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Exploring the pathways from the power of food to food cravings in a sample of Brazilian young adults

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ABSTRACT

The present study has three main objectives: a) to analyse, for the first time, the factor structure of the Control of Eating Questionnaire (CoEQ) in a Brazilian sample; b) to explore, through in-depth interviews, motivators and consequences of food cravings among participants with high scores on the CoEQ; and c) to analyse whether and how the power of food is related to food cravings. The study involved 335 young adults aged 18–30 years, balanced for sex. The CoEQ and the Power of Food Scale (PFS) were used in an online survey. The CoEQ and PFS were subjected to confirmatory factor analysis. Semi-structured interviews were also conducted with a subsample (n = 20) with high CoEQ scores. The Socratic questioning method was used for the interviews. The interviews were transcribed and analysed according to thematic content analysis. The PFS and the CoEQ showed adequate factor structure with reliable factors. The results of the qualitative analysis showed that both food availability and seeking relief from stressors serve as motives for food cravings. Concern for health and weight gain were cited as consequences of cravings, as was seeking distraction to cope with these cravings. It was found that the PFS aggregate factor was a significant influencing factor for craving control ($\beta = 0.604$; $p < 0.001$), craving for savoury ($\beta = 0.382$; $p < 0.001$), craving for sweet ($\beta = 0.414$; $p < 0.001$) and positive mood ($\beta = -0.198$; $p < 0.001$). The findings suggest that the relationship between food cravings and the power of food is significant in today's obesogenic environment.

1. Introduction

High food availability and exposure to food cues in the environment are a risk factor for increased food consumption and weight gain in susceptible individuals (Boswell & Kober, 2016). In an obesogenic environment, where the availability of highly palatable foods is ubiquitous, food choices and intake are often motivated by hedonistic rather than homeostatic reasons (Mankad & Gokhale, 2021; Marsola, Cunha, Carvalho-Ferreira, & Da Cunha, 2020), such as a *strong desire to eat* (Hallam, Boswell, DeVito, & Kober, 2016). Food cravings refer to an urge for a particular food or group of foods, which is manifested by intense and intrusive thoughts alongside a strong urge to consume. This feeling is often accompanied by a sense of lack of control and anticipation of pleasure (Taylor, 2019). Increased food cravings have been associated with higher intake of palatable foods (Massicotte, Deschênes, & Jackson, 2019). The presence of palatable food can trigger a cue-induced craving or even a state craving if the food is not physically present but easily accessible (Hallam, Boswell, et al., 2016). With this in mind, psychometric tools have been developed to help researchers and practitioners assess individual variability in hedonic hunger aspects and food cravings, such as the Control of Eating Questionnaire (CoEQ) and the Power of Food Scale (PFS).

The CoEQ was validated by Dalton, Finlayson, Hill, and Blundell (2015) as a scale that measures the frequency, intensity, specificity, and behaviour associated with food cravings by providing information about appetite and affective state. The scale was used in a cross-sectional analysis conducted by Smithson and Hill (2017) to examine the frequency and nature of intense cravings in individuals who participated in weight management programmes. The researchers concluded that feeling control over food was associated with greater weight loss, suggesting that craving behaviour influences weight management. Similar results were also observed by Dalton et al. (2017).

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The PFS was developed by Lowe et al. (2009) and was initially introduced as a scale to analyse parameters related to hedonic hunger, which is characterised by preoccupation with, and consumption of, food for pleasure in the absence of physical hunger (Horwath, Hagmann, & Hartmann, 2020; Mankad & Gokhale, 2021). The scale assesses self-reported motivation to eat palatable foods, especially in environments where food is constantly available considering three domains: food present, food tasted, and food available (Espel-Huynh, Muratore, & Lowe, 2018; Ulker, Ayyildiz, & Yildiran, 2021). In a sample of older adults living with obesity those who scored higher on the PFS were more likely to have increased cravings for palatable foods (Rejeski et al., 2012). This indicates a possible link between motivation to consume palatable foods and food cravings.

Of note, both the CoEQ and PFS do not analyse actual food consumption but possible anticipatory factors for it. Nonetheless, the context differs from the parameters of physiological hunger, as this increases in intensity due to the absence of food (Dalton et al., 2017) and can be satisfied with any type of food, whereas intense cravings are usually satisfied with specific foods (Meule, 2020). Therefore, this connection between control over the power of food and food cravings is quite logical, but thus far, little research has been conducted. While the PFS and CoEQ scales used in the present study measure similar traits, such as motivation to eat (Dalton et al., 2015; Espel-Huynh et al., 2018), they differ. The PFS analyses preoccupation with eating in the absence of physical hunger (Horwath et al., 2020) and the CoEQ assesses the intensity of craving for palatable foods and the level of control an individual perceives themselves to have over those cravings (Dalton et al., 2015). Therefore, it remains unknown whether the domains of PFS and CoEQ are related. Is the motivation to eat palatable foods closely related to the control of cravings? How does the power of food correlates the craving for sweet and savoury foods differently?

To better answer such questions, special attention should be paid to the role of sex in research on eating behaviour. Women are at greater risk of obesity, body image problems, and having food cravings than men (Hallam, Boswell, et al., 2016; Macedo & Diez-Garcia, 2014; Rodgers, McLean, & Paxton, 2015). The type of food craved, the level and frequency of cravings, and the ability to regulate food cravings are thought to be key aspects that differentiate men and women (Hallam, Boswell, et al., 2016). Given that cravings vary in men and women, it is important that research on food cravings includes both men and women.

In this research we were interested in understanding the environmental determinants of cravings or the triggers related to the presence of palatable foods in the environment. Most research to date in the field has used quantitative data. Research with qualitative or mixed methods approach are scarce in the field. However, qualitative data can contribute to a deeper understanding of the quantitative information, explain the results obtained and give meaning to the numbers (Connelly, 2009). Such in-depth information also offers value when investigating psychometric scale criterion validity. Therefore, in an effort to better understand eating motivations in an urban environment, using a mixed-methods approach, the present study had three main objectives: a) to analyse, for the first time, the factor structure of the CoEQ in a sample of Brazilian adults; b) to explore, through in-depth interviews, motivators and consequences of food cravings among participants with high scores on the CoEQ and c) to analyse whether and how the power of food is related to food cravings.

