Placebo Effects on Hunger and Food Craving: The Role of Body Image and Gender

Al-Awan, Zaineb

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Zaineb Al-Awan

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Student number: 4179315
First Examiner: Dr. Aleksandrina Skvortsova, Health, Medical and Neuropsychology Unit; Leiden University
Second Examiner: Dr. Pam ten Broeke, Health, Medical and Neuropsychology Unit; Leiden University

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Abstract

Eating beyond the required calorie intake is a characteristic in various health complications, such as obesity or binge eating disorder. This is often ascribed to our hedonic brain system, which causes us to eat for pleasure rather than hunger. The placebo effect is defined by symptom improvement in response to an inactive treatment due to expectations on its effectiveness, and has been shown to successfully alter the physiology and psychology of humans. The current project aims to investigate whether a sham vagus nerve stimulation, accompanied with placebo suggestions, can reduce hunger and food craving in normal-weight participants. Additionally, the potentially moderating effects of body image and gender are explored. In total, 66 volunteers (M = 21.3 years old, 74% female) were invited to the laboratory and allocated to either placebo or control group. All participants received a 2-minute sham stimulation, however, only the placebo group were told the intervention is expected to have hunger-reducing effects. A placebo score for hunger and food craving was calculated based on the difference between pre- and post-stimulation ratings. The *t*-test revealed that the placebo suggestions significantly decreased food craving (d = 0.69, p = .008), but not hunger (d = 0.40, p = .111). The moderation analysis showed a significant interaction effect between body image and group allocation on food craving; a more negative body image resulted in a smaller decrease in food craving for the placebo group (f^2 = 0.25, 95% CI [0.24, 2.35], p = .017). The placebo effect on hunger was not shown to be moderated by body image (p = .370). Gender had no moderating effect on either relationship (p = .534; p = .726). The study reveals that food craving can be more affected by the placebo induction than hunger. Body dissatisfaction seems to alter the individual's perception of food craving and moderates the relationship between the placebo effect and food craving. In conclusion, food craving needs to be prioritized in future interventions for health adversities related to overeating. The buffering effects of body image need to be considered as a potential risk factor in early developing stages of eating pathology.

Keywords: placebo effect, hunger, food craving, body image, gender, moderation, hedonic system, obesity, binge eating

Layman's abstract

Overeating and binge eating have become an increasingly bigger issue in our current society, with obesity being at a constant rise. This is often blamed on the fact that people more frequently consume food for pleasure rather than hunger. In an attempt to explore for effective treatment or prevention methods, the placebo effect is considered for its great potential. The placebo effect involves a response to a sham treatment with no active ingredient, and is dependent on the recipient's expectations of the treatment's success. It has been shown in the past that placebo can improve symptoms such as pain or insomnia, but could it perhaps decrease a person's hunger or food craving?

The current study aims to investigate this, and additionally looks into the impact of body image and gender on the placebo effect. To do so, we invited 66 normal-weight participants to the laboratory and attached a "vagus nerve stimulator" close to their ear where no real nerve runs, however, the participants were told that the electrical pulses are stimulating their vagus nerve. Participants assigned to the control group were given no specific information about the effects of this stimulation, while participants in the placebo group were told that it is expected to decrease their hunger.

When analysing the results, we were able to see a significant decrease in the placebo group's rating of their food craving, but not a big change in their hunger. Additionally, we found that body image was buffering this decrease in food craving, meaning that a more negative body image prevented the placebo effect to decrease their food craving. When testing whether there are differences between men and women within this placebo effect, there were no differences in either hunger or food craving.

This study can have positive implications on how just a 2-minute ineffective stimulation can convince individuals that they experience less food craving, which is the more relevant mechanism when it comes to unhealthy eating behaviour. However, body dissatisfaction needs to be considered as a risk factor, as it seems to distort the perception on food craving and can therefore make the placebo intervention less effective.

Introduction

Excess weight has become a global health issue due to the abundance in sedentary lifestyle and unhealthy eating behaviours. According to the database of Eurostat (2021), the prevalence of overweight amongst Europeans in 2019 has been estimated to be 52.7%. Being overweight or obese can have several consequences, physically, socially as well as mentally. Known comorbidities include cardiovascular diseases, type-2 diabetes, osteoarthritis and cancer (Guh et al., 2009). Carrying excess weight can also lead to prejudice, discrimination, and social stigma, which can consequently impact the mental well-being of overweight or obese people (Puhl & Heuer, 2010). Furthermore, a systematic review has concluded a consistent and bidirectional association between obesity and depression, and modest evidence for an association between obesity and anxiety (Rajan & Menon, 2017).

A primary cause for weight gain is eating beyond the required calorie intake, and thus bringing the energy levels within your body out of balance. The current obesogenic environment exposes us regularly to palatable food and encourages hedonic food intake; eating for the sakes of pleasure (Paiva et al., 2022). The hedonic brain system can thus override the hypothalamic responses of homeostatic hunger and satiety, leading to dysfunctional hunger regulation (Amin & Mercer, 2016). This lack of hunger regulation can lead to various patterns of disordered eating; one example would be a binge eating disorder, which is characterized by a feeling of loss of control while eating a large amount of food and is therefore highly associated with weight gain and obesity (McCuen-Wurst et al., 2018). Such behaviour has been found to be more dependent on food craving, which is defined by an intense desire to eat specific food (Hill et al., 2007). Hunger is not a precondition for food craving, as studies have shown that food craving can be triggered by visual cues (Bullins et al., 2013), hormone changes (Hoseini et al., 2023), and emotions (Van Strien et al., 1986). A meta-analysis has found food cue reactivity and craving to account for up to 11% of the variance in weight gain (Boswell & Kober, 2015). This was attributed to the fact that food of high palatability (e.g., chocolate) is craved most frequently. It is also worth noting that food craving is not only more prevalent amongst overweight and obese people, but also amongst normal-weight individuals with binge eating disorder or bulimia, in comparison to healthy individuals (Reents & Pedersen, 2021).

