**Article:**
de Carvalho-Ferreira, JP, Finlayson, G orcid.org/0000-0002-5620-2256, da Cunha, DT et al. (3 more authors) (2019) Adiposity and binge eating are related to liking and wanting for food in Brazil: A cultural adaptation of the Leeds Food Preference Questionnaire. Appetite, 133. pp. 174-183. ISSN 0195-6663

https://doi.org/10.1016/j.appet.2018.10.034

# ADIPOSITY AND BINGE EATING ARE RELATED TO LIKING AND WANTING FOR FOOD IN BRAZIL: A CULTURAL ADAPTATION OF THE LEEDS FOOD PREFERENCE QUESTIONNAIRE

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**Declarations of interest:** none.

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## ABSTRACT

The Leeds Food Preference Questionnaire (LFPQ) measures separable psychological components of food reward (Liking and Wanting). In this study a cultural adaptation of the LFPQ for a Brazilian population (LFPQ-BR) was examined by comparing liking and wanting scores in fasted and fed states and their association with adiposity and disturbed eating. A culturally adapted food picture database was validated by an online questionnaire completed by 162 individuals. Cluster analysis verified if the foods were accurately perceived in terms of sweetness, fat and calorie content. Subsequently, 48 male (N=21) and female (N=27) adults with mean Body Mass Index 26.6 (0.9) kg/m$^2$, and mean age 32.8 (1.4) years, were evaluated by the LFPQ-BR before and after a fixed test meal. The Binge Eating Scale was used to measure binge eating symptoms. There was a decrease in explicit liking, implicit wanting, and explicit wanting scores for food in general in the fed condition. The implicit and explicit wanting and explicit liking scores for high-and-low fat savoury food decreased and for high-and-low fat sweet foods increased to a greater extent after the savoury test meal. Body Mass Index was found to predict implicit wanting for high fat relative to low fat foods. Binge eating symptoms predicted high fat sweet explicit liking and explicit wanting in the fed condition. Finally, high fat sweet preference was found to be sex-related as females had greater implicit wanting for high fat sweet foods in fasted and fed states. The results presented here indicate that the LFPQ-BR is a useful instrument for the evaluation of liking and wanting for food in Brazil.



**Keywords:** food reward; liking; wanting; binge eating; adiposity; Brazil.

## INTRODUCTION

Overeating is an important risk factor for weight gain and because obesity prevalence is increasing worldwide (Swinburn et al., 2011), acquiring a comprehensive view of the factors that lead to overeating is crucial. It is already known that eating behaviour is not only modulated by hypothalamic circuitry, but is also determined by the hedonic system responding to an obesogenic environment (Berthoud, 2006). Natural rewards, like food, stimulate activation in the mesolimbic dopaminergic pathway (Lutter and Nestler, 2009) and individual variability in sensitivity to reward is a psychobiological trait linked to the development of obesity (Beaver, 2006).

Therefore, overeating is thought to be more than an imbalance of hormonal satiation and satiety signalling, but also occurs due to an excessive or weakened response to the hedonic aspects of food (Blundell and Finlayson, 2004). Considering the role of cognitive and hedonic aspects of eating behaviour helps to understand more than meal size and frequency, but also food preferences and choice, which are partly driven by the motivation and experience of pleasure obtained from food (wanting and liking for food). This distinction is key to comprehend overeating leading to weight gain in an environment where highly palatable and energy-dense foods are plentiful and affordable (Dalton et al., 2013b). Importantly, it is suggested that high palatable foods are consumed frequently even when energy needs are satisfied, while less tasty foods are not overconsumed and this is one of the key risk factors associated with obesity (Kenny, 2011). Thus, palatability is a key contributor to the decision to eat particularly for individuals susceptible to reward-driven eating.

The Leeds Food Preference Questionnaire (LFPQ) developed by Finlayson et al. (2007) is a computer-based platform designed to measure the separate constructs of liking and wanting according to key dimensions of food (e.g. fat/protein content and taste). The questionnaire measures ‘explicit liking and wanting’ directly using visual analogue scales and includes an

indirect measure of 'implicit wanting' using the reaction times of decisions between pairs of foods. Previous research with the LFPQ has demonstrated that liking for food, i.e. the perceived or expected pleasure value of the food, the appreciation of its sensory proprieties, or a judgment of the degree of pleasure it elicits (Dalton and Finlayson, 2014) is greater in fasted than fed states (Finlayson et al., 2008) and that liking for a recently eaten food decreases in a manner consistent with sensory specific satiation (Griffioen-Roose et al., 2010). Wanting on the other hand, i.e. the attraction that is triggered by the perception of a food or a food related cue in the environment (Dalton and Finlayson, 2014) is also increased for food in general in a fasted state (Alkahtni et al., 2016; Finlayson et al., 2008). However, it appears that wanting is more variable than liking and may differ moment to moment depending on a number of factors such as hunger state, time of day and/or the amount of attentional resources available (Dalton and Finlayson, 2014). For instance, disordered eating patterns (Dalton et al., 2013a; Finlayson et al., 2012) and a state of macronutrient imbalance (Griffioen-Roose et al., 2012) have been linked to increased wanting for specific foods.

Because cultural issues play a major role in food choice, selection, and consumption, cultural adaptation of LFQP may be necessary for use in Brazil . Studies have already shown that food choices and their motivators have a strong ethnic and cultural relationship (Januszewska et al., 2011; Prescott et al., 2002). As an example, a traditional Brazilian dietary pattern is defined by the consumption of rice, beans, green vegetables, potato, lettuce, eggs, milk, and meat (Marchioni et al., 2011). In contrast, people in the United Kingdom are likely to eat white bread, butter, tea and sugar, cakes, puddings, ham, bacon, potatoes, and vegetables (Pryer, 2001). Importantly, a previous research using the Leeds Food Preference Questionnaire (Leenaars et al., 2016) indicated as a limitation of their study the imperfect suitability of using the translated LFPQ for a Dutch population. They mentioned that some foods in the food database used in the LFPQ would be less familiar to Dutch consumers in comparison with those from the UK. For example, participants had difficult to identify one food as savoury or sweet. Therefore,

performing a validation study for the Brazilian Portuguese version (translation and food database suitability) is of major importance in using the instrument in Brazil.