2. Methods

We carried out a mixed methods approach for this study, employing a quantitative approach in the first step and a qualitative approach in the second step, i.e. a sequential explanatory design (Bartholomew & Brown, 2012). There are different definitions and cutoffs to determine adolescence and young adults in Brazil (Fiorini, Moré, & Bardagi, 2017). In this study, young adults were defined as individuals between the ages of 18 and 30. They were invited to participate through social media calls. Participation was voluntary, and all participants gave free and informed consent. The study methods were approved by the Research Ethics Committee of the *Universidade Estadual de Campinas* (CAEE: 40026320.3.0000.5404).

2.1. First step - Quantitative approach

2.1.1. Sample

Data were collected online via Qualtrics from 11th October to November 16, 2021. The survey was announced via social media (e.g., Facebook, Instagram and email) and aimed to reach a minimum of 300 participants (150 men and 150 women for balanced groups). According to Kyriazos (Kyriazos, 2018), a sample >200 would be appropriate for confirmatory factor analysis (CFA), as most factors have more than three indicators. A sample of 300 is recommended for multivariate analysis (Kyriazos, 2018). Participants answered the PFS and CoEQ, in this order, in addition to a socioeconomic questionnaire that included questions on sex, age, city and state they live in, whether they were studying or have a degree in any area of health and education level, weight (kg), height (m), email and mobile phone number.

To avoid bias, the recruitment advert stated that the objective was to assess general eating behaviour, and did not include information about the study objective (i.e., food craving assessment). Adults aged 18–30 years (both sexes) who were Brazilians living in Brazil were included. Participants with monotonous responses (standard deviation equal zero for any questionnaire) (n = 1); incomplete responses in PFS and CoEQ (n = 7) were excluded.

2.1.2. Measures - CoEQ and PFS

The CoEQ questionnaire consists of 21 indicators of food cravings and mood, and the participants are asked to answer regarding their experience over the last seven days (Dalton et al., 2015). The results are given according to four factors: craving control, craving for sweet, craving for savoury and positive mood. Four items are not included in the subscales; items 1 and 2 provide information on general feelings about appetite, and items 20 and 21 provide information on the person's degree of control over resisting a particular food they identify as being difficult to control their consumption of. Item 20 is an open-ended question that allows the participant to specify the food item they are craving. The questions of each indicator are answered using visual analogue scales ranging from 0 to 100 mm, and one item allows the participant to specify a particular food (Dalton et al., 2017). The score for each factor is the mean of the indicators. For Positive Mood, the score for item 6 is inverted; for Craving Control, the higher the value, the lower the craving control. The CoEQ indicators and scales was translated for Brazilian Portuguese by two researchers with a PhD in the field Nutrition and Psychology.

The PFS is a scale consisting of 15 indicators. It is divided into 3 factors: food available (food that is available in the environment but not physically present); food present (reactions to a food that is physically present but not yet experienced); and food tasted (reactions to a food that is physically present and being experienced for the first time) (Lowe et al., 2009). The indicators are rated on a scale from '1 - I strongly disagree' to '5 - I strongly agree' (Lowe et al., 2009). The PFS has already been used for the Brazilian population (Paiva, Carvalho-Ferreira, Penati, Buckland, & da Cunha, 2022), with a slight adaptation of the Portuguese version. The higher the total score, the more strongly the person responds to the food environment (Cappelleri et al., 2009).

2.1.3. Data analysis

For data analysis, first, the theoretical distributions of the variables were analysed using means, variances, skewness, kurtosis and the histogram of the distribution. The Kolmogorov–Smirnov test (with Lillefors correction) was used to check the normality of the data. CoEQ and PFS were subjected to confirmatory factor analysis (CFA). Although it is a validated instrument already in use in Brazil, we decided to conduct the

CFA in the PFS to ensure the quality of the constructs. CFA was performed following the original structure of CoEQ (Dalton et al., 2015) and PFS (Cappelleri et al., 2009) using robust maximum likelihood (ML) and diagonally weighted least squares (DWLS), respectively. The differences between the CFA methods are due to the difference in the scales of both questionnaires, count (CoEQ) and ordinal (PFS). The chi-square value (χ^2 with $p < 0.05$), root mean square error of approximation (RMSEA <0.08), comparative fit index (CFI >0.90), standardised root mean square residual (SRMR <0.08), Tucker–Lewis index (TLI >0.90), and goodness-of-fit index (GFI >0.90) were used to check model fit (Kline, 2016). Due to suboptimal fit of CoEQ original structure in the CFA, an Exploratory Factor Analysis (EFA) was conducted for this questionnaire. Valid items were extracted using ML. The number of factors to be retained was made using the eigenvalue criteria. EFA was performed with Promax rotation, allowing possible positive correlation among the CoEQ factors. The RMSEA (<0.08), CFI (>0.90) and TLI (>0.90) were used to check the goodness of fit (Brown, 2006). The Kaiser–Meyer–Olkin (KMO >0.70) and Bartlett's tests ($p < 0.05$) were used to check sampling adequacy. Groups (man x women) were compared using Welch's t-test and Cohen's d for effect sizes. These analyses were performed using JASP 0.16.1.

2.2. Second step - Qualitative approach

2.2.1. Sample

Only participants with high scores for craving for sweet or for savoury foods were invited (in the 4th quartile of the distribution, i.e. with a mean score of more than 68 for savoury and 71 for sweet foods) to participate in the individual in-depth interviews. For the analyses, four participant lists were created that took into account sexes (men/women) and high craving (sweet/savoury) for a purposeful sampling (Sandelowski, 1995). Participants were invited randomly until we reached the minimum number of participants of 20. The sample was chosen to create homogeneous groups, i.e., five men with craving for sweets (MSW), five women with craving for sweets (WSW), five men with craving for savoury (MSV), and five women with craving for savoury (WSV). With the sample it was possible to reach saturation.

