Rodríguez et al., 2007), but they went further by revealing that the differences between groups remained significant despite the statistical control for women's pre-experimental affective state, suggesting that negative food-induced reactions could be a core feature of ED. More recently, Foroughi and colleagues (2018) invited HC and women suffering from anorexia nervosa (AN), atypical AN (i.e., with a body mass index [BMI] $\geq$ 18 kg/m^2), bulimia nervosa (BN) and binge eating disorder (BED) to rate their level of happiness, fear and disgust prior to and whilst viewing food pictures. Compared with HC, all groups of ED participants felt more fearful and disgusted when viewing food images, even when their pre-experimental mood was controlled for. However, within the four ED groups, no significant differences were detected, suggesting that aversive responses to food could be a transdiagnosis phenomenon. Although interesting, these results contrast with those of other studies suggesting that individuals with BN behaviors can have positive, or at least, less negative reactions than AN individuals when seeing food (Burmester et al., 2021; Drobes et al., 2001; Friederich et al., 2006; Gagnon et al., 2018; Hoefling et al., 2009; Leehr et al., 2016; Racine et al., 2018).

Furthermore, it has been suggested that emotions induced by food pictures in ED women can differ according to their caloric value. By means of semi-structured interviews inviting participants to freely identify their thoughts (i.e., cognitions, emotions) during the visualisation of food pictures, McNamara and colleagues (2008) showed that an impression of negative control over the food[1]–which was predominantly evoked by high-calorie products–was accompanied by negative emotions (e.g., fear, disgust, guilt), while an impression of positive control over the food–which was mostly provoked by low-calorie items–was associated with positive emotions (e.g., happiness, safety).

A study conducted among college women emphasizes the importance of including the caloric value of food. Racine (2018) demonstrated that response towards high or low-calorie food images depended on different dimensions of dietary behaviors. More specifically, real decrease of food intake (i.e., dietary restriction) was associated with reduced pleasure responses towards both high and low-calorie food, while attempts to eat less or cognitive efforts to avoid eating (i.e., cognitive restraint) was associated to greater pleasure ratings for low-calorie food. Taken together, these results suggest that the caloric value of food might influence emotional reactions according to the type of restriction. Then, when examining ED individuals' emotional reactions to food, it seems essential to include caloric value of food. In fact, there may be no difference in emotional rating of food between ED groups when the caloric value is not considered–like in Foroughi et al. (2018)'s experiment–but there may be some differences between AN and BN women if the energy content of foods is taken into account.

Finally, some studies have already yielded a better knowledge of the nutritional value of food in ED participants, in comparison to healthy women (Beumont et al., 1981; Laessle et al., 1988). As AN and BN individuals are concerned about their body appearance (weight, shape), they are likely interested in nutrition-related issues (American Psychiatric Association [APA], 2013; Robert-McComb et al., 2012). For instance, they can read extensive literature about nutrition to find new strategies to limit their food intake and/or to increase their caloric expenditure (Laessle et al., 1988). Some even consult fitness blogs and pro-ED websites (Mento et al., 2021: Mulveen & Hepworth, 2006; Rouleau & von Ranson, 2011; Rodgers et al., 2012). Given these elements, the idea that ED individuals may have better nutritional knowledge than the general population may be still relevant. Knowing that the more caloric the food is perceived, the more intense the negative reaction is likely to be (Gonzalez & Vitousek, 2004; Houben et al., 2010), it is relevant to believe that ED individuals' nutritional knowledge can influence their emotional reactions to food. However, up until now, no study has examined the effects of objective ED women's nutritional knowledge on their emotional responses to food[2], and no experiment has investigated for possible differences between AN and BN women about their knowledge.

The aim of the present study was to examine ED women's emotional responses to food pictures, and to compare these responses according to their diagnosis, while taking into account both the caloric content of the food items presented and participants' nutritional knowledge. Regarding emotional responses to food, we predicted that women suffering from an ED would present lower positive and higher negative reactions to food pictures than HC. Moreover, we hypothesized that AN participants would show more aversive reactions to food of low and medium energy density than BN women (APA, 2013). We also predicted that AN and BN women would have a better knowledge than HC about the energy content of the food depicted. Finally, we hypothesized that their knowledge would contribute to explain their unfavorable emotional responses to food, particularly for AN women.

Methods

[1] i.e., the loss of control over food intake and related weight gain or purging behaviors.

[2] As far as we know, past literature has focused on patients' subjective perception of fat and caloric contents of food items and meals (e.g., Gonzalez & Vitousek, 2004; Sunday et al., 1992), not on objective knowledge about food products (i.e., its accuracy).

Participants

Twenty-two women suffering from an ED and 22 HC women took part in the study. ED participants were recruited among outpatients of the Programme d'intervention des troubles des conduites alimentaires (PITCA) du Centre Hospitalier Universitaire (CHU) de Québec (n = 12), a multidisciplinary hospital unit for the assessment and treatment of ED, and among users of La masion l'Éclaircie services, a community-based organization for individuals presenting ED symptoms in Quebec city (n = 10). HC women were recruited among Laval University's community by email advertisements (M_{age} = 23.41 ± 5.38 years; M_{BMI} = 21.59 ± 2.25 kg/m^2). In accordance with the criteria of the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5; APA, 2013), participants suffering from an ED were divided into two groups: the AN group (n = 13; M_{age} = 22.92 ± 3.99 years; M_{BMI} = 18.91 ± 1.86 kg/m^2) and the BN group (n = 9; M_{age} = 29.33 ± 9.68 years; M_{BMI} = 25.96 ± 5 .79 kg/m^2). Participants from the PITCA received their ED diagnosis from a psychiatrist specialized in ED (CR), while women from La Maison l'Éclaircie received theirs from a PhD student in psychology specialized in ED (CG), which was confirmed by an experienced clinical-researcher in the domain of ED (CB).