Brazil is currently facing an epidemic of obesity and overweight (Malta et al., 2014). Recently, a food guide for the Brazilian population has been published suggesting that people should consume less processed foods, i.e. foods high in fat, salt and sugar, indicating the harm excessive consumption of these foods may bring about (Ministry of Health of Brazil, 2014). However, the food choice goes beyond the perceived risk and benefits. There are several benefits of having instruments to test components of food reward in a population. A reliable method that allows the quantification of liking and wanting for different dimensions of food may be valuable to link specific food preferences to health problems (such as weight gain and eating disease), or identify risk factors (Dalton et al., 2013a; Finlayson et al., 2012). Moreover, it is useful to test different types of diets under different contexts (Cameron et al., 2014; Griffioen-Roose et al., 2012, 2011; Hopkins et al., 2016) and to link food reward to other circumstances, such as sleep restriction (Leenaars et al., 2016).

The current study aimed to adapt the original LFPQ for the Brazilian population (LFPQ-BR). Furthermore, we tested the sensitivity of this cultural adaptation by comparing liking and wanting scores in fed and fasted states and their association with adiposity and scores on the Binge Eating Scale.

## MATERIAL AND METHODS

To meet the aims of the present study, some steps were performed. First, all the text from the task was translated into Brazilian Portuguese and a food picture database was created and validated for the Brazilian population. Following this cultural adaptation, an experimental procedure was conducted to test the sensitivity of this new version of the LFPQ for a Brazilian population.

### a) Food database validation

To create a food database for the LFPQ-BR, ready-to-eat popular foods in Brazil were photographed according to standardised procedure and 60 images went through an online validation process. An online questionnaire was created and released by email and social media and 162 respondents completed it. The questionnaire aimed to verify if the food pictures were accurately recognized, habitually consumed, and that they were correctly perceived in terms of fat content, number of calories and sweetness (high/low). The answers of any registered dietician (i.e. nutritionist in Brazil) or nutrition specialists were excluded.

Each food picture was presented one at a time and the respondents were asked the following questions for each one: do you recognize this food? (yes; I am not sure; no); have you already eaten this food? (yes; I am not sure; no); do you like this food? (yes; more or less; no). Additionally, participants were asked to rate on a 7-point Likert scale (with anchor points at 'almost nothing' and 'extremely') their answer to the questions: how much fat does this food contain? How sweet is this food? How calorie-dense is this food?

Foods were considered adequate if: 80% of the sample recognize, habitually consume them, and like them and if their mean values on the 7-point Likert scale answers were above 5 for the high content of fat, calorie and sweet taste; and lower than 3 for the low content of fat, calorie and sweet taste. Further, hierarchical cluster analysis using Ward's method was made to verify

distinctions among the food items. Three clusters were constructed: 1) content of fat; 2) content of sweetness and 3) calorie amount, using the answers for each food on the Likert scale. Dissimilarity dendograms, analysis of intraclass variance and centroid mean distance were constructed.

**b) The Leeds Food Preference Questionnaire (LFPQ) and Brazilian Portuguese Version of the LFPQ (LFPQ-BR)**

The LFPQ is a computer-based task developed to provide measures of different components of food preference and food reward. The measures taken by the task and the methodology used are summarized in Figure 01. Participants were presented with an array of 16 ready-to-eat food images, which are common in the diet. Food images were chosen from a validated database, four from each category, as follows: high fat sweet (HFSW), high fat savoury (HFSA), low fat sweet (LFSW) and low fat savoury (LFSA) (Dalton and Finlayson, 2014; Finlayson et al., 2008).

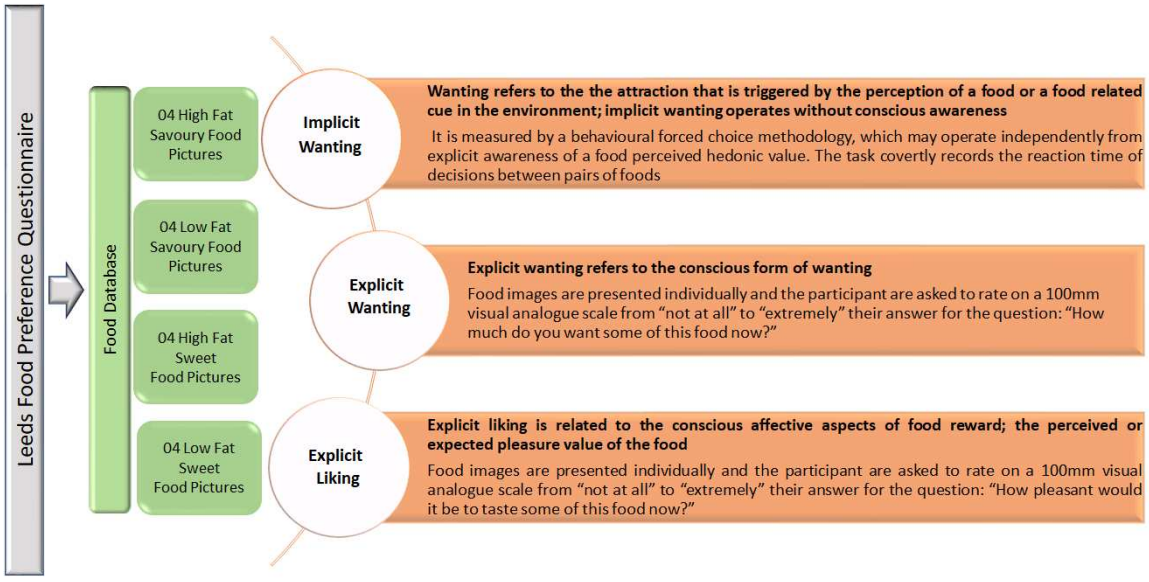


**Figure 1** Measures taken by the Leeds Food Preference Questionnaire.

Text from the original version of the LFPQ (Finlayson et al., 2007) was translated by one of the authors, a Brazilian-Portuguese native speaker with English Skills, who translated the English version into Brazilian-Portuguese. The original English task was also sent to a bilingual professor who has expertise in the area and to a certified translator. The versions were compared, discrepancies were discussed, and modifications were made to achieve the most accurate Portuguese version of the task, which was piloted before the experiment.

