



Research report

Facial affective reactions to bitter-tasting foods and body mass index in adults ☆

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ABSTRACT

Differences in food consumption among body-weight statuses (e.g., higher fruit intake linked with lower body mass index (BMI) and energy-dense products with higher BMI) has raised the question of why people who are overweight or are at risk of becoming overweight eat differently from thinner people. One explanation, in terms of sensitivity to affective properties of food, suggests that palatability-driven consumption is likely to be an important contributor to food intake, and therefore body weight. Extending this approach to unpalatable tastes, we examined the relationship between aversive reactions to foods and BMI. We hypothesized that people who have a high BMI will show more negative affective reactions to bitter-tasting stimuli, even after controlling for sensory perception differences. Given that hedonic reactions may influence consumption even without conscious feelings of pleasure/displeasure, the facial expressions were included in order to provide more direct access to affective systems than subjective reports. Forty adults (28 females, 12 males) participated voluntarily. Their ages ranged from 18 to 46 years ($M = 24.2$, $SD = 5.8$). On the basis of BMI, participants were classified as low BMI ($BMI < 20$; $n = 20$) and high BMI ($BMI > 23$; $n = 20$). The mean BMI was 19.1 for low BMI ($SD = 0.7$) and 25.2 for high BMI participants ($SD = 1.8$). Each subject tasted 5 mL of a grapefruit juice drink and a bitter chocolate drink. Subjects rated the drinks' hedonic and incentive value, familiarity and bitter intensity immediately after each stimulus presentation. The results indicated that high BMI participants reacted to bitter stimuli showing more profound changes from baseline in neutral and disgust facial expressions compared with low BMI. No differences between groups were detected for the subjective pleasantness and familiarity. The research here is the first to examine how affective facial reactions to bitter food, apart from taste responsiveness, can predict differences in BMI.

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Introduction

Research on obesity has revealed that overweight/obese people display different eating behaviours to lean people (for review, cf. French, Epstein, Jeffery, Blundell, & Wardle, 2012; Mesas, Muñoz-Pareja, López-García, & Rodríguez-Artalejo, 2012). Several studies with both children and adults agree that individuals with a higher body mass index (BMI, kg/m^2) not only consume larger amount of,

e.g., energy-dense snacks (Berteus Forslund, Torgerson, Sjöström, & Lindroos, 2005; Nicklas, Yang, Baranowski, Zakeri, & Berenson, 2003), soda/sweetened beverages (Blum, Jacobsen, & Donnelly, 2005; Malik, Schulze, & Hu, 2006; Nicklas et al., 2003) and fast food (Bowman & Vinyard, 2004; Schroder, Fito, & Covas, 2007) compared to those with a lower BMI; but also less fruit and vegetables (Alinia, Hels, & Tetens, 2009; Kahn et al., 1997; Lin & Morrison, 2002; Mohindra, Nicklas, O'Neil, Yang & Berenson, 2009). Dietary patterns or changes in patterns of food choice over time have also been linked to BMI status (e.g., Maskarinec, Novotny, & Tasaki, 2000; Pachucki, 2012). Pachucki using cluster analysis with dietary data showed that transitions to lower diet quality clusters (e.g., from fruits and legumes to low/high-fat meat and soda) were associated with a higher BMI. Since excessive fat vs. inadequate vegetable and fruit intake have been identified as risk factors for developing obesity and major diseases (e.g., Boeing et al., 2012; Bray & Popkin, 1998), there is an urgent need to understand why people at risk of obesity choose and eat differently from thinner people.

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Among the determinants of food preferences related to weight status, some studies have considered whether a predisposition to overeating might be related to hedonic processes (cf. [Blundell & Finlayson, 2004](#); [Mela, 2001](#)). In terms of taste preference ([Drewnowski, 1997](#)), these studies are based on the assumption that differences in the perceived pleasantness of foods (hedonic sensitivity), and not only in sensory perception (taste responsiveness), should explain the individual variability in BMI. Given that pleasure “comprises the positive dimension of the more general category of hedonic processing [. . .], which also includes other negative and unpleasant dimensions” ([Berridge & Kringelbach, 2008](#)), an attractive possibility is to extend this hedonic eating-based approach of overweight people to aversive tastes. Thus, subjects with a higher sensitivity to the affective value of food might be likely to have a stronger drive to eat pleasurable food as well as a higher avoidance of aversive tastes, promoting the overconsumption of palatable energy-dense products and the rejection of unpalatable healthy bitter substances. Although the results are mixed, the view that BMI is increased by a heightened liking for highly palatable foods has received support from several sources of evidence, including data from longitudinal (e.g., with the obesity-prone Pima Indian population; [Salbe, DelParigi, Pratley, Drewnowski, & Tataranni, 2004](#)) and cross-sectional studies (e.g., with the distribution of BMIs among the high-fat phenotypes; [Blundell et al., 2005](#)). Particularly interesting are the studies on the relationship between sensitivity to food reward and BMI (e.g., [Davis & Fox, 2008](#); [Franken & Muris, 2005](#)). For instance, [Davis, Strachan, and Berkson \(2004\)](#) pointed out that overweight women were significantly more sensitive to the hedonic reward of food, when comparing the self-reported scores on the *Physical Anhedonia Scale* with those of their normal weight counterparts. [Franken and Muris \(2005\)](#) also found that reward sensitivity, as indexed by *Sensitivity to Punishment and Sensitivity to Reward Questionnaire*, was positively associated with BMI in young women.