The underlying psychological causes for overeating make evident that obesity and binge eating disorder are multifactorial diseases which allows for various psychological interventions, alongside the treatments targeting the patient's physiology. Some effective psychological treatment for weight loss, and management of binge eating disorder, is

cognitive-behavioural therapy and interpersonal psychotherapy (Castelnuovo et al., 2017). One rather understudied psychological intervention for obesity and weight loss is the placebo effect.

The placebo effect in clinical practice is defined by its positive effect on patient outcomes due to the setting context and the patient's expectations (Finnis et al., 2010). A placebo can come in various forms of sham treatment, such as a pill or injection. The mechanism by which it works has been ascribed to conditioned learning, expectations and social cognition, amongst other theories (Wager & Atlas, 2015). The induction of placebo suggestions can take different forms, depending on the mechanism that is being used. Inactive medication has been shown to be effective if accompanied by positive information about the treatment, within the given context, thereby increasing the individual's expectations. Similarly, the placebo can be effective through observational learning, making use of the social cognition process (Bajcar & Bąbel, 2018). Neuropsychological studies have detected that dopamine and endorphins play a mediating role in this placebo effect, making this a neuropsychological phenomenon (Haour, 2005). The psychophysiological effects have been observed in various treatments for certain conditions or disorders, such as depression, sleep disorders, and pain (Bystad et al., 2015).

The bariatric surgery, as a treatment for obesity, has been suggested to largely be effective due to placebo; about 71% of the improvement has been credited to non-treatment specific effects (Jonas et al., 2015). Similarly, Carter et al. (2003) concluded in their review that the effectiveness of pharmacological treatment for binge eating disorder can to 33% be ascribed to a placebo response. The first systematic investigation of the placebo response in binge eating disorder found a third of their participants to be placebo responders (Jacobs-Pilipski et al., 2007). The patients experienced reduced severity of binge eating symptoms, fewer binge episodes or days and consequently reported a higher quality of life. The study by Hoffmann et al. (2018) was first to inquire into a placebo intervention that suggests satiety, and whether it can affect the participants' feelings of appetite and hunger. Their intervention included a placebo capsule and verbal suggestions of either hunger- or satiety-enhancing effects of the capsule. The results showed that a satiety-enhancing placebo intervention can indeed decrease their perception of appetite and hunger, and thus supports the notion that treatment-related expectations can positively impact satiety-enhancing medical interventions. However, not only is there a lack of replication for such results, but also, no known moderators within this relationship have been determined.

The APA Dictionary of Psychology defines body image as “the mental picture one forms of one’s body as a whole, including its physical characteristics and one’s attitudes toward these characteristics” (2018). A negative body image has been established as a risk factor for developing eating disorders (Stice, 2002). Specifically, body dissatisfaction was found to increase the likelihood for dieting and eating pathology. The review by Lewer et al. (2017) was able to conclude that body dissatisfaction is often present in people with binge eating disorder. Paiva et al. (2022) hypothesized that the relationship between body image and disordered eating may be due to the contradicting pressures and influences of our obesogenic society that still idealizes a thin body. Such standards are known to influence people to follow certain diets or engage in restrictive eating habits. However, this will lead to energy deprivation, which in turn can increase hunger and may trigger a desire for bingeing or overeating (Witt & Lowe, 2014). In previous research, body image dissatisfaction has been shown to positively influence participant’s preference towards palatable or high-caloric food (Medeiros et al., 2023). The qualitative aspect of the study revealed that people concerned with their body pay more attention to the amount they eat rather than the quality and variety of the food they consume. This engagement in controlled eating, further diminishes the individual’s internal sense of hunger or satiety; they are instead driven by external cues or emotions, which are more likely to trigger food craving in the absence of hunger. A mindfulness-based study discovered that participants, who struggled with body image issues and disordered eating, experienced less food craving after the mindfulness intervention, as they instead paid better attention to their internal state of hunger (Alberts et al., 2012). A negative body image could therefore not only be considered a risk factor for disordered eating patterns, such as overeating or bingeing, but may also buffer the effects of a hunger-reducing placebo intervention if people with a negative body image lack the interoceptive awareness of hunger states.

Gender is a frequently examined moderator in studies regarding perceived hunger and body image, as there is high variance in the behavioural eating habits, physiology of appetite, as well as the psychological food drive between men and women (Khalid et al., 2024). Women tend to practice dietary self-restraint more commonly than men, have stronger brain activation to appetite-enhancing food stimuli, and they generally report higher body dissatisfaction than men. Additionally, a meta-analysis has reported that women are less affected by the placebo induction of pain analgesia (Enck & Klosterhalfen, 2019). Thus, inquiring into gender differences within the placebo intervention could yield interesting results.

The current research firstly aims to investigate whether the aforementioned results of placebo interventions on hunger can be replicated in healthy participants. Specifically, the study tests whether placebo suggestions can decrease hunger and food craving. A sham vagus nerve stimulation was used on the participants, with the verbal suggestion of decreased hunger. Additionally, this thesis project aims to explore whether a negative body image in participants may diminish the placebo effect. Furthermore, it seems of high relevance to look into gender differences within the placebo effect, as women are known to differ in food-related attitudes and behaviour from men. Thereby, gender can be identified as a potential moderators and taken into consideration when attempting to apply these results into treatment methods.