***Implicit wanting and food preference***

Implicit wanting and food preference were measured using a forced choice methodology. Participants are presented with 96 randomized food pairs ensuring every image from each of the four categories is compared to every image from other categories, and are instructed to answer as quickly and accurately as possible "which food do you most want to eat now?". Reaction times are covertly recorded and used to compute mean response times for each food category. Both selection (positively contributing) and non-selection (negatively contributing) are recorded to calculate implicit wanting scores (frequency-weighted algorithm). A positive score indicates a more rapid preference for a given food category relative to the alternatives in the task and a negative score indicates the opposite. A score of zero would indicate that the category is equally preferred (Figure 2).

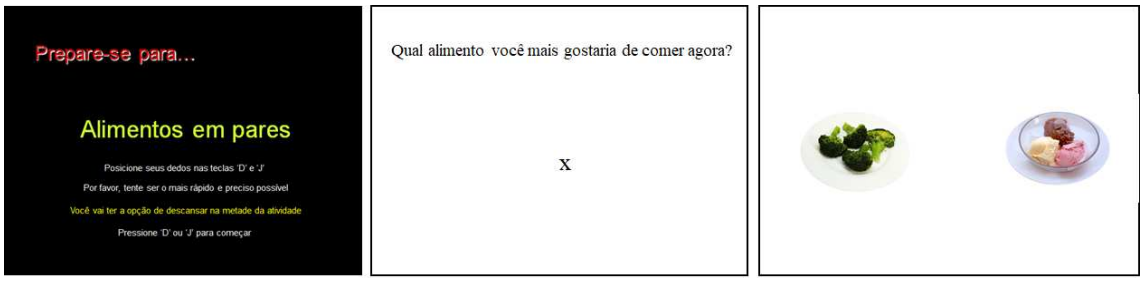


**Figure 2** Representation of the paired foods instructions and the implicit wanting trials of the LFPQ-BR.

*Which food do you most want to eat now?

***Explicit Liking and Explicit Wanting***

To measure explicit liking and explicit wanting, participants were presented with food images individually and were asked to rate on a 100mm visual analogue scale from “not at all” to “extremely” two questions for each food: “How pleasant would it be to taste some of this food now?” for explicit liking assessment and “How much do you want some of this food now?” for the explicit wanting measure. Final scores range from 0 to 100 (Figure 3).


**Figure 3** Representation of the single foods instructions, explicit liking (a) and explicit wanting (b) trials of the LFPQ-BR.

*(a)How pleasant would it be to taste some of this food now?*
*(b)How much do you want some of this food now?*
** Not at all ------- Extremely*

***Fat Appeal Bias and Taste Appeal Bias***

For each one of the constructs of food reward (explicit liking and wanting; and implicit wanting) the fat appeal bias and sweet appeal bias were calculated for explicit liking, explicit wanting or implicit wanting, according to high fat relative to low fat foods (subtracting the mean

high fat values from the mean low fat values), and sweet relative to savoury foods (subtracting the mean sweet values form the mean savoury values).

**c) Experimental procedure using the LFPQ-BR**

***Participants and Study Design***

Participants were recruited by social media and flyers with a call to participate in research about food preferences and behaviour. Forty-eight adult (above 18 and under 60 years) male and female participants were included. They participated in a voluntary basis, as they did not receive any form of reward for the study. Exclusion criteria were smoking, pregnancy, diagnosed metabolic disease such as diabetes and hypo - or hyperthyroidism, and allergies and/or aversion to the food served in the test meal or included in the LFPQ-BR.

The experiment was set up at the Dietary Technique Laboratory, which has a private air-conditioned room where the participants were evaluated. Screening was performed by email to investigate inclusion and exclusion criteria, and participants were asked to attend the laboratory following a 4-hour fast on a previously scheduled appointment between 11am and 13pm. Informed consent was obtained, and height and weight were measured with participants standing, wearing light clothes and no shoes. This was followed by testing the food preferences of the participants in fasted state, evaluated by the LFPQ-BR. A standardised test meal was provided, then 10 minutes after consuming it, the LFPQ-BR was undertaken again to evaluate food preferences in the fed state. Subjective appetite measures were undertaken before and after the test meal. Finally, the Binge Eating Scale was completed at the end of the experiment. The whole visit for each participant lasted approximately 1 hour. This study was formally approved by the ethical committee of the Federal University of São Paulo (#0531/2016) and was carried out in accordance with the principles of the Declaration of Helsinki.

***Test Meal***

The test meal was fixed at the same amount for all participants and was piloted before the experiment to adjust for taste acceptance and suitability of the amount provided. The lunch consisted of 500 gram (≅ 650 kcal) of penne, meatballs and mixed buttered vegetable (carrots, barred potato, broccoli and fine beans), 150 ml of orange juice and 150 ml of water. The test meal was planned to be predominantly savoury and we aimed to plan a balanced meal in terms of macronutrient distribution and calorie amount (Ministério do Trabalho e Emprego, 2006; Ministry of Health of Brazil, 2014) (Table 1). It was prepared fresh every day and participants were instructed to consume the meal in its entirety.

**Table 1** Nutritional value of the test meal planned to be balanced in terms of macronutrient distribution and calorie amount.

| Food | Total (g) | Protein (g) | Fat (g) | Carbohydrates g) |
|---|---|---|---|---|
| Pasta | 120.5 | 4.08 | 0.48 | 27.60 |
| Tomate sauce | 110 | 1.54 | 10.01 | 7.40 |
| Meat Balls | 124 | 26.59 | 11.13 | 11.71 |
| Buttered vegetebles | 149 | 2.28 | 3.30 | 14.37 |
| Orange juice | 150 | 1.05 | 0.15 | 11.40 |
| Total | 653.5 | 35.54 | 25.07 | 72.48 |

***Binge Eating Scale (BES)***

Binge eating symptoms were assessed using the Binge Eating Scale (BES). This is a 16-item self-report instrument to investigate behavioural manifestations (eight items) and feelings and cognitions (eight items) of binge eating. For each item, three or four statements are given that increase in severity and the participant is asked to select a statement that best describes how they usually behave/feel. Scores are summed and binge eating behaviour is classified into levels of severity: mild (scoring 17 or less), moderate (18-26) and severe (≥27) (Freitas et al., 2001; Gormally et al., 1982).