For the three groups, inclusion criteria were: a) being aged between 18 and 60 years old; b) understanding and speaking French; c) being right-handed; d) having normal or corrected-to-normal vision and audition; e) being free of drug and alcohol abuses for 3 months; f) presenting neither a psychotic disorder nor a neurological disorder; g) not showing any history of traumatic brain injury within the last 5 years; and h) not being pregnant. Furthermore, women of the HC group should not present: a) personal or family ED history; b) attempts to lose weight in the last month, and c) psychiatric disorders for which medications were prescribed and taken[3].

Procedure

Women suffering from an ED were tested in their usual health care setting, whereas HC were hosted at a research laboratory. All participants gave informed written consent prior to their participation. To reduce the influence of hungriness on tasks' results[4], all participants were instructed to eat in the 60 minutes preceding their experimental session and were met at fixed hours (i.e. after breakfast, 8:30 am; or after lunch, 1:30 pm). The session lasted around 1.5 hour. First, women had to mention the time and the content of their preceding meal, estimate their level of appetite on a 7-point Likert scale (0 = *I am not hungry*; 6 = *I am extremely hungry*), and fill in questionnaires about their affective state (i.e., BDI-II, STAI-YA). Subsequently, they had to complete the emotional rating task of food and non-food pictures. A 10-min break was then taken considering the mental load associated to the first part of the session. Finally, participants performed the energy density ranking task of food pictures. They all received a monetary compensation of 14$CAD for taking part in the study. The experiment was approved by the Ethics Committee of the CHU de Quebec (Project 2012-8 12, C11-08-088).

Tasks.

Emotional rating

Participants were seated in front of a 16-inch LCD monitor connected to a PC, at a viewing distance of 60 cm. The room was dimly lit. The software E-Prime 2.0 Professional (Psychology Software Tools, Pittsburgh, PA, and Released 2012) was employed to create and administer the task. The food and object pictures were presented in a 700 x 526 pixels colored format, at the center of the screen, on a black font. The stimuli were shown for 5 seconds, one item at a time, in a random order. Not to influence the affective rating of pictures, their specific name or nature (e.g., "garlic pork sausage", "pincers") was not provided. When a food picture was presented, women were instructed to imagine, as vividly as possible, that they were eating the product/meal depicted (i.e., salient or intent-to-eat context; Murray & Strigo, 2018). When an object picture was displayed, they were asked to imagine themselves as using the item exposed or being in its presence. After each stimulus presentation, participants had to rate the emotions elicited by the item depicted on nine dimensions: valence, arousal, happiness/joy, sadness, anger, disgust, fear, surprise and neutrality. Women were not constrained by a limited amount of time, but they were told to share their immediate and instinctive emotional reactions towards the stimuli. For each picture, the last dimension to evaluate was followed by a short recovery period of 3 seconds, and then the next image to rate was presented. To reduce attentional errors and avoid participant's confusion, the affective dimensions were always surveyed in the same order.

The valence and arousal levels of stimuli were investigated via Self-Assessment Manikin scales (SAM; Bradley & Lang, 1994; Lang, 1980), which are pictorials tools used for the measurement of a person's affective response to stimuli. The SAM scales were depicted with a 9-point gradation, each character–and the space between two adjacent characters–corresponded to an ascending intensity level ranging from 1 (*negative valence* or *low arousal*) to 9 (*positive valence* or *high arousal*). For the remaining seven affective dimensions (i.e., happiness/joy, sadness, anger, disgust, fear, surprise and neutrality), Likert scales ranging from 1 (*none*) to 9 (*very strongly*), were used to assess emotions and the degree to which they experienced it. Ratings were collected by a numeric keypad. Before starting the task, in the presence of the experimenter (CG), participants made a practice trial with an object picture (i.e., a clock).

Energy density ranking

With all the stimuli in front of them, participants were instructed to rank the food from the lowest energy-dense (least kcal/g) to the highest energy-dense (most kcal/g), according to their knowledge. A dry-erase marker and a table-napkin were given to participants, so they could write on the pictures and correct their classification easily. When they were confident about their ranking, participants were invited to transcribe it on an answer form.

Measures

Screening of ED symptomatology.

Module H of the *Structured Clinical Interview for DSM-IV-TR Axis I Disorders – Research version, Patient Edition* (SCID-I/P; First et al., 2002), adapted for the DSM-5 criteria (APA, 2013), was used to diagnose ED. The SCID-I/P has an interjudge reliability of .70-1.0 and a test-retest reliability of .82-.90 for both clinical and community samples (First et al., 2002; Pike et al., 1995; Segal et al., 1994; Williams et al., 1992).

[3] At first sight, some of participants' selection criteria might be construed as strict. It must be noted that this study was included in a larger research protocol, which involved cognitive processes evaluation (e.g., time perception) and neuropsychological measures (e.g., attention, working memory, executive functions). Therefore, it was essential to limit, as far as possible, the influence of factors that could alter women's cerebral functioning.

