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Pleasure for visual and olfactory stimuli evoking energy-dense foods is decreased in anorexia nervosa

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ABSTRACT

Although patients with anorexia nervosa have been suggested to be anhedonic, few experiments have directly measured their sensory pleasure for a range of food and non-food stimuli. This study aimed to examine whether restrictive anorexia nervosa (AN-R) patients displayed: i) a generalized decline in sensory pleasure or only in food-related sensory pleasure; ii) a modification of hedonic responses to food cues (liking) and of the desire to eat foods (wanting) as a function of their motivational state (hunger vs. satiety) and energy density of foods (high vs. low). Forty-six female participants (AN-R $n=17$; healthy controls (HC) $n=29$) reported before/after lunch their pleasure for pictures/odorants representing foods of different energy density and non-food objects. They also reported their desire to eat the foods evoked by the sensory stimuli, and completed the Physical Anhedonia Scale and the Beck Depression Inventory. AN-R and HC participants did not differ on liking ratings when exposed to low energy-density food or to non-food stimuli. The two groups also had similar physical anhedonia scores. However, compared to HC, AN-R reported lower liking ratings for high energy food pictures regardless of their motivational state. Olfactory pleasure was reduced only during the pre-prandial state in the AN-R group. The wanting ratings showed a distinct pattern since AN-R participants reported less desire to eat the foods representing both low and high energy densities, but the effect was restricted to the pre-prandial state. Taken together these results reflect more the influence of core symptoms in anorexia nervosa (fear of gaining weight) than an overall inability to experience pleasure.

1. Introduction

Energy-rich foods are particularly aversive in patients suffering from anorexia nervosa (AN). Such persons are indeed characterized by an everyday avoidance to eat high-fat and sweet foods and by an obsessive fear of gaining weight (American Psychiatric Association, 1994; Crisp et al., 2006; Kaye, 2008). Several investigators advocated that palatable foods as reinforcers are avoided in AN patients due to low sensitivity to reward or a diminished ability to experience sensory pleasure (physical anhedonia), and suggested a possible etiological role of dysfunctioning brain reward systems (dopamine and opioid systems) (Davis and Woodside, 2002; Berridge, 2007; Kaye, 2008). Although recent neuroimaging and psychophysiological studies have begun to address the hypothesis of altered reward or appetitive systems in AN patients (Friederich et al., 2006; Wagner et al., 2007; Soussignan et al., 2010), the issue remains to be clarified because studies based on self-report scales of physical anhedonia and measurement of sensory pleasure in AN patients provided conflicting results. In some studies, as compared to controls, AN women were found to be anhedonic (Bydlowski et al., 2002; Davis and Woodside, 2002; Deborde et al., 2006) and reported higher dislike for the sight of high energy foods (Bossert et al., 1991; Stoner et al., 1996; Stormark and Torkildsen, 2004; Herpertz et al., 2008), for fat taste (Drewnowski et al., 1987; Sunday and Halmi, 1990; Simon et al., 1993), and the smell of food (Schreder et al., 2008). In some studies, AN patients evinced unchanged hedonic responses to low-caloric food pictures (Bossert et al., 1991; Stoner et al., 1996), olfactory stimuli (Lombion-Pouthier et al., 2006), and sweet taste (Drewnowski et al., 1987). Finally, AN patients reported a decreased pleasure when sweet solutions were swallowed but not spat out (Eiber et al., 2002), suggesting that they exhibited an excessive fear of gaining weight rather than a diminished ability to experience pleasure. Taken together, currently available studies do not make clear whether the low sensitivity to food reinforcement in AN patients relies on (i) a general decrease in pleasure responses to any kind of actual and imagined events (i.e., anhedonia), (ii) a specific reduction in pleasure responses to food cues, or (iii) a reduction to cues carried by high energy-density foods as a consequence of fear of gaining weight. Further, little is known on how hedonic experience in AN patients relates to hunger/satiety states since in healthy people the expression of pleasure for olfactory and visual food cues fluctuates as a function of motivational states

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(Cabanac and Duclaux, 1973; Soussignan et al., 1999; Stoeckel et al., 2007; Jiang et al., 2008).