***Appetite Measures***

In order to verify the efficacy of the manipulation of the hunger/satiation state, subjective appetite measures were undertaken before and after the test meal, using a paper-based visual analog scale (VAS), where the participant selected a position on a continuous 100mm linear scale to represent their answer to the question. To evaluate hunger the participant answered the question "how hungry are you?" and the anchor points were "not at all hungry" and "extremely hungry". Desire to eat was measured by the question "how much food could you eat?" and anchor points "a small amount" and "a large amount". Finally, to evaluate fullness the question was "how full do you feel?" and anchor points were "not at all full" and "extremely full".

***Statistical analysis***

All variables underwent a compliance test to check their distribution against theoretical curves. For this, histograms were analyzed and the Kolmogorov-Smirnov test for normality and Levene test were applied to verify homoscedasticity.

General Linear Models (GLM) were used to observe the main effects and its interactions of taste (savory or sweet), fat (high or low) and condition (fasted or fed) among dependent variables: explicit liking, explicit wanting and implicit wanting. The t-Student test for related samples was used to compare different scores between two dependent groups.

Multiple linear regression models were developed to investigate the relationship between independent variables and dependent variables: explicit wanting of high fat sweet food, explicit liking high fat sweet food, implicit wanting high fat sweet food, explicit wanting sweet appeal bias and implicit wanting fat appeal bias. It was tested as independent variables for those who presented Pearson's correlation greater than 0.20 with dependent variables and only those with the statistically significant coefficient of regression remained. The insertion of

variables in the models was done by stepwise method with forward selection. The fit of the models was evaluated by residual analysis.

All analyses were conducted using Statistical Package for Social Sciences (SPSS) for Windows version 15.0.1. For all analyses, results were considered significant with $p<0.05$.

## RESULTS

### a) Food database validation

Results from the validation demonstrated that 33 food images were properly recognized and habitually consumed. Foods were considered adequate if their mean values on the 7-point Likert scale answers were above 5 for the high content of fat, calorie and sweet taste; and lower than 3 for the low content of fat, calorie and sweet taste. (Table 2). Further, we conducted cluster analysis to confirm the classification of each food in the category they were assigned.

**Table 2** Thirty three food cues validated for the LFPQ-BR, divided into the four categories.

| | Food | Reconize? | Have eaten? | Like? | Is it fat? (mean ± SD) | Is it sweet? (mean ± SD) | Is it high calorie? (mean ± SD) |
|---|---|---|---|---|---|---|---|
| High Fat Sweet | Chocolate M&Ms | 100% | 100% | 90.2% | 5.61 ± 0.8 | 5.94 ± 0.7 | 5.84 ± 0.7 |
| | Chocolate cheesecake | 91.9% | 90.2% | 80.5% | 5.45 ± 0.7 | 5.51 ±0.7 | 5.78 ± 0.8 |
| | Ice cream | 100% | 99.2% | 90.2% | 6.16 ± 0.8 | 6.00 ± 0.8 | 6.23 ± 0.8 |
| | Milk chocolate | 99.2% | 100% | 91.1% | 5.39 ± 0.8 | 5.54 ± 0.8 | 5.61 ± 0.8 |
| | *Paçoca*[1] | 88.9% | 92% | 80.5% | 5.30 ± 0.9 | 5.75 ± 0.9 | 5.67 ± 0.9 |
| | Chocolate chip cookies | 99.2% | 99.2% | 80.5% | 5.40 ± 0.8 | 5.52 ± 0.8 | 5.62 ± 0.9 |
| | Chocolate Balls* | 99.2% | 92% | 80.5% | 5.46 ± 0.9 | 5.54 ± 1.1 | 5.85 ± 0.8 |
| Low Fat Sweet | Red Grapes | 100% | 100% | 88% | 1.41 ± 0.7 | 5.08 ± 0.7 | 2.46 ± 1.1 |
| | Fruit Salad | 98.1% | 97% | 82.2% | 1.80 ± 0.8 | 5.08 ± 0.7 | 2.73 ± 0.9 |
| | Watermelon | 100% | 98.1% | 83.3% | 1.00 ± 0.0 | 5.12 ± 0.7 | 2.22 ± 1.1 |
| | Papaya | 100% | 97% | 82.2% | 1.69 ± 0.8 | 5.08 ± 0.7 | 2.36 0.9 |
| | Melon | 97% | 97% | 85.8% | 1.41 ± 0.7 | 5.05 ± 0.7 | 1.99 ± 0.9 |
| | Banana | 100% | 99.2% | 89.4% | 1.58 ± 0.8 | 5.13 ± 0.7 | 2.77 ± 1.0 |
| | Mango* | 92% | 92% | 85.8% | 2.39 ± 1.2 | 5.20 ± 1.0 | 2.85 ± 1.1 |
| High Fat Savoury | Cheeseburger | 100% | 98.4% | 80.5% | 5.93 ± 0.8 | 1.40 ± 0.7 | 6.18 ± 0.7 |
| | Pepperoni pizza | 99.2% | 99.2% | 90.2% | 5.89 ± 0.9 | 1.77 1.0 | 6.15 ± 0.7 |
| | *Coxinha*[2] | 99.4% | 97.5% | 85.8% | 6.30 ± 0.7 | 1.64 ± 0.9 | 6.42 ± 0.6 |
| | *Pastel frito*[3] | 98.1% | 96.3% | 83.3% | 5.88 ± 0.7 | 1.77 ± 0.9 | 5.86 ± 0.7 |
| | *Pão de queijo*[4] | 98.8% | 98.1% | 91.3% | 5.08 ± 0.7 | 1.72 ± 0.9 | 5.09 ± 0.9 |
| | French Fries | 98.4% | 97.6% | 86.2% | 5.89 ± 0.8 | 1.26 0.5 | 5.98 ± 0.8 |
| | Croissant with ham and cheese* | 100% | 95.9% | 86.2% | 5.29 ± 1.1 | 1.93 ± 1.1 | 5.65 ± 1.0 |
| | Salami slices* | 100% | 96.7% | 91.3% | 5.98 ± 0.9 | 1.51 ± 1.1 | 5.86 ± 1.1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Peanuts* | 95.6% | 95.6% | 85.1% | 5.08 ± 1.1 | 2.07 ± 1.4 | 5.17 ± 1.2 |
| Low Fat Savoury | Brocoli | 100% | 100% | 82.1% | 1.00 ± 0.0 | 1.00 ± 0.0 | 1.23 ± 0.5 |
| | Letuce-Tomato salad | 100% | 97.5% | 95.1% | 1.00 ± 0.0 | 1.35 ± 0.6 | 1.00 ± 0.0 |
| | Sweetcorn on the cob | 100% | 99.4% | 87.7% | 2.28 ± 1.0 | 1.91 ± 0.9 | 2.59 ± 0.9 |
| | Chicken-salad sandwich | 97.5% | 92% | 80.2% | 2.29 ± 0.7 | 1.69 ± 0.8 | 2.29 ± 0.9 |
| | Fine Beans | 95.1% | 90.2% | 83.3% | 1.64 ± 0.8 | 1.43 ± 0.8 | 1.89 ± 0.8 |
| | Tomatoes | 100% | 99.2% | 83% | 1.00 ± 0.0 | 2.03 ± 0.9 | 1.62 ± 0.8 |
| | Carrots* | 100% | 100% | 85.8% | 1.33 ± 0.6 | 2.37 ± 1.1 | 1.85 ± 1.0 |
| | Cod Meal* | 99.2% | 96.7% | 82.9% | 2.43 ± 1.1 | 2.43 ± 1.0 | 2.43 ± 1.1 |
| | Mixed salad* | 100% | 99.2% | 80.5% | 1.27 ± 0.6 | 1.35 ± 0.6 | 1.58 ± 0.8 |
| | Taboulli* | 85.8% | 82.2% | 80.5% | 2.38 ± 1.0 | 1.85 ± 1.1 | 2.85 ± 1.0 |