[4] Appetite modulates individuals' affective (valence, arousal), cerebral (activation, orientation of attention) and psychophysiological (heart rate, startle blink reflex) responses to food cues (e.g., Piech et al., 2010; Hoefling et al., 2009; Stockburger et al., 2009; Stoeckel et al, 2007; Uher et al., 2006).

Diagnostic questions of the *Eating Disorder Examination- Questionnaire* (EDE-Q 6.0; Fairburn & Beglin, 2008) were used to validate the absence of significant ED manifestations in participants of the HC group. The instrument, requiring answers on 7-point Likert scales ranging from 0 (no day, not at all) to 6 (every day, markedly), addresses the core attitudinal features and behaviors of ED pathology over the past 28 days. To be included in the study as HC, women should not present fasting (score = 0) or important restrained eating to lose weight (score < 3), nor episode of binge eating accompanied by a loss of control and usage of inappropriate behaviors to prevent weight gain (score = 0; ref. criteria used by Tokley & Kemps, 2007; Kemps & Wilsdon, 2010). Additionally, HC participants had to be satisfied with their weight and body (dissatisfaction score < 3), and these elements could not affect significantly their self-perception (score < 3). The EDE-Q has a satisfactory internal consistency (α = .78-.93 for community sample; Luce & Crowther, 1999; Mond et al., 2004a; Peterson et al., 2007) and an acceptable test-retest reliability: (*r* = .81-.94 for 2 weeks, *r* = .57-77 for about one year; Luce & Crowther, 1999; Mond et al., 2004b).

Assessment of participants' comorbid affective state.

Depressive symptoms of participants were assessed by the *Beck Depression Inventory II* (BDI-II; Beck et al., 1996), a self-report questionnaire consisting of 21 items answered on a 4-point Likert scale ranging from 0 to 3 (example item: Crying; 0 = "I don't cry any more than I used to"; 1 = "I cry more than I used to"; 2 = "I cry over every little thing"; 3 = "I feel like crying, but I can't"). The BDI-II total score assesses respondents' depressive mood in the past two weeks, with higher scores indicating more severe depressive symptoms. The questionnaire has a high internal consistency (α = .90) and a good test-retest stability (*r* =.73-.96; for review, see Wang & Gorenstein, 2013).

Anxiety symptoms of participants were assessed with the Part A of the *State-Trait Anxiety Inventory-Y Form* (STAI-YA, Spielberger, 1983). The STAI-YA measures State-Anxiety, which can be defined as feelings of apprehension, tension, nervousness and worry induced temporarily by situations perceived as dangerous. Twenty items, assessed on 4-point Likert scales, evaluate how respondents feel "right now" or felt "in a recent past" (example item: "I worry too much over something that really doesn't matter") A global score was computed by summing all items. Scores were then converted into an age-dependent T-score. The internal consistency of the whole inventory (Parts A and B) ranges from .86 to .95 and its test-retest reliability ranges from .31 to .86 (intervals fluctuating from 1 hour to 104 days; Gauthier & Bouchard, 1993; Spielberger, 1983).

Stimuli.

Emotional rating task

Out of the 58 images displayed, 46 were food pictures and 12 were non-food pictures, i.e. object pictures (including one object picture used for a practice trial). Food pictures (*n* = 30) were chosen from the Institute of Nutrition and Functional Foods' web-based food frequency questionnaire (Web-FFQ; Labonté et al., 2012), an online dietary assessment tool developed for qualifying and quantifying French Canadians' dietary intakes using digital colored photographs of various food items and meals. The Web-FFQ was used to avoid potential limits and biases due to stimuli (Piqueras-Fiszman & Spence, 2014; Spence et al., 2016), because: a) its pictures are standardized in terms of viewing point, brightness, shading, background and cropping; b) its food products are presented with the same dinnerware and utensils, and 3) different portion sizes of food items and meals are available.

To maximise the diversity and the representativeness of food stimuli showed to women, some criteria guided the selection of the photographs: 1) the four main categories of *Canada's Food Guide* (i.e., Vegetables and fruits, Grain products, Milk and alternatives, Meat and alternatives; Health Canada, 2011) and its "Other Foods" category (i.e., products that cannot be classified in the main categories, such as candies, chips, and pastries) had to be represented; 2) a reasonably comparable number of unprocessed and minimally-processed foods vs. moderately- and highly-processed foodstuffs had to be illustrated; 3) all food products had to be displayed on the same dinner plate, surrounded by the same fork and knife (i.e., beverages dispensed in a glass or a cup, and foods presented in a bowl were excluded); 4) the orientation and the localisation of the plate's content had to be similar from one picture to another (i.e., pointing towards participants and in the middle of the plate, centered; Michel et al., 2015a,b; Rowley & Spence, 2018); 5) the plate's area covered by foods had to be equivalent between stimuli minimally (Herzog et al., 2017; Kissileff et al., 2016); 6), the general nature of the food items and meals had to be easily identified or recognized (e.g., meat, cheese, pie); 7) based on past researches, foods for which positive and negative emotions could be evoked in ED and/or HC women had to be equally illustrated (e.g., strawberries, piece of cake, shellfish; Blechert et al., 2014; Charbonnier et al., 2016; Foroni et al., 2013; McNamara et al., 2008; Miccoli et al., 2016); and 8) low (< 1.5 kcal/g), medium (1.5-4.0 kcal/g) and high (> 4.0 kcal/g) energy density foods had to be shown across the collection of images selected (Rolls & Barnett, 2000). Figure 1 shows examples of food stimuli used in the experiment's tasks.