For this second step of the project, participants were contacted by telephone or e-mail (had previously agreed to be contacted) and were reminded about the study and were invited to an interview with a psychologist for more information. A total of 83 participants were contacted, and 20 agreed to participate.

2.2.2. Interview and analysis

The individual interviews were conducted online via Google Meet by a psychologist. Each interview lasted an average of 30 min. The Socratic questioning method was used (Paul & Elder, 2007). Participants answered nine open-ended questions based on four cores: origin, assumption, consequence, and evidence (Table 1). Some additional contextual questions could be included for clarity.

Table 1
Questions for the interview following the Socratic questioning method.

Core	Question
Warm up	What is your name and age? What is your favorite food? What is your job or study?
Origin	1) When in the presence of food cues (thinking, smell, visual cues …) of tempting foods, what kind of thoughts and feelings do you have? 2) Are there times when you are more likely to experience food cravings (e.g., when hungry, tired etc.): 3) Do you think your emotions (e.g., sad, happy etc.) affect your food cravings?
Assumptions	4) Why do you think it is so difficult to resist any food cravings?
Consequence	5) What is the consequence in your life of not resisting food cravings?
Coping strategies	6) What helps you to resist a food craving? 7) Is it something that you think you are able to change? (food cravings)
Evidence	8) Can you provide an example when you had a food craving?

The qualitative approach aimed to explore three defined research questions: a) What motivates participants to have food cravings? b) What impact does food cravings have on participants' life? c) What coping strategies are used for food cravings? Before the questions began, a simple definition of food cravings was provided to participants, i.e. "Food craving is defined as an intense desire to eat a specific food" (Dalton et al., 2015). In order not to bias the answers, the questions were general.

The entire content of the in-depth interviews was transcribed and analysed according to Laurence Bardin's qualitative method of content analysis of the thematic type (Bardin, 1977). In this method, speeches are divided into meaning cores, originating nonprioristic categories. The principal researcher determined the category and was later reviewed independently by three other researchers for validation and grouping. A final discussion was made for consensus. The differences between men and women and between those who craved savoury and sweet foods were determined by the count of people in each group who presented the meaning core in their speech. The qualitative data were analysed using MAXQDA© software - VERBI GmbH 2018.

2.3. Third step – Modelling

Structural equation modelling with partial least squares (PLS-SEM) was chosen to analyse the relationship between PFS and CoEQ. PLS-SEM minimises sample size limitations, makes no distributional assumptions and is an appropriate approach to deal with second-order models (Van Riel, Henseler, Kemény, & Sasovova, 2016). The hypotheses were specified *a priori, i.e.,* before the data were collected. First, a 1st-order model was tested to examine the individual effects of the PFS factors on the CoEQ factors. Since the results were significant, a 2nd-order model was tested that included an aggregate power of food factor. In both models, all indicators validated in the previous CFA were included to form the latent variables, i.e. food tasted, food present, food available for PFS and craving control, craving for sweet, craving for savoury and positive mood for CoEQ. The bias-corrected and accelerated bootstrap procedure with 5,000 samples was used to estimate the t-statistics (significance: $t > 1.96$) and p values (significance: $p < 0.05$) of the estimated loadings. The outer model (part of the model that describes the relationships among the latent variables and their indicators) was assessed using the factor loadings (>0.40), the composite reliability (CR > 0.80) and the average of the variance extracted (AVE > 0.40). The inner model (the part of the model that describes the relationships among the latent variables) was assessed using the variance explanation of the endogenous constructs, effect sizes ($f^2 > 0.10$), and predictive relevance (Stone-Geisser's $Q^2 > 0.15$). The values and indicators were used as suggested by Henseler et al. (Henseler, Ringle, & Sinkovics, 2009). The heterotrait-monotrait ratio (HTMT) of correlations was used to assess discriminant validity (< 0.85) (Hair, Hult, Ringle, & Sarstedt, 2016). Multicollinearity was assessed using variance inflation factor (VIF) values (< 3.3) (Henseler, Ringle, & Sarstedt, 2015). The PLS-SEM was conducted with SmartPLS v3.2.8 (SmartPLS GmbH. Boenningstedt - Germany) (Ringle et al., 2015).

3. Results

3.1. Sample

The sample comprised of 335 young adults and 54% females (Table 2). The mean age was 24 years old (standard deviation = 4.02). The overall mean self-reported BMI was 25.5; 6.1 kg/m^2, (women: 25.3; 7.3 kg/m^2; men: 25.8; 4.4 kg/m^2). There were no significant differences between sexes regarding age ($p = 0.58$), BMI ($p = 0.53$), and rates of obesity (17% women with obesity and 14% men with obesity, $p = 0.47$).

Table 2
Sociodemographic characteristics of the sample (n = 335).

Variables	N (%)
Age (years old)	
18–21	83 (24.7)
22–24	84 (25.1)
24–27	84 (25.1)
27–30	84 (25.1)
Sex	
Women	183 (54.6)
Men	152 (45.3)
Education level	
Completed primary education	4 (1.3)
Completed high school	26 (8.0)
Attending higher education	159 (49.1)
Completed higher education	71 (21.9)
Postgraduate	64 (19.7)
BMI classification	
Underweight (<18.4 kg/m^2)	16 (5.2)
Without overweight or obesity (18.5–24.9 kg/m^2)	150 (48.7)
Overweight (25.0–29.9 kg/m^2)	95 (30.8)
Obese (≥30.0 kg/m^2)	47 (15.3)

3.2. CoEQ confirmatory factor analysis

The original structure of CoEQ showed suboptimal fit in CFA: χ^2 = 1243.1 ($p < 0.001$); RMSEA = 0.17; SRMR = 0.10; CFI = 0.91; TLI = 0.89; GFI = 0.98. Based on this poor fit, a EFA was performed for the CoEQ. Three indicators (6, 7, and 15) were automatically excluded since they presented low factor loading (< 0.30). Indicators 1, 2 and 21 were not included, as described in the original model (Dalton et al., 2015). With this, a reasonable fit was observed for EFA: RMSEA = 0.08; CFI = 0.94; TLI = 0.90. The KMO (0.82) and Bartlett's statistic (2073.5; $p < 0.001$) of EFA were adequate. Four well-defined and reliable factors were found in CFA: craving control, craving for savory, craving for sweet, and positive mood (Table 3). All four factors presented adequate CR and AVE, explaining 67% of the total variance, and were used in the subsequent analysis.