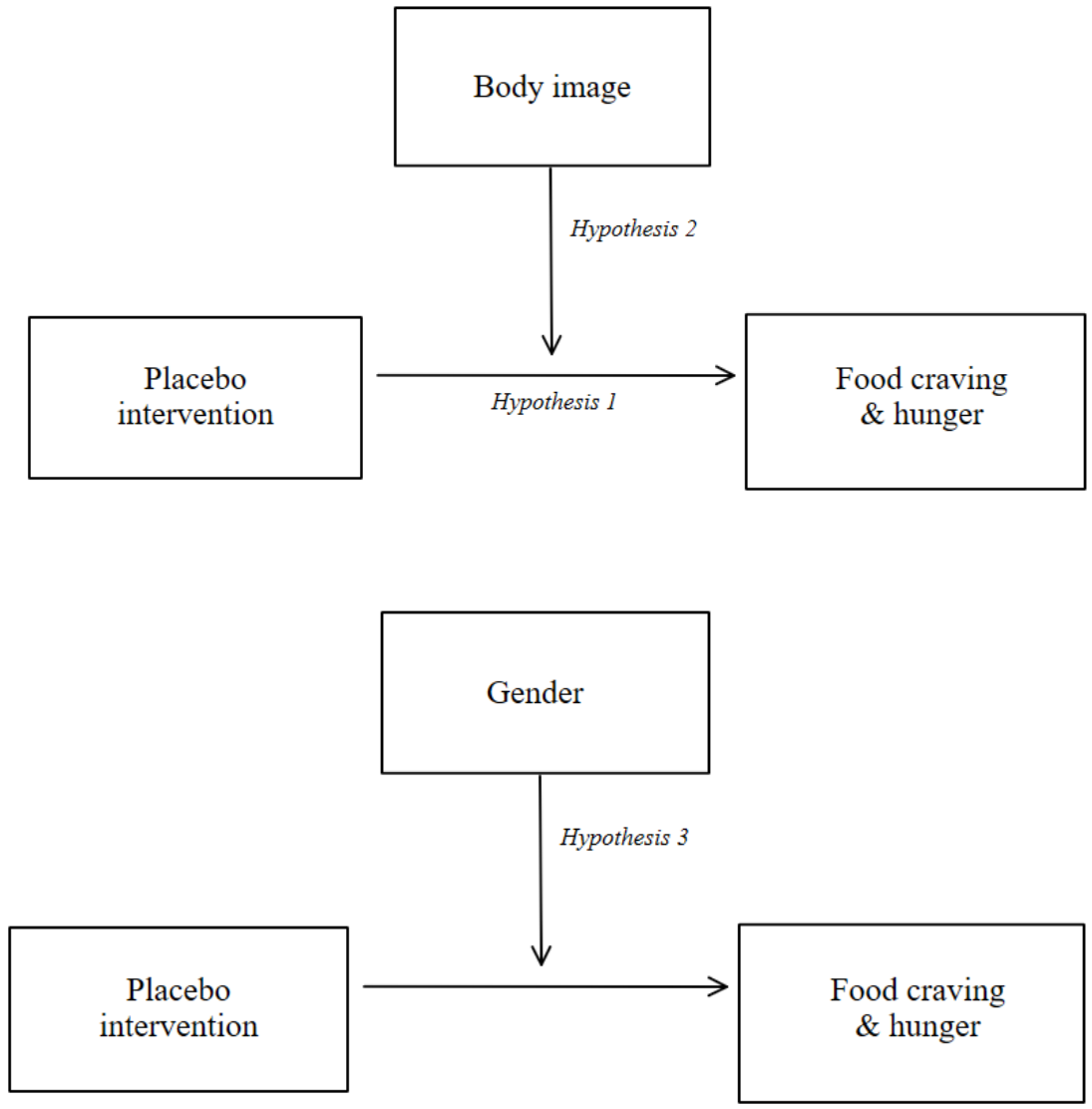
The research question contains of three parts: Can placebo suggestions decrease hunger and food craving of healthy participants?; Does body image negatively impact the placebo effect on perceived hunger and food craving of healthy participants?; Do men and women respond differently to the placebo effect?

Three hypotheses are thereupon derived from the research questions: (1) The placebo group will report lower hunger and food craving in comparison to the control group; (2) Body image moderates the effect of suggestions on hunger and food cravings: Participants with negative body image will respond to the placebo effect less than participants with positive body image: (3) Gender moderates the effect of suggestions on hunger and food craving; Female participants will be less affected by placebo than male participants. A conceptual model of these hypotheses is depicted in Figure 1.

Such results can have several implications on the objectives of health psychology; on one hand, the placebo intervention may support the treatment of health adversities related to maladaptive eating behaviours. Psychological interventions for obesity or binge eating disorder may be designed based on the principles of placebo, by for example focusing on managing patients' expectations, which could in turn enhance treatment success. On the other hand, body dissatisfaction may be considered an indicator for unhealthy eating habits, and can therefore be incorporated in the primary prevention stage for obesity or eating disorders by targeting the improvement of body image. In the attempt to further control the prevalence of eating disorders within a certain population, body image could be utilized to predict the likelihood of pathology development, if causality is confirmed.

Figure 1

Conceptual model of the moderation analysis



Methods

Design

The study used a between-subject design, which included three experimental groups. The first group is the placebo group, which received positive suggestions regarding the effects of the sham treatment. The nocebo group received negative suggestions, in opposition to the placebo group. Lastly, the study includes a control group, which received neutral suggestions. For the current thesis project, the nocebo group was disregarded in the statistical analysis, thus only the placebo and control group are compared to one another.

Participants

Healthy volunteers between the age of 18 and 35 and of any gender were allowed to participate in the study. An inclusion criteria that is meant to conceptualize health is a normal body mass index (BMI), so one within the range of 18 and 25.

The exclusion criteria of the study were the following: having eaten less than two hours before the session, drank alcohol in the last 12 hours before the session, a diagnosis of diabetes type I or II, a history or current diagnosis of an eating disorder, and being pregnant.

To calculate the sample size needed for the original study, the effect size $\eta 2 = 0.09$ from a previous study on the effects of food labelling on hunger was used (Crum et al., 2009). Based on the formula for power of Cohen (1988), the sample size calculation for a mixed between-within repeated measures analysis of variance (ANOVA) with 3 measurement moments indicated that with an alpha level of .05 and a power of $\beta = .80$, 126 participants (42 per groups) would be sufficient to detect differences in the intensity of food craving between the groups.