Figure 1. *Examples of food pictures used in the emotional rating task.*

The object pictures were extracted from the *International Affective Picture System* (IAPS; Lang et al., 2008), a widely exploited database of images for the study of emotion. As for food stimuli, the selection of object pictures relied on specific criteria: 1) the objects had to be of common use or well-known; 2) they could not refer to foods, beverages or eating; 3) as much as possible, their size had to be similar from one picture to another, and to be equivalent to the portion size of food pictures previously chosen; 4) their background color had to be close to the one of

food images (i.e., light gray beige). Moreover, according to the affective normative data of the IAPS (values on 9-point scales, ranging from 1 [*negative* or *low*] to 9 [*positive* or *high*]), the images must had: 1) a value between 4 and 6 on the Valence scale of Lang et al. (2008)'s data; 2) a value < 5 on the Emotion scales (i.e., happiness/joy, surprise, sadness, anger, disgust and fear) of Libkuman et al. (2007)'s ratings; and 3) a low Arousal value (< 5) as reported in Lang et al. (2008)'s material. In accordance with all these guidelines, the following IAPS stimuli were chosen: #6150, 7003, 7016, 7018, 7043, 7053, 7056, 7059, 7090, 7175, 7185, and 7211. When required, the visual parameters of these images were edited to be as comparable as possible to those of food pictures.

Energy density ranking task

From the 46 food pictures used in the emotional rating task, 25 were picked up as stimuli for the energy density ranking task, which was designed to assess participants' nutritional knowledge. The food pictures selected represented food items and meals easily found at local supermarkets. The food images were printed in a 8 x 6 cm colored format, on a US legal-size (21.6 x 35.6 cm) white paper. The stimuli were disposed in two columns of five pictures, totalizing three pages. The pages were laminated to facilitate their manipulation. The name, nature/flavor and cooking mode of the foods (e.g., "long-grain white rice, cooked") were labelled under each stimulus.

Statistical analyses.

All statistical analyses were carried out with SPSS 24.0 for Windows (IBM Corporation, Released 2016). All study variables were inspected for outliers and normality, and appropriate transformations were applied when needed. For all analyses, the alpha level, which was set to .05, was Bonferroni-corrected for multiple testing when required (i.e., decomposition of main effects and post-hoc comparisons). Univariate analyses of variance (ANOVAs) with post-hoc Tukey tests were performed to examine mean differences among AN, BN and HC groups on BMI, hungriness and scores on affective state (i.e., BDI-II, STAI-YA). Due to its fixed nature and its non-normal distribution, the mean age of groups was contrasted with non-parametric analyses, i.e. a Kruskal-Wallis test followed by Mann-Whitney U tests.

Emotional rating task

Participants' ratings of food and object pictures were investigated according to the intensity of their emotional responses. For object pictures, a mean score including all object pictures pooled together was calculated for each emotional dimension and each group of participants surveyed (e.g., "Objects-Valence intensity-AN"). For food pictures, to examine whether women's responses differed according to the energy density of the food displayed, the food stimuli were sorted in three classes, namely low (< 1.5 kcal/g), medium (1.5-4.0 kcal/g) and high (> 4.0 kcal/g) energy density products (Rolls & Barnett, 2000). For each of these classes, each emotional dimension and each group of participants studied, an intensity mean score was computed (e.g., "Low energy density-Valence intensity-AN").

In order to determine which variables to include in the group comparison analysis, Pearson correlations were run on the entire sample with emotional mean scores. Because valence, anger and sadness responses were strongly correlated together and with other emotional dimensions (r = .68 to .96), they were excluded from the analyses for the sake of parsimony. Surprise ratings were also excluded due to their lower relevance for the present study and their conceptual complexity (for review, see Mellers et al., 2013; Reisenzein et al., 2017). The remaining dimensions of arousal, happiness/joy, disgust, fear and neutrality were compared between AN, BN and HC groups using multivariate analyses of variance (MANOVAs). The decomposition of MANOVAs' main effect (i.e., the multivariate one) was achieved with ANOVAs, then Tukey tests were used for post-hoc comparisons.

To test associations between women's emotional responses and their comorbid affective state, correlation analyses were performed with reactions towards pictures and the STAI-YA scores. When variables were significantly related, the severity of anxiety symptoms was controlled for in the MANOVAs and ANOVAs. Because the STAI-YA and the BDI-II scores were strongly correlated (r = .86, p < .001), only the former was used as a covariate in the analyses. Finally, as the hunger level of women was not correlated with their emotional responses towards food and object pictures (all ps > .05), this variable was not entered as a covariate in the analyses concerning the stimuli-induced reactions.

Energy density ranking task

Participant's performance on the energy density ranking task was assessed by means of a precision index, which was calculated by adding up the gap, in absolute value, between each food product's real rank and the rank assigned. Thus, the higher the precision index was, the less accurate was women's nutritional knowledge about the energy density of the items displayed. According to their real energy density value, the 25 food products were sorted out as low, medium or high-energy foods, and a precision index was computed for each class, for each participant. To explore the differences between groups on these three classes, a MANOVA was run. The anxious comorbid state was not controlled for in the analyses, because no association was found between participants' precision indexes and their scores on the STAI-YA. For the same reason, the hunger level of women was not entered as a covariate in the analyses.