Foods mentioned by participants in the 20th item of the CoEQ were classified based on the content of major nutrients or ingredients. Most of the participants (42.3%) cited food rich in sugar (simple carbohydrates) as craved food item, such as sweets, chocolate and some traditional Brazilian desserts (Table 4). Fat-rich foods were the second most cited, including some savoury foods such as fries, hamburger, and hot dogs.

A CFA for PFS was performed based on Paiva et al. (2022). PFS presented adequate fit: $\chi^2 = 234.48$ ($p < 0.001$); RMSEA = 0.07; CFI = 0.98; TLI = 0.98; GFI = 0.98. Three well-defined domains were observed with adequate CR and AVE (Table 5).

Several differences were observed between the sexes (Table 6). Women had higher scores for the factors craving control, craving for sweets, food available, food tasted, and food present power of food aggregated factor. Men showed higher scores for positive mood. All significant differences showed medium to large effect size (d > 0.40).

3.3. Qualitative approach

We interviewed 20 participants with high scores of food craving for sweet or savoury foods, with average BMI: 26.9; 6.47 kg/m^2 (range: 19.0–45.1 kg/m^2) and average age: 24; 3.62 years. Ten participants were "without overweight or obesity", five were with overweight and six were with obesity. No differences were found between those who agreed and those who disagreed with the interview in terms of BMI, age, craving control, craving for sweet and craving for savoury. Table 7 shows the process of qualitative data analysis in which the meaning cores together generated categories for each research question.

The cited motivators for food cravings were 'negative feelings', 'situational aspects' and 'external cues'. All participants cited one or more negative feelings as the reason for food cravings. Most participants

Table 3
Control of Eating Questionnaire (CoEQ) indicators and factors.

CoEQ indicators	Mean; SD	Factor loadings
Craving control (CR = 0.897; AVE = 0.637)	–	–
9 - During the last 7 days how often have you had food cravings?	57.8; 27.3	0.762
10 - How strong have any food cravings been?	60.4; 25.2	0.863
11 - How difficult has it been to resist any food cravings?	54.4; 29.6	0.790
12 - How often have you eaten in response to food cravings?	56.8; 28.9	0.585
19 - Generally, how difficult has it been to control your eating?	59.8; 28.1	0.525
Craving for savoury (CR = 0.813; AVE = 0.593)	–	–
4 - How strong was your desire to eat savoury foods?	65.3; 28.7	0.390
16 - How often have you had cravings for dairy foods (cheese, yoghurt)?	39.9; 28.3	0.543
17 - How often have you had cravings for starchy foods (bread, pasta)?	51.2; 28.7	0.921
18 - How often have you had cravings for savoury foods (fries, crisps, burgers etc.)?	61.8; 27.8	0.340
Craving for sweet (CR = 0.909; AVE = 0.770)	–	–
3 - How strong was your desire to eat sweet foods?	64.2; 29.4	0.868
13 - How often have you had cravings for chocolate and chocolate flavoured foods?	60.0; 33.1	0.708
14 - How often have you had cravings for other sweet foods (cakes, pastries, biscuits, etc.)?	51.0; 32.1	0.659
Positive Mood (CR = 0.918; AVE = 0.849)	–	–
5 - How happy have you felt?	69.0; 23.6	0.860
8 - How contented have you felt?	69.5; 23.9	0.764
Not included items	–	–
1 - How hungry have you felt?[a]	55.4; 23.9	–
2 - How full have you felt?[a]	66.3; 21.9	–
6 - How anxious have you felt?	64.0; 28.7	–
7 - How alert have you felt?	50.3; 24.4	–
15 - How often have you had cravings for fruit or fruit juice?	45.1; 28.7	–
21 - How difficult was it to resist consuming this food in the last seven days?[a]	70.8; 25.8	–

[a] These indicators were also not included in the original model. CR = composite reliability; AVE = average of the variance; SD = standard deviation.

Table 4
Cited craved food on the open item of the CoEQ categorised into groups according to main nutrient content.

Food group	Frequency (%)	Cited foods
Sweet foods rich in sugar	41.3	Sweets in general; chocolate, *açaí*[a], candies, *brigadeiro*[a], and ice-cream
Savoury foods rich in fat	22.5	Fries, hamburguer, penaut, hot-dogs, *coxinha*[a], fried foods and pizza
Mixed	15.9	Cited foods from two or more different groups (e.g., stuffed bread with chocolate, pasta with cheese)
Starchy foods	13.4	Cake, bread, pasta, rice, and crackers
Dairy	2.5	Milk with chocolate, cheese, and cream-cheese
Sweet drinks	2.2	Soft drinks
Alcohol	1.9	Beer, wine, and alchool in general
Other	0.3	Coffee and pepper sauce

[a] *Açaí* = Sorbet of açaí fruit with sugar and sorted candies and fruits as a topping; *Brigadeiro* = Creamy chocolate balls made of condensed milk, butter and chocolate; *Coxinha* = breaded and fried dough-based snack filled with chicken.

Table 5
- Mean values, standard deviation, and factor loadings of the Power Food Scale (PFS) indicators.

PFS indicators	Mean; SD[a]	Factor loadings
Food Available (CR = 0.900; AVE = 0.600)	–	–
PFS 1	2.97; 1.2	0.736
PFS 2	2.40; 1.1	0.698
PFS 5	2.65; 1.4	0.749
PFS 10	2.78; 1.4	0.745
PFS 11	2.24; 1.3	0.805
PFS 13	2.07; 1.2	0.894
Food Tasted (CR = 0.854; AVE = 0.540)	–	–
PFS 8	2.92; 1.3	0.788
PFS 9	3.33; 1.2	0.621
PFS 12	2.69; 1.2	0.799
PFS 14	3.29; 1.2	0.611
PFS 15	2.98; 1.4	0.657
Food Present (CR = 0.863; AVE = 0.614)	–	–
PFS 3	3.53; 1.1	0.649
PFS 4	3.21; 1.3	0.709
PFS 6	3.13; 1.3	0.837
PFS 7	2.81; 1.4	0.750

[a] 5-point Likert scale; CR = composite reliability; AVE = average variance extracted; SD = standard deviation; #PFS is copyrighted by Drexel University, copies of the PFS can be obtained by writing to Prof. Michael Lowe lowe@drexel.edu.