As the current thesis project was written before completion of data collection, only part of the dataset, namely the data of 66 participants, was analysed.

Participants were randomly assigned to one of the three groups. Randomization is done in blocks separately for men and women, with the aim to have an equal number of men and women in each group.

Procedure

Participation sign-up was possible through the SONA System, or through a Google Form, in which the study description claimed to investigate the effects of the vagus nerve stimulator on food perception and hunger. Upon sign-up, the participant were invited for a 1-hour session in a laboratory at Leiden University. They were asked to fill out a questionnaire prior to the session that collected their demographics, ensured they meet the inclusion criteria and asked for their favourite food.

The participants were asked to refrain from eating and drinking for at least 2 hours before the session and from drinking alcohol for at least 12 hours before the session. In the introductory part of the session, each participant received a brief summary of the procedure and the first deceptive suggestion, depending on the experimental group they were assigned to. They were then asked to read and sign the informed consent form. To further check the inclusion and exclusion criteria, their weight and height were measured by the experimenter, and they were asked when they last ate and last drank alcohol.

Following this, the participant filled out the first set of questionnaires that included questions regarding their baseline hunger and food craving, body image, current mood, and how much they expect the vagus nerve stimulator to affect their hunger and craving, amongst others.

Once they had completed the questionnaire, the experimenter explained the vagus nerve stimulator to the participant and again used verbal suggestion to implement either a placebo or nocebo effect, or neither in case of the control group. More details on the placebo effect induction is given in the following section. The experimental groups were told that the stimulation occurs along the vagus nerve, however it was a sham stimulation instead, with no real effect. The participant was asked to hold the electrodes of a vagus nerve stimulator on a spot behind their ear, where no nerve runs, for two minutes, while the experimenter started the device and increased the current until the participant was able to sense it. After this was done, they were asked to fill out the next part of the questionnaire that asked about their current level of hunger, food craving, and mood.

The participant then underwent a Mental Imagery Task for about three minutes, in which they were presented a certain scenario involving their favourite food. The aim of the task was to induce food craving; the task required them to concentrate and imagine the food's structure, smell and taste as vividly as possible. Immediately after, they were asked to rate how vividly they were able to imagine the food, and also fill out the same questionnaire regarding their current hunger, craving, and mood.

Lastly, the participant completed two more computer task, namely the Food Viewing Task and the Food Choice Task. During the first task, they viewed images of low- and high-calorie food and were asked to rate each food item on its likeability and their craving for it. In the second task, they were presented with two images, a high-calorie and a low-calorie food, which they had to choose between. Afterwards, they filled out the questionnaire regarding their current hunger, food craving, and mood one last time.

To conclude the study, the experimenter debriefed the real purpose of the study to the participants in the placebo and nocebo group, and each participant received their preferred snack and a compensation of either 8.50€ or 2 SONA credits.

Placebo effect induction

The placebo group in this study received verbal suggestions in regards to the placebo effect of the vagus nerve stimulation. In the introductory part of the study, while the experimenter told the participant how the session will follow, they were told that the study aims to explore the effects of the vagus nerve stimulator on food perception. Specifically, the

experimenter told them that the vagus nerve connects the stomach to the brain, and that previous experimentation had found that stimulation of the nerve reduces hunger. After the first set of questionnaires that the participant filled out, the instructions regarding the stimulation are repeated to the participant, highlighting once again that it was expected for their hunger to decrease upon the stimulation, similar to previous reports in studies.

Measures

Hunger was measured with a Visual Analogue Scale and a question, asking the participant how hungry they are. The scale had two anchors: 'Not hungry at all' and 'Extremely hungry', and was numbered from 0 to 100.

Food craving was measured similarly; the question asked how much they want to eat their favourite food right now, with a Visual Analogue Scale underneath ranging from 0 ('Not at all') to 100 ('Extremely'). The two variables are measured at baseline, after the vagus nerve stimulator application, after the mental imagery task, and lastly, after the computer tasks.

In addition to this, the participants were asked to rate how much they expected the vagus nerve stimulation to affect their hunger. This was again measured with a Visual Analogue Scale ranging from 0 to 100. A score of 50 was captioned with the assumption that the stimulation will have no effect on their hunger, while lower scores indicated expectations of increased hunger and higher scores indicated expectations of decreased hunger.

Body image was measured with a Body shape questionnaire at baseline (Cooper et al., 1987). It includes 27 items measuring dissatisfaction and discomfort with the body experience. The answer options are on a 5-point Likert scale, ranging from 'Not at all true' to 'Completely true'. Some items are reverse coded, in order to reduce response bias. Examples of some of the statements are the following: 'I think my body is unattractive', 'I feel depressed about my body', 'My body looks good'. After reverse coding, a sum score for all items of the body image questionnaire was computed to create a body image score. This score ranges from 27 to 135, with higher numbers indicating a more negative body image.

Ethics

A CEP protocol was submitted to the ethical committee at Leiden University. The study was accordingly approved and the ethical approval number is 2024-03-07-A. Skvortsova-V1-5338.

Statistical analysis

The analyses were conducted using the programming language R (4.4.0), as well as R-Studio (2024.04.1).

For this research project, a placebo score for hunger and food craving was calculated, in which the baseline ratings of participants was subtracted from the first timepoint, namely after the vagus nerve stimulation. This calculated placebo score results in either negative scores, indicating a reduction in hunger or food craving, or positive scores, indicating an increase in hunger or food craving. This placebo score was used in all subsequent hypothesis analyses.

Explorative analyses

Some explorative analyses were run to understand the variables and their interactions with one another better. Firstly, independent samples *t*-tests were run for the baseline measures of hunger and food craving, as well as the body image score, between the placebo and control group, to ensure that the two groups do not differ from one another at baseline.