Finally, to verify if participants' emotional responses to food pictures were explained by their nutritional knowledge, emotional ratings assigned to the 25 food products submitted in the ranking task were retrieved from the rating task's results, and a mean score was calculated for each of the five affective dimensions investigated (i.e., arousal, happiness/joy, disgust, fear, and neutrality). Three multivariate multiple regression analyses (i.e., one per group) were then run to test whether the emotional ratings of food pictures (i.e., the intensity of reactions associated to them, on each dimension) would be predicted by the ranking task's global precision index.

Results

Group comparisons for age, BMI, hunger and comorbid affective state.

There were no significant differences between AN, BN and HC women for age, $H(2, N = 44) = 4.49$, $p = .106$, and for the level of hungriness preceding the experimental session, $F(2, 41) = 1.25$, $p = .296$. However, the groups differed on BMI, $F(2, 41) = 16.78$, $p < .001$, $\eta^2_p = .45$, BDI-II scores, $F(2, 41) = 22.89$, $p < .001$, $\eta^2_p = .53$, and STAI-YA scores, $F(2, 41) = 29.48$, $p < .001$, $\eta^2_p = .59$. More precisely, AN participants had a lower mean BMI than BN ($p < .001$) and HC women ($p = .003$), and BN participants had a higher mean BMI than HC ($p = .007$). For the comorbid affective state, AN and BN women showed more depressive ($M_{AN} = 22.15 \pm 16.03$; $M_{BN} = 16.67 \pm 14.85$; $p < .001$) and anxiety symptoms ($M_{AN} = 56.38 \pm 11.96$; $M_{BN} = 58.22 \pm 14.59$; $p < .001$) than HC did ($M_{BDI\text{-}II} = 2.64 \pm 2.90$; $M_{STAI\text{-}YA} = 38.95 \pm 5.40$).

Emotional rating task.

Object pictures.

For all object pictures, results showed a non-significant multivariate effect of Group ($p = .560$, see Table 1). Hence, no further analyses were achieved to examine the emotional dimensions.

	AN	BN	HC				
Variables	*M (SD)*	*M (SD)*	*M (SD)*	*λ, V*	*df*	*F*	η_p^2
Object pictures				**.80**	**10, 74**	**0.88**	**.11**
Arousal	2.69 (1.70)	3.41 (1.34)	3.54 (1.55)				
Happiness/joy	1.66 (0.42)	1.80 (0.69)	1.69 (0.73)				
Disgust	1.24 (0.53)	1.16 (0.17)	1.18 (0.34)				
Fear	1.50 (0.72)	1.48 (0.57)	1.39 (0.54)				
Neutrality	7.29 (1.39)	6.38 (0.80)	6.45 (2.10)				

Note. AN = Anorexia nervosa; BN = Bulimia nervosa; HC = Healthy controls; *M* = Mean; *SD* = Standard deviation.

Table 1: *Mean (and SD) intensity of reactions towards object pictures, for each group.*

Food pictures.

The MANOVA performed with low energy density food' responses showed a significant multivariate effect of Group ($p < .001$; see Table 2). ANOVAs ($\alpha = .01$) demonstrated a significant effect of Fear ($p < .001$, $\eta_p^2 = .63$). According to post-hoc tests, AN and BN women judged low energy density food as more fearful than HC participants did ($p < .001$, $p = .003$). The AN group also reported higher ratings of fear than the BN group ($p = .004$). When controlling for anxiety symptoms ($\alpha = .01$), the Fear effect remained significant ($p < .001$, $\eta_p^2 = .40$), but the difference between BN and HC participants on that dimension was no longer statistically significant ($p = .999$).

	AN	BN	HC						Controlling for STAI-YA		
Variables	*M (SD)*	*M (SD)*	*M (SD)*	*λ, V*	*df*	*F*	η_p^2	Post-hoc	*F*	η_p^2	Post-hoc
Low energy density foods				**.26**	**10, 74**	**7.10****	**.49**		**3.93****	**.35**	
Arousal	5.15 (1.17)	5.14 (1.41)	5.15 (1.05)		2, 41	< .001	< .001	–	2.84	.12	–
Happiness/joy	3.50 (0.95)	3.26 (1.14)	3.44 (0.89)		2, 41	0.17	.01	–	0.16	.01	–
Disgust	3.92 (1.14)	3.39 (1.08)	3.10 (1.02)		2, 41	2.40	.11	–	0.97	.05	–
Fear	4.30 (1.68)	2.48 (1.57)	1.19 (0.37)		2, 41	35.12**	.63	1, 2 > 3; 1 > 2	13.24**	.40	1 > 2, 3
Neutrality	3.22 (1.39)	3.40 (1.80)	3.45 (1.13)		2, 41	0.12	.01	–	0.81	.04	–
Medium energy density foods				**.84**	**10, 76**	**5.51****	**.42**		**3.79****	**.34**	
Arousal	6.16 (1.06)	5.35 (1.45)	5.53 (1.11)		2, 41	2.45	.11	–	2.01	.09	–
Happiness/joy	2.64 (0.85)	2.69 (0.73)	3.93 (1.24)		2, 41	8.09*	.28	1, 2 < 3	2.23	.10	–
Disgust	5.03 (1.64)	4.15 (1.46)	2.88 (1.10)		2, 41	10.77**	.34	1 >3	1.94	.09	–
Fear	6.34 (1.64)	3.86 (2.46)	1.13 (0.30)		2. 41	56.07**	.73	1, 2 > 3; 1 > 2	21.57**	.52	1 > 2, 3
Neutrality	2.59 (1.14)	3.18 (1.45)	3.03 (1.44)		2, 41	0.58	.03	–	0.73	.04	–
High energy density foods				**.97**	**10, 76**	**7.13****	**.48**		**4.51****	**.38**	
Arousal	6.87 (1.02)	5.31 (1.59)	6.11 (1.33)		2, 41	3.84	.16	–	3.70	.16	–
Happiness/joy	2.98 (1.22)	2.81 (1.08)	5.19 (1.47)		2, 41	16.22**	.44	1, 2 < 3	3.98	.17	–
Disgust	4.77 (2.11)	3.65 (1.91)	1.94 (0.93)		2, 41	14.34**	.41	1, 2 > 3	2.08	.09	–
Fear	7.15 (1.20)	4.60 (2.79)	1.06 (0.19)		2. 41	80.74**	.80	1, 2 > 3; 1 > 2	30.84**	.61	1, 2 > 3; 1 > 2
Neutrality	2.16 (1.00)	2.85 (1.40)	2.91 (1.54)		2, 41	0.94	.04	–	0.60	.03	–