Table 6
– Differences between males and females CoEQ and PFS scores.

Variable	Men (n = 152) Mean; SD	Women (n = 183) Mean; SD	*p*[a]	d
CoEQ - Craving control	51.8; 22.2	62.9; 21.0	**<0.001**	0.51
CoEQ - Craving for savoury	54.9; 18.5	54.3; 20.0	0.767	0.03
CoEQ - Craving for sweet	47.5; 28.0	67.5; 24.0	**<0.001**	0.76
CoEQ - Positive mood	73.5; 20.4	65.8; 23.0	**0.001**	0.35
PFS – Food available	2.18; 0.82	2.80; 1.05	**<0.001**	0.65
PFS – Food tasted	2.81; 0.92	3.22; 0.95	**<0.001**	0.43
PFS – Food present	2.90; 0.93	3.40; 1.01	**<0.001**	0.51
PFS – Power of Food aggragated factor	2.58; 0.74	3.10; 0.86	**<0.001**	0.64

[a] Welch's *t*-test; Bold values = significant difference with $p < 0.05$. CoEQ= Control of Eating Questionnaire; PFS= Power Food Scale; SD = Standard deviation.

(n = 18) cited that cravings were triggered by relief after a stressful day or situation. This is evident in the following quotes: *'When I am too stressed or too sad, I always take it out on food* (WSV5*); sometimes it happens after a situation at work that hurts me, or sometimes after something at home with my husband* (WSW3)*; stress is a strong trigger* (for food cravings) (MSV4). Anxiety was a relevant motivator of cravings, cited by 12 participants, especially for those who had cravings for sweets (n = 8). Some quotes clearly define the mechanisms of hedonic hunger related to anxiety, e.g. '*Sometimes it's not even hunger, sometimes I am aware that it's not 'hunger', maybe it is … I do not know if it's boredom, idleness or even anxiety, and I end up taking it out on food* (MSW1); *Also because of anxiety. I want to eat this food so badly, so I want to anticipate everything so I can eat it soon* (MSW2).' Another relevant negative feeling was idleness, e.g. *'But when I am at home, more idle, I find it much harder to resist* (MSW1).'

In contrast, some cravings were reported to be motivated by the pleasure to eat, such as the pleasure for a highly palatable meal e.g. *'I like eating, right? My mouth waters when I think of the sensations that eating can bring me, even if it's just a brief pleasure* (MSV5)'; ' *I do not know … so, what comes to my mind is that eating is very good. I love to eat, okay, it's wonderful. And the better the food is, the harder it is for you to control it if you feel it too intensely. Yes … I love to eat.* (HSW4).' It is important to differentiate this meaning core from 'uncontrollable feeling of need'. On this second, the craving is not limited to pleasure, but to a situation, e.g. after lunch - *'I like eating sweets, for example, after lunch I get a craving for sweets* (WSW2), or even a guilty conscience (e.g. '*sometimes I feel that I can not control it. But then I think I have it under control and feel guilty about it* (WSV4).' This motivator was particularly strong for women (n = 5), and not cited by men. Men, on the other hand, seemed to be more inclined to break out of the daily routine, such as eating tasty food on a Friday night or at a happy hour. Finally some external cues were cited as motivators, specially in the context of having the food available. This is evidenced by quotes: '*I think I am one of those people who do not stop eating until it ends* (WSV3); *If I do not see a certain food, I do not have much need for it. But when I see it, I eat it.* (MSW1); *So in my mind it goes on and on, you know? "You have it, you can go get it, it's within reach, go get it"* (WSW5).' The food availability seemed to be more of a problem for those with craving for sweets and women.

When asked about the consequences of cravings, participants mentioned many negative health aspects and negative feelings. Many health problems were mentioned, many of which were related to weight gain or poorer nutrition, e.g.: *'I think there are consequences, especially for health. Cravings do not lead to better health, because you always want to eat something fatter, something more calorific and everything else … You may be satisfying yourself at the moment, but it's not good for your body, right?'* (MSW1). Despite researchers' efforts to separate independent quotes, there is a clear link between cravings with health problems, body weight and some negative feelings. For example participants cited how gaining weight was bad for their esteem and health e.g., *I have always been a chubby person, but at times when my cravings for food are stronger, I usually gain weight, and this eventually affects relationships with others due to some insecurity* (MSW5); *I get fat, and wow. my self-esteem drops, and then I think "oh, I am ugly"* (MSW1).

In contrast, women showed feelings of guilt related to uncontrolled consumption and not specifically due to weight gain, e.g.: *'when I was in a very difficult moment, I knew it was not right, but I had to do it, so I blamed myself at the same time that I knew I wanted to, and then a very big feeling of guilt came. And that then got in the way so I felt … felt a bit insecure and still do* (WSW5); '*The thought that's 100% in my head is "you should not eat that*' (WSV2); '*Ah, sometimes I feel bad … I feel heavy sometimes when I eat these things in excess because we feel right … so sometimes I feel a bit guilty* (WSW2).' Still on the topic of negative feelings many participants cited the loss of control, i.e. the craving leading to an overconsumption. According to the speeches, the loss of control eventually leads to other consequences such as guilt, e.g. *'It's not 1 packet, it's 2 packets (of sweet biscuits). I wanted to be one of those people who can eat 2 to 3 biscuits, but I do not know how to do that* (MSW1); *But sometimes I can not, so I eat more than one … and then I feel bad because I can not control myself* (WSV5); *I eat a bit more to increase serotonin and then I think, "Why did I eat so much?"* (MSW1)'.Some menn did not report any consequences of food cravings, while all women cited one or more negative consequences.