Another independent samples *t*-test was conducted to compare the expectation ratings of the vagus nerve stimulator's effect on their hunger between the placebo and control groups. This manipulation check is crucial to confirm that the placebo intervention was perceived as intended.

Then, three *t*-tests were run to compare the baseline ratings of body image, hunger, and food craving between male and female participants. This is done in order to explore whether these variables differ depending on gender.

Lastly, the participants' ratings on hunger and food craving was analysed in a Pearson correlation analysis, to investigate if the two concepts were correlated.

Hypothesis Testing

1st Hypothesis (Placebo Effect). To test the hypothesis that the placebo group reports lower hunger and food craving compared to the control group, we performed two independent samples *t*-tests. The dependent variables are the placebo scores of hunger, for one analysis, and food craving, for the other. These were calculated by subtracting the baseline from the scores after the placebo manipulation. The independent variable is the group (placebo vs. control).

2nd Hypothesis (Body Image Moderating Effect). We used a regression analysis to examine whether body image moderates the relationship between the placebo effect and hunger and food craving, respectively. In the first analysis, the dependent variables is hunger, and for the second analysis it is food craving. Group served as the independent variable, while body image, treated as a continuous variable, was included as the moderating variable. To assess moderation, the interaction term between group and body image (Group*Body

Image) was included in the regression model. A significant interaction term would indicate that the effect of group on the dependent variables varies based on body image.

3rd Hypothesis (Gender Moderating Effect). To explore whether gender moderates the placebo effect on hunger and food craving, another regression analysis was conducted. The dependent variables are hunger and food craving (per analysis), and the independent variable is group. Gender is included as the moderating variable, and once again, an interaction term (Group*Gender) will be examined to assess moderation.

Assumptions, Data Checks, and Post-Hoc

Before conducting the regression analyses, we checked the assumptions of normality, homoscedasticity, and multicollinearity. Normality of the dependent variables was assessed using the Shapiro-Wilk test and Q-Q plots. Homoscedasticity of the dependent and independent variables was checked using Levene's test. To assure no multicollinearity between the predicting variables was present, the Variance Inflation Factor (VIF) was calculated. These checks ensure that the statistical analyses are valid and reliable.

If significant interactions were detected in any of the moderation models, the results will be plotted to examine the effect of the moderator on the dependent variable in each group separately.

Results

The sample size at time of analysis was $n = 66$. The average age of the total sample was 21.3 years old and 74% (49 participants) were female. The placebo group consisted of 32 participants and the control group of 34 participants, with an even distribution of gender amongst the groups. 24 participants (75%) in the placebo group were female, while 25 participants (74%) in the control group were female.

Prior to conducting the main analyses, all assumptions were checked and satisfied.

Baseline differences

The results of the independent sample *t*-tests for the baseline measures and the expectation ratings between the placebo and control group are summarised in Table 1. The two groups did not significantly differ in their baseline ratings in hunger, $t(64) = 0.04$, $p = .967$, food craving. $t(64) = –1.43$, $p = .157$, or body image, $t(64)= –0.84$, $p = .406$. The placebo group reported higher expectations in regard to how much their hunger will decrease following stimulation, in comparison to the control group, $t(64) = –6.21$, $p < .001$.

Table 1

Results of Independent Sample t-tests for the Explorative Analyses

Variable	Control		Placebo		*t*	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Baseline Hunger	48	22.31	47.78	20.94	0.04	.967	0.01
Baseline Food Craving	63.74	21.47	71.69	23.65	–1.43	.157	–0.35
Body Image	71.97	9.53	73.72	7.20	–0.84	.406	–0.21
Expectation Rating	39.38	15.79	62.56	14.53	**–6.21**	< .001	–1.53

Note. Bold font indicates statistical significance.

The explorative *t*-tests regarding the gender differences in baseline ratings revealed that there was no statistically significant difference between men and women in their body image scores, $t(64) = –0.84$, $p = .416$, in their hunger, $t(64) = –0.69$, $p = .494$, and in their food craving, $t(64) = –1.36$, $p = .183$.

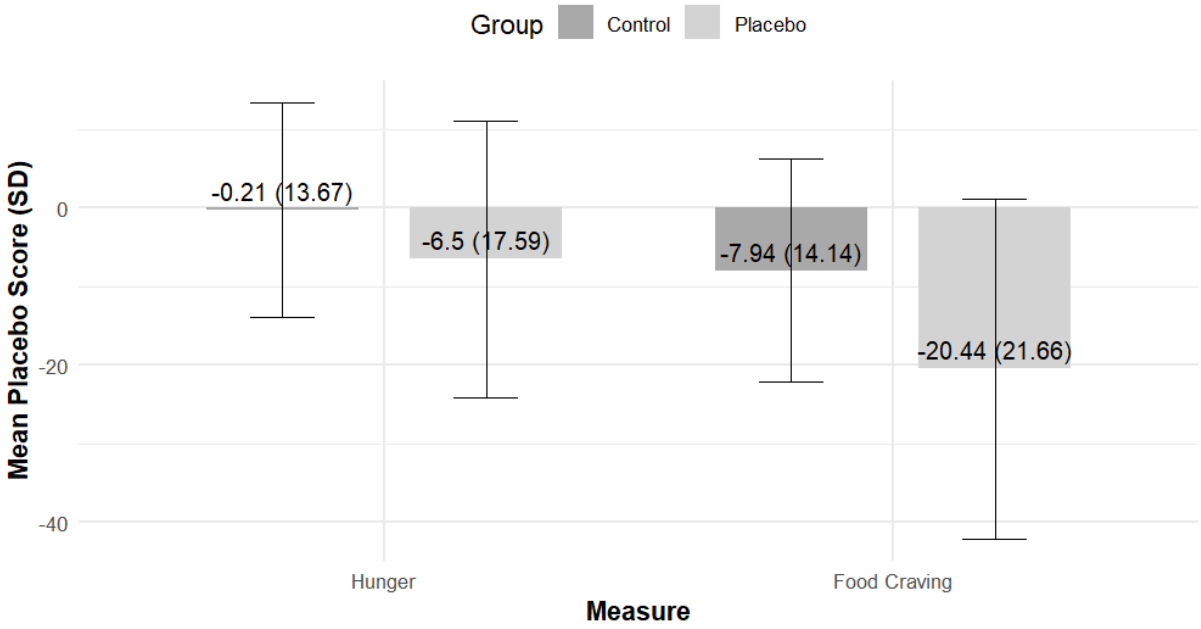
Lastly, the Pearson correlation between the baseline hunger and food craving ratings revealed a positive significant relationship, $r = 0.45$, $p < .001$.