Note 1. AN = Anorexia nervosa; BN = Bulimia nervosa; HC= Healthy controls; *M* = Mean; *SD* = Standard deviation.

Note 2. For post-hoc comparisons: 1 = AN; 2 = BN; 3 = HC.

Table 2: *Mean (and SD) intensity of reactions towards food pictures, for each group.*

For medium energy density food**,** the results also indicated a multivariate effect of Group (p < .001), then ANOVAs (α = .01) showed significant effects for Happiness/Joy (p = .001), Disgust (p < .001) and Fear (p < .001) dimensions. The size of the effects found were high, particularly for the Fear dimension (η_p^2 = .73). Post-hoc comparisons showed that the AN and BN groups had lower happiness/joy responses towards medium energy density foods than the HC one (p = .003, p = .014). Furthermore, AN women had greater disgust responses than HC (p < .001). For fear reactions, AN participants gave higher ratings than BN (p = .001) and HC (p < .001), and BN participants gave higher ratings than HC women did (p < .001). When controlling for anxiety symptoms (α = .01), the previously significant Happiness/Joy (p = .121) and Disgust effects were no longer significant (p = .157), but group differences remained on Fear (p < .001, η_p^2 = .52), except the difference between the BN and HC groups which was no longer significant (p = .450).

The MANOVA conducted with high energy density food yielded a multivariate effect of Group (p < .001), and consecutive ANOVAs (α = .01) demonstrated significant univariate effects of Happiness/Joy (p < .001), Disgust (p < .001) and Fear (p < .001). Once again, the size of the effects found were high, particularly for the Fear dimension (η_p^2 = .80). Post-hoc comparisons showed that AN and BN groups had lower happiness/joy responses (p < .001, p < .001), higher disgust responses (p < .001, p = .011) and greater fear reactions (p < .001, p < .001) to high energy density food than the HC group. In addition, AN women gave higher ratings of fear than BN participants did (p < .001). When controlling for anxiety symptoms (α = .01), the Happiness/Joy (p = .027) and the Disgust (p = .139) effects were no longer significant, but this time, the difference between BN and HC women on the Fear dimension remained significant (p = .013). The effect size of Fear also remained high, η_p^2 = .61.

Energy density ranking task

Nutritional knowledge

The MANOVA ran with the precision indexes related to food's classes of energy density did not show a significant multivariate effect of Group, indicating that AN, BN and HC women had a comparable nutritional knowledge, λ = .91, F(6, 78) = .61, p = .719, η_p^2 = .05 (see Table 3).

	AN	BN	HC				
Variables	*M (SD)*	*M (SD)*	*M (SD)*	*λ*	*df*	*F*	η^2
Performance according to food products' energy density class				**.91**	**6, 78**	**0.61**	**.05**
Low [a]	16.46 (5.46)	16.00 (7.07)	15.64 (4.95)				
Medium [b]	79.39 (7.59)	78.11 (11.13)	80.64 (8.14)				
High [c]	28.92 (6.89)	31.00 (5.29)	28.64 (6.46)				

Note. Precision index = Sum of the gap, in absolute value, between each food products real rank and the rank assigned by a participant; AN = Anorexia nervosa; BN = Bulimia nervosa; HC = Healthy controls; *M* = Mean; *SD* = Standard deviation.

[a] 7 stimuli involved. [b] 13 stimuli involved. [c] 5 stimuli involved.

Table 3: *Mean (and SD) precision index on the energy density ranking task, for each group.*

Influence of nutritional knowledge on emotional responses to food pictures.

The results of the multiple regression analysis (α = .01) conducted for each group (i.e., AN, BN, and HC) showed that women's nutritional knowledge about food products did not predict their arousal, happiness/joy, disgust, fear, and neutrality reactions towards them (all *p*s > .05). In other words, the intensity of participants' reactions to food from the emotional rating task was not explained by their objective nutritional knowledge.

Discussion

The objective of the present study was to examine ED women's emotional responses to food pictures, and to compare these responses according to their diagnosis, while taking into account both the caloric content of the food items presented and participants' nutritional knowledge. For this purpose, ED and HC women participated in an emotional rating task of food and object pictures, and an energy density ranking task of food items/meals. When appropriate, we controlled for the internal state of participants, that is their level of hungriness and their comorbid affective state, in order to reduce the effects of non-specific factors in the interpretation of results.