Different meaning cores and categories were observed regarding coping strategies. For example, some participants referred to physical activity, e.g.: '*One thing that helps me is physical activity, because it helps me with my anxiety. And I think a little about the issue of satiety. Both of these things together help me not to want to eat, because I feel less anxious and more full* (WSW1); *For example, sometimes I want to live healthier, you know, and then when I exercise I kind of remember that and think, "No, I do not need that," and then my cravings decrease and at the same time my stress is reduced* (WSV5); *I do not know … maybe I'll look for another activity, like a bike ride or something … the urge will go away* (MSV1). Some participants reported trying to choose a healthier food instead of a highly palatable food e.g., *'Sometimes you can cheat with other foods, am I right? Sometimes I put grapes in the freezer, which makes them sweeter and I eat them* (WSW4*); That does not always work, but I try to make better choices in that context. So I do not know if I eat 1 or one and a half between 3 chocolate bars* (WSV4); *If I really do not want to eat anything because I want to stick to the diet, I try to find an alternative with honey, a sweetener or something else* (MSW3)'. Some men also referred to drinking water to distract themselves and fill their stomach e.g. *'I drink a lot of water to make it feel like my stomach is*

Table 7
Determined categories, meaning cores of interviews, number of occurrences and number of participants.

Category	Meaning core	Occurrence (number of quotes)	Men (n)	Women (n)	Craving for savoury (n)	Craving for sweet (n)
Question 1 – What motivates food craving?						
Negative feelings	Relief after a stressful day or situation	39	6	8	8	6
	Anxiety	23	6	6	4	8
	Idleness	12	3	5	4	4
	Being alone or accompanied	6	4	2	4	2
	Being on restrictive diet	4	1	3	3	1
	Disordered eating	4	0	2	1	1
Pleasure to eat	Immediate pleasure	10	4	4	3	5
Situational aspects	Break out of daily routine	11	5	0	4	1
	Uncontrollable feeling of need	7	0	5	3	2
	Moments of celebration	4	1	2	1	2
	Menstrual cycle	3	0	2	0	2
External cues	Food available (in the home)	15	3	7	3	7
	External food advertisements	3	1	1	2	0
Question 2 - What are the consequences of food cravings?						
Negative health aspects	Health problems	13	6	5	5	6
	Weight gain	10	3	5	4	4
Negative feelings	Feel guilty	5	0	5	3	2
	Loss of self esteem	3	1	1	1	1
	Frustration	2	1	1	1	1
	Loss of control (overconsumption)	8	2	3	3	2
No psychological or health aspects	No consequence	4	4	0	2	2
	Increased financial cost	4	2	0	0	2
Question 3 – What are the coping strategies for food cravings?						
Health-related strategies	Choose a healthier food instead	7	3	3	3	3
	Practice physical activities	7	3	4	4	3
	Perceived healthy strategy	4	0	3	2	1
Environmental-related strategies	Look for distractions	6	1	4	4	1
	Adjust daily routine with different activities	10	3	3	4	2
	Avoid having the food available	6	2	3	3	2
Professional support	Therapy	2	1	1	0	2
	Medication	2	0	2	0	2
Negative feelings	Thinking about the negative effects on the body	2	1	1	1	1
No strategy	No strategy	3	2	1	1	2

full (MSW3).'

Having an organized, or busy, daily-routine was cited coping strategy for food cravings, evidenced by these quotes: *'When I was working, I had a lot to do, my day was very busy, my schedule was very regulated. So I had a proper time to eat, to do everything properly* (MSW1); *A routine, for example, when I am busy, when I am doing other things … my attention is on other things than eating* (WSV4); *For example, when I am very busy during the day, I do not think about it (about eating)* (MSW1).' Finally, some participants cited professional support or no strategy at all. Two participants mentioned thinking about the negative effects of a poor diet on

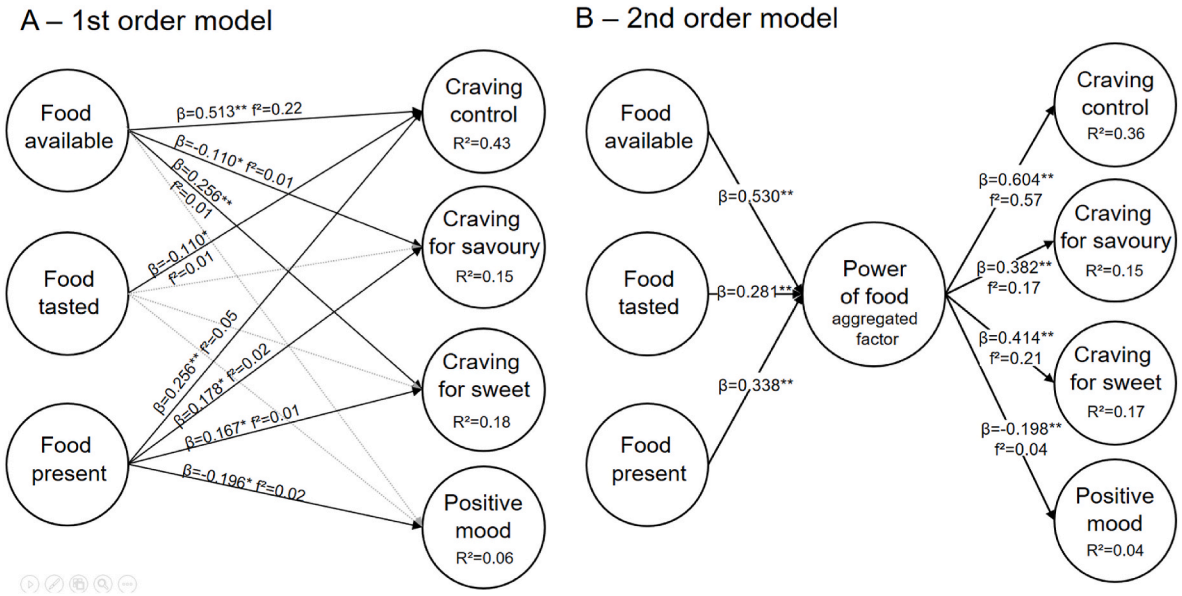

Fig. 1. A: first order final inner model; B: Second-order final inner model
*p < 0.05; **p < 0.001; p-values of the t-statistics (based on bootstraps with 5000 samples); dashed light grey line = non-significant path.