Placebo on hunger and food craving

To test whether the placebo and control group differed in hunger and food craving, two independent samples *t*-test were performed, for hunger and food craving placebo scores respectively. The placebo scores of hunger revealed no statistically significant difference between the placebo ($M = –6.5$, $SD = 17.59$) and control group ($M = –0.21$, $SD = 13.67$), $t(64) = 1.62$, $p = .111$, $d = 0.40$. However, for the food craving placebo scores, a significant difference between the two experimental groups was detected, $t(64) = 2.76$, $p = .008$, $d = 0.69$. The placebo group ($M = –20.44$, $SD = 21.66$) had a significantly bigger decrease in food craving in comparison to the control group ($M = –7.94$, $SD = 14.14$). The results are displayed in Figure 2.

Figure 2

Bar Plot of the Results of Independent Samples t-test for the Placebo Scores



Note. A negative placebo score indicates a decrease in hunger/food craving.

Moderation of Body Image

In order to test whether body image has a moderating effect between the placebo group and hunger and food craving, two regression analyses were run. Results are depicted in Table 2. The model with hunger as the dependent variable was not significant in predicting changes in the outcome variable, $R^2 = 0.06$, $F = 2.48$, $p = .069$. The second model for food craving was found to be a significant predictor of changes in the outcome variable, $R^2 = 0.20$, $F = 6.50$, $p < .001$, and the interaction between body image and group allocation predicts significant changes within the model, $B = 1.30$, $t = 2.46$, $p = .017$. The effect size of the interaction effect was subsequently calculated using Cohen's (1988) formula, and revealed a medium effect size of $f^2 = 0.25$. The scatter plot in Figure 3 shows the interaction effect of this analysis; it is visible that a higher body image score, which indicates a more negative body image, results in a smaller placebo effect in food craving.

Table 2

Moderation Analysis with Body Image as Moderator

Variable	*B*	*SE*	*t*	*p*	95% CI	
					LL	UL
			Hunger (DV)			
(Intercept)	–21.45	20.38	–1.05	.297	–62.20	19.29
Group	–38.48	34.97	–1.10	.275	–108.39	31.41
Body Image	0.30	0.28	1.05	.297	–0.27	0.86
Group * Body Image	0.43	0.48	0.90	.370	–0.52	1.38
			Food Craving (DV)			
(Intercept)	–14.11	22.62	–0.62	.535	–59.33	31.10
Group	–108.34	38.80	**–2.79**	.007	–185.89	–30.78
Body Image	0.09	0.31	0.28	.784	–0.54	0.71
Group * Body Image	1.30	0.53	**2.46**	.017	0.24	2.35

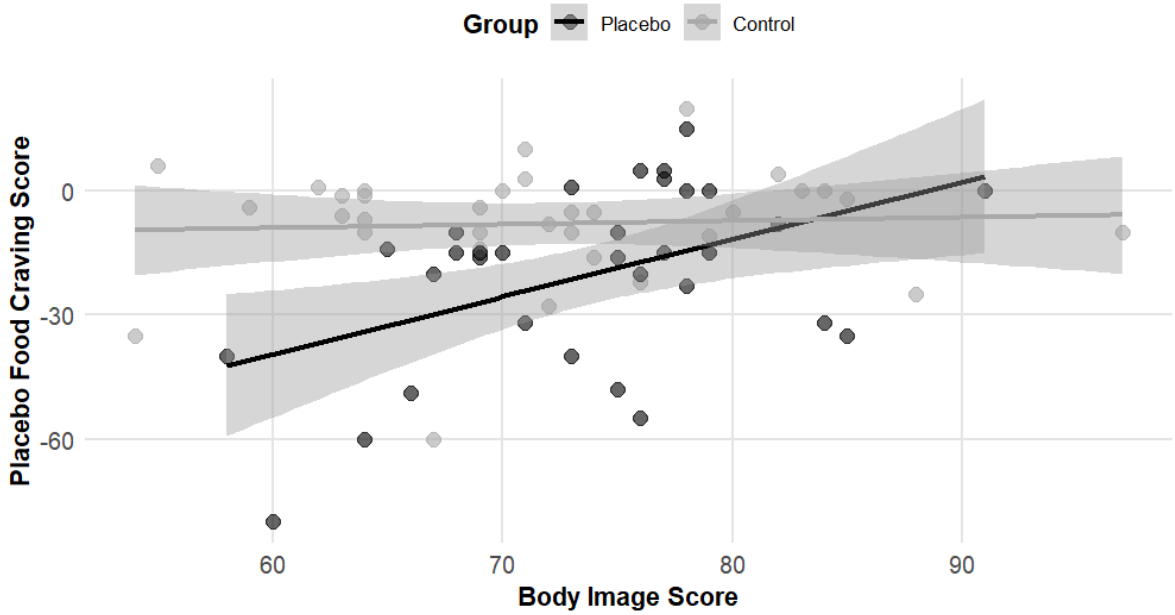
Note. R^2 = 0.06 for Hunger Model, R^2 = 0.20 for Food craving Model.

CI = confidence interval; LL = lower limit; UL = upper limit; DV = dependent variable.

Bold font indicates statistical significance.