320 1 – Candy made with peanut; 2 - Shredded chicken meat, covered in dough, molded into a shape resembling a chicken leg, battered and fried; 3 - half-circle or rectangle-shaped thin crust pies with assorted fillings,
321 fried in vegetable oil; 4 - a type of baked starch tart cookie, salt vegetable oil and cheese. SD = standard deviation. *Food image validated but not used in the present experiment.

Table 3 presents the results of the hierarchical cluster analysis for three variables (sweetness, content of fat, and calories). For each variable, three clusters were generated (C1, C2 and C3).

**Table 3** Results of hierarchical cluster analysis for three variables (content of fat, content of sweetness and calorie amount).

| Variable | Cluster | Intraclass variation | Mean distance of centroid | Clustered food items | Suggested cluster name |
|---|---|---|---|---|---|
| Content of fat | C1 | 94.96 | 9.37 | French Fries, Cheeseburger, *Pastel Frito*, Pepperoni pizza, *Coxinha*, *Pão de queijo*, Chocolate cheesecake, Milk chocolate, Chocolate M&Ms, Paçoca, Ice cream, Chocolate chip cookies, Croissant with ham and cheese, Chocolate balls, Oreos, Cheese puffs, Glazed doughnut, Salami slices, *Qindim*, Peanuts. | High fat |
| | C2 | 103.48 | 9.32 | Chicken-salad sandwich, Letuce-Tomato salad, Tomatoes, Sweetcorn on the cob, Fine Beans, Brocoli, Watermelon, Banana, Red Grapes, Papaya, Melon, Fruit Salad, Carrots, Cod meal, Cucumber, Mixed salad, Tabouli, Mango, Apple, Strawberries, Orange, White rice. | Low fat |
| | C3 | 196.81 | 13.44 | Cake, Biscuit cereal bar, Cream Crackers, Yogurt with strawberry and blueberry, White toast with butter, Bread roll, Caramel cereal bar, Cheese & crackers, Beef sandwich, Muffin, Cashews, Scrambled eggs and toast, White toast with jam, Light yogurt, Brie, Marshmallow, *Biscoito de polvilho*, Boiled sweets. | Probably high fat |
| Sweetness | C1 | 121.57 | 10.64 | French Fries, Cheeseburger, *Pastel Frito*, Pepperoni pizza, *Coxinha*, *Pão de queijo*, Chicken-salad sandwich, Letuce-Tomato salad, Tomatoes, Sweetcorn on the cob, Fine Beans, Brocoli, Carrots, Croissant with ham and cheese, Cod meal, Cucumber, Cheese puffs, Salami slices, Mixed salad, Peanuts, Tabouli, Cream Crackers, White toast with butter, Cheese & crackers, Beef sandwich, Cashews, Scrambled eggs and toast, Brie, *Biscoito de polvilho*, White rice. | Low sweet |
| | C2 | 104.63 | 9.84 | Chocolate cheesecake, Milk chocolate, Chocolate M&Ms, *Paçoca*, Ice cream, Chocolate chip, cookies, | High sweet |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Watermelon, Banana, Red Grapes, Papaya, Melon, Fruit Salad, Chocolate balls, Oreos, Glazed doughnut, Cake, Quindim, Mango, Caramel cereal bar, Muffin, Marshmallow, Boiled sweets. | |
| | C3 | 170.35 | 11.99 | Biscuit cereal bar, Yogurt with strawberry and blueberry, Apple, Bread roll, White toast with jam, Strawberries, Orange, Light yogurt. | Probably high sweet |
| Content of Calories | C1 | 102.73 | 9.70 | French Fries, Cheeseburger, *Pastel Frito*, Pepperoni pizza, *Coxinha*, *Pão de queijo*, Chocolate cheesecake, Milk chocolate, Chocolate M&Ms, Paçoca, Ice cream, Chocolate chip cookies, Croissant with ham and cheese, Chocolate balls, Oreos, Cheese puffs, Glazed doughnut, Salami slices, Cake, Quindim, Peanuts, Bread roll, Muffin, Marshmallow, Boiled sweets. | High calorie |
| | C2 | 130.03 | 9.10 | Chicken-salad sandwich, Letuce-Tomato salad, Tomatoes, Sweetcorn on the cob, Fine Beans, Brocoli, Watermelon, Banana, Red Grapes, Papaya, Melon, Fruit Salad, Carrots, Cod meal, Cucumber, Mixed salad, Tabouli, Mango, Apple, Strawberries, Orange. | Low calorie |
| | C3 | 176.35 | 12.68 | Biscuit cereal bar, Cream Crackers, Yogurt with strawberry and blueberry, White toast with butter, Caramel cereal bar, Cheese & crackers, Beef sandwich, Cashews, Scrambled eggs and toast, White toast with jam, Light yogurt, Brie, *Biscoito de polvilho*, White rice. | Probably high calorie |