Emotional responses towards food and object pictures

Participants' emotional responses according to food's classes of energy density showed that when medium and high energy food were presented, groups clearly differed on the happiness/joy, disgust and fear dimensions, but when low energy items were displayed, only the fear dimension differed across groups. For AN and BN participants, higher fear reactions were observed compared to HC for all food pictures presented, regardless of their caloric value. AN women also experienced higher fear reactions than BN participants. In addition, the results showed that while AN participants judged medium and high energy density food as more disgusting than HC did, BN women's disgust responses only exceeded those of HC for high energy food. Therefore, it seems that the caloric value of food necessary to generate disgust has to be higher with BN than with AN women. These findings are in line with those of Santel et al. (2006) and Rodriguez et al. (2007), which demonstrated respectively that AN and BN participants assessed images of high energy food as less pleasant than HC. They are also in accordance with the conclusions of Harvey et al. (2002) and those of Griffiths and Troop (2006), stating that women with high risk for ED rated images of high-density food as more disgusting than women at low risk. However, our findings extend those of previous research by distinguishing emotional responses of ED women to food based on their caloric value. They also support and extend the work of Racine (2018) conducted among college women, which revealed that an effective restriction (as seen in AN participants) is correlated with lower pleasure towards both high and low energy food, while temporary or infructuous attempts to eat less (as seen in BN participants) are associated to greater pleasure for low energy food. Such information is interesting for the development of therapeutic strategies targeting more efficiently patients' cognitions and behaviors.

Regarding the analysis of object pictures, results showed that the three groups of participants did not differ in terms of intensity of their emotional ratings. The inclusion of non-food pictures allowed to verify if participants' reactions were oriented exclusively towards food products or were explained rather by a global limited capacity to resent pleasure and/or a higher disgust sensitivity (see Aharoni & Hertz, 2012; Boehm et al., 2018; Deborde et al., 2006). The current results suggest that AN and BN participants' negative reactions were oriented exclusively towards food. This finding supports the work of Davey et al. (1998) and Troop

and al. (2002), which denoted that ED participants exhibit a higher disgust sensitivity for food and body-related stimuli, but not for other items. Consequently, it also refuted the hypotheses raised by some authors about the presence, in ED women, of a global lower disgust tolerance and a reduced general capacity to experience pleasure (Aharoni & Hertez, 2012; Boehm et al., 2018; Deborde et al., 2006).

Influence of participants' internal state

The current study also aimed to control for women's internal state. The methodological control we exerted for participants' hungriness, i.e., instructions to eat 60 minutes prior to the experiment and meeting at fixed times of the day, was shown efficient because women's appetite level before completing the tasks was low and did not differ between groups. Besides, the statistical control we applied for participants' anxious state (which were highly correlated with their depressive symptoms) in the analysis of their emotional reactions towards food pictures modified the pattern of the results. Specifically, all group effects for happiness/joy and disgust responses that were demonstrated were no longer significant when controlling for anxious state. In other words, it seems that ED participants' lower happiness/joy and higher disgust reactions towards food pictures were better explained by their anxiety state prior to the experiment. These results are consistent with those of Davey and Chapman (2009), which showed that controlling for anxiety overrides the association between disgust and ED-like symptoms. Accordingly, they postulated that the presence of anxious manifestations in individuals at risk of ED could amplify their experience of distress and negative emotions (e.g., disgust, displeasure) for sensitive stimuli. Building on these findings, anxiety state could have influenced their evaluation of food pictures by contributing to explain their aversive reactions towards them (e.g., less happiness/joy, more disgust).

Furthermore, regarding the fear effect, although it remained significant when controlling for anxiety state, the group differences observed between BN and HC women were no longer significant, except for the high-energy food category. These results contrast with those of Hay and Katsikitis (2014), which showed that ED women gave lower happiness and higher fear and disgust responses to food images than HC, even when their baseline level for these three emotions were controlled for. Nonetheless, the fact that the differences between BN and HC women were no longer significant when controlling for anxiety state on fear ratings for low and medium energy food, but remained significant for high energy food, is interesting. Patients' sense of control towards food and the anticipation of consequences associated with food ingestion may explain these results. According to McNamara et al. (2008), when women suffering from an ED experience a feeling of loss of control over food, i.e. when they believe they cannot control their intake and their weight gain and/or their binge-purge behaviors, they may experience adverse emotions. Thus, it is possible that BN women thought they could manage their consumption of low and medium energy food because binge eating episodes mainly involve high sugar and fat products (Beumont, 2002; Gendall et al., 1997; Natenshon, 2009; Rosen et al., 1986). Therefore, food with lower energy value could have been considered at lower risk for inappropriate eating behaviors and potential weight gain. As a result, in the current study, the fear reaction to high-energy food was found to be more robust than fear reactions to lower energy food categories for BN participants.

For AN participants, their fear reactions were observed above and beyond their anxiety state prior to the experiment: the higher fear reactions observed among AN participants compared to HC and BN remained significant for all food energy density categories when controlling for participant's anxiety state. Therefore, the relationship between AN diagnosis and fear reactions to food appears to be robust. These results suggest that AN participants might experience a negative sense of control and anticipated the consequences of food intake for all caloric classes of food. This hypothesis relies on the idea that a core manifestation of AN is a morbid fear of gaining weight or becoming fat (APA, 2013). Then, even for low and medium energy food, women with AN could apprehend gaining some weight (or not maintaining their actual low weight) if they ingest them, as if all foods, independently of their caloric content, could represent a serious self-directed threat (Milos et al., 2017; Paslakis et al., 2016; Steinglass et al., 2007).