Figure 3

Interaction between Body Image Score and Placebo Food Craving Score, with Regression lines for each Group



Note. Higher body image scores indicate a more negative body image.

Moderation of Gender

Lastly, two more regression analyses were performed for the moderation analysis of gender and the placebo effect, run for hunger and food craving. The model regressed on hunger was statistically insignificant in predicting changes, $R^2 = –0.0003$, $F = 0.99$, $p = .402$. The second model, when regressed on food craving, was significant in predicting changes in the outcome variable, $R^2 = 0.10$, $F = 3.38$, $p = .024$. The interaction of group and gender was not found to be significant for either hunger or food craving (see Table 3).

Table 3
Moderation Analysis with Gender as Moderator

Variable	*B*	*SE*	*t*	*p*	95% CI	
					LL	UL
			Hunger (DV)			
(Intercept)	0.44	3.18	0.14	.890	–5.91	6.79
Group	–7.73	4.54	–1.70	.094	–16.81	1.35
Gender	–2.44	6.18	–0.40	.694	–14.79	9.91
Group * Gender	5.61	8.96	0.63	.534	–12.30	23.58
			Food Craving (DV)			
(Intercept)	–6.40	3.63	–1.77	.083	–13.65	0.85
Group	–11.68	5.18	–2.26	.028	–22.04	–1.32
Gender	–5.82	7.05	–0.83	.412	–19.91	8.27
Group * Gender	–3.59	10.22	–0.35	.726	–24.03	16.84

Note. $R^2 = –0.0003$ for Hunger Model, $R^2 = 0.10$ for Food craving Model.
CI = confidence interval; LL = lower limit; UL = upper limit; DV = dependent variable.

Discussion

The research on the placebo effect on hunger and food craving is rather limited, and interactions with body image or gender have not been explored. Therefore, this project was firstly aiming to investigate whether it is possible to use the placebo effect to reduce hunger and food craving. Additionally, it explored the potential moderating effects of body image and gender. The study verbally induced participants with a hunger-reducing placebo effect, and collected self-reported data on hunger and food craving.

In regard to the first hypothesis, the placebo suggestions significantly reduces the food craving of the participants in the placebo group in comparison to the control group;

however there was no significant changes in hunger. Despite the fact that the two variables, hunger and food craving, are correlated, they are falsely used interchangeably and are not always firmly distinguished. To highlight their differences, feelings of hunger are primarily driven by internal processes, such as the release of the ghrelin hormone, while craving has both internal and external influences (Davis, 2018). Food craving may occur even in the absence of hunger sensations, as they are also driven by cognitive, emotional or environmental factors. Visual cues or mental imagery of someone's favourite food can trigger craving for this food (Bullins et al., 2013). Hormone changes during the menstrual cycle have also been shown to direct craving towards more sweet or processed food (Hoseini et al., 2023). Changes in mood or emotions may also trigger feelings of food craving, despite the absence of hunger (Van Strien et al., 1986). Therefore, interpreting the aforementioned results of the first hypothesis, there is a possibility that the placebo suggestions given to the participants only affected them psychologically, but could not impact the interoceptive sensation of hunger. This is only partially in line with results of previous literature; verbal suggestions of a hunger-reducing placebo pill was successful in reducing appetite and increasing satiety (Hoffmann et al., 2018). Another study conducted by Skvortsova et al. (2023) revealed that placebo effects induced by pharmacological conditioning of intranasal insulin reduced hunger in normal-weight participants. Geers et al. (2018) have analysed the basic processes and mechanisms that are involved in the formation of placebo expectations, and conceptualised a model that included factors such as verbal messages, setting, a doctor's lab coat, and product packaging, amongst others, to be influencing the effectiveness of the placebo effect. Therefore, it may be argued perhaps the pill and the intranasal insulin in the previously mentioned studies are more invasive methods, and could have led to a more credible pharmacological setting in the perspective of the participant. Additionally, the varying results can be ascribed to individual differences, such as attitudes, culture or prior experience, that are capable of impacting the expectations induced by a placebo treatment (Geers et al., 2018).

The analysis of the second hypothesis revealed that body image was in fact moderating the placebo effect on food craving. Once again, the effects were not statistically significant for hunger. The plot revealed the direction of this interaction, and further confirmed part of the second hypothesis, namely that a more negative body image of the participant decreased the effectiveness of the placebo suggestions on food craving. To interpret these results, previous literature have outlined the relationship that body image has on appetite or food craving. Yan et al. (2022) have indicated in their study that body

dissatisfaction was highly associated with the experience of perceived stress that derived from social comparison and the pressures of being thin. This stress was mediating the relationship between body dissatisfaction and binge eating, highlighting an important mechanism of binge eating behaviour. Interestingly, bingeing was found to be associated with lower levels of hunger; Waters et al. (2001) found support for the notion that binge eating is dependent on emotional states and cravings, rather than hunger. This can potentially explain why there was no significant effects on hunger, when the interaction of body image and placebo was explored. At this stage of the discussion, it is important to distinguish between homeostatic hunger and hedonic hunger. Hedonic hunger is an appetitive drive in order to gain pleasure from the food, rather than nutritional values or energy gain (Lowe & Butryn, 2007). They describe it as a dimension of appetite, that is characterized by an increased focus on food palatability. The widespread availability of palatable and energy-dense food has been a main contributor to weight gain, with hedonic hunger being the primary drive. However, it is often falsely concluded that this primarily occurs amongst overweight and obese individuals. Lowe & Butryn (2007) direct the reader's attention to the fact that normal-weight individuals with a poor body image may engage in restrictive eating, with the aim to achieve the socially-reinforced standards for thinness. Restrained eaters are defined by their distorted internal hunger signals, as well as the involvement of cognitive factors on their food intake (Pietrowsky et al., 2003). Therefore, this can put them in a more susceptible state to hedonic hunger and food cravings. This reflects in the results of the current project, namely that body image, even in considerably healthy individuals, can affect their perception of food craving, and even diminish the effects of placebo suggestions.