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The foods allocated on the C3 clusters of each analysis were not considered validated because the perception of the total fat, sweetness and/or calorie content appeared confusing to respondents. In other words, the third cluster indicated the participants did not consistently perceive that food as high or low fat/sweet/calorie.

Considering the above, a set of 33 food images were validated (Supplementary Figure 1) and 24 food images were used in the present experiment, 4 for each category and 2 backups for each category. The set of 16 foods were shown to participants before they started the task for the first time and the backup images were used when the participant reported strong disliking for any of the foods originally presented. The results of the food not validated for the LFPQ-BR can be seen in Supplementary Table 1 and the food pictures not validated are shown in Supplementary Figure 2.

**b) LFPQ-BR experimental results**

Twenty-one males and 27 females, born in Brazil, with a mean BMI 26.6 (±0.9) kg/m$^2$, ranging from 16.46 kg/m$^2$ to 54.28 kg/m$^2$ were evaluated in this study. Mean age was 32.8 (±1.4) years and they presented mean weight of 75.1 (±2.9) kg and height 1.67 (±0.01) metres. Family income was distributed as follow: 10.4% earn up to 2 minimum wages; 25% 2-4 minimum wages; 31% 5-10 minimum wages; 20.8% more than 10 minimum wages; and 12.8 % did not respond to this question. Percent of educational attainment levels was: 2.1% lower secondary level; 4.2% upper secondary level; 18.8% incomplete tertiary level; 20.8% complete tertiary level; and 54.1% post graduate level.

The results are expressed as mean (standard error). Fasted and fed scores of explicit liking, implicit wanting and explicit wanting of high fat savoury, low fat savoury, high fat sweet and low fat sweet, fat appeal bias and taste appeal bias are shown in Table 4.

**Table 4.** Implicit wanting, explicit liking and explicit wanting for the food categories and appeal biases of the LFPQ-BR on fasted and fed states.

| | Fasted | | | Fed | | |
|---|---|---|---|---|---|---|
| | Explicit Liking | Implicit Wanting | Explicit Wanting | Explicit Liking | Implicit Wanting | Explicit Wanting |
| HFSA | 66.8 (3.6) | 16.3 (5.2) | 60.9 (4.0) | 9.5 (1.8)[£] | -47.8 (2.0)[£] | 8.8 (1.8)[£] |
| LFSA | 65.6 (2.8) | 15.1 (3.7) | 66.4 (2.8) | 13.6 (2.0)[£] | -26.2 (2.9)[£] | 12.2 (2.1)[£] |
| HFSW | 46.3 (3.4) | -24.0 (4.7) | 41.3 (3.3) | 57.4 (4.1) | 38.7 (3.6)[£] | 53.2 (4.1) |
| LFSW | 51.6 (3.3) | -7.5 (4.8) | 50.4 (5.5) | 52.3 (4.6) | 35.2 (3.1)[£] | 49.1 (4.6) |
| Fat Appeal Bias | -2.0 (3.5) | -7.6 (6.19) | -7.3 (3.7) | 0.5 (2.0) | -9.0 (4.2) | 0.3 (2.2) |
| Sweet Appeal Bias | -17.2 (3.5) | -31.5 (5.7) | -17.8 (3.7) | 43.3 (3.8)[α] | 74.0 (2.8)[α] | 40.7 (3.7)[α] |

HFSA = High Fat Savoury; LFSA = Low Fat Savoury; HFSW = High Fat Sweet; LFSW = Low Fat Sweet

[α] Two way interaction between condition and taste; $p<0.001$

[£] Three way interaction between condition, taste and fat; $p<0.001$

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***Food reward in fasted and fed states***

*Explicit Liking*

Explicit liking was greater in fasted compared to fed state ($p<0.001$) and there was a greater explicit liking in general for sweet foods ($p<0.001$). As shown in Table 4, there was an interaction between condition and taste with a greater liking for sweet foods on fed compared to fasted condition and a three way interaction between condition, taste, and fat with explicit liking for high fat and low fat savoury foods decreasing in the fed compared to the fasted state.

*Implicit wanting*

There was a main effect of taste with implicit wanting being higher for sweet compared to savoury food ($p<0.001$). There was an interaction between condition and taste as there was an increase in implicit wanting for sweet foods in the fed compared to fasted state. Finally, there was an interaction between condition, taste and fat: implicit wanting for high fat and low fat savoury were higher in the fasted compared to fed state and the opposite for high fat and low sweet (Table 4).

*Explicit Wanting*

Explicit wanting was higher in the fasted state ($p<0.001$) and a greater for sweet compared to savoury foods ($p<0.001$). An interaction between condition and taste showed a greater explicit wanting for sweet foods in the fed compared to fasted state and, lastly, there was a three way interaction between condition, taste and fat with explicit wanting for high fat savoury and low fat savoury foods being higher in the fasted compared to fed state (Table 4).

***Comparisons between high and low binge eating scorers, sex and food reward in fasted and fed states***

Univariate analysis showed that the explicit liking sweet appeal bias (explicit liking for sweet relative to savoury food) was greater in individuals who scored more (scored greater than 7.5 [median value]) on binge eating symptoms (p=0.03). Additionally, individuals with higher binge eating symptoms scores presented greater explicit wanting for high fat sweet in the fed state (p=0.04), while scoring lower on explicit wanting low fat sweet, although this last result only approached significance (p=0.09).