1.1. Sensory modality and hedonic experience

Most of the above studies have gauged taste as the elicitor of hedonic responses, restricting exploration to stimuli that directly relate to food intake, hence excluding the differentiation of pleasure responses to food and non-food stimuli. The investigation of other sensory contributions to flavor perception and pleasure in a variety of situations could indeed provide better understanding of the cues that are meaningful to AN patients. Olfaction and vision provide such alternative cues bearing information on the hedonic value and energetic content of a given food before consumption, and thus may contribute to expectancies involved in anticipatory hunger and pleasure (Thibault and Booth, 2006), and in the amount of food to be ingested (de Wijk et al., 2004). To the best of our knowledge, investigations on sensory pleasure in AN patients have studied only one sensory modality at a time and few have considered either odor or visual cues using both food and non-food stimuli as a function of hunger/satiety. Those studies using food pictures found lower hedonic ratings in AN patients as compared to controls (Santel et al., 2006; Herpertz et al., 2008), but the effect of motivational state (hunger vs. satiety) was assessed only in one study using a rating scale with a low discriminative power (Santel et al., 2006). Furthermore, studies on hedonic responses to odors raised contradictory findings, but they were limited in the sense that they used only a single food odorant (Schreder et al., 2008), or odorants that were not categorically differentiated by the subjects as belonging to food vs. non-food sources (Lombion-Pouthier et al., 2006).

1.2. Liking and wanting of food

Recent studies have suggested at least two neural systems involved in food reward mechanisms, one mediating food hedonics ("liking"), the other mediating the incentive to eat ("wanting") (Berridge, 1996, 2007). Alterations of liking and wanting have been suggested to be involved in some eating disturbances (Mela, 2006). In one study, wanting was particularly affected in AN patients when high caloric foods were concerned (Stoner et al., 1996). However, this finding was not confirmed in a later study showing that AN patients' wanting appears similar than in healthy controls (Schreder et al., 2008). Thus, whether liking and wanting are similarly affected and whether they are dependent on an individual's motivational state remain to be clarified in anorexia nervosa.

1.3. Aims of the current study

The aims of this study are twofold. First, we shall examine whether decreased hedonic responsiveness usually reported in AN patients is specific to olfactory and visual cues carried by foods of high energy density and dependent on an individual's metabolic state, or whether it represents a generalized disturbed affective state (i.e., physical anhedonia). This will be investigated by using the level of depression as a covariate because AN patients were previously reported to be slightly depressive (Bydlowski et al., 2002), and because this affective state has a strong influence on hedonic responses to sensory stimuli (Steiner et al., 1993; Schaal et al., 2010). Secondly, we shall assess whether hedonic responsiveness to food stimuli (liking) and the desire to ingest these foods (wanting) are differentially affected in anorexia.

2. Method

2.1. Participants

Seventeen AN women of the restrictive subtype (AN-R, age: M (S.D.): 26.47 (7.12) years; BMI: 15.04 (1.93) kg/m^2) and 29 healthy control women (HC) (age: 24.52 (5.58) years; BMI: 20.38 (1.87) kg/m^2) were recruited. The HC women were recruited by local advertisements. The AN-R patients were recruited from the Nutrition and Endocrinology Department of Dijon University Hospital according to DSM-IV criteria (American Psychiatric Association, 1994). They had neither purging nor binge eating behavior. They were hospitalized because of very low BMI and malnutrition related to severe body weight loss. AN-R patients were tested during the first 3 days of hospital admission. None had any medication. A screening questionnaire was used to select the participants, with the following exclusion criteria: substance use and neurological diseases. Inclusion criteria were absence of food or odor allergies, and absence of hypoglycemia when hungry. In addition, participants of the HC group had no precedent of eating disorders.