Regarding the assumption that body mass is affected by variations in reactivity to unpleasant tastes, to date no study has specifically investigated the relation between negative affective (aversive) responses to bitter-tasting foods and body weight. The available studies which have explored weight differences as a function of taste are based on sensory (e.g., threshold or intensity; for review, cf. [Donaldson, Bennett, Baic, & Melichar, 2009](#)) but not affective variations. Although this line of evidence does not directly address our question, results seem to point out that the perception of taste intensity of bitter compounds (e.g., 6-n-propylthiouracil [PROP]) could ultimately impact body weight (e.g., [Lumeng, Cardinal, Sitto, & Kannan, 2008](#); [Tepper & Ullrich, 2002](#)). These studies suggest that greater responsiveness to the bitter taste of PROP is positively associated with a higher BMI in children, but this relationship is negative in adults. Unfortunately, it is not obvious from the gustatory perception data how the individual differences in aversive reactions may influence the body weight status, especially when sensory vs. affective aspects of taste stimuli have been separated via physiological, psychological and pharmacological manipulations in animals and humans ([Berridge, 2000](#); e.g., keeping the sensory properties of a taste unchanged, while altering its pleasantness). Therefore, the purpose of the present experiment was to compare the aversive responses to bitter-tasting stimuli, measured by subjective ratings and behavioural observations in a taste reactivity paradigm, between two healthy adult groups of varying BMI. Taking into account the evidence for a non-linear relationship between sensitivity to reward and BMI, indicating a positive relationship only in the normal and overweight range of BMI ([Davis & Fox, 2008](#)), the present study was limited to the BMI range of 17.7–29.9. We anticipated that individuals at risk of becoming overweight (BMI \approx 25) would be more responsive to the unpleasant properties of food than those with a low body

weight (BMI \approx 19). That is, high BMI should show lower scores on hedonic ratings and higher intensity of disgust facial expressions compared to low BMI, even after controlling the differences in taste responsiveness.

In view of the importance of providing a relatively pure indication of affect (isolated from the sensory and motivational properties of tastes), facial expressions were used here (cf. [Berridge, 2000](#)). This way of assessing responses to food, beyond self-report measures alone, was hoped to obtain a more exact evaluation of the relationship between the aversive reactions and BMI, given that objective measures of liking reactions may sometimes provide more direct access to hedonic systems than subjective reports ([Berridge, Robinson, & Aldridge, 2009](#)). In addition, it should be noted that many studies investigating taste preferences have found no hedonic differences as a function of body weight (for review, cf. [Bartoshuk, Duffy, Hayes, Moskowitz, & Snyder, 2006](#)), the methods used to compare sensory and affective experiences across groups being one possible explanation for these conflicting results. Concretely, psychophysical errors derived from subjective measures (e.g., visual analogue or category scales) have been suggested as a factor masking the relationship between orohedonic response and obesity ([Bartoshuk et al., 2006](#)). Moreover, unlike facial patterns, self-ratings might not represent accurate measures of pleasure/displeasure, because they may often conflate affective and motivational (i.e., desire to eat) components of food and be too overlaid with cognitions to pick up underlying core differences in food liking ([Mela, 2001](#)). In this sense, the present study additionally sought to extend prior findings (e.g., [Danner, Sidorkina, Joechl, & Duerrschmid, in press](#)) on the contribution of facial expressions to sensory evaluation and affective testing of bitter food; as well as explore the validity of hedonic self-report measures as assessment instruments of the affective experience when they are employed with bitter tastes.

Materials and method

Participants

Forty healthy adults (28 females, 12 males) from the Faculty of Agrarian Sciences (Pontificia Catholic University of Argentina, Argentina) were selected from a pool of people. Their ages ranged from 18 to 46 years ($M = 24.2$, $SD = 5.8$). Participants were asked to report their height and weight. On the basis of their BMI, two groups were formed: low BMI, consisting of lean subjects (BMI < 20; $n = 20$); and high BMI, encompassing participants that were at risk of becoming overweight and overweight (BMI > 23; $n = 20$). The BMI values of 20 and 23 corresponded to percentile 40 and 60 respectively of the reference sample and were deliberately selected in these ranges in order to establish a clear separation between BMI groups. The mean BMI was 19.1 for low BMI ($SD = 0.7$) and 25.2 for high BMI participants ($SD = 1.8$), being statistically different ($p < .05$). Exclusion criteria were aversions, smoking (more than 5 cigarettes per week; [Sato, Endo, & Tomita, 2002](#)), illnesses, a history of eating disorders, diabetes and allergy for the foods offered. Specially, participants who described themselves as being on weight-loss diets or actively losing weight were excluded; this factor might be associated to bias in reporting of sensory and affective perceptions of stimuli or influence the relationship between bitter responsiveness and body weight ([Tepper & Ullrich, 2002](#)). Subjects were contacted by e-mail and asked to participate in a research study investigating preferences for bitter foods. The experiment was approved by the Ethics Committee of the Pontificia Catholic University of Argentina. Participants were informed about the purpose of the study and that the experimental procedure would be video recorded. All subjects gave their written

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