Comparisons between sexes showed that women had greater implicit wanting for high fat sweet (-12.9 versus -38.3; p=0.007) and implicit wanting sweet appeal bias (-21.2 versus -44.9; p=0.03) compared to men in the fasted state. In the fed condition, implicit wanting high fat sweet was also greater for women (45.3 versus 30.3, p=0.03).

***Independent predictors of food reward***

All measures of the LFPQ (36 measures) in fasted and fed states were tested for correlation with the participant's BMI. Six of these measures presented $r>0.25$ and $p<0.05$. A positive association between BMI and implicit wanting fat appeal bias in the fasted state (r=0.329; p=0.023) and with implicit wanting high fat sweet in the fasted state (r=0.411; p=0.004) was observed. A negative correlation was also found between BMI and implicit wanting low fat savoury (r=-293; p=0.043) and explicit wanting low fat savoury (r=-0.331; p=0.021) in fasted state. In the fed condition explicit wanting low fat sweet (r=-0.287; p=0.048) and explicit liking low fat sweet (r=-0.301; p=0.038) presented a negative correlation with BMI.

As can be seen in Table 5, regression analysis showed that BMI was an independent factor of implicit wanting high fat sweet in the fasted state, and sex (female) was an independent factor of this variable in fasted and fed states. BMI was also an independent predictor of fat

appeal bias in the fasted state after the result was adjusted for sex. In addition, explicit wanting high fat sweet and sweet appeal bias was associated with binge eating symptoms and age in the fed state, but not when fasted. Lastly, binge eating symptoms were also an independent predictor of explicit liking high fat sweet in the fed state and not the fasted state.

It was not possible to fit a significant model for the variables high fat savoury, low fat savoury and low fat sweet in fasted and fed states.

**Table 5** Multiple regression analysis of LFPQ measures and independent factors in fasted and fed states.

| | Fasted | | | Fed | | |
|---|---|---|---|---|---|---|
| Model | Independent Variables | Standardized coefficients (β) | P | Independent Variables | Standardized coefficients (β) | p |
| Explicit Wanting HFSW | Constant† | 34.47 | **0.001** | Constant | 90.50 | **<0.001** |
| | Age (years) | -0.13 | 0.36 | Age (years) | -0.30 | **0.03** |
| | BES | 0.21 | 0.15 | BES | 0.38 | **0.008** |
| | | | | BMI (kg/m²)* | -0.24 | 0.11 |
| Explicit Liking HFSW | Constant† | 52.16 | **<0.001** | Constant | 92.60 | **<0.001** |
| | Age (years) | -0.17 | 0.24 | Age (years)* | -0.25 | 0.09 |
| | BES | 0.06 | 0.66 | BES | 0.32 | **0.02** |
| Implicit Wanting HFSW | Constant | -67.64 | **<0.001** | Constant | 45.31 | **<0.001** |
| | Sex†† (1=F;0=M) | -0.40 | **0.001** | Sex†† (1=F;0=M) | -0.30 | **0.03** |
| | BMI (kg/m²) | 0.42 | **0.002** | | | |
| Explicit Wanting Sweet Appeal Bias | Constant† | -38.07 | **0.02** | Constant | 56.04 | **<0.001** |
| | Age (years) | 0.21 | 0.15 | Age (years) | -0.35 | **0.01** |
| | BES | 0.06 | 0.65 | BES | 0.32 | **0.02** |
| Implicit Wanting Fat Appeal Bias | Constant | -57.99 | **0.02** | Constant† | -14.84 | 0.39 |
| | BMI (kg/m²) | 0.33 | **0.02** | BMI (kg/m²) | 0.11 | 0.43 |
| | Sex†† | -0.18 | 0.19 | Sex††* | -0.27 | 0.06 |

HFSW = High Fat Sweet

Bold values are significant variables (p<0.05) of significant models; *Adjustment variable; † not significant model; ††F= female; M=male; BMI=Body Mass Index; BES= Binge Eating Scale

***Subjective appetite measures in fasted and fed conditions***

Results from the VAS indicated a good manipulation of fasted/fed state. Subjective measures of hunger (62.8 ± 21.1 *vs* 4.0 ± 7.1; $p<0.001$) and desire to eat (61.2 ± 18.0 *vs* 7.2 ± 14.6; $p<0.001$) decreased significantly, while fullness (27.3 ± 21.3 vs 87.6 ± 11.4) increased significantly after consuming the test-meal. A negative correlation was found between fullness and binge eating scores in the fed condition ($r=-0.391$; $p<0.001$).

## DISCUSSION

The main aim of this study was to test the sensitivity of a culturally adapted version of the Leeds Food Preference Questionnaire for a Brazilian population (LFPQ-BR). The LFPQ presents a standardised methodology to measure distinct psychological constructs of food reward (Liking and Wanting), which is novel in Brazil. The results showed there was consistency between the LFPQ-BR results and previous studies in the literature on food reward with decreased explicit liking, implicit wanting and explicit wanting for food in general in the fed state, and an increase for sweet preferences after a savoury test meal. Binge eating symptoms were confirmed to be a relevant predictor for high fat sweet liking and wanting in the present population. Importantly, we evaluated the procedure using male and female participants with a wide range of BMI, which enabled us to test for the effect of adiposity and sex on LFPQ outcomes for the first time.

It was observed that some foods were not properly (or consistently) recognized in terms of their nutritional value (sweetness and content of fat and calories). Therefore, some food images were not considered validated for the LFPQ-BR. Additionally, a few foods were not confirmed as being habitually consumed and/or liked, thus were not considered adequate for use even though they were adequately perceived in terms of their nutritional value. All together, these measures were taken to ensure the instrument is culturally adapted.

Our results are consistent with those reported in previous studies using-the LFPQ with increased ratings of explicit measures of liking and wanting for food in general under fasted compared to fed conditions (Alkahtni et al., 2016; Cameron et al., 2014; Finlayson et al., 2008),

Furthermore, we were able to observe that explicit liking, explicit wanting and implicit wanting for both high and low fat savoury foods decreased in the fed compared to fasted state. This three way interaction is a result consistent with Griffioen-Roose et al. (2010) who reported a decrease of liking and wanting of snacks with a similar taste from a given preload, being that

savoury would have a stronger modulating effect on subsequent food choice than a sweet preload. Thus, we were able to observe in our study a form of sensory specific satiation after a predominantly savoury test-meal.