Nutritional knowledge and its impact

The results of the ranking task revealed that AN and BN women did not have better nutritional knowledge than HC about the energy density value of everyday food products. The three groups showed similar results when ranking food according to their caloric value. Furthermore, the results revealed that participants' nutritional knowledge, as we measured it, did not have a significant influence on their emotional responses; no association was found between women's nutritional knowledge and emotional reactions to food, regardless of their diagnosis. Therefore, it appears that ED participants' aversive reactions towards foods were not explained by their objective knowledge of caloric content. Instead, their emotional reactions may be influenced by their implicit cognitions about food and their subjective perception of food items' energy content, which seems to be erroneous (Eiber et al., 2005; Gonzalez & Vitousek, 2004; Provencher et al., 2009; Sunday et al., 1992; Vartanian et al., 2004).

These findings leaded to the rejection of our hypotheses regarding nutritional knowledge, but the latter were mainly based on experiments held in the 1980s, at which time food and nutrition information was not as omnipresent in the public area as it is today (i.e., Beumont et al., 1981; Laessle et al., 1988). Nowadays, nutritional information is more abundant, elaborate, and readily available to the general population. It is possible that such a new social context has contributed to reduce the gap between HC and ED's nutritional knowledge about foods' energy value (Breen & Espelage 2004; Soh et al., 2009).

Strengths and limitations

To our knowledge, this study is the first to explore ED participants' emotional responses to food according to their diagnosis and to the caloric content of the food products presented, while considering their comorbid affective state. Other strengths of the present study rely on the statistical control for participants' appetite level and on the investigation of the impact of their nutritional knowledge on their emotional reactions to foods. Furthermore, our experiment used a collection of standardized food pictures, which allowed to reduce the potential biases associated with different visual parameters, increasing the internal validity of our experiment. It should be noted that the set of food pictures used in this experiment (and their affective ratings) represents one of the first databases conceived for the examination of food-induced emotions in North-American ED individuals, most of those already available having been developed in Europe (e.g., *FoodCast research image database*, Foroni et al., 2013; *Full 4 Health Image Collection*, Charbonnier al., 2016; *Open Library of Affective Foods*; Miccoli et al., 2014, 2016). Thus, our bank of culturally representative food pictures could contribute to the development of clinical advances for North-American ED populations.

Despite its strengths, the present experiment has some limitations that must be mentioned. First, the fact that ED women, especially AN participants, may not be classified as critically ill as revealed by their outpatient status and their mean BMI outside the underweight category (i.e., > 18.5 kg/m^2). However, even if their illness's severity can appear to be low according to theses clinical aspects, the AN and BN participants of our study suffered from clear and significant ED symptoms, as assessed by a structured interview (i.e., module H of the SCID-I/Pl) and a specialized questionnaire (i.e., EDE-Q 6.0). Second, the absence of non-neutral non-food images—i.e., of pictures that could have evoked low happiness/joy and high disgust or fear responses like the food ones

did−represents another limitation. The inclusion of such stimuli could have certified even more the specificity of food pictures in the induction of aversive reactions in ED women. Nevertheless, the inclusion of object images partially contributed to demonstrate this point. Third, the ranking task of food items according to their energy density to measure participants' nutritional knowledge may have been too difficult. This could have lowered their performance and reduced the probability to find differences between groups. Indeed, the task involved ranking many food products and some of them had a fairly similar caloric content. Finally, the representativeness of food's energy density as a measure of participants' nutritional knowledge can be discussed, as this element focuses on only one aspect of this knowledge. Consequently, the use of another type of nutritional knowledge measure–e.g., a questionnaire as those elaborated by Klieman et al., 2016; Saarela et al., 2013; and Dickson-Spillmann et al., 2011–could have been more relevant given the purpose of its inclusion.

Conclusion

This study demonstrated that ED women experienced a high level of fear towards food pictures, which was neither due to their level of hungriness nor to their affective comorbid state. This fear response appeared to be specific to food, because no difference between participants' emotional responses was noticed for object pictures. Most importantly, the study takes the literature further in the field of ED by revealing clear distinctions in women's reactions according to their diagnosis and according to the caloric content of the food presented. Precisely, for all food products displayed, regardless of their energy density, AN participants showed a more intense reaction of fear than BN and HC. However, only high-calorie items led to a higher fear response in BN participants than in HC, irrespectively of their anxiety state prior to the experiment. These results underline the necessity for treatments to address explicitly ED women's fear towards common food items and meals in a way of ensuring a long-term reduction of their symptoms and their recovery. In this perspective, our results support the use of therapeutic techniques that have been shown to be valid for anxiety disorders (e.g., gradual exposure and response prevention) in order to increase the effectiveness of psychological treatment of AN and BN (Levinson et al., 2014; Reilly et al., 2017; Steinglass et al., 2011; Treasure et al., 2015; Webb et al., 2011). Finally, the study revealed that participant's aversive reactions towards food pictures were not caused by their objective nutritional knowledge about them, which suggests that implicit cognitions might rather modulate their emotional responses. In summary, the study highlighted the key role of food-induced fear in ED's symptomatology, particularly in AN, and stressed the necessity of implementing treatments that address it exhaustively in order to improve patients' eating behaviors.

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