The study was approved by the institutional ethical board of Centre National de la Recherche Scientifique (CNRS, Paris) and by the regional ethics committee (CPP-Nord Est, Dijon). All participants received complete information about the general purpose of the study and they were invited to sign written consent indicating that they approved the collection, anonymous storage and analysis of the data. At the end of the study, each participant received 15 euros.

2.2. Materials

.2.2.1. Stimuli

A pilot study conducted on a separate group of healthy control persons guided the selection of the olfactory and visual stimuli (for details, cf. Jiang et al., 2008). The olfactory stimuli included 6 aromas representing low (almond, orange, strawberry) and high energy (beef, bacon and pizza) density foods, as well as 6 fragrances [grass, domestic cleaning product (with rosemary note), jasmine, lavender, soap and rose]. Aromas and fragrances received similar subjective scores of hedonic value and subjective intensity. The 12 odorants were presented in 60-ml brown glass jars (opening diameter: 28 mm), diluted in light mineral oil (Aldrich, Saint Quentin-Fallavier, France) at a concentration of 0.5 to 2% (v/v) and absorbed on a 5×7 cm polypropylene absorbent (3 M, Berkshire, UK).

The visual stimuli were composed of 12 colored photographs that were semantically matched to the odorants: food images corresponded to the 6 aromas and object images corresponded to the 6 fragrances, respectively. The 12 pictures were also matched for hedonic value with the 12 odor stimuli. They were presented on a 17-inch flat screen (located at 75 cm in front of the participant) controlled by the Superlab software (Cedrus, San Pedro, CA).

.2.2.2. Hunger rating

Hunger sensation was assessed using a 7-point scale ranging from 1 (absence of hunger) to 7 (extreme hunger).

.2.2.3. Physical Anhedonia Scale

A validated French version (Assouly-Besse et al., 1995) of the Physical Anhedonia Scale (PAS) originally devised by Chapman et al. (1976) was used. The PAS is a 61-item self-report scale presented in a true–false format measuring the degree to which individuals are rewarded by exteroceptive (taste, smell, sound, touching, sight) and proprioceptive (movement) sensations, as well as feelings for normally pleasurable life events (e.g., sport, music, food, walk, flowers, sex, landscapes). It is intended to assess a lifelong personality defect in the ability to experience pleasure rather than a transient state of pleasure/displeasure.

.2.2.4. Beck Depression Inventory

Depression was assessed with the French version of the shortened 13-item Beck Depression Inventory (BDI), a widely used self-rating scale with established reliability and validity (Beck et al., 1974; Collet and Cottraux, 1986).

2.3. Procedure

A within-subject design was used. All participants underwent two experimental sessions on two consecutive days: on one day they were tested before lunch (pre-prandial session) and on another day they were tested after the lunch that they took at the laboratory (post-prandial session). Each session was composed of an olfactory test and a visual test. For each test, participants performed liking and wanting tasks. For the pre-prandial session, the participants were instructed to have breakfast before 7:30 am and to abstain from eating until the session (water intake allowed). Following instructions and installation, the session began at about 12:00 am, and lasted for about 45 min. For the post-prandial session, participants came to the laboratory at 12:30 and took a standard lunch composed of an entrée (100 g steamed semolina, 100 g ham with parsley and half an egg), 60 g meat, 35 g cheese, 50 g bread, 75 g cake with fruits, and a bottle of 33 cl mineral water. They were instructed to eat *ad libitum* and to take the quantity of food they could without being required to finish all the meal. They spent from 15 to 25 min to eat their lunch. The left-overs were weighted to evaluate the energy intake using the Bilnut® software (S.C.D.A. Nutrisoft, Cerelles, France).

The tests began 40 min after the end of the meal (Duclaux et al., 1973). Participants were installed in a comfortable chair in front of a table on which the screen and the odorant delivery device were placed. Two experimenters operated in an adjacent room. Participants received auditory (from earphone) and visual (on screen) instructions controlled by the SuperLab software. Their verbal responses were recorded through a microphone on a computer and noted by an experimenter located in another room. In both visual and olfactory tests, participants were instructed to rate their liking of the