We found a two-way interaction between condition and taste on the three components of food reward: explicit liking, explicit wanting and implicit wanting for sweet foods was increased to a greater extent under fed compared to fasted states. In other words, in addition to sensory specific satiation, we also observed an increased implicit and explicit wanting and explicit liking of sweet taste under fed compared to fasted states after a savoury meal, which also indicates a separation in liking and wanting in a manner consistent with the previously consumed food (transition from a wanting and liking of a savoury to a sweet taste after a savoury meal)Therefore, the cited results support the sensitivity of the LFPQ-BR to identify a switch in taste preference after a test meal.

Regression analyses highlighted that BMI was an independent predictor of implicit wanting fat appeal bias after adjusting for sex, meaning that BMI would similarly predict greater implicit wanting for high fat relative to low fat food in men and women. This finding is conceptually interesting as the implicit wanting ratings are measured by a behavioural forced choice methodology when the participant is instructed to select the food – presented in pairs – "they most want to eat now" and participant reaction time is covertly recorded. Thus, the motivated behavioural response may operate independently from the explicit awareness of a food perceived hedonic value (Finlayson et al., 2008). As further support to present the LFPQ-BR as a valid method, this finding is in accordance to Nijs et al (2010) who reported a tendency in overweight/obese women – especially in a hungry state – to have an enhanced automatic orientation towards food pictures compared to lean women. In fact, evidence for an association between reward sensitivity and BMI has been shown, suggesting that genotype, dietary factors, and signals from adipose tissue that are altered by weight status may have an effect on

dopaminergic transmission (Horstmann, 2017). Therefore, the results presented here implying an effect of weight status on high fat food preference, highlights the sensitivity of this simple, easy-to-use and accurate behavioural task (LFPQ) to provide important evidence in human food-reward research.

When it comes to sweet preferences, an interesting sex and BMI effect was found in our regression model. It was observed that sex (with female being the indicative category) and BMI were independent factors of implicit wanting high fat sweet foods in the fasted state and sex remained as a predictor in the fed state. Previous studies have shown that females tends to prefer sweet-related comfort food, while males tends to prefer savoury meal-comfort food Wansink et al (2003) and impaired control over eating sweets and mood altering effects of eating sweets were found to be more likely in female than male participants (Kampov-Polevoy et al., 2006). Why or how the hedonic sensitivity to this type of food is sex-dependent is largely unknown, however, animal data offer some support, demonstrating sex-related effects on gene expression in the mesolimbic reward system after a high fat and high-sugar cafeteria diet Ong et al (2013).

We also sought to verify the role of binge eating symptoms on the LFPQ-BR results. Previously, (Dalton et al., 2013a) have shown that both lean and obese women with high scores on the BES had enhanced wanting for high fat sweet foods and increased intake and/or craving for this type of food. We found that individuals with higher scores of binge eating symptoms presented greater explicit wanting for high fat sweet food in the fed state. Additionally, we observed greater explicit liking sweet appeal bias (explicit liking for sweet relative to savoury food) in the higher BES group compared to the lower BES group. Kampov-Polevoy et al. (2006) suggested that craving and impaired control over eating sweets is related to sweet liking. Earlier, Greeno et al. (2000) also linked the hedonic response to sweet taste to binge eating.

Moreover, the BES score was an independent predictor of explicit wanting and liking for high fat sweet food and explicit wanting sweet appeal bias. A greater wanting and liking (hedonic hunger) for high fat sweet foods in the absence of hunger (fed condition) on individuals who scored higher on BES was observed. In fact, highly palatable food continues to be consumed even when energetic needs are satisfied, which does not happen to the same extent with standard food (Finlayson et al., 2007; Kenny, 2011) and this outcome for binge eating strengthens the validation of the LFPQ-BR. Previously, Nasser et al (2008) have demonstrated that obese individuals with binge eating showed increased motivation for food when satiated, but not when hungry. Therefore, we suggestthat in the presence of physiological hunger the results would be more balanced between higher binge eating and lower binge eating groups and the difference would become greater when hunger was suppressed.

Although the manipulation of hunger state was efficient (evaluated using a 100mm visual analog scale before and after the test meal) we observed a negative association between fullness and binge eating scores at fed condition and a positive association between binge eating scores and hunger also after the meal, but this last result only approached significance. It is important to mention that reward-driven eating has been suggested to override the effect of satiety (Berthoud and Morrison, 2008), however, this is still a provocative idea because it has also been shown that weakened satiety and elevated post prandial hunger are features of binge eating disorders (Sysko et al., 2007). Therefore, in accordance with Finlayson et al. (2011), the results presented in this study would indicate that trait binge eating would be related to differences in both hunger and reward. Future studies are needed to confirm this hypothesis as (a) we have not evaluated a binge eating clinical sample and (b) we did not have high levels of binge eating severity in our sample. Thus, these findings should be interpreted with caution.

This study has some strengths and limitations. As cited, we did not evaluate a binge eating clinical sample, which could have given more clear results. Nevertheless, we were able to

distinguish responses related to hedonic eating in individuals who scored higher or lower on the binge eating scale. On the other hand, we used a wide range of BMI and this could be taken as a strength of the present study, along with the effort of having a measure of hunger/satiation to test the state manipulation. Another limitation was the sample size. Because our study is complex and employed a number of steps, it was hard to recruit participants. Some non-significante effects and differences observed in the univariate analysis could be significant in a larger sample. Furthermore, investigating a more heterogeneous sample in terms of socioeconomic status would be a very interesting issue for future research.

**In conclusion**, the LFPQ-BR, evaluated before and after a fixed test meal, demonstrated good consistency with previously reported outcomes using the original version of the platform. We were able to distinguish responses according to adiposity and perturbed eating behavior and demonstrated important sex-dependent food choices. Therefore, the results presented here indicate that the LFPQ-BR is a potentially useful instrument for the evaluation of liking and wanting for food in the Brazilian population.

**FUNDING:** This research was supported by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo), grant #2016/17230-7.

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