Lastly, the final analysis revealed no significant moderation of gender on the relationship between the placebo effect and hunger and food craving, respectively. Therefore, no difference was detected on the effects of placebo between men and women. A systematic review of reviews, meta-analyses, and meta-regressions has outlined that in only 3 out of 75 analyses, sex contributed to differences in placebo responses, namely that women were more responsive to placebo (Weimer et al., 2015). Thus, it can be concluded that varying susceptibility of men and women in the placebo effect are not probable, and that the results of the current project are in line with previous literature. Studies regarding gender differences in food craving has mostly yielded contradicting results. A review by Hallam et al. (2016) has reported that there are gender differences in the kinds of food craved, the intensity an frequency of food craving, as well as the regulation thereof. They indicated that women report more craving for sweet food (whereas men crave savoury food), that they overall

experience more intense food craving, and that they find it harder to regulate such cravings, compared to men. On the other hand, however, the study conducted by Klimesova et al. (2020) has tested differences in food cravings between genders with normal BMI and has found no significant difference in the intensity of food craving that males and females experience. However, the authors found that different mechanisms affect food craving of men and women, namely that men crave food more when it is viewed as a reward, while women are more driven by emotionally-laden situations. As the current study only examined the level of craving for their favourite food, no differentiation between the two genders was detected, indicating the need for further exploration and clarification.

Strengths and limitations

Several factors may impact the results of the current project. Firstly, due to an incomplete data set, the power of the study was lower than anticipated. Additionally, some repercussions follow the sampling method of convenience sampling. The fact that mostly university students were recruited, with an incentive for participation, resulted in a selection bias, as well as homogeneity within the sample. As a consequence of this, there is an disproportionate representation of men (26%) and women (74%). It can be concluded that the external validity of the study, including population and ecological validity, is rather low, as the results cannot easily be applied to different contexts or the general population.

Further limitations include the measures used for health and hunger. To ensure the inclusion of exclusively healthy participants, the BMI needed to be within the normal range. However, body mass does not clearly indicate how healthy an individual is or how many health risks they may develop; more relevant is where they carry the weight, making the body fat percentage a more reliable health measure (Nuttall, 2015).

Lastly, Lowe & Butryn (2007) explain that self-reported hunger tends to measure more than just the physical sensations of food deprivation, or homeostatic hunger, but often measures aspects of hedonic hunger. Thus, including only one question for hunger could potentially limit the true understanding of the participants' experience of hunger.

Despite such limitations, the study put a substantiate effort to counter some of the aforementioned factors. For once, the random assignment of the participants into each of the experimental groups can decrease selection bias. The success of the randomization is evident in the fact that there were no baseline differences in the measures between the placebo and control group in either hunger, food craving or body image. Additionally, some of the exclusion criteria function as confounding factors; the absence of an eating disorder ensures that the current thesis project can rule out the body image interaction effects found are

ascribed to potential eating disorders in participants. Any potential confounding effects of previous alcohol consumption can also be ruled out, as the participants were asked to not consume any alcohol 12 hours prior to the session; this was reassessed at the start of the session. Such measurements can thereby increase the internal validity of this study.

Lastly, by adhering to a protocol for each participant, there is consistency amongst the participants, as well as between the groups. For example, the control group also received a 2-minute sham vagus nerve stimulation, with neutral suggestions about the effects of it. Thus, a high reliability of the study's methods can be assumed.

Implications and future directions

Given that food craving can occur in the absence of hunger, it seems to be a more relevant factor to consider in treatments of disordered eating patterns. Bingeing is a core component to several diseases and disorders, such as obesity, binge eating disorder, and bulimia nervosa. The excessive calorie intake has been a leading cause for weight gain, which is frequently manifested in further health complications. Literature has clarified that bingeing is rather dependent on food craving instead of hunger (Waters et al., 2001). The current project has made apparent that food craving is easily changeable through a hunger-reducing placebo intervention. A sham 2-minute stimulation, accompanied by placebo suggestions, was effective in reducing food craving in participants. This can have several implications on future developments of treatment with the aim to reduce bingeing behaviour, namely that a placebo intervention could be a more cost-efficient and non-intrusive option in this regard.

As body image was revealed to be a moderating factor on the relationship between the placebo effect and levels of food craving, it can be considered an indicator for a distorted sense of appetite and perhaps even unhealthy eating habits. The likelihood of pathology development could be estimated in normal-weight individuals through the measures of body dissatisfaction. This can have positive implications on preventative care programmes that target the prevalence of eating disorders by aiming to reduce risk factors and enhance protective factors. Body dissatisfaction can potentially be incorporated as one of the risk factors.

Placebo effects on hunger and food craving are rather under researched. Thus, future studies can explore varying placebo interventions, with a focus on primarily decreasing food craving and appetite. The results at hand need to be replicated in participants with problematic eating habits, especially those engaging in binge eating. A more heterogeneous sample could potentially reveal results with wider-reaching and more generalizable implications. Furthermore, gender differences in susceptibility to the placebo effect, as well

as food craving, need to be further assessed due to the common contradictions in the discussed literature. Lastly, long-lasting effects of the placebo intervention need to be explored by conducting a longitudinal study with similar methods.

Conclusion

The hunger-reducing placebo suggestions were unsuccessful in decreasing participants' hunger, but was instead able to significantly decrease perception of food craving in participants of the placebo group. Additionally, this effect is moderated by body image; the more negative the body image, the less effective the placebo. Food craving is highlighted as the driving factor for unhealthy eating habits such as bingeing. Thus, it can be concluded that a shift of attention is required in the approach of managing health adversities such as binge eating and obesity; food craving needs to be prioritized in future interventions as the prime agent. Furthermore, the buffering effects of a negative body image need to be considered as a potential risk factor in the early developing stages of eating pathology.

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