the body, e.g. *'Because I want to fit into a better outfit. Because I want to wear shorts, because I do not like my legs … so it's always about aesthetics (resisting cravings)* (WSV2).' Some environmental-related strategies were also cited like avoiding the food available, e.g *'Not buying chocolate and not having these sweets at home also helps a lot* (MSW1); *To not eat them (craved food), I can not have them in the fridge* (MSV1).' Another strategy was look for distractions *e.g.: 'What has helped me is to find something to do … To find a course on the internet, I will do something … I am going to help my mother with something* (WSW5*); I have tried doing something else before looking for food … "I am going to take a shower" … and wait for some time to see if this tormenting feeling subsides a little … and I can understand what is hunger and what is not* (WSV4).

3.4. Modelling approach

First, a first-order model was calculated (Fig. 1A). A positive effect of the 'food available' domain on craving control had a high effect size ($f^2 = 0.22$) i.e. the higher the food available score was, the more and stronger craving episodes participants had, as this last variable has an inverted score. All other significant paths between PFS and CoEQ had low effect sizes ($f^2 < 0.10$). For this reason, a second-order model was tested. Since the second-order model showed better effect sizes (f^2) with similar explanatory power than the first-order model, the second-order model would be better suited to predict changes in the CoEQ factors (Fig. 1B). All factors had a reasonable effect size with $f^2 > 0.15$ in the second-order model. The only exception is the effect of the power of food aggregated factor on positive mood, which had a small effect size ($f^2 = 0.04$). The craving control showed high predictive relevance ($Q^2 = 0.22$) and adequate explanatory power ($R^2 = 0.36$). Lower predictive relevance and explanatory power were observed for other CoEQ variables - craving for savoury ($Q^2 = 0.06$; $R^2 = 0.14$); craving for sweet ($Q^2 = 0.12$; $R^2 = 0.17$); positive mood ($Q^2 = 0.02$; $R^2 = 0.04$). A multi-group analysis was tested for men and women. However, the model was not significant. Although the variables vary in strength, the path (or effect) is similar among the sexes.

Both models presented adequate discriminant validity with HTMT of correlations < 0.85. No multicollinearity issues were identified with all VIF < 3.3.

4. Discussion

The first objective of this study was to investigate, for the first time, the consistency and reliability of the CoEQ in a Brazilian sample. Consistent with other studies, (Dalton et al., 2015; Dalton et al., 2017a), the CoEQ in Brazil showed a reasonable factorial structure in the EFA. Similar to Dalton et al. (2017a), indicator 15, which refers to fruit juices, was not included in the factor craving for sweets. This is likely because fruit juices are perceived as natural and healthy (Marsola, Carvalho-Ferreira, Cunha, Jaime, & da Cunha, 2021) and are not a common choice for food cravings. The PFS also showed adequate factorial structure during the CFA. This was expected since PFS was already tested in the Brazilian population (Paiva et al., 2022). In both scales, the remained indicators presented high factor loading (> 0.50) and the constructs high reliability (CR > 0.70). The construct explained most of the indicators (AVE > 0.50). When the AVE is less than 0.50, the constructs explain more errors than the variance of the construct (dos Santos & Cirillo, 2021).

To better understand the motivations behind food cravings and how the environment might relate to these episodes, we conducted a qualitative research phase. Regarding the motivations for food cravings, many negative emotions were cited. Other research has discussed how negative feelings can arise when a craving for a particular food occurs as a relief from stressful days and anxiety (Dalton et al., 2015; Jáuregui-Lobera, Bolaños-Ríos, Valero, & Ruiz Prieto, 2012; Penaforte, Minelli, Rezende, & Japur, 2019; Potenza & Grilo, 2014; Reichenberger, Pannicke, Arend, Petrowski, & Blechert, 2021). For many people, stress alters their food choices, leading to higher caloric intake from highly palatable foods. This change is known as "comfort eating": eating palatable foods to reduce the effects of stress and provide some relief (Ulrich-Lai, Fulton, Wilson, Petrovich, & Rinaman, 2015). For example, carbohydrate cravings are well known in the literature as a form of self-medication to improve mood and overcome unpleasant affective states (Yanovski, 2003). Neurobiological mechanisms related to stress are known to potentiate the motivation and reward of highly palatable foods, increasing food cravings and the risk of overeating (Chao, Grilo, White, & Sinha, 2015; Reichenberger et al., 2021; Sinha, Gu, Hart, & Guarnaccia, 2019). According to Ulrich-Lai et al. (2015), the ingestion of palatable foods as a naturally rewarding behaviour can restrict the activation of the stress system, by acting on the brain's reward circuits. However, although there are physiological and chemical hypotheses that explain the reasons for food craving, individual and cultural factors seem to have significance (Hormes, Orloff, & Timko, 2014).

Most participants cited negative consequences for food cravings, with the most important reasons related to health and negative feelings about body shape and body image. Women reported feelings of guilt, which was not observed in men. It is noteworthy that even when asked directly about the consequences of cravings, some men did not report any, while all women mentioned at least one negative consequence. In addition, some limited coping strategies have been observed, such as drinking water to overcome the urge to eat or reducing energy intake, which has little effect on the feeling of hunger (McKay, Belous, & Temple, 2018). Participants reported worries about their health and weight gain as consequences of cravings (Hallam, Boswella, Devito, & Kober, 2016; Lowe & Butryn, 2007; Werthmann, Jansen, & Roefs, 2015). The most important strategy for overcoming cravings was adjusting routines with different activities, confirming some findings that refer to distraction as a good way to avoid the urge to consume certain foods (Forman, Hoffman, Juarascio, Butryn, & Herbert, 2013; Karekla et al., 2020).

The third main objective was to investigate the relationship between food cravings and food intake motivation, especially for foods with high palatability. The PFS seems to be related to CoEQ, but there are few detailed analyses of eating behaviour in the literature. Power of food aggregated factor was associated with a high effect size with craving control. In the first-order model, we also observed a high effect size in the path of the factor food available to craving control. This result suggests that low control over palatable food, especially food that is available in the environment, might impair craving control. The factor "power of food" also showed positive paths with high effect size to craving for sweet and savoury foods, i.e. people with low control over palatable food may have more frequent, or stronger, episodes of craving for sweet and savoury foods. This relationship between environmental aspects and food cravings was also found in the qualitative phase.

In Brazil, increasing ease of access to food apps and socioeconomic changes such as family composition and food prices are influencing the food environment (Zanetta et al., 2021). The presence of food was already cited as a motivation for increasing food cravings (Forman et al., 2007). For example, meals away from home, increased food portion sizes, and greater availability of palatable foods have increased recently (Rosi et al., 2017). Bakeries, restaurants, takeaways, supermarkets, and food delivery apps are access points for consumption inside and outside the home, promoting the availability of food at all times in urban environments. Along with the increasing development of processed and highly palatable foods, these are factors that tend to promote the consumption of convenience foods, high-energy snacks, and sugary beverages in addition to physiological needs (Blechert, Klackl, Miedl, & Wilhelm, 2016; Lake & Townshend, 2006). This can be confirmed when analysing question 20th of CoEQ. The most frequently mentioned food groups in the CoEQ open-ended question were foods high in sugar (chocolate, ice cream) and salty foods high in fat and carbohydrates (French fries, pizza), confirming data from the literature linking cravings to high-energy foods (Meule, 2020; Taylor, 2019). It is possible to

consider food craving as a precursor of excessive food consumption (Buscemi, Rybak, Berlin, Murphy, & Raynor, 2017), as a consequence of the abundance of cheap, high-calorie, and highly palatable foods.

Women scored higher on craving control, craving for sweets, and all PFS domains, whereas men scored higher on positive mood. These results were expected and are consistent with the literature which indicates that the nature, frequency and magnitude of craving (un)control is different between sexes (Aliasghari, Asghari Jafarabadi, Lotfi Yaghin, & Mahdavi, 2020; Hallam, Boswell, et al., 2016; Paiva et al., 2022; Potenza & Grilo, 2014; Rodríguez-Martín & Meule, 2015). These differences may be due to a number of factors, including hormonal and social differences between men and women. Studies demonstrating increased food cravings during premenstrual and the prenatal period (Rodríguez-Martín & Meule, 2015) as well as a greater craving for sweets in women who have a high stress response, explained by increased basal leptin and waist circumference, support the hormonal hypotheses (Macedo & Diez-Garcia, 2014). Nevertheless, the role of social determinants in sex differences must be considered, as it is a complex and multifactorial phenomenon. There is strong evidence of the link between body image dissatisfaction and the development and maintenance of eating disorders, and it has been demonstrated that women and girls are at high risk for body image problems due to internalisation of the media ideal and comparison of appearance (Rodgers et al., 2015). However, although the results for the female population are very consistent, there are still different results in the literature for food craving, with some studies showing no differences in PFS (Andreeva et al., 2019; Serier, Belon, Smith, & Smith, 2019) and CoEQ scores (Dalton et al., 2015).

As a theoretical implication, the association between PFS and CoEQ was significant and with an acceptable effect size. It will be beneficial for future studies to assess whether the available, tasted and present food influences food craving and which factors mediate these pathways. Finally, the qualitative step was important for a deeper understanding of the perceptions of people with food cravings. Qualitative methods allow the researcher to capture the meanings within the data and a contextualised understanding of the subjective experiences (Crowe, Inder, & Porter, 2015). To our knowledge, this is the first study to attempt to interview people with food cravings.

The study has many practical implications. Practitioners should be vigilant, as women might have less control over food cravings, especially for sweet food, and have less control over palatable foods. However, men also showed some relevant values for food cravings, especially for savoury foods. The qualitative section has shown that the motivators for food cravings can be different for men and women but affect both. Regardless of sex, people need to know how to deal with cravings because many negative feelings are the trigger or consequence of cravings. It will be beneficial for consumers to know how to modulate their environment to reduce cravings, as recommended by professionals in the field. These include, for example, appropriate dietary orientation, controlling the presence of palatable foods in the environment, removing barriers to healthy food intake and psychological orientation to improve emotional regulation strategies.

Limitations of the study include that it is a cross-sectional research, so it is not possible to infer causality concerning food cravings. Another limitation is that the CoEQ has not been validated for the Brazilian population. One problem was that the factor "mood" in the EFA retained only two indicators. A factor with two indicators can be problematic for many statistical reasons. We conducted various quality controls (e.g. composite reliability, variance extracted, etc.) to ensure the quality of the instrument. Nevertheless, this factor needs to be further investigated with other populations and an update of the CoEQ might be needed to improve this specific factor. Finally, the sample of the quantitative step was purposive, but not stratified or randomised. Like many studies in this area, the results cannot be generalised to other age groups and cultures. Therefore, studies with other life cycles and populations are needed for a better understanding of the phenomenon.

5. Conclusions

The CoEQ scale had an appropriate factor structure in this Brazilian sample. Women had higher scores in the craving control and craving for sweets domains and in all PFS domains, indicating sex differences. In the qualitative stage, food craving was associated with the routine, so the craved food has the function of relieving stress and anxiety. Food availability was also considered as a factor motivating food cravings. It was quite evident that most of the interviewees, especially woman, had negative feelings about their body shape as a result of food cravings. The power of food was a positive driver (i.e., the higher one, the higher the other) for craving control, craving for savoury, and craving for sweet.

The results suggest that the relationship between food cravings and the power of food is relevant in the current obesogenic environment. Understanding the feelings, perceptions and factors associated with food craving are necessary to inform interventions and guidelines for the population.

Ethical statement

The study has been performed following the Declaration of Helsinki. All participants signed an informed consent form electronically. The University of Campinas Ethics Committee approved the study (protocol: 40026320.3.0000.5404; April 15, 2021).

Declaration of competing interest

All authors declare that they have no conflicts of interests.

Data availability

Data will be made available on request.

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